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Case No: HQ09X03547

IN THE HIGH COURT OF JUSTICE
QUEEN'S BENCH DIVISION

Royal Courts of Justice
Strand, London, WC2A 2LL

Date: 23/10/2012

Before :

THE HONOURABLE MRS JUSTICE SWIFT DBE

- -

Between :

JEFFREY JONES AND OTHERS	**Claimant**
- and -	
THE SECRETARY OF STATE FOR ENERGY AND CLIMATE CHANGE	**First Defendant**
- and -	
COAL PRODUCTS LIMITED	**Second Defendant**

- -
- -

Mr David Allan QC and Mr Ivan Bowley (instructed by **Hugh James Solicitors**) for the **Claimants**
Mr Ronald Walker QC and Mr Robert O'Leary (instructed by **Nabarro LLP**) for the **Defendants**

Hearing dates: 17-31 October 2011; 7 November – 2 December 2011; 19-21 December 2011

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Judgment

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The Honourable Mrs Justice Swift :

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SECTION 1

INTRODUCTION

The litigation

1.1 This judgment concerns the cases of eight lead claimants in group litigation known as the Phurnacite Workers Group Litigation (PWGL). The claims are made in respect of men who were formerly employed at the Abercwmboi Phurnacite Works ('the Phurnacite Plant'), Aberaman, Cynon Valley, South Wales. A group litigation order (GLO) was made in the PWGL on 22 July 2009.

The claimants

1.2 Approximately 250 claimants have registered claims under the PWGL GLO for damages for respiratory disease and/or various types of cancer which they allege were caused by the exposure to dust and/or fume containing carcinogenic substances in the course of work at the Phurnacite Plant. Some of the claims have been made by former Phurnacite workers; other claims have been brought by the widows or other family members of former Phurnacite workers who have died. In the course of this generic judgment, I shall refer on occasion to all the former Phurnacite workers in respect of whom claims have been made as 'the claimants'.

The defendants

1.3 The Phurnacite Plant opened in 1942 under the ownership of a private company, Powell Duffryn Limited (PDL), which operated a number of collieries in South Wales. On 1 January 1947, as a result of nationalisation, the Phurnacite Plant was vested in the National Coal Board (NCB). From that time until 1973, it was operated by the NCB or the British Coal Corporation. From 1973 until the production of Phurnacite ceased in 1990, the Plant was operated by National Smokeless Fuel Limited (NSFL), a company which was wholly owned by the second defendant, Coal Products Limited (CPL). CPL was in turn a subsidiary of the NCB/British Coal Corporation.

1.4 The Department of Energy and Climate Change (the Department), has succeeded to the liabilities of the NCB, the British Coal Corporation and NSFL and has agreed to indemnify the second defendant fully against all damages and costs arising from this litigation. The first defendant, the Secretary of State, is conducting the proceedings on behalf of both the Department and the second defendant. I shall refer to the first and second defendants collectively as 'the defendants'. I shall usually refer to the operators of the Phurnacite Plant as the NCB (before 1973) and NSFL (after 1973).

The lead claims

1.5 The Group Register which was set up pursuant to the PWGL GLO was divided into two Schedules. Schedule A of the Group Register consists of claims for non-malignant respiratory disease, namely chronic obstructive pulmonary disease (COPD) and chronic bronchitis (CB). Schedule B consists of claims for lung cancer, bladder cancer and skin cancer. Some claimants are registered on both Schedules. It was agreed that there should be a trial of eight lead claims. I directed that each party should choose one lead claim from Schedule A, together with one case each of lung cancer, bladder cancer and skin cancer from Schedule B. Where a lead claimant had made a claim in respect of more than one medical condition, I directed that all those claims should be dealt with at the trial of the lead claims. The eight claims can be summarised thus:

Name of claimant	Medical condition
Ernest Noel Carhart, deceased	Lung cancer; COPD; CB
Raymond Davies, deceased	Lung cancer
John Griffiths, deceased	Lung cancer; CB
Ronald Lyndhurst Jenkins, deceased	Bladder cancer
David Samuel Jones	Skin cancer
David Middle	Skin cancer; CB
Frederick John Richards	Bladder cancer; COPD; CB
Michael Douglas Robson, deceased	COPD; CB

The parties' cases

1.6 The claimants' case was that, over the period for which the Phurnacite Plant was in operation, the NCB/NSFL exposed them to dust and/or fume containing carcinogenic substances in breach of their statutory duty and negligently. The claimants contended that their occupational exposure at the Phurnacite Plant had caused the various conditions in respect of which claims were made.

1.7 The defendants made a number of admissions, in particular as to breach of duty and as to the causation of non-malignant respiratory disease and lung cancer. However, those admissions were limited and a large number of issues remained to be resolved. In particular, the defendants did not accept that exposure to dust and/or fume at the Phurnacite Plant was capable of causing bladder cancer, or skin cancer of the type suffered by the two lead claimants with skin cancer claims. There was a dispute about the extent of the claimants' exposure to dust, fume and carcinogenic substances and the defendants denied causation in each individual case. They contended that all except two of the lead claims were statute-barred.

The trial

1.8 Between 17 October and 2 December 2011, I heard evidence in the eight lead cases. There was a considerable amount of lay witness evidence, together with evidence from nine expert witnesses. In addition, there was a great deal of documentation about the Phurnacite Plant from the defendants' archived material and other sources. Nine core bundles of documents were prepared for use at the trial and many other documents (known as the standard disclosure documents) were available on CD. There were also bundles of documents (such as training and employment records, general practitioner (GP) and hospital records) relating to each lead claimant. In addition, the experts produced technical and medical literature in support of their opinions. That literature ran into many lever arch files.

1.9 Because of the location of the Phurnacite Plant and the age and infirmity of some of the claimants and lay witnesses, I heard the oral evidence from them in Cardiff. The expert evidence was heard in London. At the conclusion of the expert evidence, there was a break before oral submissions, which I heard between 19 and 21 December 2011. The parties then requested me to delay finalising my judgment until after the Supreme Court had delivered their judgments in *Ministry of Defence v AB* *and others (*the *'Atomic Veterans'* case*)*[1]. After those judgments had been handed down, I received further written submissions from the parties which I have now had the opportunity of considering. With the parties' consent, I also requested one of the experts to carry out further calculations and the parties commented on those calculations in their further submissions.

1.10 At the trial, the claimants were represented by Mr David Allan QC and Mr Ivan Bowley and the defendants were represented by Mr Ronald Walker QC leading Mr Robert O'Leary.

The Phurnacite Plant

1.11 The Phurnacite Plant at Aberaman covered approximately 150 acres[2]. A river ran through the site and there was a lake, together with a number of man-made lagoons which were used for the treatment of effluent. The Plant was used for the manufacture of a smokeless fuel with the trade name 'Phurnacite' and, until its closure in 1990, it was the only site at which Phurnacite was manufactured.

1.12 The collieries owned by PDL had produced a surplus of 'small coal' (also known as 'fines' or 'duff'), i.e. fragments of coal too small to be sold as fuel. The 'duff' was of the Welsh dry steam type with a low volatile content. PDL conceived the idea of mixing the surplus duff with pitch from the coal tar distillation industry as a binding agent in order to produce a domestic fuel.

1.13 Phurnacite was made by combining crushed, dried coal with pitch and then with super-heated steam and pressing the resulting mixture into ovoid briquette shapes. The briquettes were then carbonised (i.e. heated at high temperatures in an airless oven, in order to drive off the volatile constituents of the coal and pitch mixture) in order to give the briquettes properties similar to anthracite. Anthracite is a type of coal with a high carbon content and a high calorific value. Phurnacite proved popular and was able to compete successfully with anthracite as a fuel for domestic boilers and ranges.

1.14 When the Phurnacite Plant opened in 1942, it consisted of one briquetting plant (briquetting plant 1) in which the Phurnacite briquettes were made, together with a single battery building (battery 1), in which they were carbonised. The batteries contained five blocks of eight ovens. The ovens originally installed at the Phurnacite Plant were of a French design with an inclined floor and were known as Disticoke ovens. They operated 24 hours a day, 365 days a year, at high temperatures.

1.15 The Phurnacite Plant also had a plant to deal with the various by-products of the Phurnacite manufacturing process, together with facilities for treating the effluent that was produced in the course of the manufacturing process. In addition, the Plant had all the necessary support facilities, including workshops, office accommodation, wash and shower rooms and canteens.

1.16 By the time the NCB took over the operation of the Phurnacite Plant in 1947, sales of Phurnacite were increasing and a decision was taken to expand the Plant and to increase the production of Phurnacite. A second battery (battery 2) was completed in 1951 and the briquetting plant was enlarged. In 1956, two more batteries (batteries

[1] [2012] UKSC 9
[2] See e.g. photograph at CBP/67

3 and 4) came into operation, together with a second briquetting plant (briquetting plant 2). In 1957, another battery (battery 5) was completed. In the years that followed, there was further expansion. Two more batteries were completed (battery 6 in 1968 and battery 7 in 1970). All the new batteries had a similar design of Disticoke oven as that which had originally been installed in battery 1. In 1968, when battery 6 was installed, battery 2 was closed for re-building and was not re-opened until 1973. After 1970, there were seven batteries on site although, in practice, no more than six batteries were in operation at any one time. In the late 1960s and early 1970s, the Phurnacite Plant was at its height. It reached its maximum output during that period, producing about a million tonnes of Phurnacite a year. At that time, it employed about a thousand people, mostly men from the villages near the Phurnacite Plant.

1.17 As I shall explain in more detail later in this judgment, there were concerns as early as 1973 about the long term viability of the existing Phurnacite manufacturing process and work began on identifying possible alternatives to the Disticoke oven process. Meanwhile, in 1973, battery 3 was closed down permanently. By 1980, a decision had been taken to construct a unit for manufacturing Phurnacite by means of the Ancit process which would run initially in conjunction with the existing Disticoke ovens. During 1982 and 1983, batteries 1 and 7 were re-built and re-commissioned in an attempt to improve carbonisation and to reduce pollution. In 1983, battery 4 was closed.

1.18 The Ancit plant was commissioned in October 1985 adjacent to the Phurnacite Plant. This was followed by the permanent closure of batteries 5, 6 and 7 in 1985, 1989 and 1988 respectively. The Ancit process did not prove successful and a decision was taken not to extend its use. Instead, NSFL decided to produce Phurnacite by a different process, known as the mild heat treatment process. After attempts to obtain planning permission for the construction of a mild heat treatment plant at the Aberaman site had failed, the decision was taken to close the Phurnacite Plant. Production at the Phurnacite Plant ceased with the closure of batteries 1 and 2 in 1990. There then followed a period of one or two years during which some employees were kept on to assist in the final closing down of the Phurnacite Plant prior to demolition. Subsequently, Phurnacite manufacture was transferred to a newly constructed mild heat treatment plant in North East England where it has continued ever since.

Coal, coke and pitch

1.19 Coal has a complex and variable chemical structure. Its main element, carbon, is present in varying proportions in different types of coal. Low grade bituminous coals contain about 40% carbon, whilst anthracites (coals with the least impurities and the highest calorific value) contain as much as 90% carbon. Other elements present in coal include hydrogen, sulphur, oxygen and nitrogen. Coal also contains minerals originating from the host rock in which it was formed, the most important of these minerals being silica. At the molecular level, coal is formed from large systems of fused aromatic carbon rings with cross linkages of oxygen and sulphur in combination with hydrocarbon structures. When heated to high temperatures, it has the potential to release volatile polycyclic aromatic hydrocarbons (PAHs). There are many different PAHs, some of which are known to be carcinogenic in humans.

1.20 Coke is derived from bituminous coal by carbonisation. During the carbonisation process, a complex mixture of solid particulate emissions, volatilised fumes and gases are emitted. Those emissions typically contain a range of carcinogenic chemicals including PAHs. Air samples taken at coke plants have revealed the presence of more than 60 organic compounds and more than 40 PAHs in coke oven emissions.

1.21 Pitch is a polymer usually derived from petroleum, wood or coal tar. The pitch used at the Phurnacite Plant was the residue left behind after the distillation of coal tar. Pitch is a semi-plastic material which becomes solid when cold, but tends to soften with increased temperatures. It is a complex mixture of compounds and is known to contain a high proportion of PAHs. Benzo[a]pyrene (BaP) is a PAH which is a known carcinogen and is present in coal tar pitch.

1.22 During the carbonisation process carried out at the Phurnacite Plant, the 'raw' or 'green' (i.e. uncooked) Phurnacite ovoids were heated to a very high temperature in the Phurnacite ovens. Gases and fumes containing PAHs, together with solid dust particulates, would be produced during the carbonisation process as a result of the volatilisation and condensation of the constituents of the coal and pitch being carbonised. As the gases and fumes cooled, the PAHs contained in them would become attached to the surface of the solid dust particulates emitted from the ovens. The PAHs emitted from the ovens would have included BaP. Many other organic compounds would also have been emitted, some of which are likely to have been carcinogenic.

1.23 Volatile hydrocarbons, including PAHs, would also have been released during the handling of coal and pitch at other stages of the Phurnacite manufacturing process. The release of such volatiles would have been greater when the coal or pitch was warm or had been heated.

1.24 The Phurnacite manufacturing process carried on at the Aberaman site was unique. However, the process had some features in common with the process of coke production. A considerable body of research has been conducted into the emissions produced at coke production plants and the risks to health associated with those emissions. The experts in this litigation referred extensively to epidemiological and other literature relating to coke plants.

1.25 Both coke and Phurnacite are produced by carbonisation. In coke production, the only ingredient is coal. No binding agent is used in the production of coke and there is no need for any mixing of ingredients or pressing of briquettes. Thus, there is no equivalent of the briquetting plants at a coke oven plant. By contrast, Phurnacite production required the use of pitch as a binding agent. The use of pitch had the effect of significantly increasing the potential for the emissions of PAHs and other organic substances.

1.26 In order to make coke, coal is carbonised at temperatures as high as 1,200ºC. By contrast, the optimum temperature for carbonising Phurnacite was 900°C-1,000°C, although the evidence was that, certainly in the later years for which the Phurnacite Plant was in operation, carbonisation took place at temperatures as low as about 800°C. The carbonisation of coke takes about 18-27 hours. The carbonisation of Phurnacite took only about four hours. As a consequence of the shorter carbonisation time, the number of batches (or 'charges') of Phurnacite ovoids carbonised each day at the Phurnacite Plant was significantly greater than the number of charges carbonised at a coke plant.

1.27 There were also physical differences between the plant and equipment used at coke plants and those used at the Phurnacite Plant. For example, the ovens were of a different type and the process of cooling (or 'quenching') the carbonised material was carried out in different ways. All these differences would have affected the nature and extent of the emissions of fume and dust produced during the two manufacturing processes.

1.28 Exposure to the hazardous substances contained in coke oven emissions has been sampled and measured in various ways. For many years, sampling involved the extraction of sampled airborne particulate with benzene in order to estimate the level of benzene soluble material (BSM) in the coal tar pitch volatiles (CTPVs) emitted from the ovens. The level of BSM was used as an indirect or 'surrogate' measure to estimate the level of PAHs in the relevant sample. In 1990, the Health and Safety Executive in the UK (HSE) recommended what was considered to be a more accurate method of measurement whereby benzene was replaced by cyclohexane and that new method was subsequently adopted.

1.29 An alternative surrogate measure of exposure to carcinogenic material in coke oven emissions is the level of BaP. BaP is used as a measure because it is a known carcinogen and can be taken as an indicator of the presence of other carcinogenic material and therefore as an indicator of risk.

Dust and fume

1.30 In the course of this judgment, I refer frequently to 'dust' and 'fume'. In this judgment, 'dust' is used to mean solid particulate material that remains suspended in the atmosphere for appreciable time periods. Fume is formed when vapours or gases condense to form particulates.

1.31 The exposure of an individual to the inhalation of significant quantities of coal and other types of dust can give rise to the risk of various non-malignant respiratory diseases. The non-malignant diseases relevant to this litigation are chronic obstructive pulmonary disease (COPD) and chronic bronchitis (CB).

1.32 The size of the particles contained within the dust, together with their shape and density, are very important so far as the potential risk of injury is concerned. Particle sizes are usually stated in 'microns' (µ). One micron measures one millionth of a metre. The terms 'total inhalable dust' or 'total dust' refer to all the dust that is inhaled through the nose and mouth. However, only a proportion of that dust will be small enough to penetrate and be deposited in the deep alveolar regions of the lung and cause respiratory disease. That proportion is known as the 'respirable' dust or the 'respirable fraction' of total dust and is defined as particles with a diameter of less than five microns. Dust particles with a diameter of between five and ten microns will be able to penetrate only as far as the thoracic airways. Particles with a diameter of between 10 and 100 microns will reach only the nasal passages, the oral cavity and the larynx.

1.33 The distinction between 'total dust' and 'respirable dust' is potentially important when considering the causation of COPD and CB. COPD is a condition affecting the deep regions of the lungs, so that exposure to non-respirable dust which cannot reach those regions will not cause or contribute to the condition. By contrast, larger particles of dust, as well as respirable dust, can cause or contribute to the development of CB.

Concerns about the operation of the Phurnacite Plant

1.34 Over the years of its operation, the Phurnacite Plant was the subject of much criticism and controversy. The main concerns related to the effects of its activities on local residents and on the local environment. By the mid-1950s, residents of the villages situated near to the Phurnacite Plant were complaining about the dust, fume, smoke, dirt and odours being emitted from the Plant. There were also concerns about the discharge of effluent into the river and about the possible effects on local watercourses. Those complaints and concerns were taken up by the two district councils which served the area, by the local Environmental Health Officer and the Alkali Inspectorate.

1.35 As time went on, anxiety amongst the local community about the potential hazards that might be associated with the emissions from the Phurnacite Plant increased, and there was growing pressure for something to be done. The Alkali Inspectorate and the Environmental Health Officer were involved in attempts to reduce the off-site pollution, whilst the Factory Inspectorate was concerned with emission problems within the Phurnacite Plant and with the safety of the men who worked there. The local Water Authority monitored the effluent entering the local water supply from the river running through the Phurnacite Plant and pressed for better on-site water treatment facilities at the Plant.

1.36 Within the Phurnacite Plant, the Phurnacite Plant Consultative Committee (whose membership was drawn both from Plant management and from the main Union representing the workers at the Phurnacite Plant, the National Union of Mineworkers, Cokeman's Area (NUM)) was in existence from at least the 1950s and discussed many health and safety issues at its monthly meetings. Relevant issues were also discussed regularly at meetings of the NSFL Environmental Control Committee (which was instituted in 1973) and at meetings of the NCB (Coal Products Limited) Wales Regional Health and Safety Committee and later the NCB (Coal Products Division) Joint Safety, Health and Environment Committee. In addition, the documents disclose the existence of a large number of other committees, working groups and *ad hoc* groups and working parties which were formed from time to time in order to address the problems of dust and fume emissions at the Phurnacite Plant. Much of the material set out in Section 2 of this judgment is taken from the records of meetings of those various bodies.

SECTION 2

WORKING CONDITIONS AT THE PHURNACITE PLANT

Introduction

2.1 I have heard and read a wealth of evidence and documentation about working conditions at the Phurnacite Plant during its 48 years of operation. It is impossible in the course of this judgment to do justice to all that evidence, in particular to the history of the changes made to the various parts of the Phurnacite Plant over the years. What follows is a summary of the evidence about the working conditions in the various areas of the Phurnacite Plant as I find it to be. The conclusions about the working conditions expressed in this Section of my judgment are based solely on the witness and documentary evidence, without regard to the evidence about levels of exposure to dust and/or fume which I shall examine at Section 3 of this judgment.

The witnesses

2.2 The lay witness evidence about working conditions came first from some of the lead claimants. Mr Richards, Mr Middle and Mr David Jones provided detailed witness statements and gave oral evidence. Mr Carhart and Mr Jenkins had died before the trial started but witness statements from them were available. Oral evidence was also given on behalf of the claimants by Mr David Hodges (mainly in connection with work on the batteries and in the painting gang), Mr John Lanyon (relating primarily to work on the batteries and as a pumpsman), Mr Brian Jones (mainly connected with conditions on the batteries and in the briquetting plants), Mr Glanville Harris (again relating in the main to conditions on the batteries and in the briquetting plants) and Mr Alan Saunders (dealing mostly with conditions in the briquetting plants and the work of a sampler). There were witness statements from a number of other witnesses who had died before trial or had become too ill to give oral evidence and those statements were admitted under the provisions of the Civil Evidence Act 1995 (the 1995 Act). In particular, there were witness statements from Mr Russell Pugh (whose evidence related to conditions on the batteries), Mr Trevor Turner (dealing largely with the working conditions of painters at the Phurnacite Plant) and Mr Howard Silvanus (relating mainly to work on the batteries and as a pumpsman).

2.3 For the defendants, I heard oral evidence from Mr David Foster (an assistant manager at the Phurnacite Plant from 1970 to 1972 and, between 1979 and 1994, operations manager at NCB Coal Products Headquarters), Mr Stephen Dawes (manager at the Phurnacite Plant between 1980 and 1984) and Dr Candido Choo Yin (an environmental scientist employed by NSFL in South Wales between 1979 and 1991 who was responsible for carrying out sampling of occupational exposure levels at the Phurnacite Plant). The evidence of two witnesses, Mr Kaikobad Dubash (manager at the Phurnacite Plant between 1968 and 1971) and Mr John Williams (employed at the Phurnacite Plant from 1961 until 1987 and, between 1970 and 1987, successively employed as briquetting plant 1 foreman, yard foreman, acting training foreman and training foreman) was adduced by the defendants under the provisions of the 1995 Act.

2.4 The defendants had obtained statements from a further three witnesses whom they did not call to give oral evidence. The claimants exercised their right[3] to put in those three statements as hearsay evidence; the statements were from Mr Anthony Jasper (who had been employed as a safety and environmental chemist at the Phurnacite Plant between 1982 and 1990), Mr John Shelton (foreman of the Capital Gang responsible for repairing Phurnacite ovens from 1985 and, later, engineering supervisor overseeing all civil engineering work at the Phurnacite Plant) and Mr Stephen Holdroyd (shift manager at the Phurnacite Plant between 1984 and 1990). A further witness, Mr Baylis (shift manager at the Phurnacite Plant between 1974 and May 1977 and a frequent visitor to the Plant before that) had provided witness statements to both parties but, in the event, neither party chose to rely on his evidence.

2.5 I have dealt with my assessment of the evidence of the lead claimants who gave oral evidence in my individual judgments. As to the other witnesses called on behalf of the claimants, I gained the overall impression that Mr Hodges, Mr Lanyon and Mr Harris were doing their best to assist the court by giving as accurate an account of conditions at the Phurnacite Plant as they could. Although they may have had some understandable lapses of memory, I found their evidence to be generally reliable. Mr Brian Jones worked as a shift superintendent and then a manager at the Phurnacite Plant from 1971 until its closure. He was a patently honest witness who had an extraordinarily good knowledge of the Phurnacite Plant. I found much of his evidence very helpful to my understanding of the case. He obviously took great pride in his work and in the unique manufacturing process carried on at the Phurnacite Plant. I am satisfied, however, that his enthusiasm led him at times to adopt a somewhat uncritical view of the conditions in which men at the Phurnacite Plant were required to work. I did not find Mr Saunders an impressive witness and was not satisfied that his evidence about the conditions encountered by samplers was wholly reliable. As to those witnesses who did not give oral evidence, I bear in mind that that their evidence has not been tested in cross-examination. However, I did not observe any obvious signs of exaggeration in their witness statements and they were able to give very detailed accounts of the Phurnacite Plant and of the processes carried on there.

2.6 As to the defendants' witnesses, Mr Foster appeared somewhat dismissive of the criticisms made of the working conditions at the Phurnacite Plant and was reluctant to accept the suggestion that the defendants might have done more to protect their workforce against exposure to dust and fume, for example by enforcing the use of respiratory protective equipment (RPE) at a much earlier stage than they did. I found Mr Dawes a more impressive witness. Dr Choo Yin had obviously performed his sampling work conscientiously and gave his evidence straightforwardly and fairly.

2.7 I shall now go on to consider the evidence about the various stages of the Phurnacite manufacturing process.

The system for receiving and handling 'wet' coal

2.8 Until about 1973/1974, coal was delivered to the Phurnacite Plant in open railway wagons. At that stage, the coal was described as 'wet' coal; this did not necessarily mean that the coal was covered with water, although it might be damp if there had been recent rain. The use of the word 'wet' indicated that the coal had not

3 under CPR32.5(5)

at this stage passed through the dryer in the briquetting plant and that it still contained a relatively high moisture content. A wagon of coal would be brought to one of the two covered coal tippler areas, each of which was situated near to one of the briquetting plants. The wagon was positioned and secured on a large plate (or 'tippler') which was fitted with railway tracks. The tippler was then tilted, tipping the wagon sideways and causing the coal to fall through a chute into a concrete hopper, from where it was discharged onto a conveyor leading to the briquetting plant nearby.

2.9 Usually, the 'wet' coal did not produce large quantities of dust when it was tipped. However, when the weather was warm, the coal at the top of the wagons would dry out, causing the coal tippler areas to become dusty. The coal tippler area at briquetting plant 2 was more enclosed than the tippler area at briquetting plant 1 and the dust collected in the atmosphere there to a greater extent.

2.10 The dust in the coal tippler area did not come only from the 'wet' coal. Dust containing coal and pitch, together with (at times) small pieces of raw ovoids and breeze (i.e. small pieces of carbonised coal and pitch), were collected from various points of the Phurnacite manufacturing process (in particular from the batteries) for re-use. The dust and breeze were brought to the coal tippler areas in lorries and tipped in the same way as the wet coal. A document from 1961[4] referred to a wagon of 'plant dust' (i.e. recycled dust) being tipped "occasionally" at the coal tippler areas; on those occasions, the men working in the tippler area were paid extra. It appears that, for some time at least, recycled dust was transported in the briquetting plants on dedicated dust elevators. In 1962[5], it was reported that one of the dust elevators in briquetting plant 1 was leaking with the result that, when dust wagons were tipped, dust (including pitch dust) would billow out from the elevator. In 1970, the report of an investigation into pollution at the Phurnacite Plant, carried out by the NCB Wales Briquetting Management Unit, referred to the problem of recycled dust being blown about when wagons were unloaded at the coal tippler areas[6], especially at briquetting plant 2. Men working in the tippler area were also exposed to fine dust containing both coal and pitch which escaped from the pug outlets.

2.11 Once the wet coal arrived at one of the briquetting plants, it was tipped into one of a number of wet coal bunkers ready for use. The wet coal bunkers were about 50 feet in height; they were square at the top and narrowed to a conical shape at the bottom. Each bunker had a grate at the bottom which was used to control the flow of coal out of the bunker. The bunkers at briquetting plant 1 had a total capacity of approximately 960 tonnes and the capacity of those at briquetting plant 2 was about 2,800 tonnes.

2.12 Until the mid-1960s, the Phurnacite Plant used predominantly Welsh dry steam coal, which was at that time plentiful. Over time, however, it became increasingly difficult to obtain sufficient quantities of this type of coal. The other types of coal that were available were of a different volatile content to the dry steam coal and were not as well suited to the manufacture of Phurnacite. This made the manufacturing process (in particular, the carbonisation of the ovoid briquettes) more difficult and also affected the quality of the finished product. As a result, it became necessary to mix a number of different types of coal together in order to achieve a

[4] CB1/139
[5] CB1/154
[6] CB2/35

blend that resembled the properties of the original Welsh dry steam coal. This was done by filling the wet coal bunkers with different types of coal and mixing the contents of the various bunkers in the desired proportions as the coal was discharged from the bunkers. However, that system of mixing did not prove entirely successful and it was decided that a more radical solution was required.

2.13 As a result, a new system of blending different types of coal for use in the Phurnacite manufacturing process was introduced in 1973/74. The object of the new system was to achieve a uniform blend of coal with a volatile content similar to that which had originally been used for the manufacture of Phurnacite. A large open coal blending site was created in an area of the Phurnacite Plant some considerable distance from both the briquetting plants. The new coal blending site consisted of four (later six) stacks or 'pads' of wet coal arranged in long rectangular shapes. Coal was delivered to the blending site where automatic stackers spread the coal in layers, each layer containing coal from a different source. When the stacking process was complete, the layered coal was removed from the pad by means of a large machine called a 'reclaimer', which was mounted on rails running along each long side of the pad. As the reclaimer travelled along the pad, a large barrel at its centre rotated, scooping up coal in buckets and depositing it onto a conveyor belt which ran back through the barrel of the reclaimer. From there the coal was transferred by means of a series of conveyors (the 'wet coal conveyors' or 'blended coal conveyors') across the river and the railway to one of the two briquetting plants. At the briquetting plants, the coal was fed into one of the wet coal bunkers.

2.14 The coal blending site was in the open air and dealt mainly with wet coal. Nevertheless, dust was generated at this site, at the point where coal was tipped from wagons and from the stockpiles of wet coal. The dust blew about and was the subject of complaints by local residents. Dust was also emitted as a result of the action of the reclaimer. In February 1976, a system for spraying wagons with water prior to tipping was said to be "well advanced" and there were plans for the reclaimer to be partially enclosed[7]. In May 1976, it was reported that the spray installation for the suppression of dust on the layer blending pads had been completed and that, since then, there had been fewer complaints of dust pollution than in the previous two months[8]. I infer from the fact that these steps were considered necessary that significant quantities of coal dust had been generated previously.

2.15 Dust was also emitted when the coal was tipped onto one of the conveyors which carried it from the coal blending site to the briquetting plants. The coal was delivered to the briquetting plants by means of overhead conveyors which were covered on the top and sides. A walkway or gantry ran alongside each conveyor. Except for certain sections (i.e. those above the railway and the river) the floors of the walkways were not solid. As a result, dust, breeze and small pieces of coal fell through the walkways and were deposited on the ground below. The conveyors had continuous moving belts which carried the coal from one end of the conveyor to the other end before passing over rollers and making their return run on the underside of the conveyor. Spillages occurred when coal became stuck to the conveyor belt and was then dislodged from the underside of the conveyor as the belt made its return run. There were also spillages at transfer points. In 1975, the Alkali Inspectorate carried

[7] Stear2/126
[8] Stear2/148

out a survey of atmospheric pollution at the Phurnacite Plant[9]. The defendants were recommended to undertake modifications to the undersides of the overhead conveyors to make them dust-tight and to install and maintain suitable belt wipers at the ends of the conveyors in order to remove any spilled material before the belt returned. In 1977, modifications to the conveyors were carried out and belt cleaners were installed.

2.16 After the installation of the coal blending site, it appears that the coal tippler area at briquetting plant 1 was closed. The coal tippler area at briquetting plant 2 continued to be used as a standby if there was a breakdown or other incident which prevented coal from being moved from the blending site to the briquetting plants. Once the coal blending site was in use, recycled dust and breeze were added to the wet coal stored at the coal blending site, rather than at the coal tipplers. Sometimes, breeze was stored in other parts of the Phurnacite Plant. A report produced in December 1978[10] recommended that a 75-tonne stock pile of breeze situated near the offices should be removed.

2.17 Despite the introduction of the coal blending site, the problems associated with the type of coal used in the Phurnacite manufacturing process persisted. Indeed, it was suggested by one witness[11] that the previous system of mixing coal had been preferable in that, when the mixture of coal being used was causing manufacturing problems, it had been possible to change the mixture quickly and easily by adjusting the quantities of each type of coal drawn from the wet coal bunkers. With the new system, the wet coal bunkers were filled with the ready-blended mixture and, until those stocks were used, the mixture could not be changed.

Conclusions on the working conditions of men handling wet coal

2.18 I do not consider that, in general, work at either the coal tippler areas or the coal blending site involved a great deal of exposure to dust from the processes carried on there. However, men working in the coal tippler areas (in particular the coal tippler area for briquetting plant 2, which was situated close to the briquetting building and the ESPs) would have been exposed to a considerable amount of dust from the processes being carried out nearby. In addition, it is clear that, when wagon loads of recycled dust were tipped, the men employed at the tippler areas would have been exposed to a considerable amount of dust containing pitch.

2.19 The coal blending site was situated some distance from the briquetting plants and the batteries and I do not consider that the men working there would have been exposed to significant quantities of dust on a regular basis.

The pitch handling areas

2.20 Until the mid-late 1970s, there were two pitch handling areas at the Phurnacite Plant - one for each briquetting plant. Each pitch handling area had a shed and a pit, known as a ‘pitch bay’, where pitch in solid form was delivered in open wagons. The wagons containing the pitch were lowered into the pitch bay so that the pitch could be discharged. The solid pitch had to be broken up in the wagons by men using picks

[9] CB3/283
[10] CB6/119
[11] Mr Richards

and pneumatic tools, then shovelled out of the wagons and down a chute into a crusher or 'pitch cracker' which reduced it to small pieces. All these operations produced large quantities of pitch dust. The job of the 'pitch men' was physically hard and involved repeated dermal exposure to pitch, together with inhalation of pitch dust.

2.21 Many of the men who worked in the pitch handling areas developed phototoxicity, i.e. hypersensitivity to the sun such that, if the subject does not protect himself, sunburn-like symptoms (sometimes known as 'the smarts' or – in the context of the Phurnacite Plant – 'Phurny burn') result. As they left work, the men would seek to protect themselves against the sun by putting towels over their faces. Some of the men developed pitch warts. It was largely because of the effects of pitch on the pitch men that a sauna was installed at the Phurnacite Plant in about 1971. Because of the working conditions in the pitch handling areas, the regular pitch men were amongst the best paid workers at the Phurnacite Plant and worked shorter shifts than men employed in other jobs. In addition to the regular pitch men, men working overtime at the Phurnacite Plant and those employed as general labourers (or 'spare men') were frequently required to work in the pitch bay and a number of the lead claimants had done so.

The pitch elevators

2.22 From the pitch cracker, the crushed pitch was fed onto an open conveyor and then onto one of the pitch elevators which carried it up to one of the pitch bunkers for storage until it was required for use. The pitch crackers and the pitch elevators were prone to breakdowns and frequently required the attention of fitters and rigger/platers. Repair work involved working in the sub-ground floor area of the briquetting buildings, where pitch accumulated in large quantities. I describe this work in some detail later in this judgment.

Liquid pitch

2.23 The possibility of using liquid pitch instead of solid pitch in the manufacture of Phurnacite was being considered by the NCB by 1968/1969, if not earlier. However, it was not until April 1975 that the use of liquid pitch was introduced in briquetting plant 1. From that time on, the pitch handling area, pitch cracker and pitch elevators at briquetting plant 1 were no longer used. Also in 1975, mechanical shovels were introduced for the removal of solid pitch from wagons in the pitch handling area at briquetting plant 2. After pressure from the Alkali Inspectorate, liquid pitch was eventually introduced in briquetting plant 2 in mid-1977.

2.24 Following the introduction of liquid pitch, the heavy exposure to dust associated with the handling of solid pitch was removed. However, during the course of the Phurnacite manufacturing process, the liquid pitch would on occasion solidify and cause blockages which had to be cleared by teams of fitters and rigger/platers.

Conclusions on the working conditions of men working in the pitch handling areas

2.25 It is clear from the evidence that the men employed in the pitch handling areas were exposed to high levels of pitch and pitch dust. It was because of the dust emissions in the pitch handling areas that the Alkali Inspectorate were pressing for the transfer to liquid pitch. Mr Foster, an assistant manager at the Phurnacite Plant in the early 1970s, accepted in oral evidence that the working conditions of men employed in the pitch bays were "pretty dreadful". I agree with that assessment. Those working conditions continued until 1975 when the pitch handling area at briquetting plant 1 closed. The introduction of mechanical shovels in briquetting plant 2 that same year must have effected some improvement there but it is clear that concerns about the conditions persisted until the introduction of liquid pitch in mid-1977. It is not clear why the transition from solid to liquid pitch took so long.

The briquetting plants

2.26 Each of the briquetting plants consisted of a number of separate buildings and structures[12]. These included a dryer house (in which the wet coal was stored and dried); a furnace house and a boiler house (housing, respectively, the furnace which provided the hot air for the coal dryers and the boilers which provided superheated steam for the pugs); the briquetting building, also known as the 'press house' or 'press hall' (in which the mixing of the crushed and dried coal and pitch took place, together with the pressing and initial screening of the raw ovoid briquettes); and the trommel house (where further screening took place and small fragments of otherwise perfect ovoid briquettes were removed and misshapen and broken pieces of the ovoid briquettes were collected for re-use in the Phurnacite manufacturing process).

2.27 The two briquetting plants operated separately. Broadly speaking, briquetting plant 1 served batteries 1 and 2 and half of battery 3, whilst briquetting plant 2 served the other half of battery 3 and battery 4 together with, when they came into operation, batteries 5, 6 and 7. These arrangements changed from time to time as the number and combination of batteries in operation altered. The processes carried out at each of the briquetting plants were the same. They were subject to some changes over the years, although the essential briquette making process remained unaltered.

2.28 Briquetting plant 2 was significantly larger than briquetting plant 1. Briquetting plant 1 had three presses. When briquetting plant 2 opened in 1956, it also had three presses. A fourth press was added to briquetting plant 2 in 1957 and, in 1970, a fifth (much larger) press was built in a separate press house ('press house 5') adjacent to the briquetting building. The briquetting plants operated for 22 hours a day. Their task was to produce a sufficient supply of raw ovoids to keep the ovens on the batteries charged for 24 hours a day. A breakdown in either of the briquetting plants would have a potentially serious impact on production levels.

2.29 Each press had its own separate production line. There were three presses (and therefore three production lines) in briquetting plant 1 and, after 1970, five presses (and five production lines) in briquetting plant 2. At any one time, however, one of the presses in each briquetting plant, together with its production line, would be out of operation, either because repair or maintenance work was being carried out or because the press was on standby for use in the event of a breakdown elsewhere. Each production line had its own plant and equipment, i.e. bunkers, conveyors, elevators, dryer and other machinery.

The storage of coal

2.30 The evidence was that some dust was created when coal was dropped into the wet coal bunkers and also when it was allowed to flow out of the bunkers. The dust

[12] A cross sectional plan of a briquetting plant can be seen at WS2/189

would include some recycled dust containing pitch. The wet coal would sometimes become stuck inside the bunkers (or frozen in cold weather) and would require 'poking' with long metal bars in order to dislodge it. This problem persisted for many years and gave rise to dust. In 1977, vibrating devices were fitted to the wet coal bunkers in briquetting plant 1 in order to address the problem and similar devices were on order for the wet coal bunkers in briquetting plant 2. I have assumed that the latter were installed a short time later.

The process for mixing coal

2.31 Until the introduction of the coal blending site in 1973/74, the wet coal was discharged from the wet coal bunkers onto a rotating feed table with metal arms or 'ploughs' which were used to control the flow of coal of different types. The wet coal was then fed from the feed table onto a scraper chain conveyor from where it fell into a box under the conveyor and was fed onto another conveyor. The wet coal was then taken by bucket elevator up to the top of the coal dryers in one of the dryer houses.

2.32 After the introduction of the coal blending site, the wet coal was blended before reaching the wet coal bunkers. Once the coal arrived at the bunkers, it was stored without any distinction being made between the contents of each bunker. There was therefore no longer any need to mix different types of coal at the point of discharge from the wet coal bunkers. Otherwise, the process for getting wet coal to the dryer house remained the same as previously.

The dryer house

2.33 The coal dryers were vertical metal towers about 30 feet high and about eight feet in diameter. Immediately adjacent to each dryer was a furnace in which gases were heated before being forced under pressure into the base of the dryer. Within each dryer were a number of circular metal plates set at angles. Coal was fed into the dryer through a chute leading from the top of the wet coal elevator into the top of the dryer. As the coal fell down through the dryer, it was circulated round the plates, thus ensuring that it was exposed to the hot gases for a long enough period to remove most of its moisture content. The resulting water was then evaporated off. Once the coal reached the bottom of the dryer it was discharged via a worm feeder onto a conveyor. After passing through the dryer, the character of the coal changed. It became more abrasive and gave off a fine dust. It was clear from the evidence that considerably more dust was emitted on the 'dry' side of the briquetting process than on the 'wet' side and that the dust on the 'dry' side was much finer than the dust on the 'wet' side.

2.34 The coal dryers were sealed top and bottom. However, the seals were not perfect and the dust, which was under pressure and had been rendered very fine by the drying process, would often be forced through gaps around the seals of the dryer and would enter the surrounding atmosphere. The worm feeders at the bottom of the dryers had a number of slides in their bases which could be opened to allow the dry coal to drop onto the selected conveyor. It was common for dust to escape through these slides and to hang in the air around the conveyor.

2.35 Immediately above each of the dryers was a cyclone which was designed to remove the dust particles from the gases being drawn off from the top of the dryer. The cyclone pulled the gases in and rotated them at high speed. As the gases rotated, the dust particles were forced to the sides of the cyclone. They dropped to the bottom of the cyclone and were subsequently removed. Dust would escape from the cyclones, causing the area outside the top of the dryers to be generally dusty.

2.36 When the dryers in briquetting plant 1 were first installed, the hot gases from the dryers, together with the dust produced during the drying process, were emitted straight into the atmosphere above the dryer house. These emissions gave rise to complaints from local residents and from the local district authority. As a result, in 1956, two electrostatic precipitator stacks (ESPs) were installed to deal with the dust from the dryers in briquetting plant 1. There were three dryers but only two ESPs were installed so that, when maintenance was carried out on one of the ESPs, a single ESP had to deal with the dust from all three dryers. When briquetting plant 2 was installed in 1956, it had five ESPs, one for each dryer[13].

2.37 The ESPs were large metal structures which were intended to clean the exhaust gases from the dryers before they were discharged into the atmosphere. The hot gases and dust were forced through a negatively charged metal grille and then between positively charged metal collecting plates. The dust accumulated on these collecting plates. A hammer would periodically strike the side of the ESP, causing the accumulated dust to fall from the collecting plates to the bottom of the ESP. The dust collected by the ESPs was composed of very small particles which were described by one witness, a former manager of the Phurnacite Plant[14], as "almost fluid". Mr Jasper, who was employed as a safety and environmental chemist at the Phurnacite Plant between 1982 and 1990, described how the dust was so fine that it would pass through his clothing and stick to his skin. He said that the dust was difficult to remove, even by prolonged showering.

2.38 The ESPs did not work as well as had been hoped. When an excessive amount of dust accumulated on the collecting plates of an ESP, it would 'trip out', causing a large cloud of dust to be emitted into the atmosphere from the top of the ESP stack. The effect of this is evident from photographs[15]. When dust emissions occurred, the horizontal baffles on the tops of the ESPs tended to direct the dust towards other buildings nearby. The emissions would happen in particular when one ESP was required to collect the dust from more than one dryer. Estimates as to how frequently the tripping out occurred varied as between the various witnesses but I am satisfied that, in the 1960s and the early-mid 1970s, it happened on average at least once a day, probably more, and that it was a major source of the dust which was deposited in and around the Phurnacite Plant. The defective operation of the ESPs was the cause of considerable concern to local residents, the local district authorities and the Alkali Inspectorate.

2.39 In the mid-1970s, modification and refurbishment to the ESPs at both briquetting plants were carried out and were initially reported to have been successful. In February 1976, it was reported that the average annual emissions from all the ESPs had been reduced to about 156 tonnes – still a sizeable amount. However, the problems at briquetting plant 2 continued and, in July 1976, an investigation found that, when the dust from three dryers was handled by only two ESPs, dust emission rates increased fivefold and, when two dryers were served by one ESP, there was a thirteenfold increase in emissions. Further testing in March 1977 revealed that

[13] Illustrated at CBP/44, CB65 & CBP/76 (briquetting plant 2)
[14] Mr Dubash
[15] e.g. WS3/154 at GH9

emissions from the ESPs had reduced. However, when one ESP was processing the dust from two dryers, the emissions still exceeded the levels set by the Alkali Inspectorate. In December 1978, a report by the Technical Department of NSFL observed that, under normal operating conditions, the emissions from the ESPs at briquetting plant 1 were "just acceptable" but, when the need to carry out maintenance work on one or more of the ESPs reduced the number of ESPs in use, the emissions became "unacceptable".

2.40 In May 1980, the Alkali Inspector identified the dust emanating from the ESPs, particularly at briquetting plant 1, as one of the "main causes" of continuing "unacceptable" emissions from the Phurnacite Plant. In November 1980, the Alkali Inspector wrote to Mr Howson, managing director of NSFL, insisting that, since only half the ESPs at the Phurnacite Plant were in operation, no more than one dryer should be used. Mr Howson would not accept that restriction and sent a letter to the Alkali Inspectorate, informing them of that fact. Problems continued until, in 1981, steps were taken to refurbish the ESPs at briquetting plant 1 and to install continuous electronic monitoring in an attempt to reduce the incidence of 'trip outs'. After disappointing results initially, this resulted in a significant reduction in dust emissions from that source.

2.41 The practice of operating more than one dryer with a single ESP did still happen on occasions, however, and tripping out still occurred, although less frequently than previously. In March 1982, the Alkali Inspector visited the Phurnacite Plant at a time when a single ESP was dealing with the emissions from more than one dryer. He observed a "heavy black continuous emission of coal dust to atmosphere". He wrote to the NCB threatening prosecution and issued an Improvement Notice. The NCB appealed the Notice which was then modified. They then complied with the modified Notice and, by June 1983, there was a noticeable reduction in emissions. Mr Dawes, manager of the Phurnacite Plant between 1980 and 1984, said that, at times during that period, the ESPs would fail once or twice a day. It seems that there were plans to overhaul three of the ESPs between 1983 and 1985, but problems with discharges from the ESPs were still being reported in December 1986.

2.42 The dust collected by the ESPs ('precipitator dust') was re-introduced into the Phurnacite manufacturing process. In February 1957, it was reported[16] that an average of 11 tonnes of dust per day (i.e. over 4,000 tonnes per annum) were being recovered from the ESPs in briquetting plants 1 and 2 and were being re-used in the Phurnacite manufacturing process.

2.43 The exact point at which the precipitator dust was introduced back into the Phurnacite manufacturing process varied from time to time. In the early 1960s, there were complaints about precipitator dust blowing back into the briquetting building from the coal tippler area at briquetting plant 2. This suggests that precipitator dust was being deposited in the coal tippler area at that time and was passing through the coal dryers with the 'wet' coal. By 1970, the system was that precipitator dust was fed straight into the disintegrators although, by August 1971, the system appeared to have changed again so that the precipitator dust was fed directly into the pug.

[16] CB1/104

2.44 In August 1971[17], a Working Party of the NCB Coal Products Division Environmental Control Committee stated that about six tonnes of precipitator dust an hour were being recovered and introduced back into the Phurnacite manufacturing process. They observed that the dust was not really suitable for re-use in the Phurnacite manufacturing process but that it could not be sold or disposed of easily in any other way. In 1973[18], tests revealed that the seven ESPs at the Phurnacite Plant produced about 3,000 tonnes of dust per annum.

2.45 The use of precipitator dust in the Phurnacite manufacturing process was generally considered to be a major contributor to the dusty conditions in the briquetting plants. In the late 1960s and early 1970s, the precipitator dust was still being carried on open conveyors from which it readily became airborne. For that reason, in 1973, a system for pelletising dust from the ESPs was tried out in briquetting plant 1. In 1976, a temporary system was trialled in briquetting plant 2. It is not clear when, if ever, a permanent system was finally installed, although a document dating from 1981 refers to a pelletiser being modified and commissioned. Mr Brian Jones suggested that the pelletiser may never have proceeded beyond the trial stage. He said[19] that an experiment with a pelletiser had been carried out but it was found that the problems with the pelletiser outweighed the benefits to be derived from its use.

The pug floor

2.46 A conveyor transported the coal (now known as ‘dry’ coal) to the bottom of one of the dry coal elevators. The coal was fed onto the elevator which took it up from the dryer house to the first floor (the ‘pug floor’) of the briquetting building. The pug floor was a large open area covering the whole of the first floor. The coal was then tipped onto another conveyor belt which dropped it into one of the dry coal bunkers.

2.47 Until the early 1970s, at least some of the conveyor belts on the pug floor at briquetting plant 2 were open and generated a considerable amount of dust. In the early 1960s, there were frequent complaints about the dust in briquetting plant 2. In December 1962[20], conditions on the pug floor of briquetting plant 2 were described as “frequently intolerable”. It was hoped that the installation of a new enclosed Redler conveyor on the pug floor would improve the working conditions there. The installation was delayed for some time but, when it was complete, the improvement was only partial since there was still one open conveyor on the pug floor. Conditions were described as still “very bad” at times. The Union representative considered that the only way to solve the problem was to extend the Redler conveyor to cover the whole of the pug floor. The management at the Phurnacite Plant resisted this for some time but, in January 1964, they appeared ready to agree that the enclosed conveyor should be extended[21]. However, after a further inspection[22] of the area, they declared that the existing conditions were “satisfactory” and that there was no need to extend the enclosed conveyor. They suggested that, instead, efforts should be made to

[17] CB2/100
[18] CB9/310
[19] TD7/23
[20] CB1/157
[21] CB1/179
[22] Stear1/46

introduce adequate suction devices and to improve general housekeeping. However, it is clear that conditions continued to be very dusty on occasions.

2.48 Spillages from conveyors and conveyor breakdowns (which resulted in excess quantities of coal and pitch piling up on the conveyor system) gave rise to additional dust. There was also a problem with dust from the ESPs entering the pug floor through gaps in the wall of the briquetting building. In 1970, it was reported that precipitator dust was falling off conveyors onto the pug floor. In 1972, the conveyors carrying coal from the dryers to the dry coal bunkers in briquetting plant 2 were still open. A paper prepared for the NCB Briquetting Committee[23] in December 1972 by Mr JP White, NCB Group Director (Briquetting), observed that a great deal of dust emanated from the open conveyors, "giving rise to bad working conditions and atmospheric pollution". He proposed that a totally enclosed scraper conveyor should be installed on the pug floor of briquetting plant 2. The conveyor was finally installed in 1973 and this improved conditions on the pug floor.

2.49 The tops of the dry coal bunkers were square and about five or six feet of each bunker extended above the level of the pug floor. The lower part of each bunker was below pug floor level and tapered into a conical shape towards the bottom. There was an inspection door in the side of each bunker which could be accessed from the pug floor. Coal was stored in the dry coal bunkers until it was required for the next stage of the manufacturing process. From time to time, 'blowouts' or 'surges' occurred in the dry coal bunkers when the coal that had built up around the sides of a bunker suddenly collapsed and escaped from the bottom of the bunker. When this happened, the amount of dust emitted from the bunker would be so great that men working in the dryer house or on the conveyor that carried coal away from the bottom of the dry coal bunkers (the 'measuring belt') would have to vacate the building until the dust had settled and the atmosphere had cleared a little. It was then necessary for the men to clean up the dust, using brushes and shovels and/or a vacuum cleaner. Some of the witnesses suggested that a 'surge' in one of the dry coal bunkers would occur as often as once a shift. I am satisfied that it was a frequent occurrence before about the mid-1970s. After that time, vibrators were fitted to the dry coal bunkers which appear to have solved the problem of 'surges'. 'Surges' were also caused when the coal feed to the dryers was interrupted, causing recycled dust alone to be fed into the dryers and from there into the dry coal bunkers. On occasion, a 'surge' would also occur on a conveyor belt.

The 'back end'

2.50 When dry coal was needed for the Phurnacite manufacturing process, the required amount of coal would be discharged through a chute from the bottom of the dry coal bunker onto the measuring belt which was situated on the ground floor (known as the 'press hall floor') of the briquetting building. The area around the measuring belt was often known as the 'back end'. The measuring belt weighed the coal so as to ensure that the correct amount of coal went into the pug. Before the introduction of liquid pitch, solid pitch was added to the dry coal on the measuring belt so as to achieve the correct proportions of coal and pitch. The measuring belt was open and dust was given off from the dry coal and the pitch. The measuring belt then took the dry coal (together with the solid pitch, when used) through a cage known as a 'disintegrator' or 'pulveriser', which revolved at high speed, crushing the coal (and

[23] CB3/35

the solid pitch, when used) into tiny pieces. Problems occurred if the coal and pitch did not feed correctly onto the measuring belt. In that event, it was possible for coal to be fed into the disintegrator without any pitch or for pitch alone to be fed into the disintegrator.

2.51 When liquid pitch was first introduced, it was added to the dry coal on the measuring belt. However, this caused blockages and the system was later changed so that the liquid pitch was injected directly into the disintegrators. The liquid pitch was hot at the time it was injected but, as it started to cool down, it became hard. If the coal and pitch mixture was not kept moving with sufficient speed through the process, the liquid pitch would solidify in the disintegrator, causing blockages and breakdowns.

The 'pug'

2.52 Having passed through the disintegrator, the crushed dry coal and pitch dropped onto a further conveyor belt known as the 'mixture belt' which took it to the mixture elevator. When solid pitch was used, some dust was created at the bottom of the mixture elevator, at the point where the coal was transferred into the elevator. When the solid pitch was replaced by liquid pitch, the amount of dust emitted was reduced. The mixture elevator was an enclosed bucket elevator which transported the mixture of crushed coal and pitch back to the pug floor and then dropped it into the top of the 'pug'.

2.53 The pug was a vertical cylindrical vessel about eight to ten feet high and four and a half feet in diameter. A central shaft ran through the pug. Attached to the shaft were paddles which rotated in order to mix the coal and pitch. A counter-current flow of superheated steam was passed through the mixture at high pressure and vented via a chimney at the top of the pug. When solid pitch was used, the steam caused the pitch to melt and coat the particles of coal. After the introduction of liquid pitch, the steam inside the pug kept the pitch in a liquid state during the coating process. At the bottom of the pug, the mixture of coal and pitch, which by that time had a plastic, dough-like consistency, was discharged at a temperature of about 100ºC into an enclosed worm feeder which carried it on to the press.

2.54 As the coal and pitch were fed into the pugs, a considerable amount of dust was created. Dust was also forced out of the top of the pugs under pressure during the mixing process. If a problem such as a breakdown occurred, the pitch in the mixture would solidify and would cause a blockage in the pug. In that event, the pug would have to be cooled down before men were able to go inside it and remove the solid coal and pitch mixture using pneumatic tools. This operation would produce large quantities of dust containing pitch. Mr White's report of December 1972, prepared for the NCB Coal Products Division Briquetting Committee, described the conditions in which men worked in the area of the pugs as "appalling". He advised that prompt remedial action was necessary.

2.55 Initially, discharges from the pugs were emitted directly into the atmosphere by means of outlet pipes which passed through the briquetting plant roofs. This caused problems at both briquetting plants. In 1966, there were complaints about dust which was being blown off the roof of briquetting plant 2 and into the 'tunnel' between the briquetting plant and the adjoining coal tippler area. In August 1970, a report on pollution at the Phurnacite Plant stated that tests had shown that the discharges of dust from the pug outlets were as high as 390 lbs per hour per pug. The dust emitted was extremely fine and the outlet pipes regularly became blocked. Emissions from the pug outlets were described as "by far the major source of pollution from the briquetting plant". The outlet pipes protruded only a short distance above the roofs of the briquetting plants[24] as a result of which much of the dust discharged from the outlet pipes settled back onto the roofs of the briquetting buildings, from where it had to be removed daily by sweeping.

2.56 It appears that, by 1962, Drummond washers had been installed on the four pug outlets at briquetting plant 2 but they were ineffective and required frequent repair. The washers would cause the dust to be mixed with water, thereby forming slurry which would then be pumped into one of the lagoons situated at the Phurnacite Plant. From the lagoon, the dust could be scraped out and sold as a low grade fuel to power stations. In 1972, the Drummond washers were replaced with Roberts scrubbers. In about 1971, a Drummond washer was fitted to the pug outlet at press house 5 but this was replaced by a Roberts scrubber in November 1972. Also in November 1972, an inspection at briquetting plant 2 revealed the continued presence of fine particles of dust (varying in depth from half an inch to 12 inches) on the roof of the briquetting building. Tests revealed that the Roberts scrubbers were effective in removing the larger particles of dust but that some of the fine dust particles were still being emitted into the atmosphere. In 1973, total emissions from four of the pugs at briquetting plant 2 were found to be about 112 tonnes per annum, whilst emissions from the pug in press house 5 were 75 tonnes per annum.

2.57 There were also problems with the pug outlets at briquetting plant 1. In 1966, there were complaints about dust accumulating around the pug outlets and becoming "an increasing nuisance" when it was blown all over the Phurnacite Plant in windy weather. It was suggested that Drummond washers might be fitted to the pug outlets. In 1967, it was reported that the accumulation of dust on the roof of the briquetting building was at least six inches deep and was blowing back onto the pug floor and into the coal tippler area. A modification to the pug outlets was being considered. By early 1973, there were still no scrubbers fitted to the pug outlets on briquetting plant 1. It was estimated that approximately 620 tonnes of dust per annum were being emitted from the three pugs there. A short time afterwards, Roberts scrubbers were fitted to the pug outlets and these reduced the amount of dust emitted. Nevertheless, the problem continued to some extent and, in September 1973, there was a complaint about a build-up of dust on the roof of the briquetting plant at briquetting plant 1 which needed clearing.

The press hall

2.58 The worm feeders leading from the pugs fed the hot, dough-like mixture of coal and pitch into the presses. Each press consisted of a pair of rollers, incorporating a number of half-ovoid moulds[25]. The coal and pitch mixture passed between the rollers which moulded the mixture into uniform ovoid shapes. The raw ovoids were then fed over a 'reciprocating screen', consisting of a metal sheet with holes in it. The sheet vibrated, causing broken ovoids and 'fins' (the additional bits of coal and pitch mixture that remained attached to the ovoids when they left the press) to fall through the holes into a reject bunker below. From time to time, the contents of the reject

[24] illustrated at CBP/59 (briquetting plant 1) and CBP/78
[25] See photograph at CBP/79

bunker were loaded into wagons and taken either to the disintegrator (which appears to have been the system in the early days of the Phurnacite Plant) or (when the quantity of rejected material made that system impracticable) to the coal tippler areas where they were tipped into the wet coal bunkers for re-introduction into the Phurnacite manufacturing process. Later, the rejected material was carried back to the disintegrators by means of conveyors. Mr Foster suggested that, at some time, waste material from the press screens was recycled straight back into the press.

2.59 The evidence did not suggest that the processes of pressing or screening the raw ovoids produced large quantities of dust. However, it is clear that the levels of dust in the press halls were generally high. A document prepared following a joint inspection of the Phurnacite Plant by representatives of the NCB and the Union in January 1961 referred to a film of dust lying “everywhere” in the briquetting buildings with “heavy deposits of dust on top of the press”. There was extraction equipment in the briquetting buildings, but the overwhelming evidence was that this was wholly insufficient to deal with the large quantities of dust created there.

The trommel house

2.60 The next stage in the Phurnacite manufacturing process was for the raw ovoids to pass from the briquetting buildings to one of the trommel houses. There were two trommel houses, one for each of the briquetting plants. The trommel houses were built on stilts with an open area underneath[26]. In the trommel houses, the raw ovoids passed through the ‘trommel’ or ‘trommel screen’, a large metal drum within which a number of bars rotated, causing defectively shaped and broken ovoids to be discarded and any remaining fins still adhering to the ovoids to be knocked off. The fins were stored at the trommel house for recycling back into the Phurnacite manufacturing process.

2.61 A great deal of fine dust was generated as a result of the screening process carried out in the trommel houses. Following the opening of briquetting plant 2 in 1956, there were concerns about the amount of dust being generated in the trommel house (‘trommel house 2’). In early 1960, a dust collection unit was installed and was said to have improved conditions “tremendously”. The trommel was fitted with bag filters to collect the dust produced by the screening process. These bags required manual ‘rapping’ to knock the dust down into the bags. In addition, they had to be emptied regularly. Despite the reported improvement following installation of the dust collection unit, a film of fine dust was seen in trommel house 2 at the time of an inspection in January 1961 and, when an inspection door in the trommel was opened, the vibration caused a cloud of dust to fall out of the trommel.

2.62 In January 1961, there were plans to install a similar dust collection unit in the trommel house at briquetting plant 1 (‘trommel house 1’). By July 1961, however, the unit had still not been ordered and a Union representative reported that conditions in trommel house 1 were “very bad” and were affecting the whole of the surrounding area. By January 1963, there had been no progress with the installation of the dust collection unit in trommel house 1; it seems that the unit was not fitted until some time in the mid-1960s.

[26] See white building in the photograph at WS3/82

2.63 Meanwhile, it was reported that large quantities of dust were continuing to accumulate in trommel house 2. This was said to be caused, at least in part, by dust spillages during the loading of wagons removing dust from the trommel house for recycling. In 1964, there were complaints about the dust conveyor which carried dust from trommel house 2 to briquetting plant 2. In 1970, it was reported that parts of trommel house 2 were "thick with dust" because the dust collection unit at trommel house 2 was not functioning efficiently.

2.64 By 1970, when production at the Phurnacite Plant was reaching its peak, the system for collecting the dust and breeze produced during various parts of the manufacturing process for re-introduction into the Phurnacite manufacturing process was coming under strain. The matter was discussed at a meeting of the Phurnacite Plant Consultative Committee in October 1970. It seemed that there was no system in place for the regular emptying of the bunkers in which dust and breeze was stored for recycling. As a result, large quantities of dust and breeze were accumulating at certain points in the manufacturing process. A more efficient system of collecting the material for re-introduction into the Phurnacite manufacturing process was clearly needed.

2.65 An investigation into pollution at the Phurnacite Plant carried out in October 1970 found that the dust collection unit at trommel house 2 was ineffective. The dust collection bags were not being emptied regularly and consequently they frequently became blocked with damp dust from the raw ovoids. It was suggested that one solution might be to replace the unit with an automatic system. By April 1972, a new dust collection system was being trialled at trommel house 2. This was intended to reduce the amount of fine dust being carried with the raw ovoids to the shuttle car floors of the batteries. Later that year, a new fully automatic dust collection and extraction system was installed in trommel house 1 which greatly improved conditions there.

2.66 In the early 1970s, the system of dealing with reject material from the presses in briquetting plant 2 became overloaded, as a result of which an "emergency dumping point" for dust and breeze was established under the trommel house for press house 5. The dust collection system was unable to cope with the increase in dust levels as a result of which a new system was installed in 1976. This system consisted of a 50-tonne split bunker in which the dust and breeze could be collected and stored prior to re-introduction into the Phurnacite manufacturing process. Using feeders fitted with a vibration device, the bunker would deliver the reject material onto a new enclosed conveyor leading to the disintegrators. In addition, a fully automatic dust collection and extraction system was installed (similar to that previously fitted in trommel house 1).

2.67 In 1980, the Alkali Inspector visited the Phurnacite Plant after complaints from local residents. He observed that the conveyor used for returning reject material from trommel house 2 to briquetting plant 2 was shut down for repair. The production of Phurnacite briquettes was continuing, with the dust being discharged at ground level. The dust collection system on the trommel was not operating as a result of which dust was being emitted from the trommel house. No attempt had been made to contain or damp down the dust, which was being blown about.

2.68 No men were permanently employed in the trommel houses. However, workers would have had to visit the trommel house regularly to ensure that the screening process was working properly and, when the dust collection systems were installed, to operate them. In addition, cleaning, repairs and/or maintenance had to be carried out from time to time and the dust and breeze which accumulated in the trommel house had to be removed. The task of replacing a trommel screen was regarded as one of the dustiest jobs in the Phurnacite Plant and a special 'trommel payment' was made to the men who undertook this task.

Conveyors in the briquetting plants

2.69 I have mentioned some of the conveyor belts in the briquetting plants and the problems of dust associated with them. The construction of the conveyors inside the briquetting plants changed several times during the period for which the Phurnacite Plant was in operation. It is not easy to discern exactly which conveyors and elevators were enclosed at any given period and which were open. It seems that, in briquetting plant 1, most of the conveyors and elevators carrying both wet and dry coal (or dry coal and pitch) were enclosed, rather than open. However, a document from October 1970 referred to the fact that briquetting plant 2 had an open belt conveying system for wet coal, as a result of which conditions were worse at briquetting plant 2 than at briquetting plant 1. I have already referred to the conveyors on the pug floor of briquetting plant 2 which were not fully enclosed until 1973. Open conveyors can be seen in some of the photographs of the briquetting plants[27].

2.70 Even when the conveyors were enclosed, dust and debris would still escape, particularly through the grids in the base of the conveyors, through gaps where parts of the structure were missing and at transfer points, i.e. the points where the coal and/or pitch were dropped or otherwise fed from one conveyor to another or from a conveyor into a container such as bunker. With conveyors that had a continuously rolling belt, dust and debris fell from the return run of the belt. Conveyors were sometimes overloaded, as a result of which spillages occurred. The recycled breeze which was added to the Phurnacite mixture was highly abrasive and would cause the casings and seals of the conveyors to become worn and fail, allowing leakages to occur.

2.71 Large amounts of coal and pitch dust would collect in the pits beneath the conveyors and elevators in the briquetting plants. Fitters and other tradesmen would have to access the pits in order to carry out work there and they would be exposed to dust containing pitch. Coal and pitch dust would also collect on the floor and surfaces at sub-ground floor level of the briquetting plants. A large amount of moving machinery (e.g. belts and motors) were housed at sub-ground floor level in a confined space. Fitters and other tradesmen would have to visit the sub-ground floor level regularly in order to repair machinery in cramped, dusty and dirty conditions.

Conclusions on the working conditions in the briquetting plants

2.72 In the briquetting buildings, there was widespread dust. Mr Jasper, who was employed at the Phurnacite Plant during its last eight years in operation, said that "...the whole place *[i.e. the Phurnacite Plant]* was filthy". In his opinion, "the dirtiest part was the briquetting area, where drifts of precipitator coal dust were always present". Mr Foster, who held a management position at the Phurnacite Plant in the

[27] e.g. CBP/81; WS2/135

early 1970s, agreed that the dust was worst in the briquetting buildings, although he said that it was a nuisance throughout the Phurnacite Plant, even in the offices. Mr Holdroyd, who occupied a management post at the Phurnacite Plant in the 1980s, recalled seeing a layer of black dust on a cup of tea on the table in the briquetting plant foreman's office. (The office was located in a shed inside one of the briquetting buildings.) Mr Middle described how, "If you were reading a newspaper inside the briquetting plants, within a short time you would not be able to read the newspaper without shaking it to remove the dust". Mr Brian Jones' evidence was that there was nowhere within the briquetting buildings that was free from dust. Dr Choo Yin, who visited the Phurnacite Plant frequently from 1979 onwards, said that "conditions in the press hall were very hot and dusty, a mixture of coal and pitch dust … very fine coal dust particles coated in tar/pitch, most of it respirable in size". Mr Dubash, manager of the Phurnacite Plant in the late 1960s/early 1970s, recalled that men working in the briquetting buildings would have blackened faces by the end of the shift.

2.73 There was some extraction equipment in the briquetting buildings but the overwhelming evidence was that it was not powerful enough to deal with the vast quantities of dust that were generated there. Although a number of measures were taken over the years to reduce dust levels, it is clear from the evidence of those employed at the Phurnacite Plant in the 1980s (e.g. Mr Jasper, Mr Holdroyd and Dr Choo Yin) that those measures were never really effective. It is clear also that the dust permeated the dryer houses and the boiler houses, together with every level of the briquetting buildings and the separate press house at briquetting plant 2. Dust was not confined to areas immediately adjacent to the places where specific parts of the manufacturing process were carried out. Mr Harris' recollection was that dust:

> "…was given off from numerous places in and around the plant and the dust accumulated and hung in the air for long periods of time. There were never any occasions when the air in the briquetting plants could reasonably be described as clean or clear."

2.74 The men who worked full-time in the briquetting plants, together with those who visited the briquetting plants from time to time, were exposed to these dusty conditions throughout the time they were there. The evidence was that the dust generated in the course of the different stages of the processes carried out in the briquetting plants varied in type. Before the coal was dried, any dust given off had the usual appearance of coal dust. After drying, however, the dust changed in character. It was then extremely fine, became airborne very easily and would readily pass through workers' clothes and come into contact with their skin. After the mixture had passed through the pug, any dust that was emitted from the raw ovoids was coarser and more abrasive than the dust emitted from the coal and pitch mixture before it entered the pug.

2.75 I am satisfied that both the briquetting plants were badly affected by dust. Briquetting plant 1 was older and in a generally more rundown condition than briquetting plant 2. However, briquetting plant 2 was larger than briquetting plant 1 and produced a much greater number of ovoids. The evidence was that, taken overall, more dust was generated in briquetting plant 2 than in briquetting plant 1.

2.76 The dust emitted as a result of the various processes conducted in the briquetting plants also had a considerable impact on other parts of the Phurnacite

Plant. Until the mid-1970s, there were substantial emissions of dust containing pitch from the pug outlets. I am satisfied that some of that dust would have re-entered nearby buildings and added to the dust levels there. The remainder of the dust emitted from the pug outlets would have been dispersed. Much of it would eventually have been deposited on the ground and on other surfaces in and around the Phurnacite Plant, from where it would have been liable to be disturbed by the wind. The sweeping of accumulations of dust from the roofs of the briquetting buildings would have added to the amount of dust dispersed around the Phurnacite Plant.

The raw ovoid conveyors

2.77 A complex system of belt conveyors (known as the 'raw ovoid conveyors') carried the raw ovoids from one of the two trommel houses to the shuttle car floor of one of the batteries, about 60-70 feet above ground level[28]. Once at the battery, the conveyors would carry the raw ovoids to the appropriate area of the shuttle car floor. The conveyors covered a considerable distance and there were multiple transfer points. Initially, the raw ovoid conveyors were uncovered. Walkways ran alongside the conveyors and the men used those walkways as a convenient means of getting from the briquetting plants and trommel houses up to the shuttle car floors at the top of the batteries. The walkways were also used by the fitters and other tradesmen whose job it was to repair and maintain the conveyors. There were gaps in the surface of the walkways and there were no collection trays under the conveyor belts. Dust from the raw ovoids would fall from the conveyor belts and from the walkways and was then blown about the Plant. At some time, wipers were fitted to the ends of the conveyor belts in order to remove excess dust and breeze which might otherwise be spilled on the belts' return run. In August 1966[29], it was reported at a meeting of the Phurnacite Plant Consultative Committee that almost all the wipers on the conveyor belts required renewal and that, because of the poor condition of the wipers, a considerable amount of breeze was being dropped under the conveyors. Mr Middle described how, when carrying out work at a workbench positioned under one of the raw ovoid conveyors, the metal plate he was working on rapidly became covered with dust falling from the conveyor above him. He had to stop work from time to time and shake the metal plate in order to remove the dust that had accumulated on it.

2.78 There was a longstanding problem with dust generation at the many raw ovoid conveyor transfer points. In August 1970[30], a report on pollution at the Phurnacite Plant stated that considerable quantities of dust accumulated at transfer points on the raw ovoid conveyors; in windy conditions, this tended to blow into the atmosphere. It was said to create "unsatisfactory working conditions". Spillage of ovoids from the raw ovoid conveyors was also said to be a continuing problem. By the end of 1972, consideration was being given to taking measures to reduce the amount of dust and also to reduce spillage at transfer points. Dust suppression by means of wet sprays was tested at some transfer points.

2.79 In November 1975, the Coal Research Establishment (CRE) produced a report[31] ('the CRE report') on dust emission from the raw ovoid conveyor transfer points at the Phurnacite Plant. There were 29 such transfer points, of which 24 were usually in use. The Introduction to the CRE report acknowledged that the transfer

[28]Part of the network of raw ovoid conveyors can be seen on the photos at WS3/81 and 82
[29] SD6/16
[30] CB2/6
[31] Syred 4/178

points on the raw ovoid conveyors were "obvious sources of pollution" and that, when they were in operation, the air round them was "darkened". Since many of the transfer points were situated high above ground floor level, the fine particles of dust emitted at them were liable to become windborne and to disperse within and beyond the boundaries of the Phurnacite Plant. It was recognised that, as well as being a nuisance, the dust from the raw ovoids was a hazard to health. The object of the work carried out by the CRE was to establish the existing dust emission levels and to test the efficiency of a water spray dust suppression system that had been designed to deal with the problem of dust emissions from the conveyor transfer points.

2.80 The CRE team carried out sampling, using an air extraction rig which was designed to enable accurate sampling of the dust emissions, despite the fluctuating concentration and size distribution of those emissions. The sampling revealed that the average rate of dust emission from the various transfer points was 91g per transfer point per minute. The rates of dust emission varied as between the transfer points. The highest rates (between 160 g and 230 g per minute) occurred above the outgoing belt carrying the raw ovoids to the shuttle car floor of battery 5. It was noted that, at that transfer point, the raw ovoids were dropped vertically from one belt onto another through a distance of 56 inches, longer than the drop at any other transfer point. The authors of the CRE report calculated that, at the existing rate of emission, the total amount of dust emitted from the raw ovoid conveyors in a year was 550 tonnes. Their experiments led them to conclude that the best means of suppressing the emissions was by water sprays. They calculated that water sprays would reduce the amount of dust emitted by about 85%. Consideration was subsequently given to the installation of water sprays at transfer points and to the possibility of covering transfer points. In August 1975, the Alkali Inspector noted[32] that raw ovoid conveying was one of the areas of dust emission that required reduction and he advised NSFL to reduce spillages, to enclose the transfer points and to use water sprays the reduce dust emissions.

2.81 In early 1976, NSFL gave approval in principle to funding the installation of water sprays at all raw ovoid transfer points. However, it was soon recognised that simple water sprays would have a detrimental effect on the quality of the raw ovoids and would not be wholly successful in suppressing dust. Instead, an irrigated cyclone was installed for testing purposes. This had the effect of removing 98% of the dust created at the transfer point where it was situated, whilst causing no operational problems and requiring little maintenance. It was recognised that, if irrigation cyclones were to be installed at all transfer points, there would have to be a system of disposing of the slurry of dust mixed with water that would be produced. It was envisaged that this could be done by extending the existing system of disposal of the slurry produced by the Roberts scrubbers fitted to the pug outlets at the two briquetting plants, and by incorporating a new scheme for water clarification.

2.82 It is clear that, by October 1976, NSFL were becoming concerned at the potential costs (about £447,000) of the irrigated cyclone system. By May 1977, there was a clear division of opinion between the Board of NSFL and local managers about the issue. The Board were expressing doubts about the likely efficacy of the irrigated cyclone system and the problems of devising a water clarification scheme that would be acceptable to the Water Authority. Mr Gaskell, general manager of NSFL Wales,

[32] CB3/289-91

argued[33] that the trials of the irrigated cyclone had been very successful. He pointed out to the NSFL Board that, even if the irrigated cyclone project did not go ahead, the Phurnacite Plant would still require a new water clarification scheme. A system of water sprays would be cheaper than the irrigated cyclone system but was unlikely to meet the requirements of the Alkali Inspectorate. He suggested that a conventional system of dust extraction would be difficult to design and maintain and would involve complex arrangements for the collection and disposal of the dust which would accumulate at transfer points. Furthermore, it was unlikely to cost significantly less than the irrigated cyclone system.

2.83 In July 1977, an application for final approval for the necessary expenditure to fund the installation of the irrigated cyclone system was submitted to the NSFL Board, but was not given. Instead, the Board indicated that the application should be re-submitted at a later date. Meanwhile, trials of the irrigated cyclone system were to continue and work on a water clarification scheme that would be acceptable to the Water Authority was to be pursued.

2.84 A detailed report on the problems of pollution at the Phurnacite Plant published in December 1978 noted that much of the dust from raw ovoid handling was deposited on the batteries or within 100 yards of them. The report recommended the provision of a water clarification scheme sufficient to deal with all the dust generated by the Phurnacite manufacturing process. By May 1979, two alternative schemes for water clarification were being examined. In the event, neither the water clarification scheme nor the irrigation cyclone system was ever implemented. Mr Foster attributed this to the local Water Authority who, he said, wanted some form of mechanical separation of the contamination from the water before it went into the lagoons. It is not clear why this requirement could not be met.

2.85 The problem of dust emissions from the raw ovoid conveyors had persisted and, in May 1980, the District Alkali Inspector wrote to the manager of the Phurnacite Plant complaining about the emissions, together with the dust emissions from a number of other sources at the Plant. In September 1980, the District Alkali Inspector followed up those complaints by serving 14 Improvement Notices requiring action on the part of the Phurnacite Plant management. One such requirement was for the installation of hoods and enclosures to the raw ovoid equipment in order to contain the dust emitted at transfer points and at the bunker tops. The Alkali Inspectorate required the work to be completed by May 1981.

2.86 A document containing a summary of anti-pollution measures carried out in 1981[34] in response to the Improvement Notices stated that specially designed chutes for the transfer points of the raw ovoid conveying system had been purchased and that a method had been designed to stop dust seeping through the floors of the walkways that ran alongside the raw ovoid conveyors. In the event, however, the implementation of these measures was considerably delayed. By November 1982 the proposed sealing of the walkway floors had still not taken place and, in March 1983, the new chutes had yet to be installed. It seems that a further Improvement Notice was served some time before June 1985, again requiring action to prevent the emission of dust from the raw ovoid conveyors. That Improvement Notice was withdrawn

[33] CB5/80
[34] CB8/52-53

because conditions had improved[35]. It may be that the improvement in conditions came about because the steps proposed in 1981 were eventually taken. Nevertheless, it appears that, as late as the beginning of 1989, there was still a problem at some of the raw ovoid transfer points. Minutes of a meeting of the Phurnacite Plant Health and Safety Committee in January 1989 recorded that, when the necessary money was available, the transfer points were to be taken out and the conveyor belts joined. In the event, of course, the Plant closed the following year so that work was never done.

2.87 Some of the dust which escaped from the raw ovoid conveyors would have been blown back onto the batteries, in particular onto the shuttle car and oven floors. It is probable, however, that much of the dust was dispersed and eventually deposited around the Phurnacite Plant and, depending on the wind conditions, beyond its boundaries.

The batteries

2.88 The design of the seven batteries[36] was not entirely uniform but, essentially, they were similar and operated in the same way. There were five production lines in each battery. Each production line had its own plant and equipment, including eight ovens (known as a ‘block’), in which the raw ovoids were carbonised. The plant and equipment for each production line were situated on four separate levels of the battery: the shuttle car floor, the oven floor, the quenching car floor and the ramps (also known as ‘the wharf’). All four sides of the shuttle car and oven floors were open, and the battery had a pitched roof. The quenching car floor and the ramps were situated entirely in the open air.

The shuttle car floor

2.89 The shuttle car floor was situated immediately below the roof of the battery[37]. It had no forced ventilation or extraction system. The open sides of the building meant that the shuttle car floor was exposed to the wind and weather. Nevertheless, the low pitched roof (one witness estimated that the roof was only about 12-14 feet above the floor) made the area relatively enclosed. The shuttle car floor was situated above the oven floor. The shuttle car floor was not solid but contained gaps through which the oven floor could be seen by men working on the shuttle car floor[38]. These gaps allowed dust, fume and gases to pass up from the oven floor to the shuttle car floor and dust from the shuttle car floor to fall down onto the oven floor.

2.90 Despite the fact that the shuttle car floor was situated within the battery where carbonisation took place, it was regarded as part of one of the briquetting plants. Supervisory staff from the briquetting plants oversaw the work done on the shuttle car floor of the batteries and men from the briquetting plants were required to carry out the work of shuttle car operators.

2.91 The shuttle car floor gave access to 40 vertical bunkers (known as the ‘raw ovoid bunkers’ or ‘charge bunkers’), each situated immediately above one of the ovens on the oven floor below. The raw ovoid bunkers were situated below the level

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[35] CB9/3/36
[36] One of the batteries is illustrated at CBP/58 and one at WS1/275. A cross-sectional plan of a battery is at WS1/216
[37] See photograph at WS 1/124
[38] See photograph at WS1/129

of the shuttle car floor and above the oven floor. Each charge bunker held just over two tonnes of ovoids.

2.92 Once they arrived on the shuttle car floor, the raw ovoids were dropped from the raw ovoid conveyor into the reversible 'shuttle conveyor' (also known as the 'shuttle car'). When the ovoids were dropped, a considerable amount of dust was emitted. The shuttle cars ran on tracks up and down the shuttle car floor, feeding the raw ovoids down chutes into the charge bunkers. In general each charge bunker was filled twice during a shift. The filling of each charge bunker took about 15 minutes and the process of filling bunkers produced large quantities of dust.

2.93 For many years, the shuttle cars were operated by means of controls situated on one side of the car. When the wind was blowing in a certain direction, it would cause dust from the raw ovoids to be blown directly at the shuttle car operator. The possibility of fitting remote controls to the shuttle cars, so as to avoid the shuttle car operators having to work near to the source of the dust, was investigated in 1963. In the event, however, remote controls were not installed until 1976. These proved very successful in reducing the dust exposure of the shuttle car operators.

The oven floor

2.94 On the oven floor[39] of each battery were 40 ovens, arranged in five blocks of eight ovens and running the length of the battery. The circular charge holes of the ovens were at floor level. The ovens were built of brick and were situated below floor level. Each had a capacity of about two tonnes of ovoids. During the carbonisation process, the charge holes were covered with metal lids which rested on frames set into the brickwork of the oven. The lids were fitted with seals which were designed to ensure that fume and gases did not escape from the ovens during the carbonisation process.

2.95 The area around the charge holes of the ovens was commonly known as the 'oven tops'. All four sides of the batteries were open to the elements at oven floor level. The movement of dust, fume and gases and the manner in which they were distributed on the oven floor depended largely on whether there was a significant amount of wind and, if so, in which direction it was blowing.

Charging the ovens

2.96 Raw ovoids were discharged from the charge bunkers through chutes into large metal containers known as 'charging cars'[40], which moved along tracks between the blocks of ovens. A charging car would be moved into position directly below the charge bunkers for a block of eight ovens. In all the batteries, except batteries 6 and 7, the charging cars were moved manually into position by two charging car operators. On batteries 6 and 7, the charging cars were operated electrically. The charging cars were open at the top and bottom, and acted as funnels, allowing the raw ovoids to pass from the charge bunkers into the charge holes of the ovens. The process of charging each block of ovens took about 10-15 minutes.

[39] Part of the oven floor of a battery is illustrated at CBP/69 & 70 & WS1/126
[40] See photographs at WS3/92 & CBP/91

2.97 After a block of ovens had been charged, the charging car would be moved to the next block of ovens to be charged and the lids of the ovens that had been charged would be replaced. The gas men would switch on the gas supply to the charged ovens, causing the heat in the ovens to increase and the process of carbonisation to begin. The five blocks of ovens on each battery were charged in sequence so that adjacent blocks were not being charged or discharged at the same time. The carbonisation process took about four hours and, since the batteries operated 24 hours a day, the operation of charging and discharging was repeated continuously throughout each shift. In 1971, it was calculated that, on average, the contents of one oven at the Phurnacite Plant were discharged every 70 seconds throughout the day, so that 1,224 ovens were charged and discharged every 24 hours.

2.98 Neither the chutes of the charge bunkers nor the tops of the charging cars were enclosed. As a result, the operation of dropping the raw ovoids into the ovens gave rise to large quantities of dust which entered the atmosphere and settled on the floor and other surfaces[41]. In addition to the dust, considerable spillage of raw ovoids occurred during the charging process. Photographs of the oven floor[42] show dust and raw ovoids lying on the oven tops. The charging car operators and the spare men who worked on the oven tops would sweep up the dust and debris from time to time but it is clear from the evidence that the appearance of the oven tops in the photographs was fairly typical of their usual state. Some of the spillages were due to seepage from the base of the raw ovoid bunkers. In 1974, tests were carried out to ascertain the quantity of coal/pitch dust and debris which escaped from the bunkers between charges. The total annual amount of material escaping in this way was estimated at 200 tonnes.

2.99 As the raw ovoids were dropped into the charging cars, they passed over a screen designed to remove some of the excess dust from the raw ovoids. The dust fell through the screen and was then collected in hoppers which required regular emptying. This was done by transferring the dry dust manually into a barrow and tipping it into a bunker. From there it was taken back to the briquetting plant coal tipplers (later the coal blending site) for re-introduction into the Phurnacite manufacturing process. In October 1970, it was estimated that 130 tonnes of dust per week were recovered from the oven floor hoppers at the six batteries then in operation. It was thought that, if a more effective system of dust collection were to be introduced, twice as much dust would be available for collection and recycling.

2.100 The ovens were kept at high temperatures at all times. Whilst they were being charged, the raw ovoids that entered the ovens first would begin to carbonise and would give off smoke and fume containing particulate material. During charging, each block of ovens was connected to a smoke main, the purpose of which was to draw off the smoke and fume under suction and to prevent them from being emitted through the charge holes during charging. However, the smoke main did not always work effectively, largely due to the inadequate depth of the 'bucket seals' which were intended to isolate the ovens from the smoke main. As a result, large amounts of smoke and yellow fumes were given off during charging. In 1971, a report prepared for the Environmental Control Committee [43]described the dense yellow fumes given off during charging at batteries 1, 3, 4 and 5 as "unacceptable both from the point of

[41] See for example WS1/126 & CBP/70
[42] e.g. CBP/70, 82 & 118 & WS3/363 & 365
[43] CB2/100

view of the working conditions and environmental pollution". The bucket seals fitted to the ovens at those batteries were to be enlarged in an attempt to improve suction. However, when the Alkali Inspector conducted an inspection of the plant in August 1975[44], the extraction systems were still not working effectively and it was reported that there were "copious smoke emissions" from the charge holes whilst charging was going on. In 1977, efforts were being made to achieve smokeless charging of the ovens on batteries 6 and 7, although it was acknowledged that there would be difficulties in making the necessary alterations to the older batteries. The problem was reported to be still persisting in 1979.

Carbonisation

2.101 During the carbonisation process, the oven tops became very hot and the dust and debris lying on the oven tops would also heat up and would begin to carbonise[45], emitting smoke, gases and fume containing particulate material.

2.102 The ovens were kept under positive pressure during carbonisation and fume and gas would leak from them. In the early-mid 1960s, there was a problem with some of the oven lids which were too small, causing leakage around the outer edge of the lids. Sometimes, inadequate cleaning of the oven lids or of the frames on which they rested would prevent the lids from fitting tightly. In addition, oven lids would become warped and the seals around the lids were prone to perishing. In July 1971, an inspection carried out on behalf of the Environmental Control Committee[46] observed "considerable gaseous discharges from some of the oven doors", although this was not evident at the time of a further inspection a week later. Because of the problems of leaking oven lids, it was the practice for the men working on the oven tops to use the (uncarbonised) dust and debris which had been spilled during the charging of the ovens as a sealant for the oven lids. They would sweep the material over the oven tops and around the oven lids. During carbonisation, this material would become hard and would form a seal. However, the heat from the ovens would cause the material to carbonise and to emit smoke and fumes. This was a problem in the early 1960s, when an instruction was given to use carbonised breeze (which would not have given off the same level of fumes as the uncarbonised material) as a sealant. However, the practice of using uncarbonised material persisted. Even when the men working on the oven tops used carbonised breeze, the breeze tended to become contaminated with raw ovoid dust and debris which had been spilled on the oven tops during charging so that fume and gases would still be given off. Mr Jasper, safety and environmental chemist at the Phurnacite Plant between 1982 and 1990, described how, on occasion, there would be mounds of coal dust smouldering on the oven tops. He said that a 'coal tar fog' pervaded the oven tops and the 'oven sides', i.e. the area on the quenching car floor near to the doors of the ovens.

2.103 At various times, alternative materials (e.g. stone and brick dust, clay and silica) were used as a sealant for the oven lids but, on each occasion, the use of the alternative materials lapsed and the practice of using raw ovoid dust and debris was resumed. The practice continued until late 1984 or early 1985, when the Factory Inspectorate issued an Improvement Notice, requiring NSFL to use an alternative material for sealing the oven lids. In 1985, it was reported that a suitable alternative

[44] CB3/292
[45] See photograph at CBP/118
[46] CB2/101

material was being used on batteries 6 and 7 and that its use would shortly be extended to the other batteries.

2.104 The condition of the brickwork inside the ovens deteriorated with constant use. Leaks occurred through gaps in the brickwork and at the joints between metalwork and brickwork. The ovens had originally been intended for use for only about 15 years before they were renewed[47] but, by the 1970s and 1980s, some ovens had been in use for significantly longer than that. In 1977, a survey carried out by Mr Scargill, then Managing Director of NSFL, showed that some or all of the ovens were suffering from increased wear of the brickwork below the charge holes, as well as from bowing and cracking of the oven walls and wear on the brickwork immediately above the base of the ovens. After 1977, some ovens were re-built, but not all. Batteries 3, 4, 5 and 6 were shut down in the mid-late 1980s but, before then, they had continued in operation whilst in a poor condition, with leakage of fume occurring through cracks in the brickwork of the ovens during carbonisation.

The removal of smoke, gas and fumes from the ovens

2.105 During the carbonisation process, gases would be removed from the ovens by suction. The gases would flow through a cast iron ascension pipe known as an ‘elephant’ and into a ‘purifying box’ or ‘smoke box’. The elephants and smoke boxes, one for each oven, were situated along the side of the oven tops.

2.106 The elephants, the smoke boxes and the surrounding brickwork were exposed to constant heat from the ovens and from the fumes and gases passing through the elephants and smoke boxes. As a result, the brickwork around the base of the elephants would frequently crack, causing fumes to escape[48]. The men working on the oven tops would carry out running repairs to the brickwork using asbestos rope or fire clay to plug the cracks. When the damage became more extensive, masons and/or fitters would attend to carry out more lasting repairs. As a result of excessive wear, splits and gaps would sometimes develop in the elephants and the smoke boxes and leaks would occur. In 1963[49], for example, it was reported that the smoke boxes on battery 5 had developed leaks and that the resulting fumes were affecting the shuttle car operators.

2.107 In the early days of the Phurnacite Plant, the elephants vented the fumes and gases emitted from the ovens during carbonisation into the atmosphere of the oven floor, only about four feet above the oven tops. As a result, the men working on the oven tops and on the shuttle car floor were exposed to the vented fumes and gases. At the trial, there was some uncertainty as to when that arrangement changed. Documents that came into existence in September 1956[50] and in 1957 suggest that there were plans to erect venturi stacks[51], with smoke washers, on the battery roofs in the late 1950s. Although the primary purpose seems to have been to meet the concerns of local residents about atmospheric pollution being emitted from the Phurnacite Plant, it was also recognised that the emission of fumes and gases at roof level would alleviate the unpleasant working conditions of men working on the

[47] Mr Dawes: TD10/41/3
[48] See, e.g. photograph at WS1/243
[49] Stear2/103
[50] CB1/101
[51] See photograph at WS3/359

batteries. It appears from subsequent documents[52] that a pilot venturi stack was tested but did not prove as satisfactory as had been expected. Battery 5 was constructed with venturi stacks and smoke washers already in place and it was intended to install similar equipment on the remaining batteries in the future. It is clear from the evidence of the witness, Mr Brian Jones, and of the lead claimant, Mr Richards, that the venturi stacks for the batteries other than battery 5 were not installed until the late 1960s and that, up to that time, the fumes and gases produced during the carbonisation process were discharged from the off-takes situated adjacent to the elephants.

2.108 When installed, the venturi stacks dispersed the fumes and gases from the ovens into the atmosphere above the batteries. However, the discharges remained the subject of complaints from local residents. In 1972, John Zink burners were fitted to the venturi stacks[53]. These burners were intended to burn off the fumes and gases discharged from the ovens during the carbonisation process, thereby ensuring that the smoke emitted into the atmosphere above the batteries was clean and free from pollutants. However, the burners frequently failed to ignite, as a result of which untreated fumes and gases were permitted to escape into the atmosphere[54].

2.109 The John Zink burners were designed only to deal with the fumes and gases produced during carbonisation, not the smoke and gases produced during charging. Problems therefore arose when the burners were used to burn off the smoke and gas emitted during charging of the ovens. The report of an inspection conducted by an NSFL investigating team in 1978[55] stated that the yellow discharges frequently seen from the John Zink burners were "quite unacceptable". It suggested that the problem arose in particular during "poor operating conditions when charging", when the smoke main could not cope with the amount of smoke and gases being emitted from the ovens as they were being charged. In those circumstances, the smoke and gases would be diverted to the John Zink burners. In 1978, the same investigating team identified the John Zink burners as a significant source of solid particulate emission due to incomplete combustion[56].

2.110 Monitoring of the Phurnacite Plant with a time lapse camera in May 1979 revealed prolonged periods of black smoke emission from the battery chimneys, together with frequent and prolonged emissions of fumes and black and yellow smoke from low level sources on the batteries[57]. In a letter written to the plant manager in May 1980, the Alkali Inspector complained of frequent and extensive emissions of dark smoke from the battery chimneys (particularly those serving batteries 1, 2, 4 and 5), together with leakage of smoke and 'green' gas (i.e. gas from partially carbonised ovoids) from the oven tops and gas off-take pipework and smoke, grit or dust from the battery tops, the smoke washer vents and the John Zink flares during oven charging and discharging[58]. The conditions at that time were so bad that the Alkali Inspector wanted the offending batteries taken out of operation until sufficient repairs had been carried out. This was not done and, two months later, the same problems were still persisting[59].

[52] e.g. CB2/18/120 & CB/21/143
[53] Stear2/197
[54] see e.g. photographs at WS1/242
[55] CB6/58
[56] CB6/169
[57] CB6/323
[58] CB7/124-125
[59] CB7/135

2.111 In September 1986, the Industrial Air Pollution Inspector carried out observations at the Phurnacite Plant over a period of 7½ hours. He reported that, during that time, only 17 out of the 34 blocks of ovens which had been discharged had produced satisfactory emissions. Of the 17 blocks producing unsatisfactory emissions, 11 were considered to have caused a level of yellow gas emission which was "totally unacceptable"[60]. The Inspector attributed the problem to the incomplete carbonisation of ovoids.

2.112 The fitting of the venturi stacks did not eliminate entirely the discharge of fumes from the elephants on the oven floor during carbonisation. Blockages of the gas collection systems would cause excessive build-ups of pressure in the ovens, forcing fumes and gases to leak out of the charge holes near to where men were working on the oven tops. If the pressure in the ovens became too high, the men working on the oven tops would open the elephants in order to divert the fumes and gases out of the top of the elephants. In those circumstances, it would be the lesser of two evils.

2.113 The process of carbonising the Phurnacite ovoids would usually take about four hours. In order to ascertain whether carbonisation of the ovoids was complete, the gasman or foreman would open one of the oven lids. If the gas and fumes emitted from the charge hole were deep yellow in colour, the ovoids were not fully carbonised. If the discharge was white or clear, carbonisation was complete and the ovoids were ready for discharge. Before discharge, the gasman would disconnect the block of ovens from the gas main.

The quenching car floor

2.114 The red hot carbonised ovoids were then discharged through large doors at the bottom of the oven or 'oven sides', i.e. at quenching car floor level[61]. Two 'quenching car attendants' were employed to discharge the ovens. They would move the quenching car into position. The quenching car resembled a large metal tank with funnels at both ends and contained a large quantity of cold water. The quenching car attendants would open the doors of the oven using controls situated in a small cabin which protected them from being burned whilst the ovens were discharging. The ovoids would drop out of the ovens and into the quenching car.

2.115 As the ovoids entered the water, a large cloud of steam was discharged from the quenching car funnels and extended up the side of the battery[62] to the level of the oven and shuttle car floors. The men working on the oven tops would attempt to move out of the path of the plumes of steam. However, the extent to which they were able to avoid the steam depended largely on the work they were doing and the weather conditions at the time. The steam contained large quantities of dust and grit. In 1970, a study[63] of pollution at the Phurnacite Plant revealed that the steam given off during the discharge of carbonised ovoids from a single block of ovens could contain as much as 50lbs of dust and grit. It was recognised that this contributed to the unpleasant working conditions on the batteries and also added to the generally heavy burden of corrosion at the Phurnacite Plant.

[60] CB9/134
[61] See photograph at CBP/90
[62] See photographs a CBP/37, 55,56 & 58 & WS1/255
[63] CB2/8

2.116 Much of the steam from the quenching car, together with the dust and grit contained in it, entered the atmosphere of the oven floor and the shuttle car floor. At some point in the 1960s, the design of the funnels on the quenching cars was altered with the intention of directing the steam away from the batteries. However, the steam continued to be blown back towards the batteries. A report by the NCB Scientific Department written during the mid 1970s estimated that about 1½ tonnes of fine dust were deposited on the oven tops every day as a result of dust given off during the charging of the ovens, together with the dust contained in the steam from the quenching cars.

2.117 By 1970, battery 6 had been fitted with quenching towers incorporating grit arresters which were said to have removed "at least 85% of the problem" although, in 1974, the grit arresters were said to remove only about 75% (50-70 lbs) of the grit produced during each 'quench'. Battery 7 had five quenching towers when it was built. Meanwhile, quenching car cooling systems were proposed for the other batteries. The 'Spruce' system (which involved thorough stirring of the contents of the quenching car, together with the pumping in of large quantities of water in order to maintain a temperature of no more than 70ºC) had been installed on battery 2 when the battery was re-built. Battery 2 was re-commissioned in 1973 and the Spruce system was working satisfactorily in 1974[64]. The Spruce system was extended to battery 1 in 1977[65] and there were plans to install similar systems at batteries 6 and 7 in the future. By 1978, this was still under consideration and it was indicated that it would not be done until 1980 at the earliest[66]. In 1983, the Spruce system was abandoned after an accident caused by an interruption to the electrical supply to a quenching car. The works manager of the Phurnacite Plant advised that many of the electrical connections at the Plant were "temperamental" and it was thought better to abandon the system altogether[67].

'Poking' the ovens

2.118 When the carbonisation process worked correctly, the carbonised ovoids would fall out of the ovens under gravity, leaving the ovens completely empty. The men working on the oven tops would then 'crack open' the oven lids[68], placing them at an angle to avoid, as far as possible, direct exposure to the heat and fume being given off from the charge holes. The ovens would then be ready for the next charge of raw ovoids.

2.119 However, on occasion, some of the ovoids formed a cluster and would become stuck inside the ovens. When that happened, it was necessary to 'poke' the oven with a long metal pole in order to dislodge the clustered ovoids and empty the oven completely. Poking would be done first by the quenching car attendants from the oven sides[69]. If they were unable to dislodge all the clustered ovoids, the men working on the oven tops would have to remove the oven lids and poke the ovens through the charge holes. This task involved the men standing almost directly above the open charge holes in order to reach inside the oven and exert sufficient leverage to

[64] CB3/207
[65] CB5/234
[66] CB5/307
[67] CB8/228
[68] see photograph at WS1/160 Figure 28
[69] See photograph at CBP/89

remove the clustered ovoids. In that position, they were exposed at close quarters to the heat, fume and gases coming out of the ovens.

2.120 The evidence showed that poking of the ovens was required from time to time even in the early years of the operation of the Phurnacite Plant. Mr Russell Pugh described poking during the first period of his employment from 1946 to 1955[70]. Mr David Jones worked on the oven tops from about 1962 until 1964 and he recalled having to poke the ovens regularly; he suggested that he would spend on average about 10-15 minutes poking each block of ovens that was discharged. Mr Middle was also employed on the oven tops in the early 1960s. He recalled spending periods of between 15 minutes and two hours at a time poking the ovens. Mr Foster[71] agreed that it would probably be fair to say that poking was never an infrequent occurrence, but he said that it became much more frequent and of longer duration as the years went on. In 1969, it was reported to the NCB Briquetting Committee that there had been problems with ovoids sticking in the ovens due to the type of coal that was being used. This had led to considerable losses in production and to increased pollution, which had given rise to complaints from local residents. In October 1971, Mr Ineson, then manager of the Phurnacite Plant, informed the Public Health Committee of the local district council that 'sticks' (i.e. clustering) were now few and far between as there was no problem with the coal being used.

2.121 In the years that followed, the problem of clustering of ovoids in the ovens increased. There were a number of reasons for that. Probably the most important was the change in the type of coal used in the manufacture of Phurnacite. The original purpose of the Phurnacite process had been to use surplus (and, therefore, cheap) duff from local collieries. Over time, the supply of Welsh dry steam coal diminished and alternatives had to be found. Attempts were made to mix blends of different coals (particularly anthracite) to mimic the properties of the dry steam coal that had originally been used. These attempts met with limited success. When the blending did not work well, the quality of the Phurnacite briquettes produced was adversely affected and the problem of clustering increased. A report for the period 1972/1973[72] by the CRE mentioned the problems of clustering. It was in an attempt to improve the system of coal blending that the new coal blending site was installed in 1973/1974.

2.122 There is no doubt that clustering and the consequent problems with discharging ovens increased during the 1970s. In January 1977, it was reported that a survey of the ovens on battery 1 showed damage to the inside of ovens, almost certainly due to wear and tear caused by the metal bars used for poking. In June 1978, a report on the viability of the Phurnacite Plant[73] referred to the fact that ovens were requiring poking for 20-30 minutes at a time. Mr John Lanyon, who was a spare man on the batteries from 1968 until about 1974, regarded poking as "a rough, hard job … the worst job of all on the batteries". He recalled that the time taken to poke an oven would vary depending on the mixture of coal being used. It could take 20 minutes or it could take "hours or even all shift". Eventually, it was agreed that poking should attract an additional payment, the condition for payment being that it had taken at least an hour to poke a block of eight ovens. Mr Howard Silvanus worked on the oven floor in the 1970s. His evidence was that it was sometimes necessary to poke for an hour or so. On other occasions, it was less difficult but he said that "sometimes it was murder".

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[70] WS1/33
[71] D9/46/12-47/1
[72] Stear2/33
[73] Syred5/226

2.123 In an attempt to reduce the need for poking and to improve the quality of the Phurnacite ovoids, a number of additives (e.g. molasses, sulphite lye and ammonium sulphate) were added to the ovoid mixture as binding agents. However, for one reason or another, none of these additives proved suitable and their use was discontinued. The 1977/1978 CRE report[74] recorded that sulphite lye had proved very successful. However it produced an unpleasant odour which was unacceptable to local residents. Ammonium sulphate was to be used as a replacement on a trial basis. By 1979[75], the use of ammonium sulphate was "standard practice", although it was causing some problems. It appears to have been used intermittently during the 1980s, but not thereafter.

2.124 It is plain from the documentation that the problem of clustering became particularly serious in the late 1970s/early 1980s. Excessive poking led to blocks of ovens being out of action for long periods between charges and caused considerable loss of production. In November 1979[76], the manager of the Phurnacite Plant reported that production amounting to 77 blocks of ovens had been lost during the previous four weeks due to "hard poking". In the four weeks prior to 23 February 1980[77], 134 blocks of ovens had been lost for the same reason, mainly over a 12-day period when coal was being used from one specific area of the coal blending site. Over the five weeks to 27 September 1980[78], difficulties with discharging the ovens occurred on 33 days, resulting in the loss of between one and 32 blocks of production per day, a total of 362 blocks in all. The problems were attributed to the quality of pitch being used in the ovoid mixture. In November 1980, a reduction in poking problems was reported. Only 40 blocks had been lost over a four-week period. During the four weeks to 28 February 1981[79], 88 blocks were reported to have been lost. Some of these were said to have been due to higher than normal proportions of pitch in the ovoid mixture but, for most of the time, there was no obvious reason. Poking occurred on 29 days in the five-week period to 28 March 1981[80], resulting in the loss of 194 blocks and on one occasion provoking a dispute and walk out by the men working on the oven tops. In April 1981[81], it was reported that poking had been necessary on every day of the previous four-week period; the problem had been eased towards the end of the period by reducing the coking coal content of the ovoid mixture. In March 1982, the authors of a report prepared by the CRE observed 22 blocks of ovens being discharged. The period taken to discharge one block varied between nine minutes and more than one and a half hours. Over the four weeks to 20 August 1983[82], 221 blocks were lost. In October 1983[83], it was reported that poking had increased significantly during the testing of different coal, resulting in 170 blocks of production being lost.

2.125 The principal cause of the clustering of ovoids inside the ovens appears to have been problems with the coal and/or pitch used to make the ovoids. However, other factors also played a part. Incomplete carbonisation due to inadequate and/or uneven temperatures during carbonisation was recognised to be a contributory cause of

[74] Stear2/68
[75] Stear2/70
[76] CB7/68
[77] CB7/89
[78] CB7/199
[79] CB7/281
[80] CB7/305
[81] CB8/174
[82] CB8/208
[83] CB8/231

clustering. Damage to the brickwork inside the ovens and problems with the gas supply to the ovens resulted in heat being lost and ovoids being carbonised at temperatures which were less than optimum. These problems increased as the batteries became older. On occasions, in an attempt to increase production, a conscious decision would be taken by members of the management staff to carbonise ovoids for less than the usual four-hour period.

2.126 In addition, it had been the practice from an early stage in the life of the Phurnacite Plant to fill the ovens beyond their recommended capacity. In June 1967[84], it was noted that the ovens were running "above their rated capacity". In August 1970, a report on sources of pollution at the Phurnacite Plant[85] noted that the practice of filling the ovens to maximum capacity had started in the 1940s and had been continued ever since. The practice was "completely contrary to original recommendations" since the ovens were designed to be operated with some free space. In August 1971, a report of the Environmental Control Committee Working Party on pollution control at the Phurnacite Plant[86] advised that a study should be conducted into the effects of over-filling the ovens "as presently practised" because it tended to result in the top layer of ovoids not being completely carbonised. In August 1975[87], the Alkali Inspector observed men filling the ovens to overflowing and levelling them off with a shovel and it appears that this continued to be the accepted practice.

2.127 As well as contributing to the problem of clustering, the incomplete carbonisation of ovoids also resulted in increased emissions of thick yellow fumes and 'green' gases from the charge holes of the ovens and from the quenching cars during discharge of the ovens. As the amount of poking increased, the oven lids and doors had to be kept open for longer and the exposure of men working on the oven tops, at the oven sides and on the ramps to the gases and fume given off by the red hot ovoids became greater.

2.128 In the Spring of 1980, NSFL began a programme of rebuilding the ovens of some of the batteries. The heat distribution in the rebuilt ovens was much improved and carbonising was more effective, as a result of which less fume and 'green' gases were emitted on discharge of the ovens. In September 1980[88], NSFL decided, as a temporary measure, to increase the carbonising times on the older batteries, where the ovens had not yet been rebuilt. Ten months later, the experiment was reported to have been effective in reducing pollution on discharge of the ovens, although it had resulted in lower throughput and increased costs.

The ramps

2.129 The quenched ovoids ran out of the quenching car down an inclined ramp[89] or wharf. On occasions, some of the ovoids would still be red hot. The rampsman was equipped with a water hose which he would use to cool down the ovoids when necessary. Once he had done this, he would open a door to discharge the ovoids onto a series of conveyor belts which carried them to the screen house. The rampsman

[84] CB1/207
[85] CB2/12
[86] CB2/102
[87] CB3/292
[88] CB8/3
[89] CBP/43

would be exposed to some of the steam, fumes, dust and grit given off in the process of discharging the ovens. Dust was produced as the ovoids dried out and passed through the various transfer points on the conveyor. Dust and breeze accumulated under the ramps and conveyors and was blown about in windy weather.

The screen house

2.130 The screen house was an enclosed building in which a three-stage screening process was carried out. The Phurnacite ovoids were dropped down chutes onto the vibrating plates of the screens. Rejected material dropped from the screens onto the screen house floor. Ovoids that 'passed' the screening process were loaded into railway wagons or lorries for onward distribution. Broken ovoids ('nuts') were saleable and were also loaded for distribution. Breeze was collected and transported to the briquetting plants for re-introduction into the Phurnacite manufacturing process. The dropping of the ovoids onto the screens and of dust and breeze onto the floor produced dust. Two men were regularly employed at the screen house. One was responsible for loading the ovoids and nuts for transport out of the Phurnacite Plant. The other was employed on the cleaning of wagons and lorries which had previously been used to deliver coal to the Plant in order to prepare them for loading with the finished Phurnacite ovoids.

Conclusions on the working conditions on the batteries

2.131 During the first 25 years or so of the operation of the Phurnacite Plant, when the fumes and gases resulting from the carbonisation process were vented from the off-takes just above the heads of the men working on the oven tops, working conditions on the oven and shuttle car floors must have been dreadful. Even after the installation of the venturi stacks, however, the men on the oven tops were still exposed to fumes and gases from the charge holes of the ovens, from leaks in the brickwork of the ovens and elephants and from material smouldering on the oven tops. They were also exposed to large quantities of dust and grit produced by the charging and discharging of the ovens and the charging of the raw ovoid bunkers above the ovens, together with the dust which accumulated on the oven tops. When the John Zink burners did not work properly, untreated fumes and gases were discharged into the atmosphere and would re-enter the batteries if the wind was blowing in a certain direction. The open sides of the batteries meant that dust, grit, fumes and gases were blown about the oven and shuttle car floors. If the wind was blowing in the wrong direction, it must have been impossible to avoid exposure to them. Sweeping up spillages of dust and debris from the oven tops would have caused further dust to enter the atmosphere.

2.132 Conditions were even worse when clustered ovoids had to be poked out of the ovens. I am satisfied that clustering was a common occurrence throughout the life of the Phurnacite Plant although it undoubtedly became a more frequent occurrence in the mid-late 1970s and the 1980s. It is not surprising that Mr David Jones described the oven tops as "a filthy and horrible place to work". Mr Brian Jones had previously worked on coke ovens. He contrasted the conditions at the coke plant with those on the Phurnacite ovens:

> "The Phurnacite process was particularly unpleasant. From my experience of working at a coke oven plant, there is no comparison between the Batteries producing coke and the

> Batteries producing Phurnacite. The Phurnacite Battery process created a particularly unpleasant environment to work in due to the dust, fumes, gases and vapours that could be present in the atmosphere on the Oven Floor."

2.133 Conditions on the shuttle car floor were not much better. It was situated just under the battery roof which must have exacerbated the effects of the dust and fume. It is plain from the evidence that the shuttle car floor was considered one of the most unpleasant places to work. One of the witnesses[90] related how spare men from the briquetting plants would be required to deputise for the shuttle car operators during their breaks. He said that the spare men (who were after all no strangers to a dusty environment) would "draw straws to see who was the unfortunate that had to go up there."

2.134 The men working on the oven sides were exposed to the steam, fume, dust, and grit from the quenching operation and also had the unpleasant task of poking the ovens from the bottom when clustering of ovoids occurred. In general, however, the evidence was that the conditions on the quenching car floor and the ramps and in the screen house were rather better than on the oven tops or the shuttle car floor.

The by-products plants

2.135 There were two by-products plants at the Phurnacite Plant, each of which served a number of the batteries. Each by-products plant included an exhauster house from where the processes carried on in the by-products plant were monitored and controlled.

2.136 The evidence relating to conditions in the by-products plants was relatively limited. Within the large body of documentary evidence that was available to me, there were few references to the by-products plants. The witness evidence related mainly to exhauster house 1 and to the by-products plant associated with it. Two of the lead claimants, Mr Richards and the late Mr Jenkins, worked in exhauster house 1 for a number of years, Mr Richards worked there between 1957 and 1966 and Mr Jenkins from October 1979 until January 1989. Mr Richards gave oral evidence about conditions there during his period of employment.

2.137 Evidence about conditions in exhauster house 1 during the 1970s and 1980s came from Mr Silvanus and Mr Lanyon, both of whom had worked there as pumpsmen. Mr Silvanus was employed there from 1979 until 1986 and Mr Lanyon from about 1974 until January 1984. Mr Silvanus signed a witness statement in November 2010 but died before the trial started. Mr Lanyon gave oral evidence. Although he was plainly somewhat infirm, he was a good witness. He had an excellent memory of the duties of a pumpsman and did his best to answer the questions asked of him fairly and accurately.

2.138 The evidence focused on the duties of the pumpsmen, who worked closely with the exhaustermen in and around the exhauster houses. Over the years, there were some changes to the layout of the exhauster houses and to the processes carried out there. I have referred to some of those changes in the summary of evidence that follows. There may have been others of which I am unaware. However, I am

[90] Mr Alan Saunders

satisfied that the working conditions of the men employed in exhauster house 1 remained much the same throughout the life of the Phurnacite Plant.

The layout of exhauster house 1

2.139 Exhauster house 1 was approximately 40-50 feet long, 20-25 feet wide and at least 30 feet high. It had two floors, although the upper floor covered only about half the area of the lower floor. Access to the upper floor was by means of a door reached by a set of external steps. On the upper floor there were two gas turbines (only one of which would be working at any one time) and a pump known as a smoke exhauster. These pieces of equipment were used to extract smoke and gases from the ovens before and during the carbonisation process and to clean the extracted gases so as to enable them to be re-used in the Phurnacite manufacturing process.

2.140 The lower floor of exhauster house 1 (sometimes known as the pump house) contained a number of pumps. These were used for the extraction of tar and ammonia from the gases produced during the carbonisation process. During the 1940s, 1950s and 1960s, the lower floor of exhauster house 1 housed two tar pumps, two ammonia pumps and three re-circulation pumps. By the late 1970s, only the tar pumps remained. There were two ammonia pumps housed in a small building near the ammonia plant and two re-circulation pumps (or ‘oven liquor pumps’, as they came to be known) situated outside the exhauster house building in the open air. The area where the tanks were situated was known as the ‘tank farm’.

2.141 In order for the carbonisation of ovoids to be successful it was necessary for as much air as possible to be removed from the ovens. When the raw ovoids were being dropped into the ovens, a considerable amount of smoke and yellow sulphurous fumes were produced. As a block of ovens was being charged, the gas off-take would be opened and the smoke exhauster in the exhauster house would be switched on. The smoke exhauster would then draw the smoke and fumes from the ovens along the smoke main to a liquor wash tower where they were sprayed with water to remove the impurities contained in them. The water and impurities were then run off into tanks known as ‘drag tanks’, whilst the cleaned smoke was discharged into the atmosphere by the smoke exhauster through a high funnel in the roof of exhauster house 1.

2.142 Once a block of ovens was fully charged, the gas off-take would be closed, the smoke exhauster would be turned off, clean gas would be fed into the ovens in order to heat them and the carbonisation process would begin. The carbonisation process would produce fumes and gases, including vapourised tar from the pitch contained in the ovoids. Those fumes and gases were removed from the ovens by suction, using the gas turbines in the exhauster house, and then flowed through the elephants and the smoke box where they were sprayed with hot liquor. The spraying would cause much of the vapourised tar, together with ammonia, naphthalene and other impurities, to fall out and to mix with the liquor. The gases that remained, together with the liquor, would then be carried away from the batteries in a ‘foul’ gas main pipe. From there, the liquor would drop out into the drag tanks, whilst the gases would pass into the gas collection main and then through de-tarrers, coolers and a naphthalene washer. The clean gases would then pass into the gas turbines and, after undergoing a further purification process, would be stored in gas holders ready for re-use as fuel for heating the ovens.

The tank farm

2.143 The drag tanks containing the liquor were closed containers about 20-30 feet long and 10 feet high. Their contents could be inspected by means of sliding open sections in the top of the tanks. A heavy residue of impurities would collect in the bottom of the drag tanks and would be removed daily by a scraper chain. Tar would settle above the residue of impurities, with the liquor on top. As the drag tank filled up, the liquor contained in it would flow out through outlet pipes in the side walls of the tanks. The liquor would pass into the first of three recirculation tanks, each of which would fill up in turn as the liquor in the previous one reached the level of the outlet pipes. Meanwhile, tar would be accumulating in the drag tanks. When it reached a certain level, it would be run off into a tar separation tank (also known as a settling tank). The tar separation tank would also contain tar collected from other sources, including the de-tarrers. The drag tanks, the tar separation tank and the recirculation tanks were heated so that their contents remained in a liquid state. The tar would settle in the bottom of the tar separation tank from where it was pumped by the tar pumps in the exhauster house into tar storage tanks for use in the boilers or for onward transmission to a refining plant. The hot liquor from the recirculation tanks was either pumped by the re-circulation pumps back to the batteries for re-use or pumped by the ammonia pumps to the ammonia plant or an ammonia storage tank.

2.144 As well as the drag tanks, tar storage tanks and re-circulation tanks, each of the by-products plants contained a number of other tanks. There were stripping tanks containing hot steam pipes through which oil produced in the course of the gas purification process was passed. Heating the oil separated out the impurities contained in it. The clean oil was then stored for re-use, whilst the residue (a mixture of benzene and toluene known as ‘benzole’) ran into ‘tank 19’, the tank used to store waste products. Naphthalene removed by the naphthalene washer also went into ‘tank 19’, together with waste materials collected from other processes. Those materials included tar which would be pumped out of ‘tank 19’ into one of the re-circulation tanks using the tar pumps in the exhauster house. ‘Tank 19’ was a large metal tank which was sunk into the ground, with its top at ground level, and encased within a concrete sump. Its contents could be inspected via a hatch in the top of the tank. By the 1970s, another ground tank (which I shall refer to as the “ground (waste) tank”) had been installed to take waste products.

2.145 The cleaning out of the tanks on the tank farms was a particularly unpleasant task which was usually carried out by spare men, yard labourers or men working overtime. When tar was pumped out of the tar storage tanks, a clay-like residue would be left in the bottom of each tank. A gang of men would be detailed to clean out the tank and to remove the residue, a task which could take days – or even weeks – at a time. The men were provided with wellington boots, overalls and gloves, but not respirators. Two men at a time would enter the tanks through a small hole cut in the side and would shovel the tar residue out of the opening whilst other men transferred it to a dumper truck. The fumes within the tank were very strong and, after about half an hour, it would be necessary for the men to change roles. Because of the unpleasant nature of the job, a bonus was paid to those men who carried it out. The same process was followed when the other tanks were cleaned out.

The roles of the exhaustermen and pumpsmen

2.146 On each shift, there would be two men, an exhausterman and a pumpsman (also known as a 'booster man'), working in each exhauster house. The work of the pumpsman and exhausterman was vital to the success of the carbonisation process and the men holding these positions underwent a period of concentrated training. The exhausterman was responsible for operating the smoke exhauster and the gas turbine pumps. He would have to liaise closely with the men working on the oven floor in order to ascertain when to open and close the gas off-take valve of the smoke exhauster and when to operate the gas turbine to remove the gases produced during carbonisation. The operation of the controls was a continuous process and required the exhausterman to remain in the exhauster house for the whole of his shift, apart from designated breaks when the pumpsman would cover for him. The exhausterman would also have to take and record readings from various gauges and meters situated in the exhauster house in order to ensure that the equipment was working properly and that the gases extracted from the ovens were kept at the correct temperatures.

2.147 The pumpsman was responsible for dealing with the by-products produced by the carbonisation process. He would make regular checks on the levels of the various tanks and would operate the pumps as necessary in order to move the contents of the tanks to their appropriate destinations. He would also cover for the exhausterman and help him with tasks such as changing from one gas turbine to another. The evidence about the way in which a pumpsman would divide up his time differed slightly as between witnesses. I am satisfied that he would spend about half his shift in the exhauster house and the remainder of his time checking tanks and performing other duties outside.

Exposure to dust and fume in the exhauster house and by-products plant

2.148 The defendants' documents contain few references to problems with dust and fume in the exhauster houses or the by-products plants. In January 1960, a complaint of excessive fumes in exhauster house 1 was reported and a request was made for a cabin to be built. A document dating from May 1960 indicated that the cabin had been erected. An undated document probably originating from the late 1960s[91] identified a number of sources of odour in the by-products plants. In April 1973, there were concerns about the leakage of tar into the surface drainage system in the area of exhauster house 1 and 'tank 19'. It was decided that the whole area needed cleaning. Arrangements were made to remove tarry deposits, after which a cleaning programme was to be implemented[92]. In 1974, at a meeting between the NSFL Wales Management Unit and the Alkali Inspector[93], the by-products plants were described as "non-polluters". I take this to mean that it was not considered that the by-products plants contributed to pollution problems outside the Phurnacite Plant. That does not mean of course that the men working in the by-products plants were not exposed to dust and fume.

2.149 Despite the fact that the documents do not disclose evidence of continuing problems with dust and fume in the area of exhauster house 1, the evidence of those who worked there suggested that they were exposed to considerable amounts of dust

[91] Stear3/299
[92] CB3/109 and Syred4/261
[93] SD16/4/17

and fume. The main problem in exhauster house 1 was said to be the fume caused by leaks from the joints of pumps. The pumps were in constant use and sustained a good deal of wear and tear. They would develop leaks which would be repaired using gland packing. The packing would soon work loose, causing liquid to drip from the joints. It was not always possible to get a fitter to come immediately to repair a leak so the pumpsman would attempt to carry out running repairs but these would work only temporarily. As a result, hot tar (and, in the 1950s and 1960s, hot ammonia, liquor and other impurities as well) would be deposited on the floor of the exhauster house. The evidence was that these hot liquids gave off unpleasant fumes. The fumes emanating from the tar pumps were described as particularly offensive, especially when the pumps were being used to pump tar from 'tank 19'.

2.150 The pumpsman would position trays in order to catch the drips from the pumps and other spillages. He would carry the drip trays to 'tank 19' to empty them. On occasion, a drip tray would overflow causing tar or other substances to be deposited on the floor. Spillages would sometimes occur when drip trays were moved and would splash onto the pumpsman and the floor. Tar would be transferred onto the pumpsman's hands and gloves and the pump controls would become covered in tar. The training document completed at the end of Mr Jenkins' training in 1980 confirmed that the pumpsman's duties included the cleaning of the pumps and the area around them every shift, together with the cleaning and replacement of drip trays.

2.151 The exhausterman would sweep and mop the floor of the upper level of the exhauster house 1 daily. The pumpsman would clean the lower floor. Mr Richards described how he and his colleagues would use benzole from 'tank 19' to remove tar deposits from the floor. He said that the benzole gave off unpleasant fumes and a pungent smell. He said that benzole was also used to clean tools and even to clean tar from the pumpsman's hands. For much of his time in exhauster house 1, there were no washing facilities and no hot water. The only available washing facilities were situated in the shower block, a considerable distance away. I accept Mr Richards' evidence about the use of benzole during the 1950s and 1960s. There is some supporting evidence from Mr Middle, another lead claimant. In the absence of any other solvent, it is understandable that the men used whatever was to hand in order to remove tar deposits. Washing facilities were installed in exhauster house 1 in about 1965 and, from that time, a suitable cleanser was provided so that it was no longer necessary for the men to use benzole for cleaning their hands. Neither Mr Silvanus nor Mr Lanyon mentioned using benzole for cleaning purposes. It seems probable that, by the time they came to work in exhauster house 1, the practice had ceased.

2.152 The evidence was that, in the 1970s and 1980s, deposits of tar on the floor were heated using a steam lance before being removed with a shovel. The evidence was that steam cleaning of this kind would produce pungent fumes and would also cause the pumpsman to become splashed with tar.

2.153 The witnesses said that, as well as fumes, there was a great deal of dust in exhauster house 1. The dust came, not from the processes carried on in the exhauster house itself, but from the other plant and equipment in the area, in particular the ESPs, trommel house 1 (which was situated close by) and the various conveyors nearby. Dust would enter the exhauster house through the doors and windows. The evidence was that the level of dust was such that the exhausterman would have to sweep the upper floor of the exhauster house and clean dust from the equipment there at least once a shift. His cleaning activities would cause dust to fall onto the lower floor of the exhauster house. At no time was there any system of extraction or forced ventilation in exhauster house 1. Mr Lanyon accepted that dust levels in the exhauster house were always less than in the briquetting plants but nevertheless said that, on a windy day, the dust in the exhauster house would be "terrible". This was in contrast to the evidence of Mr Brian Jones, who had never worked in the by-products plant but visited there in the course of his duties as a shift superintendent. He described the by-products plants as "dirty areas, not dusty areas, beyond the background…" and said that conditions inside the exhauster house were not dusty.

Outside the exhauster house

2.154 As well as his work inside the exhauster house, the pumpsman would have to carry out a number of tasks outside. He had to make regular visual inspections of the contents of the various tanks and check the levels of material in the tanks using taps known as drain cocks. This latter task would involve running a small amount of liquid out of each tank into a container. The contents of the tanks were heated and the evidence was that the pumpsman would be exposed to unpleasant fumes whilst performing these tasks. The witnesses said that the fumes from 'tank 19' were particularly pungent. Mr Richards recalled that, when looking inside 'tank 19', he would often use a mirror in order to avoid having to lean over the inspection hatch and breathe in the fumes. It seems that, throughout the period from the 1950s to the 1980s, the metal top and sides of 'tank 19' were in poor condition, with holes through which material leaked from the tank into the gap between the sides of the tank and the concrete sump surrounding it. It would often be necessary to siphon the material that had escaped from 'tank 19' back into it. 'Tank 19' filled up quickly and therefore required frequent checking. It sometimes had to be pumped out two or three times a shift. It was situated near to the door of exhauster house 1 and fumes from it would waft inside the building.

2.155 Both Mr Silvanus and Mr Lanyon described the cleaning out of drains using a steam lance. Their evidence was that, in the 1970s and 1980s, the pumpsman's duties included the regular opening and steam cleaning of all the pipes and drains leading to 'tank 19', the ground (waste) tank and the de-tarrers. Some of the drains were situated on the lower floor of the exhauster house, whilst others were outside. Sometimes, when a drain pipe was being unblocked, tar would shoot out of the pipe being steamed onto the floor of the exhauster house or the ground outside and the pumpsman would have to clean it up. On occasion a drain became blocked with tar or naphthalene and steam would be applied in order to clear the blockage. The pump columns also had to be steam cleaned to prevent tar and pitch from solidifying inside. Sometimes, tanks required cleaning with a steam lance. Mr Silvanus said that the condition of the tanks deteriorated over the time he worked as a pumpsman. They were not cleaned out as frequently as they should have been, as a result of which solid tar built up in the bottom of some of the tanks and blockages occurred. The pumpsman had to apply steam to clear the blockages. The evidence was that all these activities produced large quantities of unpleasant fumes.

2.156 In April 1975, liquid pitch was introduced in briquetting plant 1. The liquid pitch loading bays were situated near the ground (waste) tank. Spillages from tankers delivering liquid pitch would run into the drains leading to the tank. The pumpsman would have to steam clean the drains and pump out the contents of the ground (waste) tank, including the liquid pitch.

2.157 When working on the day shift, the pumpsman would have to pump tar from the tar storage tank into tankers which would then transport the tar away from the Phurnacite Plant. A large tar storage pump was used for this purpose. It was situated in a building known as the small pump house (later the 'exhauster pump house'), which was no more than about ten feet square and was situated near to the tar storage tank. In the 1950s and early 1960s, rail tankers were used to transport tar. The pumpsman would have to stand on top of each tanker as it was being filled and watch as the tar was pumped out of the tar storage tank into an access hole in the top of the tanker. The tar storage tank was heated so as to keep the tar in a liquid state. The access holes in the tankers were significantly larger than the pipes through which the tar was pumped and the hot tar gave off fumes which escaped out of the access holes. The task of filling each tanker would take about half an hour and, during an average week, a pumpsman would fill two or three tankers a day. The evidence was that, because of the fumes, this was a most unpleasant job.

2.158 In the mid-1960s, the railway tankers were largely replaced by road tankers. Mr Richards' evidence was that, from that time, he would operate the pump from inside the small pump house, whilst the tanker driver watched the level of tar in the tanker. Thus, he was no longer exposed to tar fumes from the tankers as they were being filled. However, there were problems with tar leaking in the small pump house and tar fumes were constantly present in the atmosphere. Furthermore, the pipes used to fill the tankers had to be steamed out daily, causing further tar fumes to be given off.

2.159 Mr Lanyon's evidence was that he did not believe that there was "a dirtier job with more exposure to fumes" at the Phurnacite Plant than that of a pumpsman.

The effects on the pumpsmen

2.160 The witnesses described how, whilst working in exhauster house 1, their eyes would frequently water due to the dust and fume to which they were exposed. Mr Silvanus said that the fumes would make him cough and splutter and, on occasion, he would be unable to breathe and would have to run outside and get some fresh air. He said that this would happen two or three times a shift. The men's overalls would become covered in various materials and the tar would soak through to their clothes underneath. Any exposed area of skin would turn yellow. Even after showering and changing, their clean clothes would become stained yellow and, at night, their bedclothes would also be stained. They suffered from phototoxicity and had to avoid sunlight since, if they were exposed to it, their skin would burn. The yellowing of the men's skin and the phototoxicity from which they suffered demonstrate that they must have had significant dermal exposure to pitch.

Conclusions on the working conditions in exhauster house 1

2.161 The defendants accepted that there would have been some background dust in and around exhauster house 1 from the various processes carried on nearby. They conceded also that there were problems with leakages, especially of tar. However, they contended that persons working in the by-products plants were exposed to low levels of dust and little or no fume. They relied on the paucity of documents referring to complaints about conditions in the by-products plants as support for their position.

2.162 The evidence from the claimants' witnesses spanned a good number of years and was in general very consistent. I accept that the job of a pumpsman was a dirty one which involved a good deal of dermal exposure to tar in a solid and liquid state and therefore to pitch, one of the main constituents of tar. This is evidenced by the yellowing of their skin and their episodes of 'Phurny burn'.

2.163 I have no doubt that the men working in the exhauster houses and at the tank farm were frequently exposed to substances that gave off pungent and unpleasant odours and, on occasion, produced the unpleasant effects which the witnesses described. Much of this exposure would have occurred whilst they were in the open air but I accept that there would also have been exposure to strong-smelling substances – in particular, tar – inside the exhauster house. The fumes produced when carrying out steam cleaning of drains, pipes and tanks would have been particularly unpleasant.

2.164 I am satisfied also that the men working in the exhauster houses were exposed to dust containing pitch which had escaped from the nearby buildings, in particular from the ESPs on top of the dryer house and the trommel house at briquetting plant 1. The amount of dust was no doubt variable and would have depended on the weather conditions and other factors, but I accept that it was significant. The dust gathered on surfaces in the exhauster houses and had to be swept up on a daily basis. That task would have generated yet further dust exposure. I am satisfied, however, that, even at its worst, the dust in the exhauster houses was far less heavy than in other parts of the Phurnacite Plant, especially the briquetting buildings. It was no doubt for that reason that the conditions in the exhauster houses were the subject of only a few references in the contemporaneous documents. By comparison with the conditions encountered by those working in the briquetting buildings and on the shuttle car and oven floors of the batteries, the conditions experienced by the pumpsmen may well have seemed relatively clean.

Exhauster house 2

2.165 Exhauster house 2 was a newer and larger building than exhauster house 1, and contained fewer pumps. The evidence was that there were some problems with leaking pumps, resulting in tar and other substances being deposited on the floor. There was also a good deal of dust. Generally, however, the evidence was that the conditions in exhauster house 2 were rather better than in exhauster house 1.

The sample rooms

2.166 One of the lead claimants, the late Mr Griffiths, worked as a sampler at the Phurnacite Plant between 1975 and 1984. The evidence about working conditions in the sample rooms came mainly from Mr Saunders. Mr Saunders appeared to have a good knowledge of the Phurnacite Plant and the sampling and other processes carried on there although, as I have already indicated. I did not find him a wholly satisfactory witness.

The sampling team

2.167 The manufacture of good quality Phurnacite briquettes required the use of coal with specific properties. If there was no single type of coal available that would fulfil the necessary criteria, it was necessary for a number of different types of coal to be blended together to achieve the required result. The defendants instituted a system of monitoring the properties of the coal delivered by their suppliers by analysing coal samples on a daily basis. Testing of Phurnacite ovoids (both raw and carbonised) was carried out daily as part of the defendants' quality control system. Tests were also carried out on liquid samples taken from the by-products plant, the pitch bay, the boiler house, the river and other sites at the Plant. The tests were carried out in part to ensure that the manufacturing process was working satisfactorily and in part to monitor the effects of pollution from the Phurnacite Plant on the local air quality and water supply. The sampling team consisted of three coal samplers, one plant sampler, two Phurnacite samplers and an effluent officer. They were responsible for obtaining the various samples and preparing them for onward transmission to the Plant laboratory.

2.168 Mr Saunders' evidence, which I accept, was that Mr Griffiths was mainly employed on coal sampling, although he would undertake plant sampling when working overtime or covering for the absence of other members of the sampling team. The summary of evidence that follows is focused on the work of a coal sampler and a plant sampler.

The work of a coal sampler

2.169 Most of the time of a coal sampler was spent collecting samples of coal and preparing them for analysis in one of the coal sample rooms. Until 1973/1974, when the new coal blending site was created, preparation of coal samples was carried out in two small cabins, each situated near to the coal tippler area of one of the briquetting plants. Once the coal blending site came into operation, the coal tippler area and sample room for briquetting plant 1 were no longer used. Mr Saunders suggested that the coal tippler area and sample room for briquetting plant 2 continued to be used for some time after 1973. Mr Harris (a witness in the case of the lead claimant, Mr Robson) said that they were used only when there were interruptions to the process carried out at the coal blending site. I prefer Mr Harris' evidence on this point and I am satisfied that, after 1973, most of the coal samplers' activities would have been conducted in the sample room situated on the ground floor of the wagon tippler control room which was adjacent to the coal blending site ("the coal blending site sample room"). Since Mr Griffiths' employment as a sampler began in 1975, he would have spent most of his time working in the coal blending site sample room.

2.170 Both the coal sample room for briquetting plant 2 and the coal blending site sample room were very small; Mr Saunders estimated that they measured about five metres long, three metres wide and between two and three metres high. His evidence, which I accept, was that they had no dust extraction facilities. Usually, only one coal sampler would be working in a coal sample room at any time. On occasion, however, two coal samplers might be carrying out preparation work in a coal sample room.

2.171 The preparation of samples of raw and carbonised ovoids, and of the samples taken by the effluent officer from other parts of the site, was conducted in the main sample room, which was larger than the coal sample rooms. In 1972, when Mr Saunders became a sampler, the main sample room was in a building near to batteries 5 and 6. It was later replaced by a new main sample room situated near to the plant offices and administration block. Extraction fans were installed in the new main sample room. Mr Saunders could not say when the location of the main sample room changed, although it must have been prior to September 1980 since the new main sample room is shown on the site plan of the Phurnacite Plant dating from that time. It is possible that the main sample room may have been in its original position for some years after Mr Griffiths started work as a sampler.

2.172 At the start of a shift, the coal sampler would visit the main sample room to collect his equipment. On the occasions when the coal sampler was engaged in plant sampling, he would prepare his samples in the main sample room. Each consignment of coal delivered to the Phurnacite Plant was sampled for analysis in the Plant laboratory. As the coal passed along the conveyor taking it to the blending rollers, the coal sampler would take scoopfuls of coal from different parts of the consignment. Sometimes, he would take the samples of coal from the wagon in which the coal had been delivered. The evidence was that the collection of coal samples was not a particularly dusty process.

2.173 Once the coal sampler had obtained about 20 lbs (equivalent to about 9,000 g) of coal from one consignment, he would take it in a bin or 'jar' to the coal sample room and empty it onto a metal plate on the floor. He would then divide the coal he had collected several times, discarding part of it each time until he was left with about 1,500 g of coal. The object of this exercise was to obtain a representative sample of coal for analysis. He would then weigh the 1,500 g of coal before placing it onto a tray and into a drying machine (known as an Apex dryer) where it was dried at a high temperature. Whilst the tray of coal was drying, the coal sampler would collect further coal samples, carrying out the same procedure each time. Up to 20 trays of coal could be dried at any one time.

2.174 Once a tray of coal had been dried, the coal sampler would remove it from the drying machine. He would tip the coal out onto another tray before re-weighing it. By this time, the weight of the coal would have reduced to approximately 1,200 g. He would then pour the dried coal into a crushing machine which ground it into a very fine flour-like dust. The crushed coal dust was fed automatically into a container situated under the crushing machine. The coal sampler would then empty the contents of the container into a sample bottle and label the bottle. He would repeat the process until the required number of samples (15-20 each shift) had been prepared. At the end of his shift, he would deliver the filled sample bottles to the laboratory.

2.175 Mr Saunders' evidence was that substantial amounts of dust were created at the point where the dried coal was tipped from one tray to another. He said that the dust would blow back into the sampler's face and would create a cloud that would hang in the air for a considerable period of time. He described how, if a coal sampler did not fit the container to the crushing machine firmly enough, a large quantity of very fine dust would escape when the crushed coal was discharged from the drying machine. He said that the emptying of the crushed dust into the sample bottle also generated dust. His evidence was that there were rarely any times during a shift when the air in the coal sample room could properly be described as clean or free from coal dust. He described how a coal sampler's overalls and areas of exposed skin would be black by the end of a shift. He estimated that a coal sampler's exposure to dust whilst in the coal sample room would have been about 75% of the level he would have encountered in the briquetting plants.

The work of a plant sampler

2.176 The work of a plant sampler involved scooping up quantities of raw ovoids as they came off the presses in the briquetting plants. In order to do this, the plant sampler would stand next to the press operator. He would collect about 20 lbs of ovoids at a time. He would then leave the ovoids outside the briquetting plant for collection by a dumper truck and would walk to the other briquetting plant. There he would collect another 20 lbs of ovoids from the presses. Mr Saunders estimated that the task would take a plant sampler about half an hour in briquetting plant 1 and about one and a half hours in briquetting plant 2.

2.177 The plant sampler would then return to the main sample room, to which the raw ovoids would have been delivered. He would take nine ovoids from each consignment and crush them. In the past, that job was done by hand, using a metal implement. Later, a machine was used. He would then place the crushed ovoids into a sample bottle for onward transmission to the Plant laboratory before returning to the briquetting plants to obtain further samples. Mr Saunders did not suggest that the processes carried out by the plant sampler in the main sample room gave rise to a great deal of dust. However, he described other processes carried out by other samplers (mainly connected with the sampling of carbonised ovoids) which did produce large quantities of dust. His evidence was that, despite the extraction system, dust was visible in the atmosphere of the main sample room most of the time.

Discussion and conclusions about working conditions in the coal sample and main sample rooms

2.178 The dust created in the course of working in the coal sample room would mainly have been coal dust. It is possible that, on occasion, there might also have been some pitch dust from dust and/or breeze which had been recycled from various parts of the Phurnacite manufacturing process. In the main sample room, any dust generated from the raw or carbonised ovoids would have contained both coal and pitch.

2.179 The documents disclosed by the defendants contained few references to the working conditions in the various sample rooms. In October 1962, the presence of dust was noted in one of the sample rooms[94]. In August 1963, it was reported that dust conditions in the sample room were "very bad" and the dust was said to be "deplorable" when samples were being prepared[95]. It was said that constant cleaning was necessary to remove the dust and that a portable vacuum cleaner was frequently borrowed from the Plant baths for this purpose. The Union representative made a request for the sample room to be re-located and for the new sample room to be equipped with suitable ventilation and extraction equipment. It seems that the references in the documents of 1962 and 1963 must have related to the original main sample room described by Mr Saunders. At some time before 1980, that room was replaced by the new main sample room in which Mr Griffiths worked from time to time. The new main sample room had an extraction system albeit, according to Mr Saunders' evidence, that system was not sufficient to prevent visible dust from being in the air of the room for much of the time. I am not aware of any further references in the defendants' documents to conditions in the sample rooms. In particular, I am not

[94]CB1/155
[95]CB1/166

aware of any complaints about the working conditions in the new main sample room or in any of the coal sample rooms.

2.180 I am satisfied that the references in the defendants' documents are to the main sample room, rather than to any of the coal sample rooms. Those references date from well before the time Mr Griffiths started work as a sampler and there is no reason to believe that they represented conditions in the coal sample rooms in the mid-1970s. It is clear from the evidence that a much wider range of processes was carried out in the main sample room than in the coal sample rooms.

2.181 I accept that some dust was generated in the coal blending site sample room as a result of the activities described by Mr Saunders. It is clear that the work of a coal sampler involved one significant source of dust, i.e. the process of tipping 1,200g of dried coal from one tray to another. That task was performed 15-20 times a shift. I find that there were also occasional incidents when the container attached to the crushing machine became accidentally displaced. I also accept that some dust was caused by the transfer of the fine dust from the container into sample bottles. Given the absence of extraction facilities and the confined space within the coal sample rooms, I can well understand that the dust produced by these operations would have remained in the air for some time before settling. The dust would have accumulated on the floor and other surfaces of the sample room during the working day. If this was not cleaned up, it would inevitably have been disturbed as the coal sampler moved around in the course of his work. The cleaning up of the accumulated dust would have caused further exposure to dust. However, I regard Mr Saunders' suggestion that the exposure to dust in the coal blending site sample room would have been 75% of that which would have been encountered in one of the briquetting plants as something of an over-estimate.

2.182 The dust to which a coal sampler would have been exposed in the coal blending site sample room would have consisted in the main of coal dust. I accept that there may have been some exposure to recycled pitch dust on the odd occasion. However, I consider that this would have been very infrequent since the purpose of coal sampling was to ascertain the properties of the coal being delivered by suppliers. It therefore seems unlikely that samples would have been taken from coal which had already been contaminated by recycled material. There would, I accept, have been a greater potential for exposure to pitch dust before 1973/1974, when the coal sample rooms near the coal tippler areas were in daily use. It is clear from the evidence that recycled dust was tipped at the coal tippler area and that this gave rise to significant emissions of coal and pitch dust. However, any exposure that Mr Griffiths would have had from that source would have been very limited since he would not have worked near to the coal tippler area adjacent to briquetting plant 2 very frequently.

2.183 The plant samplers would have had exposure to considerable amounts of dust in the briquetting plants. There would also have been some exposure to dust (including dust containing pitch) in the main sampling room. However, Mr Saunders did not suggest that the levels of dust in the main sample room were any more substantial than in the coal sample rooms.

SECTION 3

OCCUPATIONAL EXPOSURE LEVELS AT THE PHURNACITE PLANT

3.1 Having considered at Section 2 the witness and documentary evidence concerning working conditions at the Phurnacite Plant, I shall now discuss the evidence relating to occupational exposure levels there. Before doing so, I shall say something about the occupational exposure standards applicable to the Phurnacite Plant.

The setting of occupational exposure standards

Dust

3.2 By the 1940s, it was well known that exposure to high levels of coal dust was capable of causing pneumoconiosis and that continued exposure of a man in the early stages of pneumoconiosis was likely to exacerbate his condition. The NCB had established its own standard of 'approved conditions' governing what was considered to be an acceptable level of coal dust in mines. Conditions were 'approved' in collieries (other than anthracite collieries) if they complied with the relevant standard of 'permissible dustiness' which was not more than 850 particles of respirable size per cubic centimetre (ppcc). A particle of 'respirable size' is a particle measuring between one and five microns.

3.3 The notion of 'approved conditions' was originally developed with the object of permitting men who were already suffering from pneumoconiosis to continue to work in the mines without further risk to their health. However, the standard became more widespread and came to govern the NCB's notion of what constituted 'safe' exposure and what did not. The system of 'approved conditions' was much criticised by Turner J (as he then was) in the British Coal Respiratory Disease Litigation (BCRDL) lead actions. He observed that the NCB appeared to have become "mesmerised" or "corrupted" by the notion that it was only if a coal face was not 'approved' that anything needed to be done to reduce the level of dust concentration. When the NCB first carried out sampling at the Phurnacite Plant, it was with the risk of pneumoconiosis in mind and the standard they applied was that of 'approved conditions'.

3.4 Despite the fact that the carcinogenic properties of pitch have been well known for many years, no occupational exposure limits or 'threshold limit values' (TLVs) relating specifically to dust containing pitch have ever been formulated. Furthermore, it appears that, until the mid-late 1970s, there were no TLVs governing occupational exposure to dust or particulates emitted at premises such as the Phurnacite Plant. In 1975, in response to an enquiry from NSFL, the HSE advised[96] that there were no TLVs governing exposure to coal and coke dust. By way of guidance, the HSE told NSFL that it was unlikely that they would regard the requirements of section 63 of the Factories Act 1961 as satisfied if personal sampling showed that workers were being exposed to shift average concentrations of coal or coke dust in excess of 10 milligrammes per cubic metre (mgm^{-3}) for total dust or 5 mgm^{-3} for respirable dust. The HSE were unable to give any positive information about "safe" concentrations of partially carbonised coal and pitch dust. However,

[96] Jones1/132

their advice was that, where that type of dust was emitted, a higher standard of dust control than that required for "ordinary" coal dust would be expected. They pointed out that, in premises where pitch-bound briquettes were being manufactured, the Patent Fuel Manufacture (Health and Welfare) Special Regulations 1946 would be applicable.

3.5 Consistent with the advice given by the HSE, when the Factory Inspector carried out monitoring of dust levels at the Phurnacite Plant in 1975[97], he used a TLV for total dust of 10 mgm^{-3}. A document from 1979[98] refers to a TLV for nuisance particulates of 10 mgm^{-3} and a TLV for respirable dust of 2 mgm^{-3}.

Polycyclic aromatic hydrocarbons

3.6 Between the 1940s and the 1960s, awareness of the hazards associated with exposure to PAHs was developing. In 1967, the American Conference of Government Industrial Hygienists (ACGIH) introduced an occupational limit (the 'ACGIH TLV') for exposure to CTPVs. The ACGIH TLV required that the amount of BSM in the CTPVs should not exceed an eight-hour time-weighted average of 0.2 $mgm^{-3}$of air. The ACGIH TLV was subsequently adopted as an established Federal standard in the USA and coke oven operators were required to comply with that standard.

3.7 Meanwhile, in the UK, the Factory Inspectorate suggested that the ACGIH TLV should be applied to work on coke ovens. In the early 1970s, the Committee on the Assessment of Occupational Exposure (CAOE) was established. This was a Committee composed of representatives from the NCB, the British Steel Corporation (BSC) and the Factory Inspectorate. At the first meeting of the Committee in April 1973, the CAOE accepted the ACGIH TLV as an interim exposure standard pending further investigation into the risks posed by emissions from coke ovens.

3.8 The CAOE indicated its continued acceptance of the ACGIH TLV in 1975. Around that time, there were discussions in the USA about a possible change to the TLV. It was suggested that it might be more appropriate to measure the concentration of BSM in respirable, rather than total, dust. There was also a proposal for a new TLV of 0.3 mgm^{-3} for respirable particulates, with no specific reference to BSM. It is clear, however, that, throughout the late 1970s and during the early to mid 1980s, the UK Factory Inspectorate continued to apply the ACGIH TLV of 0.2 mgm^{-3} of BSM in total dust.

3.9 The Control of Substances Hazardous to Health (COSHH) Regulations 1988, which came into force in 1989, did not provide a specific occupational exposure standard for CTPVs. Between 1989 and 1993, a limit of 0.14 mgm^{-3} was specified in the relevant Guidance. However, this limit was based on a measurement of matter soluble in a solvent other than benzene so that the limit cannot be directly compared with the ACGIH TLV of 0.2 mgm^{-3} for BSM.

3.10 BaP has been recognised as a potential carcinogen for many years. No 'safe' limit of exposure to BaP is known to exist. No TLV for BaP has ever been set.

[97] Stear7/80
[98] Syred 3/15

Monitoring at the Phurnacite Plant

Forms of sampling

3.11 The defendants' documents contain information about the monitoring of occupational exposure levels to dust and other substances that was undertaken in the working areas of the Phurnacite Plant. This monitoring fell into two categories: static sampling and personal sampling.

Static sampling

3.12 Static sampling, as its name suggests, is undertaken by means of a sampling unit which is positioned in the working area and remains in the same position throughout the sampling period. In the 1950s and 1960s, a unit known as a "thermal precipitator" was used for static sampling at the Phurnacite Plant. This unit could take only short term measurements of respirable dust. Particles of dust measuring between one and five microns (µ) were measured by collecting them on a glass and physically counting them using a microscope. Initially the results were reported in ppcc. The accuracy of readings taken by means of thermal precipitators has been the subject of controversy. There was a tendency for particles captured by the precipitator to overlap and thus to be missed when counting took place. Investigations have suggested that dust readings taken by thermal precipitators could be under-estimated by a factor of as much as two.

3.13 From the beginning of the 1970s, the results of sampling at the Phurnacite Plant were stated in gravimetric units, i.e. mgm^{-3}, rather than ppcc. Measurements in ppcc can be converted into mgm^{-3} by applying a factor known as a 'mass number index' (MNI). The selection of the appropriate MNI depends on a number of factors, including the nature of the dust which is being measured.

3.14 From the 1970s, static sampling was conducted at the Phurnacite Plant using either a mains-powered Hexhlet sampler or, more frequently, a battery-powered MRE 113A (MRE) sampler. The units collected both total and respirable dust. They were fitted with an elutriator which separated out all the non-respirable particles of dust and allowed the particles of smaller diameter (the respirable dust) to pass through to a final collection filter which was then weighed. By this means the respective weights of the non-respirable and respirable dust could be determined and, since the air flow rate and the duration of the sampling operation were known, the figures for total and respirable dust in mgm^{-3} could be calculated.

3.15 Static sampling can only give information about the concentration of total and respirable dust at the point where the intake of the sampler unit is situated. It may provide valuable information about the dust levels produced by certain operations, about general dust levels in the area and about the relative proportions of total and respirable dust. What it cannot do is to provide accurate information about the exposure of a worker employed in the area during the course of a shift. Static sampling takes no account of the worker's movements during the course of a shift, of varying levels of exposure according to his position or of any absence from the working area, for example during breaks. In order to ascertain the actual exposure of a person working in a relevant environment, it is necessary to carry out personal sampling.

Personal sampling

3.16 Personal sampling was undertaken at the Phurnacite Plant using a sampler worn by a worker during a whole shift. A portable battery-operated pump unit was attached to the wearer's belt. The pump was connected by a plastic tube to the sample head in which a filter was mounted. The sample head was positioned on the wearer's lapel with the inlet near his breathing zone. The sampler was designed to collect, insofar as it was possible, the same number and size of dust particles as the wearer would inhale. The unit used for personal sampling at the Phurnacite Plant was the Casella Model C (Casella) sampler. The basic Casella sampler collected total dust only. An extra cyclone fitment was available by which the respirable particles of dust could be separated out for later measuring. At the end of the shift, it was possible to calculate in mgm^{-3} the average concentration of total dust (and, when the cyclone fitment was used, the average concentration of respirable dust also) to which the wearer had been exposed in the course of his shift.

3.17 Whilst it is impossible to be absolutely certain, the available documents strongly suggest that personal samplers were issued only to operatives working on specific processes (e.g. moving pitch, operating the press, shuttle car or charging car, cleaning out a pit), rather than to 'peripatetic' workers (such as fitters, painters and riggers) who would move between different tasks and/or areas during the course of their work or to supervisory staff, who would not always be taking an active part in the relevant processes.

Sampling for substances other than dust

3.18 So far, I have referred only to sampling carried out in order to ascertain levels of exposure to dust. An employer may also wish to ascertain the average concentration in the atmosphere of other substances to which his employees may be exposed. In the case of the Phurnacite Plant, the NCB took a decision in the early 1970s to measure average concentrations of BSM and BaP, in addition to dust.

3.19 The measurement of BSM was carried out by taking the total dust samples (whether obtained by means of static or personal sampling), placing them in a benzene solvent and filtering and evaporating the resulting solution. The dried residue was then weighed to give the concentration of BSM in mgm^{-3}. The concentration of BaP contained in the BSM was also measured in a similar way, although it was expressed in microgrammes per cubic metre (μgm^{-3}).

3.20 At times, concentrations of gases such as ammonia, sulphur dioxide, hydrogen sulphide, benzene, toluene, xylene and naphthalene were also measured at the Phurnacite Plant. I have not dealt with the results of this gas sampling which is irrelevant for present purposes.

Sampling in the 1950s and 1960s

3.21 It is clear from the defendants' documents that, during the 1950s and 1960s, there was no system of regular monitoring of exposure levels at the Phurnacite Plant. However, some sampling did take place.

3.22 Static sampling using a thermal precipitator was carried out in the Phurnacite Plant in February 1951[99] (in briquetting plant 1); in November 1954[100] (in briquetting plant 1 and on the oven tops of batteries 1 and 2); and in September 1964[101] (in briquetting plants 1 and 2). The thermal precipitator measured the concentration of respirable dust only.

3.23 The purpose of the sampling at this time was to ascertain whether exposure levels at the Phurnacite Plant (particularly in the briquetting plants) gave rise to a risk of pneumoconiosis. All the sampling results fell well below the NCB's 'approved conditions' limit of 850 ppcc. No doubt the NCB were reassured by that. It is possible that other sampling exercises were carried out during this period but the evidence clearly shows that it was not until the early 1970s that a programme of systematic monitoring was undertaken.

3.24 So far as is known, no personal sampling took place at the Phurnacite Plant before 1971.

Sampling in the 1970s and 1980s

3.25 In 1970, Dr Rogan, chief medical officer of the NCB, suggested that personal sampling should be undertaken at a number of plants operated by the NCB, including the Phurnacite Plant. This suggestion was accepted and, in 1971, the Environmental Control Working Party of the NCB Coal Products Division indicated their intention of initiating a systematic programme of monitoring levels of exposure to total dust, BSM and BaP by way of personal sampling.

3.26 The results of the personal sampling conducted at the Phurnacite Plant between September 1971 and March 1983 are recorded in a one-page summary, *Personal Exposure Levels at Phurnacite*[102], which was prepared as part of a report for presentation to a meeting of the NSFL Environmental Control Committee in June 1983. During the hearing, this summary came to be known as *Table 6.4* (its designation in Professor Syred's Generic Report) and I shall refer to the summary by that title hereafter. Similar programmes of personal sampling were also undertaken at ten other NSFL plants, nine of these being coke works; the tenth was the Homefire Solid Fuel Works. The report presented to the NSFL Environmental Control Committee in June 1983 included summaries of the personal sampling results for all those plants, as well as the Phurnacite Plant.

3.27 When personal sampling was carried out at the Phurnacite Plant, the system was to select one or two men working in each of the locations to be sampled. Their exposure levels would then be monitored whilst they worked on the same shift (e.g. the afternoon shift) over four successive days. Sometimes, it was not possible to use the same men for four successive days' shifts. In those circumstances, another man performing the same work on the same shift would be used. The exposure levels for each job over the four days were totalled and the average (arithmetical mean) exposure level over an eight-hour shift was calculated. The geometric (rather than the arithmetical) mean was also calculated and entered on *Table 6.4*.

[99] Stear1/93
[100] Stear1/95
[101] Stear1/151
[102] Syred 1/131 and Appendix A to this judgment

3.28 Dr Choo Yin was in charge of the personal sampling programme at the Phurnacite Plant from 1979 until its closure. He explained that, at the time of the sampling, a paper record would be made of the results for each individual sampled. Dr Choo Yin said that he was aware of the potential risk to workers who were exposed to carcinogenic substances. If he saw a man in a working position, or undertaking a task, where he was liable to be exposed to excessive dust or fume, he would advise him to change his position or his working method so as to minimise his exposure. For example, if he saw a man sweeping up dust, he would advise him to use a vacuum cleaner. He was not involved in the analysis of the samples or in the calculation of exposure levels. He said that, sometimes, it was clear from the atypical size and quality of dust particles on a sampler filter that the dust had not come from the atmosphere. This might occur if an operative had leaned forward causing the sampler head to come into contact with a dusty surface. It might be the result of interference with the sampling unit by the man wearing it. He said that, if there appeared to be "something not quite right" about a sample, he and his colleagues would note the circumstances on their paper record and would discard the sample. None of the samplers' paper records have survived.

3.29 Reports of the results of personal sampling exercises were produced periodically for the use of the Environmental Control Committee and others within the NSFL management. Some (but not all) of those reports have survived. Unlike *Table 6.4*, they usually contained details of the exposure levels of each of the men wearing the personal samplers on each of the days for which sampling was carried out.

3.30 In addition to the personal sampling programme, some static sampling was also carried out. Dr Choo Yin's evidence was that, during the periods when personal sampling was being conducted, a MRE sampler would be placed somewhere in the general area where the personal sampling was being carried out. The object of the static sampling was to ascertain the respirable content of the dust being generated in the area. There were also certain *ad hoc* sampling exercises (both static and personal) undertaken from time to time, sometimes no doubt as a result of complaints about dust or fume levels in specific areas.

Sampling results between 1971 and 1983

3.31 I shall now consider the results of the sampling carried out at the Phurnacite Plant between 1971 and 1983.

1971-1972

3.32 In September 1971[103], personal sampling took place in one of the pitch bays, and on the shuttle car, oven and quenching car floors of one of the batteries. Further personal sampling was carried out in July 1972 on the shuttle car, oven, quenching car and ramp floors of a battery (whether or not it was the same battery as previously is not known). The personal sampling results for 1971 and 1972 contained in *Table 6.4* revealed levels of BSM that ranged between 0.2 mgm^{-3} and 1.9 mgm^{-3}, i.e. at or significantly above the ACGIH TLV. Of the total dust measurements, only one (11.4 mgm^{-3} on the shuttle car floor) was above the 10 mgm^{-3} limit recommended by the

HSE in 1975. BaP levels ranged from 2.5 μgm^{-3} (on the quenching car floor) to 31 μgm^{-3} (on the oven tops).

3.33 Meanwhile, static sampling was conducted on the oven tops in December 1971 and June 1972, and showed total dust concentrations averaging 5 mgm^{-3} and 10 mgm^{-3}, with BSM levels averaging 1.3 mgm^{-3} and 1.9 mgm^{-3}. It was reported that 34% of the dust was in the respirable size range. In December 1971 and June 1972[104], static sampling near the shuttle car control panel was carried out and revealed average total dust levels of 9.6 mgm^{-3} and 6.3 mgm^{-3}, with BSM concentrations of 0.9 mgm^{-3} and 0.5 mgm^{-3}. It was noted that only 2% of the total dust was of respirable size. However, the heavy dust burden made working conditions unpleasant. Static samplers detected high levels (11-37 mgm^{-3}) of total dust in the area of the quenching car in July 1972, of which between 2% and 51% was in the respirable size range.

3.34 In June/July 1972[105], static sampling for respirable dust, using a MRE unit, was carried out in the pitch bays at the Phurnacite Plant, in conjunction with personal sampling of the men working in the pitch bays. The average total dust and BSM concentrations were high (17.6 mgm^{-3} total dust and 3.9 mgm^{-3} BSM in one pitch bay and 5.7 mgm^{-3} total dust and 5.3 mgm^{-3} BSM in the other). However, average respirable dust levels were low (0.14 mgm^{-3} in one pitch bay and nil in the other). Similar personal and static sampling[106] was carried out near to the conveyor belt which conveyed the mixture of coal and solid pitch from the disintegrator to the pug (the 'pug belt'). Average dust and BSM concentrations were 9.2 mgm^{-3} and 1.7 mgm^{-3} on personal sampling. Static sampling revealed an average percentage of respirable dust of 49%.

3.35 Further static sampling was carried out in July 1972[107] using Hexhlet and MRE samplers on the shuttle car floor, the oven tops and the quenching car floor at one of the batteries. The sampling revealed high levels of dust on the shuttle car and quenching car floors (averages of 103 mgm^{-3} and 20 mgm^{-3} respectively), with an average of only 2.4 mgm^{-3} on the oven tops. Respirable dust averaged 2.3% of total dust on the shuttle car floor, 34% on the oven tops and 25% on the quenching car floor. The percentages of respirable dust measured on the shuttle car and quenching car floors were believed to be artificially low because of the effects of the wind which had blown the larger particles of dust onto the sampler. A similar explanation was given for the high concentrations of total dust on the shuttle car floor.

3.36 In November 1972[108], static sampling by MRE sampler was conducted in the location of the pug belt, on the shuttle car floor, on the oven tops and on the quenching car floor. Levels of total dust were low near the pug belt and on the oven tops but high on the shuttle car floor (103 mgm^{-3}) and the quenching car floor (17.2 mgm^{-3}). The percentages of respirable dust were, for the pug belt (51%), the oven tops (38%), the shuttle car floor (1.26%) and the quenching car floor (19%). The levels of BSM exceeded the ACGIH TLV. The concentration of BSM on the quenching car floor was 5.46 mgm^{-3}, more than 27 times the ACGIH TLV.

[104] Syred4/128
[105] CB3/16
[106] CB3/17
[107] CB3/19
[108] CB3/24

1972-1975

3.37 *Table 6.4* contained no results of any further personal sampling between July 1972 and June 1975. It seems that the programme of regular personal sampling was suspended during that period. Similarly, static sampling appears to have ceased in November 1972 and not to have been resumed until October 1975. The reason for the suspension of sampling is not known. It cannot have been because the early sampling had proved reassuring. On the contrary, it had shown that in some areas at least, the concentrations of dust and, in particular BSM, gave rise to a health hazard, as well as making working conditions very unpleasant.

1975-1979

3.38 Some time between May and August 1975[109], the Factory Inspectorate carried out a sampling exercise at the Phurnacite Plant. This included personal sampling of individuals working in the pitch bay at briquetting plant 2 and on the shuttle car, oven, quenching car and ramp floors of battery 6. They also conducted static sampling of the general atmosphere near one of the presses in briquetting plant 2. Total dust concentrations were relatively high on the shuttle car floor (12.5 mgm^{-3}-16.7 mgm^{-3}) and low (1.1 mgm^{-3}-1.9 mgm^{-3}) on the quenching car floor. BSM concentrations were in excess of 0.2 mgm^{-3} for all operators except those working on the quenching car and ramp floors. The highest reading was 4.2 mgm^{-3} in the general area of the press hall in briquetting plant 2.

3.39 Regular personal sampling of personnel at the Phurnacite Plant recommenced in June 1975[110], with a further session in August 1975[111]. The results can be seen in *Table 6.4* and I refer to them later in this Section. Some additional sampling was carried out between 1975 and 1979. Most of the additional sampling to which I shall refer was static sampling. It is possible (but not certain) that some of the results of what I have taken to be 'additional' personal sampling were in fact included in *Table 6.4*.

3.40 In addition, in early June 1975, the NSFL Scientific Branch (Wales) carried out an environmental survey in battery 4. This involved personal sampling of the exposure levels of men working on the shuttle car, oven, quenching car and ramp floors. Static sampling was also conducted by means of two MRE samplers, one positioned on a girder above the oven tops (i.e. at shuttle car floor level) and one in the cabin used by the quenching car operator, about four feet above the quenching car floor. High average total dust concentrations were measured in the samplers worn by the shuttle car operator (57.6 mgm^{-3}) and the two oven top workers (22.9 mgm^{-3} and 29.53 mgm^{-3}). BSM concentrations were in excess of the ACGIH TLV for process operatives working in all the relevant areas on battery 4. Static sampling revealed that, on the girder above the oven tops at shuttle car floor level, the average total dust concentration was high (24.02 mgm^{-3}), with a respirable content of 8%. In the quenching car operator's cabin, the total dust concentration was 14.10 mgm^{-3}, again with a respirable proportion of 8%.

[109] Stear7/80
[110] CB3/250
[111] Stear 7/85

3.41 The second part of the environmental survey was carried out in late June 1975[112] at the briquetting plants. Personal samplers were issued to the press operator, the pug man and the back end man working on press 5 in briquetting plant 2 and to men working in the pitch bay at briquetting plant 1, in one of the sample rooms (unidentified) and to belt cleaners on the raw ovoid belt. MRE static samplers were placed in the cabin of the operator of press 5 and near to the operator of press 3 in briquetting plant 1. The personal sampling revealed very high concentrations of total dust for the belt cleaners (an average of 308.99 mgm^{-3} over the three days of sampling). The next highest average total dust concentration (10.52 mgm^{-3}) was for the operator of press 5. Average BSM concentrations for all operatives (except the man working in the sample room) were in excess of the ACGIH TLV. The average BSM concentration for the belt cleaners was particularly high (19.03 mgm^{-3}). Static sampling revealed that the respirable fraction of total dust in the location near press 5 (in briquetting plant 2) was 18.5% and near press 3 (in briquetting plant 1) it was 25.6%.

3.42 In September and October 1975, the NSFL Scientific Branch (Wales) carried out a second environmental pollution survey at the Phurnacite Plant. The first part of the survey in September 1975[113] was designed to measure - by personal sampling over four days of the same shift - the exposure levels of a press operator, a pug man and a back end man working in briquetting plant 1, compared with the exposure levels of men doing similar jobs in briquetting plant 2. The exposure level of a pitch man was also measured. In addition, MRE static samplers were placed in locations near to the point at which dust from the ESPs was added to the coal feed belt in briquetting plant 2. The object was to enable the impact of the dust pelletisers, which were due to be fitted shortly afterwards, to be assessed.

3.43 The personal sampling showed a high average concentration of total dust (79.96 mgm^{-3}) for the back end man in briquetting plant 2 although there was some concern about the authenticity of the very high results on two days of the sampling period. High levels were also measured for the pug man (29.1 mgm^{-3}) and the press operator (13.68 mgm^{-3}) in briquetting plant 2. The results for briquetting plant 1 were significantly lower. Average BSM concentrations in briquetting plant 1 were all under 0.2 mgm^{-3}, whereas all those in briquetting plant 2 exceeded that level, averaging between 0.32 mgm^{-3} and 1.26 mgm^{-3}. The average total dust concentration for the pitch man was 6.54 mgm^{-3}, with an average BSM concentration of 1.13 mgm^{-3}.

3.44 The second part of the survey was carried out in October 1975[114] and covered battery 2. Men working on the shuttle car, the ovens, the quenching car and the ramps were fitted with personal samplers. The results showed moderately high average levels of total dust (12.55 mgm^{-3} and 17.76 mgm^{-3}) on the shuttle car floor and the oven tops, with average BSM concentrations varying between 0.31 mgm^{-3} (on the ramps) and 2.96 mgm^{-3} (on the oven tops).

3.45 In December 1975[115], the NSFL Wales Management Unit carried out a further survey at the Phurnacite Plant. The survey involved personal and static sampling in briquetting plants 1 and 2. Average concentrations of total dust in briquetting plant 1 varied between 15.61 mgm^{-3} (for the back end man) and 22.77 mgm^{-3} (for the press

[112] CB3/266
[113] Stear 7/83
[114] Stear7/88
[115] CB4/68

man) and in briquetting plant 2 from 16.12 mgm^{-3} (back end man) and 36.85 mgm^{-3} (press man). BSM concentrations were all well in excess of 0.2 mgm^{-3}, with that for the press man in briquetting plant 1 being particularly high (12.56 mgm^{-3}). The locations of the two MRE static samplers were not described, save that one was in briquetting plant 1 and the other in briquetting plant 2. They showed respirable dust percentages of 18.6% and 17.21% respectively. Again, all the BSM readings were in excess of the ACGIH TLV.

1976-1979

3.46 On 27 October, 1976[116], the Phurnacite Plant Works Consultative Committee were addressed by Mr Smith, NCB's chief scientist for Wales, who reported on the results of recent personal sampling at the Plant. He informed the Committee that the average dust levels for the pitch bays, briquetting plant 1 and briquetting plant 2 were, respectively, 6 mgm^{-3}, 15 mgm^{-3} and 18 mgm^{-3}. The average BSM concentration on the oven tops was 17 mgm^{-3} although the majority of readings were about 10 mgm^{-3} with the "occasional high figures" accounting for the high average. The average BSM concentration on the shuttle car floor was 15 mgm^{-3}. It was hoped that the recent "modernisation" (i.e. the installation of remote controls) would reduce the exposure of the shuttle car operator. The "norm" for the quenching car and ramp floors was said to be 5 mgm^{-3}, with a few higher readings. Mr Smith observed that the BSM measurements were "very erratic". He said that the TLV of 0.2 mgm^{-3} was "not very practical" for the Phurnacite Plant. It had been devised for use in coke ovens where pitch was not used. Since the constituents of pitch were soluble in benzene, it was, he said, not surprising that BSM concentrations at the Phurnacite Plant exceeded the TLV.

3.47 During the period between 1976 and 1979, the programme of regular personal sampling continued at the Phurnacite Plant and other plants operated by NSFL. Personal sampling was in general carried out in each area of the Phurnacite Plant once a year (twice in 1976) and involved workers in the pitch bay at briquetting plant 2, at the press, pug and back end of each briquetting plant and on the shuttle car, oven, quenching car and ramp floors of one of the batteries. Sampling in the pitch bays ceased in mid-1977, with the introduction of liquid pitch in briquetting plant 2. No sampling results are recorded for the shuttle car floor in 1978 or 1979. Sampling on the ramps appears to have ceased altogether in 1978.

3.48 During this period, the ranges of average total dust, BSM and BaP concentrations to which the relevant operatives were exposed were as illustrated in the Table below:

LOCATION	RANGE OF DUST CONCENTRATIONS mgm^{-3}	RANGE OF BaP CONCENTRATIONS μgm^{-3}	RANGE OF BSM CONCENTRATIONS mgm^{-3}
Pitch bay	2.4 – 10.2	13.4 – 134.0	0.6 – 3.5
Briquetting plant 1			
Press	6.8 – 27.9	6.3 – 23.4	0.3 – 2.1
Pug	11.4 – 32.6	2.4 – 36.5	0.7 – 2.8
Back end	9.5 – 59.2	1.9 – 127.6	0.3 – 2.2
Briquetting plant 2			

[116] CB4/183

Press	8.1 – 24.4	10.6 – 46.9	1.0 – 3.4
Pug	3.6 – 18.3	0.6 – 99.8	0.3 – 4.0
Back end	11.5 - 34.4	3.0 – 56.1	1.0 – 4.9
Shuttle car floor	5.6 – 41.9	5.7 – 57.7	1.0 – 5.7
Oven tops	14.4 – 22.4	10.5 – 81.7	1.9 – 3.3
Quenching car floor	3.4 – 6.9	1.5 – 24.1	0.6 – 0.9
Ramp floor	1.3 – 11.6	0. – 20.6	0.2 – 1.2

3.49 All except three of the measurements of BSM concentrations (those three being on the ramps) were in excess of the ACGIH TLV of 0.2 mgm^{-3}. The highest measurement (5.7 mgm^{-3} on the shuttle car floor in 1976) was more than 28 times the TLV. BaP concentrations ranged between 0.6 µgm^{-3} (on the ramps and near the pug) and 127.6 µgm^{-3} (at the back end of briquetting plant 1 in 1976). Some of the BaP concentrations measured (in particular, in the pitch bay, at the back end of briquetting plant 1, near the pug at briquetting plant 2 and on the oven tops) were very high indeed.

3.50 In February 1979, further static sampling was carried out in briquetting plant 2[117]. The sampling was conducted at the specific request of the Phurnacite Plant's Medical Officer and Safety Department. The purpose of the sampling was to determine the concentrations of dust (both respirable and total), BSM and BaP in the atmosphere at various locations where men were employed on cleaning duties. Static samplers were positioned above one of the conveyor belts and sampling was carried out whilst men were cleaning up spillages in the pits below the conveyor belt, whilst men were shovelling spillages through a hole in the wall at ground floor level near the belt and whilst men were cleaning a blockage from beneath one of the presses in the vicinity of the belt. As well as two static samplers, two personal samplers were placed in positions near to the static samplers. One personal sampler was used to measure total dust and the other personal sampler measured respirable dust.

3.51 The sampling results showed that, during the cleaning of the pits, the average total dust concentration was 86.9 mgm^{-3} with respirable dust of 6.13 mgm^{-3} (7.1%). During the cleaning up of spillages, the equivalent figures were 77.6 mgm^{-3} and 5.10 mgm^{-3} (6.6%). Whilst the jiggers were being cleaned out, the figures were 860 mgm^{-3} (one day's sampling only) and 4.72 mgm^{-3} (0.5%). All the results for total dust greatly exceeded the TLV for nuisance particulates of 10 mgm^{-3} and most of the results exceeded the TLV for respirable dust of 2 mgm^{-3}. The average concentrations of BSM during the three operations were 8.65 mgm^{-3}, 10.91 mgm^{-3} and 23.43 mgm^{-3}, whilst the average concentrations of BaP were respectively 55 µgm^{-3}, 23.5 µgm^{-3} and 312 µm^{-3}. Results from two static samplers placed above the conveyor belt showed average total dust concentrations of 11.67 mgm^{-3} and 30.75 mgm^{-3}, with respirable fractions of 7.2% and 5.1% respectively. The average BSM concentrations were 1.34 mgm^{-3} and 1.87 mgm^{-3} and the average BaP concentrations 13 µgm^{-3} and 10.8 µm^{-3}. The results of the sampling gave rise to a recommendation that some form of respiratory protection should be worn when cleaning work was being carried out.

[117] Syred 3/14

1980-1983

3.52 The programme of personal sampling continued in the period from 1980 to 1982. In each of the three years, there were two sessions of sampling in at least some locations within the Phurnacite Plant. In December 1982[118], a decision was taken to reduce the frequency of sampling to once a year for reasons of economy. As a result, *Table 6.4* (which, as I have said, was prepared for a meeting in June 1983) contains the results of only one session of personal sampling in 1983. That was carried out in March 1983 on one of the batteries. Thereafter, although the evidence suggests that personal sampling continued, no results are available for the whole of the period until the production of the Phurnacite ceased in 1990. There are no results either for any static sampling that might have taken place between 1980 and 1983 or at any time thereafter.

3.53 During the period between 1980 and 1983 the ranges of total dust, BSM and BaP concentrations were:

LOCATION	**RANGE OF TOTAL DUST CONCENTRATIONS** mgm^{-3}	**RANGE OF TOTAL BSM CONCENTRATIONS** mgm^{-3}	**RANGE OF BaP CONCENTRATIONS** μm^{-3}
Briquetting plant 1			
Press	10.3 – 18.3	0.6 – 2.4	3.4 – 6.5
Pug	15.8 – 42.1	0.6 – 3.0	2.1 - 5.6
Back end	14.3 – 62.0	0.8 – 1.9	3.4 – 6.3
Briquetting plant 2			
Press	9.8 – 30.9	0.6 – 4.2	1.8 – 17.4
Pug	17.8 – 145.3	1.1 – 7.4	ND [*none detected*] – 14.5
Back end	13.4 – 38.2	0.7 – 2.4	1.0– 17.0
Shuttle car floor	16.1 – 203.4	1.2 – 23.9	11.2– 103.4
Oven tops	11.7 – 22.7	1.9 – 4.9	24.9 – 43.7
Quenching car floor	3.0 – 7.4	0.3 – 0.8	1.5 – 9.8

The limitations of the sampling data

3.54 The results of the personal sampling carried out between 1971 and 1983 set out in *Table 6.4* represent the main source of data available for the purpose of assessing the individual exposure levels of the lead claimants. Some information can also be gleaned from the results of the static sampling which was conducted from time to time.

3.55 As all the technical experts pointed out, the sampling data has its limitations. Before 1975, sampling (both personal and static) was sporadic. There are no results of any sampling in the 1940s, and only three sets of results of static sampling from the 1950s and 1960s. No personal sampling was conducted until 1971. Even when a regular programme of personal sampling began, it was usually performed only once (at the most twice) a year in each area, raising question marks about how representative the results are. Until the mid-1980s the programme of personal

[118] CB8/155

sampling did not include the measurement of respirable dust. The evidence of Dr Choo Yin was that it was only from the mid-1980s that an additional cyclone fitment was used in conjunction with the Casella samplers in order to measure respirable, as well as total, dust. However, no results survive of any sampling conducted between March 1983 and the cessation of production at the Phurnacite Plant in 1990.

3.56 Before the mid-1980s, respirable dust was measured by means of static samplers which are not necessarily representative of the exposure of an operative working in the relevant area. There is doubt as to whether the proportion of respirable dust as measured by means of a static sampler can be equated in any meaningful way with the proportion measured by way of personal sampling.

3.57 The sampling that was carried out at the Phurnacite Plant did not cover the areas where some of the lead claimants worked, in particular the coal sample rooms and the exhauster houses. Nor are there any documents relating to the exposure levels of men who carried out peripatetic jobs (such as painters, fitters, riggers) or of those who worked in a supervisory capacity.

3.58 In due course, I shall have to consider, in the case of each individual claimant, whether there is sufficient evidence to enable me to make findings as to his probable exposure levels.

The technical evidence relating to occupational exposure levels

3.59 Despite the limitations of the sampling data to which I have referred, all three technical experts felt able to reach conclusions about the exposure levels of individuals working at the Phurnacite Plant, based on the data that was available to them.

The technical experts

3.60 The three technical experts who gave evidence about exposure levels were Professor Nicholas Syred for the claimants and Mr Martin Stear and Professor Stephen Jones for the defendants.

3.61 Each of the experts produced lengthy Generic Reports, together with Individual Reports dealing with each of the lead claimants. Their Individual Reports contained estimates of the relevant claimant's levels of exposure to dust, BSM and BaP during his time at the Phurnacite Plant. Shortly before the start of the trial, Professor Syred filed a Supplemental Report, dealing with the similarities between the fumes produced by the carbonisation of Phurnacite ovoids and those emitted during the smelting of aluminium by a method known as the Söderberg process. Subsequently, Professor Jones produced a Supplemental Report (his first Supplemental Report), responding to matters contained in Professor Syred's Generic and Supplemental Reports (in particular, his comparison between the carbonisation process at the Phurnacite Plant and the Söderberg process), and also with other topics, including the issue of 'background' exposure levels.

3.62 After the hearing in Cardiff, all three experts provided revised calculations for the exposure levels of the individual lead claimants. Mr Stear produced a Supplemental Report, incorporating his revised calculations and addressing other matters, including 'background' exposure levels, levels of respirable dust and his estimates of the exposure levels of peripatetic workers, as compared with process operatives who carried out one job in the same location on a regular basis. Professor Jones provided a further Supplemental Report (his second Supplemental Report), in which he set out revised calculations of the exposure levels of the lead claimants and addressed topics such as the exposure levels of peripatetic workers, and whether the calculations of exposure levels should be adjusted to take account of overtime hours worked. The experts continued to provide further information during their oral evidence about their methods of calculation, together with amended figures to take account of previous errors of calculation and/or other changes.

3.63 In the course of writing my judgment, and with the consent of the parties, I requested Professor Jones to carry out additional exposure calculations for the lead claimants, based on my (provisional) findings of fact. I shall refer to that additional work later in my judgments in the individual lead claims.

3.64 I shall now proceed to consider the evidence of each of the three experts. Their evidence extended over more than eight days and occupied (together with their supporting documents) 29 lever arch files. I shall deal with their evidence on this topic as briefly as I can.

Professor Syred

3.65 Professor Syred recently retired as Head of the Medical Engineering Division, Cardiff School of Engineering, University of Wales. His main field of research included combustion, energy and environmentally related work including gaseous, liquid and solid fuels, cyclone dust separators, gas cleaning in general, coal and dust control and motion. His previous history of prestigious appointments, prizes, research awards and consultancies make clear that he is a very distinguished expert in his field.

3.66 As an expert witness, however, Professor Syred was not entirely satisfactory. His evidence was somewhat discursive and repetitive and was not always focused upon the point at issue. More significantly, however, some of the calculations in his Report were manifestly unreliable.

3.67 Professor Syred used the results of static sampling conducted at the Phurnacite Plant as a basis for calculating the proportion of total dust emitted that was of respirable size. He reached the conclusion that the respirable fraction of the dust emitted in the briquetting plants and on the oven tops was 50%. He sought to support that finding by constructing various 'models', based on a number of assumptions. The defendants argued, and I accept, that some of those assumptions were arbitrary and/or unrealistic. For example:

(a) Professor Syred assumed[119] that when the oven lids were cracked open, hot fumes and dust exited the ovens at a typical rate of 33 metres per second, which would equate to 74 mph. That assumption cannot be correct. As the defendants pointed out, if it were, the men working on the ovens would have been in daily danger of being fatally burned.

(b) When calculating the settling rate of particles in air, in order to establish how far from sources of emission it would be possible for particles of

[119] Syred1/21

greater than respirable size to travel[120], Professor Syred made an arithmetical error which resulted in his calculation of the residence times of particles in air being lower, by a factor of 10, than it should have been. He concluded that particles measuring 5 microns or less had a residence time in air of more than 90 (rather than 900) seconds, whilst particles measuring 20 microns would remain in the air for only 5 (rather than 50) seconds. The error was pointed out by Professor Jones in his first Supplemental Report, and was immediately accepted by Professor Syred. What I found surprising was not the fact that the arithmetical error was made, but that the results of his calculations had not struck Professor Syred as odd or wrong until the error was pointed out to him. The error affected a number of his later calculations.

(c) When modelling the build-up of total and respirable dust in a dust cloud from dust generated at a raw ovoid transfer point[121], Professor Syred assumed no air circulation at all, an assumption which I am satisfied was wholly unrealistic.

(d) When calculating the dust emissions from material handling systems[122] at the Phurnacite Plant, Professor Syred stated that he was assuming "quiescent" air conditions, i.e. wind conditions less than 0.1 metres per second. However, he then reproduced two Figures (2.3 and 2.4) which had appeared earlier in his Report and which in fact assumed no air changes at all. Again, I do not consider that this assumption was tenable.

(e) When modelling the respirable dust levels in the briquetting plants[123], Professor Syred took as his starting point the dust concentrations measured by the CRE at transfer points on the raw ovoid conveyor running from the trommel houses to the shuttle car floors of the various batteries[124]. He assumed, for the purposes of his calculation, that dust emissions occurred from one point in the dryer house of briquetting plant 1, one and a half points in the dryer house of briquetting plant 2, one point each in the briquetting buildings of both briquetting plants and one point in press house 5 of briquetting plant 2. He further assumed that the amount of dust emitted at each point was the same as the average dust emission from each transfer point on the raw ovoid conveyor, i.e. 91 grammes per minute. I find it quite impossible to understand how that assumption could be valid, since the nature of the material being handled in the dryer houses and in the briquetting plant prior to pressing was quite different from that being carried by the raw ovoid conveyors. Moreover, the processes carried out in the briquetting buildings produced dust from a large number of sources, not just one or two points. The total amount of dust emitted may have been more or less than that generated by the raw ovoid conveyors.

(f) When modelling the proportion of respirable dust present in the dryer houses and briquetting buildings of briquetting plants 1 and 2, Professor Syred assumed four air changes per hour[125]. There was no evidence to support this assumption and in oral evidence Professor Syred accepted that the number of air

[120] Syred 1/30 Figure 2.2
[121] Syred 1/31-32, Figure 2.3 and 2.4
[122] Syred 1/49-52
[123] Syred 1/59-66
[124] Paragraph 2.80 of this judgment
[125] Syred1/59-66

changes was very low. However, he considered that it was realistic because of the evidence about poor ventilation in the briquetting plants. When making the same calculation for press house 5, however, he changed that assumption to 10 air changes per hour, explaining that the press house 5 was of much newer construction (it was opened in 1970) than the other briquetting buildings and would have had much better ventilation. Again, there was no evidence to support Professor Syred's figure of 10 air changes per hour. The defendants pointed out that, if Professor Syred had made the same assumption of four air changes per hour for press house 5 as in his previous calculations, the result would have been that there would have been more respirable dust than total dust.

3.68 I did not find the result of these modelling exercises – namely that they confirmed Professor Syred's calculation that the proportion of respirable dust in the briquetting plants and on the oven tops was 50% – convincing or helpful. The various calculations and assumptions that I have referred to did not form part of Professor Syred's estimates of exposure levels in the individual lead cases. He based those estimates on the actual data available from personal and static monitoring carried out at the Phurnacite Plant. Nevertheless, the matters I have referred to, together with other features of Professor Syred's evidence, led me to have doubts about the reliability of his evidence generally.

Mr Stear

3.69 Mr Stear has a Bachelor of Science degree in chemistry and has professional qualifications in the field of occupational hygiene. He spent ten years working for a private company providing occupational hygiene services. In 1983, he joined the HSE as a Specialist Inspector in occupational hygiene. He was promoted to Principal Specialist Inspector in 1997, heading the Organic Chemicals and Asbestos Section. In that capacity, his work involved advising on hazardous substances, including PAHs. He has provided technical expertise to the HSE, to other Government Departments and to Government Ministers and has sat on various joint industry liaison groups and committees, advised on legislation and written guidance documents on hazardous substances. He left the HSE in 2004, since when he has worked in a private consulting capacity.

3.70 I did not find Mr Stear an impressive witness. His evidence, like that of Professor Syred, was discursive and repetitive. At times, he appeared to be fulfilling the role of an advocate, rather than that of an expert witness. For example, he was asked whether he had been able to ascertain why personal sampling had ceased in 1972 and had not re-started until 1975[126]. Since he did not know why this had happened, the answer to the question should clearly have been "No". Instead, Mr Stear answered by explaining that the fact that no sampling had been undertaken did not mean that the defendants had not been carrying out "investigations". He suggested that they had not been "resting on their laurels and doing nothing". They had been making improvements during that time. He suggested that the decision not to carry out sampling might have been part of a "structured programme" or an issue of "resource commitment" to other sites. These suggestions were matters of pure speculation on his part and were of no assistance to me. It appeared to me that they

[126] TD19/91

demonstrated a reluctance on Mr Stear's part to make any concession that might reflect badly on the defendants.

3.71 When asked about the delay on the part of the defendants in providing RPE for men working at the Phurnacite Plant, in particular on the oven tops, Mr Stear was reluctant to acknowledge that the delay had been excessive and/or unacceptable[127]. He gave a series of lengthy answers, offering a variety of possible reasons for the delay. He suggested that the perception of the NCB might have been that the dust and fume on the oven tops were not substantial and/or offensive; that they were busy taking other precautions; that there were "complicating factors"; that it was a "difficult situation"; that there were approved respirators on site (albeit not used much); that, from 1973 until 1980/81, the NCB were "looking into" the use of respirators; that it would not have been appropriate to treat the provision of RPE as an "urgent matter".

3.72 There were many other similar examples, which confirmed my impression that Mr Stear was a highly partisan witness.

Professor Jones

3.73 Professor Jones has had a somewhat unusual career path. He has a degree in Chemistry and a PhD in Chemical Physics. He spent 15 years working in the nuclear industry in a number of roles connected with the scientific aspects of occupational and environmental safety. His work was concerned mainly with the assessment of exposure to ionising radiation, including the inhalation of radioactive aerosols, and the evaluation of potential risks to health. In recognition of his scientific work, he was appointed a visiting Professor at the School of Biological Sciences at Liverpool University in 1989.

3.74 About ten years ago, Professor Jones was seconded to (later employed by) the Westlakes Research Institute, a charitable institution supported by British Nuclear Fuels to advance the development of scientific research in West Cumbria. During his time there, he carried out consulting work in the field of occupational and environmental safety in industries other than the nuclear industry. He was appointed an Honorary Professor – then a full Professor – of Environmental and Occupational Toxicology at the University of Central Lancashire. The Westlakes Research Institute is no longer in existence and Professor Jones now works as a private consultant. Through his work in the nuclear industry, Professor Jones developed an active interest in epidemiology. He gave evidence in relation to the causation of lung, bladder and skin cancer and, although he has no medical or biological qualifications, his knowledge and understanding of the relevant epidemiological material was extensive.

3.75 I found Professor Jones an impressive witness. His evidence was thoughtful, well-expressed and had every appearance of objectivity. Two aspects of his evidence in particular (the production of his 'modelling dispersion exercise' and his approach to the calculation of the cumulative exposure to BaP required to double the risk of lung cancer) demonstrated the fairness of his approach. He was prepared to accept the views of opposing experts when appropriate, regardless of whether or not his own change of view was favourable to the defendants and/or corresponded with the view of the defendants' other experts. Whilst I did not accept every aspect of his evidence,

[127] TD21/1-53

in most respects I found his approach preferable to that of the other two technical experts.

The experts' calculations of individual exposure levels

Professor Syred

3.76 Professor Syred used the data contained in *Table 6.4* to produce an average of the results of the personal sampling for total dust, BSM and BaP carried out during the period from 1971 to 1983. He calculated average exposure levels for all the areas of the Phurnacite Plant where sampling was undertaken, together with average exposure levels for all areas within each of the briquetting plants separately and for the two briquetting plants overall. He also calculated average exposure levels for two combinations of areas (the oven tops and the quenching car floor and the quenching car and ramp floors), as well as for the whole Phurnacite Plant (including and excluding the pitch bays). All these average exposure levels are set out in the revised version of *Table 6.5* in his Generic Report[128].

3.77 Also contained in *Table 6.5* are average figures for exposure levels during the cleaning of pits in briquetting plant 2. These were based on the results of the static sampling carried out in February 1979[129] during three different cleaning activities, one of which was sampled for one day only. As I have already observed, the results of that one day's sampling was extremely high (total dust of 860 mgm^{-3}, BSM of 23.43 mgm^{-3} and BaP of 312 μgm^{-3}) and they had a considerable effect on the average exposure levels for the three activities. There was considerable dispute at the trial as to whether the figures could properly be regarded as representative. Neither of the other two technical experts used the data from February 1979 in their calculations.

3.78 Professor Syred did not consider that the sampling data for 1971-1972 were sufficient to justify a conclusion that exposure levels were lower during that period than in the period from 1975 onwards. He considered that the evidence suggested that conditions in the 1940s, 1950s and 1960s had been as bad – if not worse – than during the 1970s and early 1980s. He pointed out that the sampling results for the 1980s did not show any reduction in exposure levels. If anything, exposure levels appeared to be rising in the early 1980s. Therefore there was no basis for assuming that exposure levels became lower after 1983. He considered that the fairest approach was to assume that the exposure levels remained constant throughout the life of the Phurnacite Plant. Thus, the average exposure levels contained in *Table 6.5* formed the basis of Professor Syred's calculations of exposure levels in the individual cases. I shall discuss Professor Syred's use of the figures contained in *Table 6.5* in more detail when considering his calculations of exposure levels in the individual lead cases.

Mr Stear

3.79 Like Professor Syred, Mr Stear based his estimates of the exposure levels of the lead claimants on the personal sampling data contained in *Table 6.4*. The data for 1971 and 1972 consisted of two sampling results each for the shuttle car floor, the oven tops and the quenching car floor, and one result each for the pitch bays and the

[128] Syred 1/131a
[129] Paragraph 3.51 of this judgment and Syred3/17

ramps. Mr Stear used those data to calculate the average concentrations of total dust and BSM in each of the relevant areas of the batteries. He then did the same with the data for the period from 1975 to 1983[130]. He explained that he had calculated the average exposure levels for the two periods separately in order to reflect the fact that the concentrations of total dust and BSM appeared to be lower during the earlier period than in the later period. He attributed the apparent increase in the personal exposure levels of workers on the batteries between the period from 1971 to 1972 and the period from 1975 until 1983 to the worsening problem of ovoids clustering in the ovens, necessitating frequent and lengthy periods of poking. He estimated that the exposure of operatives working on the oven tops would have been about 7.5 times higher when the ovens were being charged and discharged than at other times. When poking out clusters of carbonised ovoids from the ovens, their exposure would have been particularly high. He concluded from the available evidence that the problem of clustering became particularly serious from about the mid-1970s and, from that time, led to higher exposure levels for process operatives working on the shuttle car floor, oven tops, quenching car floor and ramp floor.

3.80 As to the period before 1971, Mr Stear observed that there were no personal sampling data for that period with which the post-1971 data could be compared. He suggested that the evidence showed that clustering of ovoids during the carbonising process first became a real problem some time during the 1960s. If that were so, exposure levels on the batteries during the 1940s, 1950s and early to mid 1960s might well have been lower than those recorded for 1971 and 1972.

3.81 As a result, for the purpose of his calculations of individual exposure levels, Mr Stear assumed different levels of exposure on the batteries during three separate periods of time. For the period from 1968 to 1974, Mr Stear calculated the exposure of those working on the batteries by reference to the (very few) sampling results from 1971 and 1972 recorded in *Table 6.4*. For the period from 1975 to the cessation of production at the Phurnacite Plant in 1990, he used the data for the period 1975-1983 in *Table 6.4*. For the period prior to 1968, Mr Stear assumed that exposure levels were about 85% of those for 1971-1972. Mr Stear's Generic Report did not contain full information about the exposure levels of dust, BSM and BaP which he had used in his calculations of individual exposure levels in the lead cases. In the course of his cross-examination, Mt Stear produced a further Table[131], setting out this data.

3.82 Mr Stear's figures for average exposure levels on the batteries during the 1940s, 1950s, 1960s and early 1970s were significantly lower than those of both Professor Syred and Professor Jones. By contrast, the exposure levels of dust, BSM and BaP which he used for the batteries (save for the shuttle car floor) during the period from 1973 to 1990 were very similar to those that appeared in Professor Syred's *Table 6.5*. His figure for average exposure levels on the shuttle car floor were significantly lower than those of Professor Syred because he excluded what he considered to be aberrant figures (203.4 mgm^{-3} for dust, 23.9 mgm^{-3} for BSM and 103.4 μgm^{-3} for BaP) recorded on one occasion in 1980.

3.83 So far, I have referred only to Mr Stear's use of the personal sampling data for the batteries. The first personal sampling results in the briquetting plants recorded in *Table 6.4* are for 1975. Mr Stear used the sampling data for the period 1975-1983

[130] Stear 1/229 Table II
[131] Stear Supp/Table 2

contained in *Table 6.4* to calculate the average concentrations of total dust, BSM and BaP in the pitch bay, and at the press, pug and back end of each of the two briquetting plants for the entire period of operation of the Phurnacite Plant. He did not suggest that, in the case of the briquetting plants, different exposure levels should be applied to different periods of time. The figures he used were similar to those contained in *Table 6.5*, although, unlike Professor Syred, Mr Stear set out the figures for the working areas of briquetting plants 1 and 2 separately.

Professor Jones

3.84 Having considered the data contained in *Table 6.4* , Professor Jones reached a number of preliminary conclusions[132]. He noted that the data was quite sparse, with considerable variability. Unlike Mr Stear, he did not consider that the variability in the data for different periods could properly be interpreted as representing real changes in working conditions over time. He concluded that there was no clear distinction in the exposure levels found at the various different areas sampled (i.e. the pug, back end and press) in the briquetting plants. On the batteries, however, concentrations on the quenching car and ramps were consistently lower than those for the oven tops and shuttle car floor. He noted that there was some evidence that concentrations were higher in briquetting plant 2 than in briquetting plant 1, although the difference was not large. There were, he said, some results that appeared to be "enormously high". He considered excluding those results but (unlike Mr Stear) decided against it, observing that, in any event, their exclusion would not greatly reduce the overall averages.

3.85 Professor Jones decided that, for the purpose of calculating individual exposure levels, it would be sensible - rather than producing average exposure levels for each individual area sampled - to use average concentrations for larger areas. Thus, he calculated average exposure levels for the pitch bays (until 1977), the two briquetting buildings together, the oven tops and the shuttle car floor together, and the quenching car and ramps together. Like Professor Syred, he calculated from the data contained in *Table 6.4* a single average figure representing the exposure level for each area and applied that same figure throughout the period for which the Phurnacite Plant was in operation. He did not make any distinction between the exposure levels to be applied on the batteries during different periods.

Discussion and conclusions on occupational exposure at the Phurnacite Plant

3.86 The data derived from personal and other sampling conducted at the Phurnacite Plant suggest that the highest average levels of dust were to be found in the briquetting plants (21 mgm^{-3}) and on the oven and shuttle car floors of the batteries (24.2 mgm^{-3}), with significantly lower levels on the quenching car floor and the ramps (4.5 mgm^{-3}). Levels of BSM were highest on the oven tops and the shuttle car floors (3.2 mgm^{-3}), although significant levels were detected in the briquetting plants (1.9 mgm^{-3}). BaP levels were highest on the oven tops and shuttle car floors (35 μgm^{-3}), with significant levels also in the briquetting plants (13 μgm^{-3}). Average levels of total dust, BSM and BaP were generally higher in briquetting plant 2 than in briquetting plant 1.

[132] Jones 1/21

3.87 The pattern which emerges from the exposure data is, therefore, strikingly similar to the picture painted by the witness and documentary evidence and provides support for that evidence. The fact that the exposure data accord with the hierarchy of exposure levels described by the witnesses and suggested by the defendants' documents demonstrates that – despite their limitations – the data are at least representative of the relative levels of exposure in different areas of the Phurnacite Plant.

3.88 The exposure data relating to the pitch handling area are rather more equivocal. The average total dust levels are not as high as might have been expected from the description of the working conditions given by the witnesses and from the picture painted by the defendants' documents. The highest measurement of total dust recorded in the pitch bays in *Table 6.4* was 10.2 mgm^{-3} in 1976 and the average level was 5.9 mgm^{-3}. This was substantially lower than the level of 17.6 mgm^{-3} measured in June/July 1972 by means of a static sampler in one of the pitch bays. Average BSM and BaP levels in the pitch bays for the period 1971-1977 were 21 mgm^{-3} and 47 μgm^{-3} respectively. This latter level was the highest average BaP level recorded at the Phurnacite Plant. There are only a few results for sampling in the pitch bay and this may be one reason for the apparently unrepresentative exposure levels recorded there. Be that as it may, given the strength of the witness and documentary evidence about the working conditions in the pitch handling areas, the personal sampling results do not cause me to alter the conclusions I expressed about those conditions in Section 2 of this judgment.

3.89 The data contained in *Table 6.4* relate only to the periods 1971-1972 and 1975-1983. The issue arises as to what, if any, light the data shed on exposure levels during other periods of the operation of the Phurnacite Plant.

3.90 The disparity between the data used by Mr Stear and by the other two experts when calculating levels of exposure on the batteries prior to 1975 was one factor that caused their estimates of the claimants' total exposure levels to be very different. By way of illustration, the experts' figures for exposure levels on the oven tops are compared in the following Table:

Period	**Professor Syred**			**Mr Stear**			**Professor Jones**		
	Dust	**BSM**	**BaP**	**Dust**	**BSM**	**BaP**	**Dust**	**BSM**	**BaP**
Pre-1968	16.2		33.94	7.4	1.4	.	24.2	3.2	35
1968-1975	16.2	2.43	33.94	8.7	1.6	24.4	24.2	3.2	35
1975-1990	16.2	2.43	33.94	17.3	2.5	35.3	24.2	3.2	35

3.91 I do not consider that Mr Stear's conclusion that average exposure levels on the batteries would have been significantly lower for the period 1968-1974 than for the period 1975-1990 and lower still for the period up to 1968, was justified. There was a very limited amount of data available for the period 1971-1972 and I accept Professor Jones' view that the data were insufficient to justify a conclusion that the working conditions during that period were significantly different from the conditions that existed from 1975 onwards. It is clear from the evidence that the clustering of ovoids was a problem throughout the life of the Phurnacite Plant and had been a feature of the working conditions on the oven tops and the quenching car floor well before 1975.

3.92 I have accepted in Section 2 that the problem became worse from the mid-1970s onwards. However, I do not accept that the increase in the problem led to such a significant change in working conditions as was suggested by Mr Stear. It seemed to me that he focused on the exposure caused by clustering of ovoids to an excessive extent, whilst ignoring other sources of exposure to dust and fume on the oven tops.

3.93 Nor can I accept that the levels of exposure would have been significantly lower during the period up to 1968. I have found in Section 2 that, until the late 1960s, fumes and gases produced during the carbonisation process were discharged just above the heads of the men working on the oven tops and just below those working on the shuttle car floor. It seems to me that, if anything, conditions prior to the late 1960s must have been worse than those which existed from the mid-1970s onwards.

3.94 I am satisfied that the approach adopted by both Professor Syred and Professor Jones, namely to assume that exposure levels on the batteries remained similar to those contained in *Table 6.4* throughout the life of the Phurnacite Plant, is reasonable and appropriate, having regard to the witness and documentary evidence.

3.95 I accept that, given the fact that there are comparatively few results for individual areas within the buildings of the two briquetting plants, Professor Jones' decision to use one overall figure to represent the average level of exposure in all those buildings is likely to afford the most reliable assessment of the exposure levels of men working in the briquetting plants. This approach generally accords with the evidence of the witnesses about the conditions throughout the buildings in the briquetting plants. Professor Jones' decision to use average levels of exposure for the oven and shuttle car floors and for the quenching car floors and ramps was also appropriate in my view.

3.96 Professor Jones and Professor Syred used all the sampling results contained in *Table 6.4* in order to calculate average exposure levels. Mr Stear, however, excluded one set of results for the shuttle car floor on the ground that he considered the results to be "aberrant". I do not consider that his decision to exclude those figures was justified. It is plain from Dr Choo Yin's evidence that those responsible for carrying out the sampling would discard what they considered to be suspect results. The fact that the results in question were not discarded would suggest that they were not considered to be aberrant at the time. Furthermore, this was not the only occasion when dust levels on the shuttle car floor were found to be high. On two occasions in 1972, dust levels of 103 mgm^{-3} were measured by a static sampler placed in the position occupied by the shuttle car operator. These high dust levels were attributed at the time to the effects of the wind on the movement of the dust particles. It may be that the prevailing weather conditions also caused the results which Mr Stear considered to be aberrant. However, the shuttle car operator would have had to contend with the effects of weather conditions on a daily basis, together with any additional exposure to dust that they might cause. It is not surprising that dust levels on the shuttle car floor were high, bearing in mind the huge amounts of dust emitted at the raw ovoid conveyor transfer points, many of which were at shuttle car floor level and the large quantities of dust produced by the processes being conducted on the oven and shuttle car floors.

3.97 In general therefore I regard Professor Jones' approach to the calculation of exposure levels as fair and reasonable and I consider that, on the basis of the available data, his calculations represent the best estimate of the exposure levels of men working at the Phurnacite Plant. The Tables of 'exposure matrices' used by Professor Jones in his calculations of the exposure levels of the individual claimants are set out at Appendix 2 of this judgment.

3.98 However, I note Dr Choo Yin's evidence that, when carrying out sampling exercises, he would advise the men how to reduce their exposure levels by adopting a different position or working in a different way. I have no doubt that, in doing so, he had the men's welfare in mind. But his actions would of course have had the effect of reducing the exposure levels of the men being sampled from what they would have been had the men been performing their work in their customary fashion. Dr Choo Yin also said that his impression was that there would usually have been some tidying of the workplace before he and his sampling team arrived. That being the case, I consider that the results of the personal sampling set out in *Table 6.4* – and therefore Professor Jones' calculations, which are based on those results – are likely to under-estimate the actual exposure of the men working at the Phurnacite Plant.

3.99 The results of the sampling carried out during cleaning operations revealed very high concentrations of dust, BSM and BaP. In the light of the evidence I have heard, that is not surprising. The working conditions of men carrying out cleaning duties were particularly dusty and unpleasant. Whenever cleaning was undertaken, this would also have increased the exposure of those working nearby.

Exposure levels in other parts of the Phurnacite Plant

'Background' exposure levels

3.100 The data contained in *Table 6.4* comprise the results of personal sampling carried out in a number of key areas of the Phurnacite Plant where exposure to dust and fume was a matter of real concern. The programme of monitoring did not extend to other working areas, such as the exhauster houses or (save on one occasion) any of the sample rooms. Nor did it extend to the measurement of exposure levels around the Phurnacite Plant generally.

3.101 In the modelling exercises within his Generic Report, Professor Syred made various assumptions about the ingress of respirable dust into the briquetting buildings from external sources such as the ESPs and the pug vents. These assumptions did not form part of his calculations of individual exposure levels. In his first Supplemental Report, Professor Jones considered Professor Syred's assumptions. Professor Jones noted that his own original Generic Report and his Reports in the individual lead cases had made no allowance for any exposure to dust, BSM and BaP that might have arisen in areas of the Phurnacite Plant other than the areas for which sampling results were included in *Table 6.4*. However, some exposure would inevitably have been caused by the dispersal of dust released into the atmosphere from the processes carried on at the Phurnacite Plant.

3.102 Professor Jones elected to fill this gap by undertaking a computer modelling exercise (his 'modelling dispersion exercise') to calculate the concentrations of respirable dust, BSM and BaP resulting from emissions of dust and fume into the atmosphere at various areas of the Phurnacite Plant. For this purpose, Professor Jones used a recognised software package developed in collaboration with the UK Environment Agency. The calculations carried out for the purpose of the model took into account variables such as meteorological conditions, the effects of terrain on dispersion, the height of exhaust stacks, efflux velocity, the temperature of emitted gases and the effects of buildings around emission points. A computer model of the Phurnacite Plant was set up, identifying emission points and using data on actual emissions taken from the defendants' documents. Professor Jones concluded from those documents that emissions from the pug vents had reduced very substantially from about 1974. He therefore calculated two separate sets of exposure data to show the effects of this reduction. The exposure levels resulting from the modelling dispersion exercise are set out in the Tables at Appendix 2 of this judgment.

3.103 Having carried out the modelling dispersion exercise, Professor Jones revised his calculations of exposure levels in the individual cases to take account of 'background' exposure levels for the various areas of the Phurnacite Plant referred to in the Tables at Appendix 2. The addition of 'background' exposure levels to his assessments of exposure levels was, of course, favourable to the claimants and Professor Jones' decision to carry out this work was an example of the fairness with which he approached his role as an expert witness.

3.104 It was impossible, within the time available, for Professor Syred to carry out any detailed investigation into the validity of the modelling dispersion exercise or of the data which underlay it. Nor is it feasible for me to make any assessment of its validity. However, the claimants were content to accept the 'background' levels of exposure calculated by means of the modelling dispersion exercise. Mr Stear also accepted the 'background' levels and subsequently revised his own calculations to take account of 'background' exposure.

3.105 It is clear from the witness and documentary evidence that large quantities of dust were emitted in the course of the various processes carried on at the Phurnacite Plant and that the dust was dispersed into the atmosphere around the Phurnacite Plant site and beyond. The dust would have come from many sources, the main sources being the ESPs, the raw ovoid conveyors and, until the mid-1970s, the pug outlets. Much of the dust would have contained pitch. Some of that dust would have blown into the buildings at the Phurnacite Plant. Some would have settled on the ground and on roofs and other surfaces from where it would have been liable to be distributed by cleaning operations or by the wind. There would therefore have been some potential for exposure to dust containing pitch all over the Phurnacite Plant. I have already referred to Mr Foster's evidence that dust was a nuisance, even in the offices.

3.106 It is plainly not possible to ascertain the dust levels in all parts of the Phurnacite Plant over the life of the Plant. Those levels would have been variable and would have been influenced by a large number of factors. However, Professor Jones' model, which was based on data about actual emissions, provides some reasonable basis on which to work. It has in effect been accepted by all the experts and I am content to adopt it as the basis for assessing exposure in areas of the Phurnacite Plant other than those for which sampling results are contained in *Table 6.4*.

Exposure levels in and around the exhauster houses

3.107 The two lead cases relating to work in and around the exhauster houses were those of Mr Richards (whose claim is for bladder cancer, COPD and CB) and Mr

Jenkins (whose claim is for bladder cancer alone). Both men worked in exhauster house 1 and, as I have already observed, the evidence I heard related more or less entirely to that exhauster house. It was suggested that working conditions in exhauster house 2 were rather better than at exhauster house 1 but I am not in a position to reach any firm conclusion about that.

3.108 There is no record of any measurements of exposure levels in the exhauster houses, whether by means of static or personal sampling. Inevitably, this causes difficulty in assessing the levels of dust, BSM and/or BaP to which men who worked in the exhauster houses were exposed. The experts came to somewhat different views on this issue.

3.109 Professor Syred considered that the most appropriate comparator for the exposure to BSM and BaP of men working in the exhauster houses was the exposure of men working in the pitch handling areas. This was because the men working in the exhauster houses had a considerable amount of exposure to tar, 50-60% of which would consist of pitch. Professor Syred referred in particular to the evidence that the pumpsmen had used steam cleaning equipment to remove tar deposits. He said that the application of high pressure steam to tar causes fine particles of dust and other materials contained in the tar to be dislodged and dispersed into the atmosphere. As a result, the levels of BSM and BaP to which the pumpsmen were exposed are likely to have been high.

3.110 Professor Syred accepted that the levels of dust in the exhauster houses would have been significantly lower than the levels encountered in the briquetting plants. The exposure levels from the pitch bays which he had used reflected that fact. He had used an average level for total dust of $5.85mgm^{-3}$, based on the data for the pitch bays contained in *Table 6.4*. That average level represented about 28% of the average levels of total dust over the whole of both briquetting plants. Professor Syred had adopted the average levels for BSM and BaP, again based on the data for the pitch bays contained in *Table 6.4*. Those levels were 21 mgm^{-3} for BSM and 47.15 μgm^{-3} for BaP. It was subsequently conceded by the claimants that the BaP level in the exhauster houses contended for by Professor Syred was unrealistically high.

3.111 In his original Generic Report, Professor Jones noted that the processes carried on in the by-products plants involved liquid and gases at comparatively low temperatures. He considered that the main exposure in the exhauster houses and elsewhere in the by-products plants would have been to hydrocarbons with low boiling points and high velocity at lower temperatures. He said that, although the pumpsmen would have been exposed to what they described as ‘fumes’, those ‘fumes’ would in fact have been vapourised hydrocarbons. The vapours would have had a strong odour and may well have produced the various effects (e.g. coughing and spluttering and difficulty breathing) described by the witnesses. Professor Jones said that benzene would have been the main constituent of the vapours; toluene, naphthalene and xylene would probably have been present as well. He referred to data from a survey of benzene concentrations in coke works which suggested that, even in by-products plants which (unlike the Phurnacite Plant) had separate benzole processing plants, few workers had exposure to benzene in excess of the exposure limits advised by the HSE. Professor Jones considered that the exposure of the pumpsmen at the Phurnacite Plant to benzene was likely to be, on average, no more than a few parts per million.

3.112 When carrying out his original calculations in the cases of Mr Richards and Mr Jenkins, Professor Jones assumed that they had had no exposure to dust, BSM or BaP during the periods for which they worked as pumpsmen. He was criticised by the claimants for having taken that approach. However, it is clear that he did so because at that stage he had no data on which to base an estimate of exposure levels in the exhauster houses. It is clear that, after submitting his first Generic Report, he gave further thought to the matter and carried out his modelling dispersion exercise, as a result of which he was able to estimate the 'background' exposure levels for the exhauster houses. It does not seem to me that he can properly be criticised.

3.113 In the calculations contained in his second Supplemental Report, Professor Jones assumed that Mr Richards and Mr Jenkins had had some exposure to BSM and BaP during their time as pumpsmen. This exposure was not assessed by reference to the witness evidence about working conditions in the exhauster houses. Instead, it was based on the 'background' levels of BSM and BaP for the relevant area produced by the modelling dispersion exercise. Those 'background' levels were, for Mr Richards (whose employment as a pumpsman was before 1974), total dust of 4.8 mgm^{-3}, BSM of 1 mgm^{-3} and BaP of 10 μgm^{-3} and, for Mr Jenkins (whose employment as a pumpsman was after 1974), total dust of 4.3 mgm^{-3}, BSM of 0.88 mgm^{-3} and BaP of 8.8 μgm^{-3}. (In fact, those figures related to exhauster house 2 whereas both men worked at exhauster house 1. The 'background' exposure level figures for exhauster 1 produced by the modelling dispersion exercise were rather lower for exhauster house 1 than for exhauster house 2.)

3.114 Professor Jones acknowledged that his 'background' exposure level figures did not make allowance for any dermal exposure to tar or its constituents and that they did not include any additional exposure to dust that would have been caused by the sweeping of dry dust from the upper floor of the exhauster house onto the lower level. He acknowledged that such exposure might have occurred but observed that it was impossible to quantify it in any meaningful way.

3.115 In his original Reports in the cases of Mr Richards and Mr Jenkins, Mr Stear concluded that they may have had some 'background' exposure to dust and fume whilst working as pumpsmen, including exposure to BSM and BaP. However, he considered that their exposure levels would have been significantly lower than those experienced by process operatives in the batteries or briquetting plants. He accepted also that there would have been some dermal exposure to tar. He acknowledged that activities such as clearing blockages or spillages using a steam lance would be a potential source of exposure to fume containing PAHs, but suggested that this type of activity would not have been undertaken often. He concluded that the available data were insufficient to enable the exposure levels of men working in the exhauster houses to be accurately estimated. Having seen Professor Jones's evidence of 'background' exposure levels, Mr Stear amended his calculations to adopt the figures from Professor Jones's modelling dispersion exercise, although he (correctly) adopted the concentrations applicable to exhauster house 1.

Discussion and conclusions about exposure in and around the exhauster houses

3.116 It was not suggested by the claimants that the 'background' exposure levels used by Professor Jones were a serious under-estimate of the levels of exposure of men working in the exhauster houses. However, it was contended that the 'background' levels did not take any account of certain types of exposure. In particular, they did not take account of any additional dust exposure from daily sweeping of the exhauster houses. I accept this contention and I accept also that the 'background' levels of exposure levels did not take any account of the effects of steam cleaning.

3.117 I accept the contention made on behalf of the claimants that the exposure of the pumpsmen to dust, BSM and BaP would have been greater than the 'background' exposure to which anyone merely standing in the vicinity of the exhauster house would have been exposed. The presence of dust in a relatively confined space, and the disturbance and dispersal of dust caused by daily sweeping, would inevitably have resulted in increased exposure to dust, BSM and BaP over and above 'background' levels. I accept also that the steam cleaning which formed part of the pumpsmen's work, certainly in the 1970s and 1980s, would have led to the emission of and exposure to PAHs. How high the levels of exposure to dust, BSM and BaP would have been is, however, impossible to say. There is no way of quantifying the additional exposure over and above the 'background' levels.

Exposure levels in the coal sample and main sample rooms

3.118 I have previously referred[133] to an occasion in June 1975[134] when personal sampling of exposure levels was carried out to measure the exposure levels of a sampler working in what was referred to in the report of the sampling results as the "sample house". The personal exposure samples were taken a few months after Mr Griffiths started work as a coal sampler. They were part of a larger exercise directed at comparing exposure levels in briquetting plants 1 and 2. It seems likely therefore that the sampler whose exposure levels were measured was a plant sampler (not a coal sampler) and that the work upon which he was engaged was the sampling of ovoids from one of the briquetting plants. It is likely also that he was working in the main sample room. Whether or not that was the original main sample room near to batteries 5 and 6 or the 'new' main sample room is not clear. The mean dust concentration for the sampler was 5.38 mgm^{-3}, which was higher on that occasion than the levels for the pug man and the back end man in press house 5 and for the pitchman. The level of BSM was 0.07 mgm^{-3} and the level of BaP was 0.15 $\mu g\ m^{-3}$.

3.119 The experts' views about the likely exposure levels of a coal sampler were very different. Professor Syred based his assessment on Mr Saunders' evidence that, whilst working in the coal sample room, a coal sampler such as Mr Griffiths would have had 75% of the average dust exposure level of a man working in the briquetting plants calculated by reference to *Table 6.4*. Professor Syred accepted that the levels of BSM and BaP in the coal sample room would not be as high as those encountered in the briquetting plants. Instead, he used the average exposure levels of BSM and BaP for the ramps, calculated by reference to *Table 6.4*. Professor Syred assumed that, when gathering coal samples, a coal sampler would have had the average exposure levels for all areas of the Phurnacite Plant, excluding the pitch bays.

3.120 Professor Syred assumed that a plant sampler working in the main sample room would have had an exposure level of 75% of the average for a man working in the briquetting plants. For the time spent collecting ovoids in the briquetting plants, he used the exposure levels for the presses. For periods when the plant sampler was

[133] See paragraph 3.41 of this judgment
[134] Stear4/183

walking from one location to another, he used the average exposure levels for all areas of the Phurnacite Plant, excluding the pitch bays.

3.121 Mr Stear considered that a coal sampler would have had only a small amount of exposure to coal dust, with negligible or no exposure to BSM or BaP. He estimated the amount of dust at about 1% of the average level to which a process operative in the briquetting plants would have been exposed. In the revised calculations contained in his Supplemental Report, he allowed some 'background' exposure, as calculated by Professor Jones's modelling dispersion exercise. Mr Stear accepted that a plant sampler would have received additional exposure to dust, BSM and BaP.

3.122 Professor Jones adopted a somewhat different approach to that used by the other two experts. In his Generic Report, he pointed out that there appeared to have been no personal sampling of the exposure levels of operatives working in the coal handling areas of the Phurnacite Plant (i.e. those areas, such as the coal blending site and the tippler areas, where 'wet' coal was handled). He had therefore considered whether it was possible to find exposure levels for a similar type of work carried out at premises other than the Phurnacite Plant. He considered that a suitable comparison would be the exposure level of process operatives working in the less dusty areas of a coal preparation plant. He referred to dust sampling in coal preparation plants carried out by Pneumoconiosis Field Research (PFR). The measurements resulting from that sampling exercise were reviewed in 2007 by the Industrial Injuries Advisory Council (IIAC) when considering occupations for which COPD should be prescribed as an industrial disease[135]. IIAC concluded that, of the various jobs carried on in a coal preparation plant, the only one which was consistently associated with a mean concentration of respirable coal dust greater than 1.5 mgm^{-3} was work on the screens.

3.123 Professor Jones considered that it would be fair (indeed possibly an over-estimate) if he were to assume that a coal sampler would have been exposed to a total dust concentration level of 10 mgm^{-3} during the time he was working in the coal sample room. In addition, he would have spent some time at the coal blending site, for which Professor Jones assumed a total dust exposure level of 0.30 mgm^{-3}, that being the appropriate 'background' level taken from his modelling dispersion exercise. Professor Jones did not consider that a coal sampler would have had any exposure to BSM or BaP during the course of his work.

3.124 Based on the data relating to coal preparation plants, Professor Jones estimated that a plant sampler would also have been exposed to a total dust concentration level of 10mgm^{-3} whilst working in the main sample room. For the periods spent collecting ovoid samples in the briquetting plants, he used the exposure levels for total dust, BSM and BaP in the briquetting plants, calculated from the data in *Table 6.4.*

3.125 It seems to me that Professor Jones' approach of equating a coal sampler's exposure to dust with that of a worker in a less dusty area of a coal preparation plant is preferable to the approaches adopted by either Professor Syred or Mr Stear. In particular, I was puzzled by Professor Syred's assumption that the levels of BSM and BaP to which a coal sampler would have been exposed were comparable to the exposure levels of a man working on the ramps. It seems to me that the working

135 *Chronic Obstructive Pulmonary Disease (COPD) – Chronic Bronchitis and Emphysema* (2007) IIAC; Jones6/176

conditions of, and the nature of the product handled by, a coal sampler and a rampsman were very different.

3.126 I found the comparison drawn by Professor Jones between the work of a coal sampler and that of a man employed in a coal preparation plant more helpful, although I share his view that the resulting total dust exposure level of 10 mgm^{-3} for a man working in the coal blending site sample room may well be an over-estimate. That level is, after all, only just below half the dust exposure level for the briquetting plants (21 mgm^{-3}) and higher than any other area of the Phurnacite Plant save for the oven tops. If dust levels in the sample rooms had been so high, I would have expected there to have been a history of complaints about conditions there.

3.127 Like Mr Stear, Professor Jones assumed that, whilst working in the coal blending site sample room, a coal sampler would have had no significant exposure to BSM or BaP. I consider that their approach must be correct. In the coal blending site sample room, the coal sampler would have been dealing mainly with newly delivered coal which would have been uncontaminated by pitch from recycled ovoids or pitch dust. Since the purpose of coal sampling was to analyse newly delivered coal, it is unlikely that samples would generally have been taken from coal that was already contaminated by recycled material. I accept that there might have been some exposure to dust containing pitch when a coal sampler was working in the coal sample room near the tippler area at briquetting plant 2. However, this would be impossible to quantify other than by reference to 'background' exposure levels.

SECTION 4

OTHER ISSUES RELATING TO EXPOSURE LEVELS

4.1 In this Section, I shall discuss a number of other issues relating to exposure levels at the Phurnacite Plant. The first of these is the measurement of respirable dust levels. I shall then go on to consider the exposure levels of men other than process operatives, and the effect of overtime working.

The measurement of respirable dust levels

4.2 Relatively few of the results of sampling conducted at the Phurnacite Plant contained data for respirable dust. Although it seems from Dr Choo Yin's evidence that, at least from the mid-1980s, the personal sampling that was conducted included measurements of respirable dust levels, no personal sampling results for respirable dust are available. The data about respirable dust which are available come from infrequent static sampling exercises that were carried out in various areas of the Phurnacite Plant at different times. Details of that sampling are set out at Section 3 of this judgment.

Professor Syred

4.3 Professor Syred listed the results of the static sampling exercises conducted in various parts of the Phurnacite Plant between September 1972 and March 1979 at *Table 6.3* of his Generic Report[136]. (As Professor Jones pointed out, Professor Syred omitted the results of static sampling over one of the conveyor belts in the briquetting plant conducted in 1979 which would potentially have been relevant.) Those results showed widely differing percentages of respirable dust.

4.4 Professor Syred's evidence was that measurements of respirable dust taken by means of a static sampler cannot be assumed to be equivalent to the measurements derived from a personal sampler fitted with a cyclone attachment. In support of this assertion, he referred to a paper, *A Study of Techniques for Sampling Airborne Dust/Fume at Coke Ovens*[137], published in 1971 by the Institute of Occupational Medicine (IOM). I shall refer to this paper as 'the IOM document'.

4.5 The IOM document reported the results of a study comparing the performance of three dust sampling systems (the Casella personal sampler and the MRE and Hexhlet static samplers) at the NSFL Avenue Coke Works. All three samplers were set up to measure both total and respirable dust and were mounted close together. As usual with static samplers, the intakes on the MRE were horizontal, whilst the intake on the Casella was inverted in order to simulate the position of the human nostrils. The study revealed that the MRE sampler consistently measured larger total dust concentrations than the Casella personal sampler. Respirable dust concentrations were similar for the two samplers but, because the total dust levels measured by the Casella sampler were lower, respirable dust formed a much higher percentage of the total dust levels for that sampler. The implication of the results reported in the IOM document was that, had measurements of total and respirable dust been made at the Phurnacite Plant using Casella personal samplers, a higher ratio of respirable to total

[136] Syred1/124
[137] Syred3/21

dust would have been obtained for Casella samplers than for static samplers operating side by side with them. Professor Syred calculated that the respirable dust levels measured by a Casella personal sampler would have been 1.84 times the levels that were in fact measured by the MRE static samplers used at the Phurnacite Plant. He contended that the same factor of 1.84 should be applied to the measurements taken at the Phurnacite Plant by means of the Hexhlet sampler.

4.6 In *Tables 6.3a-e*[138] of his Generic Report, Professor Syred extracted from *Table 6.3* the results of the static sampling in different areas of the Phurnacite Plant (the pitch bay, the briquetting plants, the oven tops, the quenching car floor and the shuttle car floor), and of the static sampling conducted during cleaning operations in briquetting plant 2. In respect of each of *Tables 6.3a-e*, Professor Syred set out the actual total dust measurements resulting from the sampling. Where a static sampler had measured respirable dust, he set out that measurement also, together with the percentage of respirable dust contained within the total dust measurement. He then 'corrected' the percentage of respirable dust as measured by the static sampler by increasing it by the factor of 1.84 he had calculated by reference to the IOM document. The resulting figure was intended to represent the percentage of respirable dust that would have been measured had the sampling been conducted using a Casella personal sampler. Using those corrected figures, Professor Syred then calculated the average percentages of respirable dust measured in each location. He concluded that (to round figures) the respirable percentages of total dust in the various locations were as follows:

LOCATION/WORK	RESPIRABLE DUST %
Pitch bays	1%
Briquetting plants	50%
Oven tops	50%
Shuttle car floor	3%
Quenching car floor	30%
Cleaning operations in briquetting plant 2	4.73%

4.7 Professor Syred included those percentages in his *Table 6.5*[139] and used them when calculating exposure levels in some of the individual lead cases.

4.8 Professor Syred's calculations of respirable dust levels were criticised by the defendants in a number of respects. The criticisms can be summarised thus:

(a) the calculations were based on very few readings. In the calculation for the briquetting plants (*Table 6.3b*), two results of sampling on the pug belt resulted in respirable dust percentages of more than 90%. The remainder of respirable dust percentages in the briquetting plant were between 31% and 46% and the two readings had badly skewed the average respirable dust percentage;

(b) the results of sampling should have been weighted according to the amount of total dust measured on each occasion. If that had been done the average 'corrected' respirable dust percentage for the briquetting plants would have been 43% (rather than Professor Syred's figure of 54.58%, which he "rounded down" to 50%). Similarly, if weighted, the average 'corrected'

[138] Syred 1/125-130
[139] Syred 1/131a

respirable dust percentage for the oven tops (*Table 6.3c*) would have been 23%, rather than 52.49% (rounded down to 50%);

(c) the use of the 1.84 correction factor was not necessarily sound since the MRE sampler might not have been used in the same way in the study described in the IOM document as when sampling at the Phurnacite Plant and the head sizes of the Casella samplers might well have been different. Notwithstanding this criticism, however, Professor Jones accepted that it was appropriate to use the correction factor.

Mr Stear

4.9 In his Generic Report, Mr Stear first addressed the issue of respirable dust in the briquetting plants. He observed that the briquetting plants handled the constituents of Phurnacite briquettes in a number of different forms, from coal and pitch dust to the raw ovoids. The proportion of respirable dust emitted at each different stage of the manufacturing process would vary. For that reason, and because of the paucity of available data relating to respirable dust concentrations in the briquetting plants, he did not regard it as appropriate to attempt to estimate what proportion of the total dust measured during personal sampling in the briquetting plants would have been respirable. In general, he believed that the proportion of respirable dust in the briquetting plants was probably less than on the oven tops[140].

4.10 As to the batteries, Mr Stear said that there was again little data about the proportion of respirable dust emitted in the various working areas. Nevertheless, he was able to express a view. He discussed the reports of sampling exercises conducted at the Phurnacite Plant and other NSFL plants in 1972[141]. He concluded[142]:

> "Given the wide variability of results, I believe the only conclusion that can be drawn with any confidence is that the respirable fraction is probably less than 50%. As such, any estimation of how much exposure was in the respirable fraction should assume 50% of the total inhalable results presented previously."

4.11 Mr Stear went on to state[143] that an estimate of 50% respirable dust might be reasonable. His Generic Report included a Table[144] in which he presented respirable dust exposure levels for various areas of the batteries. Those exposure levels were approximately half the levels for total dust. Later in his Generic Report, he suggested that his estimate of 50% respirable dust on the batteries was intended to represent the "maximum" percentage, although probably "erring on the high side". He commented that it might have been higher on some occasions, although the data suggested that it was generally less than 50%.

4.12 At their Joint Meeting, Professor Syred and Mr Stear discussed the issue of respirable dust. In their Joint Statement, they said:

[140] Stear 1/134
[141] Stear4/71 & 86
[142] Stear1/146
[143] Stear 1/148
[144] Stear1/229 Table 11

> "We agree that whenever someone was exposed to dust, the dust would have comprised some fraction of respirable dust. We agree that the information is limited with regard to the amount of respirable dust, but the best estimate is approximately 50% of the dust generated, although it was probably a lower fraction in some areas of the works."

4.13 By the time Mr Stear wrote his Supplemental Report, his views about respirable dust had changed somewhat. He considered that the figure of 50% respirable dust on the ovens could not be used with any degree of confidence[145]. He cast doubt on Professor Syred's interpretation of the IOM document. He suggested that, in the absence of any other data, calculations of respirable dust should be based on the data contained in *Table 6.3* of Professor Syred's Generic Report[146]. That data contained widely varying measurements, from 51% respirable dust (on the pug belt) to 1.3% respirable dust (on the shuttle car floor). In oral evidence, Mr Stear did not accept that the contents of his Generic Report and of the Joint Statement were in any way inconsistent with the views expressed in his Supplemental Report. At one point in his evidence, he appeared to suggest that, during his meeting with Professor Syred, he had merely "gone along" with Professor Syred's view so as to achieve an agreed answer on the issue of respirable dust. That assertion was plainly untenable given the contents of his Generic Report. In fact, he had obviously changed his view after the Joint Meeting. Why he persisted in refusing to accept that fact, I do not know. His change of mind may well have occurred for good reason and would not in itself have been a ground for criticism.

Professor Jones

4.14 In his Generic Report, Professor Jones attempted to calculate exposure levels to respirable dust in various areas of the Phurnacite Plant. He used, first, the results of the static sampling carried out in 1951, 1954 and 1964. Those results contained measurements (in ppcc) for respirable (but not total) dust. For the purpose of the calculation, Professor Jones converted the sampling results from ppcc into gravimetric units (mgm^{-3}). He described this as a "rough" conversion, using an MNI of 17.7 which, he said, was a typical value for coal preparation plants. He acknowledged that he could not be certain that the MNI was appropriate for use at the Phurnacite Plant. He was adamant, however, that any overlap of particles on the thermal precipitator that might have affected the accuracy of the particle count would have been corrected by the MNI.

4.15 Professor Jones also used the small number of sampling results from the period 1971-1982 for which both respirable and total dust concentrations were available. He took a simple average of the respirable fractions. That resulted in an average respirable fraction of 21% for the briquetting plants and 16% for the oven tops. The calculations were not set out in Professor Jones' Generic Report and it was not entirely clear how he had reached his figures. When first asked about this in his oral evidence, he could not recall precisely what data he had used or how he had made his calculations. He examined the data again overnight during his oral evidence. On re-considering the data, Professor Jones realised that he had failed to take into account

145 Stear Supp /3
146 Syred 1/124

the results of sampling in the briquetting plant in November 1972. If included, those results would have increased the respirable fraction in the briquetting plant to 22.8% (before any 'correction' to reflect the difference between the results measured by a static and a personal sampler). If he had also added in the measurements taken over one of the conveyor belts in February 1979[147] (the measurements which had been omitted by Professor Syred), the respirable dust fraction would have reduced again to 17%.

4.16 In his first Supplemental Report, Professor Jones considered Professor Syred's estimates of respirable dust levels. He concluded, as have I, that many of the assumptions underlying Professor Syred's modelling exercise were arbitrary, and in some cases unrealistic, and that little or no reliance could be placed on the results. He considered that actual measurements of the proportion of respirable dust present at the Phurnacite Plant provided a more reliable basis for determining exposure levels to respirable dust than results obtained by modelling. However, he acknowledged that the data were very sparse and that his estimates based upon that data may therefore be very unreliable.

4.17 As to his calculation of the respirable dust fractions on the batteries, Professor Jones frankly acknowledged that it had been incorrect. He had failed to take into account some of the available data. Using all the data now available to him, he calculated respirable fractions of 14.3% for the oven tops, 1.2% for the shuttle car floor (on the basis of one result only) and 22% for the quenching car floor. The fact that the respirable fraction for the quenching car floor was more than that for the oven tops appeared counter-intuitive and Professor Jones agreed that it was "strange".

4.18 Professor Jones went on to consider the IOM document on which Professor Syred had relied. He accepted that it was appropriate to increase measurements of respirable dust taken by means of a MRE static sampler by a factor of about 1.84 (he calculated the relevant figure at 1.82) in order to reflect the proportion of respirable dust that would have been measured if a Casella personal sampler, rather than a MRE static sampler, had been used.

4.19 Professor Jones emphasised that there were a number of ways in which the respirable fraction could be calculated. He had adopted the same approach as Professor Syred, namely taking the ratio of each sampling result, then averaging the ratios. An alternative method would have been to take the ratio of the average total dust against the average respirable dust from all the sampling results. That would have resulted in significantly lower respirable fractions. He said that it would only be appropriate to use that method if one could be sure that the exposures were representative. A third method would have been to plot the sampling results on a graph and obtain an average respirable fraction in that way. However, he acknowledged that this was not a satisfactory way of proceeding on such limited data. Overall, Professor Jones considered that the method which he and Professor Syred had adopted was probably the most appropriate. However, he concluded that, given the very limited data available, and the various different methods of analysing them, the results could be widely varying.

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[147] Paragraph 3.51 of this judgment

Discussion and conclusions on respirable dust

4.20 It is plainly unfortunate that the defendants did not institute a system of the personal sampling of respirable, as well as total, dust levels earlier than the mid-1980s. It is unfortunate also that the results of the static sampling for respirable dust (which, according to Dr Choo Yin, was carried out in conjunction with personal sampling at least from the time of his arrival at the Phurnacite Plant in 1979 until the introduction of personal sampling for respirable dust in the mid-1980s) are no longer available. As it is, the data that are available are sparse and extremely variable.

4.21 The calculations based on that data undertaken by both Professor Syred and Professor Jones were subject to a number of uncertainties. They were based on very few sampling results. That of itself renders any conclusion very unreliable. A single abnormally high or low sampling result would have had a disproportionate effect on the results of the calculations. In addition, Professor Jones had included results from the sampling conducted in the 1950s and 1960s. There are doubts about the accuracy of the results produced by the types of static sampler used in the sampling exercises conducted at that time. Even if Professor Jones was right in saying that the use of the MNI would have corrected any possible inaccuracy caused by particle overlap in the thermal precipitator, the accuracy of the conversion from ppcc to gravimetric units would depend on the use of the appropriate MNI. I do not know whether the use of an MNI appropriate to a coal preparation plant is valid in the context of the conditions at the Phurnacite Plant. If it is not, then the conversion process would be flawed. It is debatable whether it is preferable to exclude the data from the 1950s and 1960s on the ground that they may be unreliable or to include them on the basis that, despite their possible unreliability, they do at least increase the total amount of data available.

4.22 There was an issue as to whether or not the results of sampling for respirable dust should be weighted according to the amount of the total dust measured on each occasion. There was also considerable uncertainty as to how the respirable fraction of dust should be calculated. Indeed it was clear from the way Professor Jones' evidence on this topic developed that the exercise presented so many difficulties that I could have no real confidence in the reliability of any calculations made. Having said that, however, I am satisfied from the witness evidence that there was a high proportion of respirable dust in the buildings at the two briquetting plants. The material being handled in many areas of the buildings consisted of fine dry dust. I find the evidence of Dr Choo Yin, who referred to the presence in the press hall of "very fine coal dust particles coated in tar/pitch, most of it respirable in size", particularly significant. Despite the problems with Professor Syred's evidence, it may well be that his estimate that 50% of the dust in the briquetting buildings was of respirable size was reasonably accurate.

4.23 Taken overall, however, I do not consider that I can reach any reliable conclusions about the percentage of respirable dust present in the various areas of the Phurnacite Plant.

The exposure levels of men other than process operatives

4.24 There was a difference of opinion between the three technical experts about how to assess the exposure levels of 'peripatetic' workers (such as painters, fitters or riggers) and of men working in a supervisory capacity. I am satisfied that personal samplers were issued only to operatives working on specific processes (e.g. moving pitch, operating the press or pug, working on the shuttle car, oven tops or quenching car, cleaning out a pit), rather than to peripatetic workers, who would move between different tasks and/or areas during the course of their work, or to supervisory staff, who would not always be taking an active part in the relevant processes.

4.25 When assessing the appropriate levels of exposure for peripatetic employees and supervisory staff, three distinct and different issues arise. The first issue is what division of the individual's shift is appropriate, as between his various duties and the different areas in which he might work and therefore the different exposure levels he might have? For example, a process operative may spend all his shift (except for specified breaks) operating a machine in a dusty working area, whilst a supervisor may spend 20% of his time doing paperwork in the office/canteen, 20% of his time walking between various locations, and only 60% of his time in the same dusty working area as the process operative. It was broadly accepted by all three experts that the two men in that example would have different levels of exposure and that some reduction in exposure levels should be assumed during the periods for which the supervisor was away from the dusty working area. The same would go for a fitter, whose average working day might be divided between one or more dusty working areas and a less dusty environment, such as a workshop.

4.26 The second issue is whether, during the periods for which the supervisor, fitter or other peripatetic worker is working in a dusty area, his exposure levels will be the same as those of the process operatives working in the same area? The three experts disagreed on this issue. Professor Syred's position was that there were no adequate data which would allow him to calculate the exposure levels of workers carrying out peripatetic jobs or working in a supervisory capacity. He therefore made his assessments of individual exposure levels on the basis that, during the periods for which they were exposed to dust and/or fume in working areas, no distinction should be drawn between the exposure levels of workers carrying out peripatetic jobs or working in a supervisory capacity and the exposure levels of process operatives working in the same areas.

4.27 Mr Stear disagreed with this approach. He considered that it was obvious that those workers who were not actually operating the processes which produced the dust and fume would have lower levels of exposure than the men who were doing so.

4.28 In the calculations contained in his original individual Reports, Professor Jones made no distinction between the exposure levels of peripatetic workers and those employed in a supervisory capacity and the exposure levels of process operatives. However, in the revised calculations of the exposure levels of the individual lead claimants contained in his second Supplemental Report, Professor Jones explained that, when he had made his original calculations, he had not been sure whether the personal sampling results in *Table 6.4* included the results of sampling of peripatetic employees or those with supervisory roles. If they had, the average exposure levels resulting from the sampling would have taken account of the lesser exposure of men who were not process operatives. Having heard the evidence of Dr Choo Yin and re-considered the matter, he had concluded that the likelihood was that the wearing of personal samplers had been confined to process operatives. Thus, he considered it appropriate to treat the exposure of peripatetic employees and supervisory staff differently from that of process operatives. He concluded that they would, in general, have had less exposure than process operatives working in the same areas. Professor Jones was subject to some criticism from the claimants for his change of mind on this issue. However, I found his reasons for revising his views entirely understandable. It seemed to me that, in his original Reports, he had given the claimants the benefit of the doubt. It was only when he was satisfied of the likelihood that the personal sampling had been confined to process operatives that he considered it appropriate to make any reduction to reflect the lesser exposure of peripatetic employees and supervisory staff.

4.29 It seems to me clear that Mr Stear and Professor Jones were correct in their assertion that, whilst in working areas, peripatetic workers and supervisory staff would in general have had lower exposure levels than process operatives employed in the same areas. I found Professor Syred's failure to acknowledge the point both unrealistic and unhelpful.

4.30 The third issue is what proportion of the exposure levels of a process operative will a peripatetic worker or a man employed in a supervisory capacity have? The experts' differing assessments of the exposure levels of men who were not process operatives resulted, in some of the individual lead cases, in widely differing estimates of the claimant's exposure levels.

4.31 In his original individual Reports Mr Stear ascribed different percentages of exposure to the various peripatetic and supervisory roles. After hearing the evidence given in Cardiff, he revised those percentages in some of the individual lead cases. In his Supplemental Report, he explained that he had derived from the evidence a "hierarchy of exposure" which he had applied to the lead claimants. That hierarchy was:

Process operatives in "dry areas" of the briquetting plants and batteries	100%
Shift fitters	75%
Foremen	50%
Shift superintendents	25%
Riggers	25%
Yard foremen	10%
Painters	less than 10%
Samplers	less than 10%

4.32 He amended his calculations in the individual lead cases accordingly. I shall refer to his amendments further in my judgments in the individual lead cases.

4.33 Professor Jones considered that foremen, shift superintendents and riggers would have had 50% of the exposure of process operatives during periods spent in the relevant working area, whilst painters would have had 30%. He considered it reasonable to assume that fitters would, on balance, have had the same exposure as process operatives. His reasoning was that, whilst they may have had less exposure from operating plant and machinery, they would have had periods of much greater exposure when opening up conveyors and other dusty plant and machinery and when cleaning surfaces before starting work. In general, therefore, he assumed significantly higher exposure levels for peripatetic and supervisory employees than Mr Stear.

Supervisory staff

4.34 Having set out the stances taken by the experts, I shall consider the position of the supervisory staff. Three of the lead claimants were members of the supervisory staff for at least part of their employment at the Phurnacite Plant. Mr Richards worked as a process foreman on batteries 1 and 2 between 1966 and 1981 and as a yard foreman from 1982 to 1985. Mr Carhart was a process foreman on batteries 1 and 2 between 1962 and 1977 and chief heater foreman from 1977 until 1985. Mr Robson was a shift foreman in one of the briquetting plants between 1956 and 1960, a shift superintendent for the briquetting plants and the batteries from 1961 to 1970 and a shift superintendent for the two briquetting plants between 1971 and 1979.

Process foremen

4.35 The process foremen who worked in the carbonisation plant (also known as ‘oven foremen’) supervised the carbonisation process. Each of them usually covered two batteries. Evidence about their role was given by Mr Richards and Mr Pugh (himself a process foreman on batteries 1 and 2 between 1970 and 1985). Mr Brian Jones (who, as a shift superintendent on the batteries between 1971 and 1984, had direct responsibility for the three process foremen working on the same shift as himself) also gave evidence about the role of the process foremen generally and that of the lead claimant, Mr Robson, in particular. Mr Richards and Mr Brian Jones gave oral evidence. Mr Pugh was too ill to attend but provided a detailed witness statement.

4.36 Each process foreman was responsible for the oven floor, the quenching car floor and the ramps of two batteries, together with the screen house for one of the batteries. It seems that at least some of the process foremen may also have had some responsibility for the by-products plants. Mr Brian Jones and Mr Richards referred to this. Mr Richards’ evidence was that, for at least some of the period when he was a process foreman for batteries 1 and 2, he was also responsible for half of battery 3. This may have been during the period between 1968 and 1973 when battery 2 was being rebuilt.

4.37 Mr Pugh and Mr Brian Jones agreed that the majority of a process foreman’s time was spent on the oven floor and the quenching car floor. Those were the areas where problems generally arose. The other areas usually ran without incident. During the course of a shift, the process foreman would have to check the temperature of the 40 ovens on each battery to ensure that the correct heat was maintained during carbonisation. He would have to clean the accumulations of carbon from the oven flues using a long steel rod. Mr Richards’ evidence was that this was a job usually carried out when working on a rest day. He would inspect the oven chambers on discharge to ensure that the carbonisation process was operating correctly. He would also be at hand to assist in dealing with any problems that occurred. Throughout all these tasks, the process foreman would be in close proximity to the ovens and would be exposed to the fume and dust previously described. When on the quenching car floor, he would be in the vicinity of the open oven doors whilst carbonisation, poking and quenching of the discharged ovoids was taking place**.** He would visit the ramps and screen house to ensure that the operations there were running smoothly. In the event of a problem with production in the briquetting plants, the process foreman might also have to visit the shuttle car floor in order to check on the supply of raw ovoids available for carbonisation.

4.38 Mr Pugh, Mr Richards and Mr Brian Jones all gave different assessments of the proportion of time spent by a process foreman working in each different area. I have dealt with those assessments in my individual judgments in the cases of Mr Carhart and Mr Richards. In reaching my assessments, I have taken into account the periods of time which I have found they would have spent outside the working areas of the batteries. The remainder of their time would have been spent on the oven floor, the quenching car floor, the ramps, in the screen house and on the shuttle car floor.

4.39 In calculating exposure levels for Mr Carhart and Mr Richards, Professor Syred assumed that, whilst they were carrying out their duties as process foremen in the working areas of the batteries, they were exposed to the same levels of dust and fume as were the process operatives employed in those areas. He adopted the same approach for other lead claimants who were employed as supervisory staff.

4.40 In his original Reports in the individual lead cases, Professor Jones adopted the same approach as Professor Syred. However, in his Second Supplemental Report, he changed his approach and made his calculations on the basis that, as process foremen, both Mr Carhart and Mr Richards would have had only 50% of the exposure levels of process operatives employed in the areas where the two men worked. He said that such a deduction accorded with his own experience of relative exposure levels in the nuclear industry as between process operatives and supervisory staff. However, he took into account the fact that the supervisory staff would also have been subjected to the ‘background’ levels of exposure calculated from his modelling dispersion exercise. Therefore, rather than simply deducting 50% of the exposure levels as calculated using the data in *Table 6.4*, Professor Jones made an adjustment to reflect additional ‘background’ exposure.

4.41 In his original Reports in the lead cases, Mr Stear proceeded on the basis that the exposure levels for supervisory staff would have been about 50% of those of process operatives. In his Supplemental Report, he remained consistent in that view. Having read Professor Jones’ first Supplemental Report, setting out the ‘background’ exposure levels calculated by means of his modelling dispersion exercise, Mr Stear adopted those ‘background’ exposure levels and included them in his revised calculations.

4.42 I cannot accept Professor Syred’s assumption that supervisory staff such as process foremen would have been exposed to the same levels of dust and fume as process operatives who worked continuously as, for example, charging car or quenching car operators. Process foremen would not have been responsible for charging the ovens or cracking open oven lids on a regular basis. Unless they were carrying out the task of poking an oven (which I accept did happen on occasion), they would usually have been able to remove themselves from the immediate vicinity of the fumes emitted during poking operations. They would not have been responsible regularly, if at all, for opening oven doors and releasing the cooked ovoids into the quenching car. When visiting the shuttle car floor, they would not have been personally engaged in charging the shuttle car bunkers with raw ovoids. Nevertheless, I am satisfied that the job of a process foreman was very much a ‘hands on’ troubleshooting role which required him to be present wherever and whenever a problem affecting the carbonising process (of which the clustering of ovoids in the ovens was a common example) arose. If a process foreman carried out his duties conscientiously, he would inevitably have spent a large proportion of his time in the vicinity of the ovens whilst carbonisation, charging and discharging was taking place and would have been exposed to significant amounts of dust and fume. Conditions on the batteries, which I have described in Section 2 of this judgment, were not such that it would have been possible to avoid the dust and fume emitted there.

4.43 I consider it probable therefore that, whilst carrying out his duties in the working areas of the batteries, a process foreman would have experienced about 75% of the exposure levels of a process operative working in the same areas.

Chief heater foreman

4.44 The chief heater foreman was in charge of the hydraulic main attendance gang covering all the six batteries which were in operation at any one time. His responsibility was to ensure that the ovens were kept at the correct temperature at all times. The chief heater foreman would spend all his time working on the oven floor and on the quenching car floor of the batteries. He would inspect the heating controls, the flues and pressure gauges and would assist with any problems which arose in relation to the heating of the ovens. I find that, when carrying out his duties in the working areas of the batteries he would have experienced a similar level of exposure to that of a process foreman, i.e. about 75% of that of a process operative working in the same areas.

Shift superintendent

4.45 Prior to 1971, the shift superintendents were responsible for supervising work in both of the briquetting plants and the batteries. In practice, most of a shift superintendent's time would have been spent in the briquetting plants, leaving little time for working on the batteries. In 1971, the job was split so that both the briquetting plants and the batteries had their own shift superintendents.

4.46 Mr Harris and Mr Brian Jones gave evidence about the work of a shift superintendent and about the work of the lead claimant, Mr Robson, in particular. They emphasised that there was no such thing as an 'average' shift for a shift superintendent. Every day was different. However, they did their best to describe what the job entailed.

4.47 Mr Harris described how the shift superintendent for the briquetting plants would usually visit every part of both briquetting plants at least once during each shift. Ideally, he should have made two rounds of the briquetting plants but this was not always possible. The round would involve inspecting work in the coal handling areas (the tipplers, and later the coal blending site), the pitch bays (until the introduction of liquid pitch), the wet coal bunkers, the conveyors used for transporting wet coal, the coal dryers, the furnaces, the conveyors used for transporting dry coal, the dry coal bunkers, the measuring and mixture conveyors, the disintegrators, the pugs, the press houses, the trommel house, the raw ovoid conveyors and the shuttle car floor of each battery. The shift superintendent would sometimes have to visit the oven floor of the batteries, and the by-product plants, if his deputy was absent, but would usually concentrate mainly on the areas previously mentioned. If there were any mechanical or other problems in a particular area, the shift superintendent would spend more time there. He would discuss with the foreman and the process operatives what needed to be done and would arrange for fitters, electricians or other tradesmen to attend if necessary. He would usually spend longer in briquetting plant 2 than in briquetting plant 1 since briquetting plant 2 was larger and more prone to problems.

4.48 Mr Harris described how the shift superintendent's day would start with a handover with the outgoing shift superintendent, followed by a meeting with the foreman on duty. It might be necessary to call in at the fitting workshop before going off to the briquetting plants. He said that some of the shift would be spent walking between the various working areas. Shift superintendents would not generally remain in a dusty area unless it was necessary to do so. During the day shift, the shift superintendent would visit the foreman's offices in the briquetting buildings to discuss with the foreman any problems that had arisen. At the conclusion of his shift, the shift superintendent would spend about an hour completing a report on the shift and any problems that had arisen.

4.49 When calculating exposure levels for Mr Robson, Professor Syred assumed that, when carrying out his duties as a shift superintendent in the working areas of the briquetting plants and batteries, he would have been exposed to the same dust levels as the process operatives employed in those areas. In his original Report in Mr Robson's case, Professor Jones adopted the same approach as Professor Syred. In his Second Supplemental Report, however, Professor Jones changed his approach. In his revised calculations, he assumed that a shift superintendent, like a process foreman, would have had about 50% of the exposure levels of a process operative working in the same areas, together with 'background' exposure.

4.50 As I have already indicated, in the revised calculations in his Supplemental Report, Mr Stear reduced his estimate of the levels of dust to which a shift superintendent would have been exposed from 50% to 25% of the levels experienced by process operatives working in the same area.

4.51 The job of a shift superintendent was peripatetic and, for a significant part of each shift, he would be moving between working areas carrying out his inspection duties. Whilst he was in the working areas (in Mr Robson's case, mainly in the briquetting buildings), he would be exposed to the general dusty atmosphere in those buildings and, for much of his time, he would be standing directly beside men who were working on the dust-producing processes and/or carrying out urgent repairs on dusty plant and equipment. I am satisfied that Mr Stear's assessment of 25% of the exposure levels of a process operative working in the same area is a significant under-estimate. Nor do I accept that a shift superintendent would have had as much exposure to dust as the foreman responsible for the same area. I consider that a foreman would be more likely to remain in one position for some time, supervising the work in hand or giving practical assistance. A shift superintendent, by contrast, would be likely to wait until the necessary work was in hand before moving off to another area. I consider it reasonable to assume that, when in a working area, a shift superintendent would have had 60% of the exposure levels of a process operative.

Peripatetic work

4.52 Four of the lead claimants had peripatetic jobs for at least part of their employment at the Phurnacite Plant. Mr Middle worked as a rigger's labourer, then a rigger/plater. Mr Robson and Mr David Jones spent time working as shift fitters. Mr Davies was employed as a painter. In the judgments in their individual claims, I have summarised the evidence about their relative exposure levels during the periods when they occupied peripatetic roles. Suffice it to say at this stage that in general my assessments approximate more closely to those of Professor Jones than to the levels suggested by Mr Stear.

Overtime

4.53 An issue arose between the three experts as to whether overtime should be taken into account when calculating the claimants' exposure levels. Overtime records have survived in only four of the eight lead cases and those records that have survived are somewhat sparse. It seems that the records were usually compiled for the purposes of calculating the claimant's redundancy entitlement and tended to cover only the last few months or weeks of his employment at the Phurnacite Plant.

4.54 From the available records, Professor Syred calculated the average weekly number of hours' overtime worked for each of the four claimants for whom records have survived. He assumed that the average weekly amount of overtime extracted from the records had remained constant over each claimant's entire working life. For the claimants in respect of whom no records were available, he used the average weekly number of hours' overtime calculated by reference to the four claimants whose records have survived. The addition of overtime has the effect of significantly increasing the hours for which each individual claimant was exposed to dust and/or fume and, when applied to average exposure levels, it produced a sizeable increase in the total exposure levels.

4.55 The defendants argued that the available records may not have been representative of the actual overtime worked by the claimants over the whole period of their employment at the Phurnacite Plant. Mr Stear made no allowance for overtime.

4.56 Professor Jones assumed a basic working year of 1,900 hours. Having looked at the epidemiological evidence relating to the exposure of underground coal miners from which he had derived a relationship between exposure to respirable dust and loss of lung function[148], he concluded that it was appropriate, when considering exposure levels to dust for the purposes of COPD and CB, to take into account additional hours worked over and above the basic annual hours. Accordingly, he adjusted his figures for total and respirable dust to take account of overtime. In doing so, he used the same overtime data as did Professor Syred. He made clear that he had reservations as to whether those data accurately represented the amount of overtime worked by each of the lead claimants. Nevertheless, he was content to use them.

4.57 Professor Jones did not consider it appropriate to take overtime into consideration when considering exposure to BSM and BaP in connection with the causation of cancer. In the case of lung cancer, he considered it unlikely that the epidemiological studies from which he had derived his risk factor for lung cancer had involved any analysis of the number of hours worked by the coke workers or aluminium smelters who were the subjects of the studies. He thought it probable that those employed in the industries with which the studies were concerned would have worked at least some overtime. Consequently, he considered it inappropriate to make any adjustment in respect of overtime performed by workers at the Phurnacite Plant.

[148] Jones1/65 et seq.

4.58 The evidence is that most men employed at the Phurnacite Plant regularly worked overtime. The usual arrangement was that they had two rest days a week. Most men appear to have worked for one of those rest days, often on jobs different from their usual duties. In addition, some men would work double shifts on occasion or would sometimes work on both their rest days. Whilst the available overtime records are sparse, I am satisfied that they represent a reasonably accurate picture of the hours actually worked by the lead claimants. I accept that overtime should be taken into account when considering a claimant's exposure to dust. However, for the reasons given by Professor Jones, I accept also that it would not be appropriate to take into account overtime when considering the risks of cancer associated with exposure to BSM or BaP.

SECTION 5

BREACH OF DUTY

Overview

5.1 The Phurnacite manufacturing process was initially undertaken with a view to converting cheap, readily available materials into a useful and profitable product. The venture met with considerable success and, during the 1950s, 1960s and early 1970s, manufacturing capacity at the Phurnacite Plant was continually expanded. However, that expansion was not accompanied by the installation of suitable infrastructure to deal with the dust, fume and effluent emitted from the Phurnacite Plant. It is clear that, at least from the early 1950s, there were serious concerns about the atmospheric and other pollution caused by the Phurnacite manufacturing process. Those concerns caused the Alkali Inspectorate and the local district council to press the NCB to take remedial measures. This pressure was maintained and increased over a period of more than three decades until the cessation of Phurnacite production in 1990.

5.2 By the late 1960s, the NCB were already discussing making radical changes to the way Phurnacite was manufactured. It was recognised that the Disticoke ovens gave rise to a pollution problem which was described in 1967 by the deputy technical director of the NCB Coal Products Division as seemingly "insurmountable". Nevertheless, two further Disticoke batteries were built at the Phurnacite Plant, the first commissioned in 1968 and the second in 1970.

5.3 By June 1972, however, the uncertainties about the future of the long term market for Phurnacite, together with the recognition of the difficulties of maintaining the plant and equipment used for manufacturing Phurnacite led to a decision by the NCB CPD Divisional Board to curtail capital expenditure on the Phurnacite Plant. The relevant Minutes[149] stated:

> "Apart from the introduction of items such as facilities to improve coal blending, completion of work on No. 2 battery, and anti-pollution measures, capital expenditure should be curtailed. Batteries should be kept in the best condition possible so as to achieve maximum output over the next few years without involving the Board in heavy capital commitments on battery rebuilds."

5.4 As a consequence of this "make-do-and-mend" policy, as it was termed by Mr Scargill, then manager of the Phurnacite Plant, in a document written in 1975[150], the previous policy of re-building batteries after 15 years' service was discontinued, with the result that the condition of the older batteries deteriorated and manufacturing capacity fell. Mr Scargill described the Disticoke ovens as "outdated"; they failed to meet "modern standards in pollution control" and were expensive to maintain and operate. Mr Scargill recommended that the Divisional Board should consider replacing the Disticoke ovens with an alternative manufacturing process.

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[149] Syred5/214
[150] Syred5/221

5.5 The problems of pollution associated with the Disticoke ovens were exacerbated by the reduction in the availability of coal which was suitable for use in the Phurnacite manufacturing process. During the hearing, it was suggested on behalf of the claimants that the NCB/NSFL should have done more to secure adequate supplies of suitable coal. It was argued that economics had played a significant part in the NCB's decision to use local coal supplies, rather than looking further afield (even abroad) for the right type of coal. I do not consider that I am equipped to express a view about those criticisms. I did not hear detailed evidence on the topic of coal supply and did not find Professor Syred's assertion (based on internet research conducted whilst he was giving evidence) that the NCB could readily have obtained supplies of suitable coal from France particularly compelling. I shall proceed on the basis that, for whatever reason, the Phurnacite Plant experienced increasing problems with production and pollution because much of the coal used in the manufacture of Phurnacite was not really suitable for that purpose.

5.6 The overwhelming impression I have gained from the documents is that the major measures to reduce emissions of dust and fume at the Phurnacite Plant were undertaken directly in response to pressure from outside agencies, in particular the Alkali Inspectorate. In the late 1950s, it was pressure from the Alkali Inspectorate that led to the installation of the ESPs to deal with the dust produced by the dryers and to the plans (albeit apparently not implemented until about a decade later) to install venturi stacks on the batteries. In the mid-1970s, action by the Alkali Inspectorate resulted in the refurbishment of the ESPs, the introduction and extension of the 'Spruce' system of quenching, the installation of a new dust collection system in trommel house 2 and of hydraulically operated pug doors, together with many other anti-pollution measures. Intervention by the Factory Inspectorate (including the threat of an Improvement Notice) led to the change from solid to liquid pitch in briquetting plant 2 in 1977. Pressure from the Factory Inspectorate and the issuing of an Improvement Notice also led to the provision in early 1981 of Racal airstream helmets (together with instructions to wear them) for men working on the oven tops. In the mid-1980s, the issuing by the Factory Inspectorate of an Improvement Notice at last ended the long standing practice of using uncarbonised dust and breeze to seal oven lids.

5.7 By the early 1980s, the ageing plant and equipment was producing worsening pollution problems and the Alkali Inspectorate were becoming increasingly insistent in their demands for action to reduce the atmospheric emissions which persisted. I have referred in Section 2 to some of the requirements imposed by the Alkali Inspectorate at that time. In a letter written to a third party in September 1981, the District Alkali Inspector confirmed that, in his opinion:

> "… the emissions of smoke, grit, dust and smelly gases from the Phurnacite Plant constitute the worst local air pollution in the United Kingdom."

5.8 It is clear that, in many instances, NSFL accepted the criticisms made by the Alkali Inspectorate and took steps to remedy them. As time went on, however, they came to regard some of the demands made by the Alkali Inspectorate as unreasonable. Mr Foster explained that, provided that a change recommended by the Alkali Inspectorate would not adversely affect production and appeared sensible and economically viable, NSFL would be prepared to implement it. However, they would not comply with demands made by the Alkali Inspectorate which they regarded as unreasonable, unlikely to be effective and/or likely to be economically damaging; examples of such demands were that NSFL should take a battery out of production or operate it at half capacity. He said that, by the 1980s, the attitude of the senior management within NSFL had hardened. Their view was that, as long as the Phurnacite Plant was operating within the legal limit for industrial emissions and was safe from prosecution, they were fulfilling their obligations and need not do more.

5.9 Many of the modifications and improvements made to the Phurnacite Plant and the processes carried on there had the incidental benefit of reducing workers' exposure to dust and fume emissions. There is also evidence of action being taken to deal with complaints raised by members of the workforce at the Phurnacite Plant. The Minutes of meetings of the Phurnacite Plant Consultative Committee contain many examples of criticisms about working conditions being raised and being dealt with by changes to working practices and equipment. The problems at the Phurnacite Plant were discussed regularly at meetings of other NSFL and NCB Committees and were well known to the NCB/NSFL management. I have no doubt that there were some men employed by the NCB/NSFL over the years – including members of the Phurnacite Plant management staff – who did their best to effect improvements in the working conditions at the Phurnacite Plant.

5.10 In general, however, the attitude of the NCB/NSFL to the safety of their workforce appears to have been reactive, rather than proactive. This attitude is illustrated by their delay in completing the process of changing from solid to liquid pitch, by their apparent inability to identify a suitable alternative material for the sealing of ovens and to enforce its use, and by their delay in introducing and enforcing the use of RPE. It is also exemplified by their failure to take appropriate action to respond to the levels of exposure to BSM and BaP revealed by the personal sampling carried out during the periods 1971-1972 and 1975-1983, despite the fact that those levels cannot (or should not) have provided any reassurance that their workers were being properly protected and in many instances were worryingly high. Levels of exposure to dust frequently exceeded the relevant TLV and most of the sampling results revealed BSM in excess of the ACGIH TLV of 0.2 mgm^{-3}.

5.11 In October 1976[151], Mr AF Smith, the NCB's chief scientist for Wales, addressed a meeting of the Phurnacite Plant Consultative Committee about the results of recent personal sampling. He noted, apparently without comment, that the average dust levels in the briquetting plants were significantly in excess of the recommended level of 10 mgm^{-3}. He observed that the levels of BSM found were "very erratic" and well in excess (an average of 17 mgm^{-3} on the oven tops and 15 mgm^{-3} on the shuttle car floor) of the "target figure" of 0.2 mgm^{-3}. He observed that the target figure was "not very practical" for the Phurnacite Plant since the tests had been devised for coke ovens which did not use pitch. He did not express any concern that the figures might indicate that workers were being exposed to potentially harmful levels of carcinogenic material or any indication that steps should be taken to protect them. He merely commented that the target figure "would probably be amended in the future". That incident illustrates the attitude of the NCB/ NSFL management at the time.

5.12 In some instances, it is clear from the documents that the NCB/ NSFL were reluctant to take certain precautions because of the potential cost. I am satisfied that cost was a significant factor in the delay in introducing suitable RPE for workers on

[151] CB4/246

the oven tops. It is evident too that cost was also a major factor in the failure to solve the problem of the dust being emitted from the raw ovoid conveyors, despite the scale of the problem and the effects it was having on local residents and on the men working near the conveyors. Dr Choo Yin observed in his witness statement:

> "HSE took the view that the company should aim to achieve lower than Threshold Limit Values (TLV) levels, and to reduce exposures to the lowest levels possible. The company attitude, however, tended to be that they should get levels below the TLV – within the TLV as the legal limit. There was a culture within the company of working to approved limits rather than reducing to the lowest level practicable. The company would try to reduce levels but, on balance, the cost of measures to reduce the levels was always a major consideration."

5.13 I am satisfied that Dr Choo Yin's assessment was accurate. However, insofar as the exposure levels of many of the defendants' workers were concerned, NSFL were not in fact meeting the relevant threshold levels of exposure.

5.14 It seems that, from 1980 onwards, NSFL[152] virtually ceased to undertake environmental measures aimed at reducing atmospheric pollution from their plants for financial reasons. In December 1982, the decision was taken to reduce the frequency of personal sampling of exposure levels to harmful substances for reasons of economy. It seems that the newly re-constituted Environmental Control Committee (which had been disbanded in 1980) would have preferred to abandon personal sampling entirely but decided against this course because:

> "… the need for the Company to be seen to be monitoring the parameters was accepted, and only by carrying out surveys now could any future improvements be demonstrated."

5.15 It is plain that there was no intention to act on the results of the personal sampling that was to be carried out in the future.

5.16 I have already described many of the improvements that did take place. Some made a real difference to the working conditions at the Phurnacite Plant. Others were less effective or gave only temporary benefit. The amount of dust and other waste material generated by the Phurnacite manufacturing process was such that sophisticated equipment such as the cyclones and ESPs that removed dust from the dryers had difficulty in coping with it. The age and design of the Phurnacite Plant, the nature of the materials used in the Phurnacite manufacturing process and the failure to maintain a regular programme of rebuilding ovens all added to the problems. Having read and heard the evidence about the dust, dirt, heat and fume to which men working at the Plant were exposed and having viewed the photographs, it is clear to me that, despite the various measures that were taken, the working conditions at the Phurnacite Plant remained very poor throughout the period of its operation.

[152] CB8/154

The allegations of breach of duty

5.17 The claimants allege breaches of various provisions of the Factories Acts, 1937, 1959 and/or 1961; breaches of provisions of the Patent Fuel Manufacture (Health and Welfare) Special Regulations 1946 (the 1946 Regulations) and breaches of the COSHH Regulations 1988. They also allege common law negligence.

Breaches of the provisions of the Factories Acts

5.18 The relevant provisions were section 47 of the Factories Act 1937 (the 1937 Act) and section 63 of the Factories Act 1961 (the 1961 Act) which provided for protection against dust, fume and other impurities; section 4 of the 1937 and 1961 Acts, which imposed a duty to ventilate; and section 5 of the Factories Act 1959 (the 1959 Act), later replaced by section 29 of the 1961 Act which imposed a duty to provide a safe place of work.

Section 47 of the 1937 Act and/or section 63 of the 1961 Act

5.19 Section 47 of the 1937 Act, which was reproduced in section 63 of the 1961 Act provided:

> "In every factory in which, in connection with any process carried on, there is given off any dust or fume or other impurity of such a character and to such extent as to be likely to be injurious or offensive to the persons employed, or any substantial quantity of dust of any kind, all practicable measures shall be taken to protect the persons employed against inhalation of the dust or fume or other impurity and to prevent its accumulating in any workroom and, in particular, where the nature of the process makes it practicable, exhaust appliances shall be provided and maintained, as near as possible to the point of origin of the dust or fume or other impurity, so as to prevent its entering the air of any workroom."

5.20 The duty to take all practicable measures arises if one or more of a number of pre-conditions are met. Those pre-conditions are, in the case of dust, if the dust was (a) likely to be injurious to the persons employed, or (b) likely to be offensive to the persons employed, or (c) of any substantial quantity. In the case of fume, the pre-conditions are that the fume was (a) likely to be injurious to the persons employed, or (b) likely to be offensive to the persons employed. For the purposes of the Factories Acts, 'fume' includes 'gas or vapour'.

5.21 The defendants' final position at trial was to accept that each of the lead claimants had been exposed to a substantial quantity of dust at the Phurnacite Plant. Indeed, they admitted that any worker who had been employed on the oven tops or other parts of the batteries or in the briquetting buildings during the period from 1947 until 1980/81 would have been exposed to a substantial quantity of dust. They did not accept that workers would have been exposed to a substantial quantity of dust in those locations after 1980/81 because Racal airstream helmets (for use on the oven tops) and 3M masks (for use elsewhere) were provided and widely used after that time. The defendants also admitted that workers in the pitch handling areas would have been exposed to a substantial quantity of dust during the period from 1947 until the change to liquid pitch (which occurred in 1975 at briquetting plant 1 and 1977 at briquetting plant 2) and the consequent closure of the pitch handling areas.

5.22 In their final written submissions, the defendants did not accept that workers in the exhauster houses would have been exposed to a substantial quantity of dust. Nor did they accept that there would have been exposure to a substantial quantity of dust in the coal sample rooms, although they accepted that they had been in breach of duty in the case of Mr Griffiths, the only coal sampler amongst the lead cases. They indicated that there were other locations at the Phurnacite Plant, such as the coal blending site and other outdoor areas, in respect of which they would deny breach of duty on the basis that the men working there had not been exposed to a substantial quantity of dust.

5.23 The defendants' admissions related only to the concession that workers employed in certain areas of the Phurnacite Plant would have been exposed to a substantial quantity of dust and that they had therefore been required under the provisions of section 47 of the 1937 Act and/or section 63 of the 1961 Act to take all practicable measures to protect them. They did not accept that the other pre-conditions of section 47 of the 1937 Act and/or section 63 of the 1961 Act (namely that workers had been exposed to dust and/or fume that was "likely to be injurious" or "likely to be offensive") had been met or (in the case of "likely to be offensive") that, if met, it gave rise to a duty the breach of which would sound in damages. I have considered those other pre-conditions in the event that they might turn out to be significant in the context of the Phurnacite litigation as a whole.

5.24 I shall consider first the meaning of the phrase "likely to be injurious". In *Knox v Cammell Laird Shipbuilders Limited*[153], Simon Brown J (as he then was) reviewed the previous case law before concluding that:

> "…the question posed by section 47 is whether the employers should have recognised the risk that fume inhalation might well injure some of the workforce operating in confined spaces."

5.25 In *Anderson v RWO Power Plc*[154] Irwin J adopted that interpretation. I adopt it also. It is clear from the authorities that the words "likely to be injurious" imply a degree of foresight about the possible risks. Thus, the claimants must prove that the defendants should have recognised at the relevant time, according to the knowledge and standards of the day, that such exposure might well injure workers exposed to the relevant dust and/or fume. It is not necessary that the defendants should have recognised the specific nature of the risk involved; all that is required is a recognition of the risk of some personal injury.[155]

5.26 The defendants admitted that they were at all times aware that exposure to a substantial quantity of dust was likely to cause COPD and/or CB. They admitted also that the dust and fume emitted from the oven tops and the dust emitted at the pitch handling areas (until their closure) and at the briquetting plants were potentially injurious in that they contained PAHs. However, they contended that, until the early

[153] Unreported (30 July 1990) Transcript at 94c-d
[154] Unreported (22 March 1990) Transcript at paragraph 48
[155] *Page v Smith* [1996] AC 155

1970s, there was no reason for them to believe that exposure to dust or fume containing PAHs gave rise to a risk of lung, bladder or skin cancer or that the emissions from the Phurnacite ovens might give rise to any risk of respiratory disease.

5.27 The defendants accepted that, from 1970, after the publication of American studies[156], which showed increased risks of respiratory cancer amongst workers employed on coke ovens, they knew or ought to have known that there was an increased risk of lung cancer due to occupational exposure to dust and fume at the Phurnacite oven tops. However, they denied that, at any time between 1947 and 1990, they should have recognised (a) that there might be a risk of lung cancer arising from exposure to dust or fume in any part of the Phurnacite Plant other than the oven tops, (b) that there might be a risk of bladder cancer associated with work at the Plant, (c) that there might be any risk of skin cancer associated with inhalation of dust or fume at the Plant and (d) that there might be a risk of respiratory disease arising from Phurnacite oven emissions. They therefore contended that, other than that emitted from the Phurnacite ovens after the early 1970s, the dust and fume to which workers at the Phurnacite Plant were exposed were not "likely to be injurious" within the meaning of section 47 of the 1937 Act and/or section 63 of the 1961 Act.

5.28 The defendants were aware of the risks of non-malignant respiratory disease associated with inhalation of substantial quantities of coal and other dust. They admitted that they had known throughout the period for which the Phurnacite Plant was in operation that dermal exposure to pitch was liable to cause various skin lesions, including skin cancer. In a paper delivered in May 1952, Dr Rogan, then chief medical officer of the NCB, referred to the fact that men working with tar and its derivatives (including pitch) were "all liable to occupational skin disease, simple or malignant, to a greater or lesser degree".

5.29 The 1946 Regulations are relevant here. They did not apply to the coke oven industry. They applied only to factories making patent fuels and using pitch as a binding agent. The Phurnacite Plant was such a factory. The 1946 Regulations imposed a number of duties on factory owners, including duties to prevent the escape of dust by the provision of mechanical exhaust equipment or adequate ventilation. The Preamble to the 1946 Regulations explained why additional precautions were considered necessary in premises where pitch was being used as a binding agent. It stated

> "Whereas the Minister of Labour and National Service is satisfied that the manufacture in factories of briquettes, ovoids or other blocks of fuel consisting of coal, coal dust, coke or slurry with pitch as a binding agent is of such a nature as to cause risk of bodily injury to persons employed in connection therewith."

5.30 Those words, taken together with the provisions of the 1946 Regulations, made it quite clear that dust containing pitch was believed to carry with it a risk of injury over and above that associated with coal dust. The fact that many of the Regulations imposed absolute duties on the factory owner emphasised the risk that was perceived to be involved. By 1946, it was known that pitch contained PAHs

[156] In particular those by Lloyd *et al* and Redmond *et al*

including BaP which was a pure carcinogen. I have no doubt that the defendants were well aware of that fact. If they were not, they should have been.

5.31 The defendants were certainly aware of the possible risk of cancer associated with coke ovens. A paper published in 1947[157] had pointed to the possibility that certain occupations, including the charging of coke ovens, carried a significant risk of lung cancer. A paper by Sir Richard Doll published in 1952[158] identified an excess risk of lung cancer amongst gas workers who had been exposed to carcinogenic hydrocarbons. Dr Rogan's paper of 1952 referred to the fact that it was "fairly certain" that the fume emitted by coke ovens contained "cancer-producing substances", including BaP. He advised that, in view of the risks, exposure to fumes during the charging of ovens "should be reduced to the minimum" when new plant was designed. He reported that the NCB were carrying out research into "the cancer problem among NCB coke oven workers". That research continued for several years thereafter.

5.32 In 1956, a report was published giving details about the research[159]. It had consisted of an examination of the causes of death of past and current workers at the NCB's coke works who had died between 1949 and 1954. The NCB Scientific Department's Annual Reports for 1952[160] and 1953[161] contained references to the study and the NCB received a provisional report of the study dating from 1954[162]. That provisional report referred to the "small excess" of deaths due to cancer, in particular cancer of the respiratory system, amongst past and present oven workers. The final report of the study did not identify an overall excess of risk of lung cancer. There was however an excess risk (albeit not statistically significant) for men who had worked on the coke ovens at some time during their employment at a coke works.

5.33 A further study by Sir Richard Doll *et al*, published in 1965[163] identified an excess risk of lung cancer amongst coal carbonising process workers employed in gas works, which Sir Richard and his co-authors linked to the high levels of BaP found in the atmosphere of gas retort houses. Meanwhile, in 1967, the first ACGIH TLV for CTPVs of 0.2mgm^{-3} was introduced in the US. It is not disputed that the NCB was aware of that standard and its purpose.

5.34 In December 1970, an internal document produced by an unnamed member of the staff of the NCB (probably a doctor or scientist) in response to the recent publication of a study by Lloyd *et al* referred to the fact that "attempts to assess the apparent health hazard of working on coke oven batteries" had been going on since the early 1950s:

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157 Kennaway EL and Kennaway NJ. *A further study of the incidence of cancer of the lung and larynx.* British Journal of Cancer 1(3);260-198:Jones6/225

158 Doll R. *The causes of death among gas workers with special reference to cancer of the lung* (1952). Br J Individual Medicine : 9(3): 180-185: Jones 3/14

159 Buck C and Reid DD *Cancer in coking plant workers* (1956). British Journal of Industrial Medicine: 11(2): 75/104: Jones 2/237

160 CB1/7

161 CB1/11

162 CB1/33

163 Doll R, Fisher RE et al. *Mortality of gas workers with special reference to cancers of the lung and bladder, chronic bronchitis and pneumoconiosis'*. British Journal of Industrial Medicine 22:1-12: Jones 3/20

> "… since there seems little doubt that under certain conditions work on coke ovens may lead to the development of cancer or respiratory diseases."

5.35 Those words strongly suggest that the NCB had been aware of the ongoing research and the concerns about health risks that had given rise to it.

5.36 There can be no doubt in my view that the NCB/NSFL were or should have been aware of the real possibility that the emissions of dust and fume containing pitch at the Phurnacite Plant might give rise to a risk of injury. They were plainly aware of the concerns about the possible link between coke oven emissions and various types of cancer and about the research which was being conducted. That research related to coke plants, where pitch was not used as a binding agent. It should have been evident to the NCB/NSFL that the use of significant quantities of pitch in the Phurnacite manufacturing process might give rise to an even greater risk of injury than that presented by coke ovens. Thus, I find that the claimants have succeeded in establishing that, throughout the period between 1947 and 1990, the NCB/NSFL exposed their workers to dust and fume that were "likely to be injurious".

5.37 Based on the evidence I read and heard from those who worked at the Phurnacite Plant, I have no difficulty in finding that the dust and fume to which the men who worked in many parts of the Phurnacite Plant, (in particular the pitch bays, the buildings in the briquetting plants and the batteries), were exposed were "likely to be offensive". I did not understand the defendants to be seriously disputing that fact. However, the defendants contended that, even if the dust and fume were "likely to be offensive", that would not be sufficient to found a claim for civil liability. In making that contention, they relied on observations made *obiter* by Latey J in the case of *Cartwright v GKN Sankey Ltd*[164] :

> "First, there are the words "or offensive" in section 63(1) and their materiality, if any, in this case. At an early stage Mr Cox said that he would contend that if the fume was not injurious the plaintiff had a cause of action on the ground that it was "offensive". Mr Clothier objected, pointing out, as is the fact, that there is nothing in the pleadings to that intent and that to introduce it now would be to open up a new field of inquiry and evidence. I agreed with him. Nor can I see that it would avail the plaintiff. The words "or offensive", being disjunctive and in contradistinction to "injurious", suggest that though there might be an injuria it is difficult to see what damnum there could be calling for compensation. It is, in my opinion, a purely penal provision to ensure reasonable welfare or amenity conditions of working. Mr Cox did not pursue the argument or his application to amend – rightly in my opinion."

5.38 However, in *Brooks v J & P Coates*[165], the leading byssinosis case, when the point was fully argued, Boreham J took a different view. He said at 174E-175B:

[164] [1972] 12 KIR 453
[165] [1984] ICR 158

> "…. The question remains, if it was not injurious to their health, was it offensive to them or to take the second leg, was it given off in a substantial quantity? In my judgment there is no doubt – and I have done my best to describe the sort of conditions which prevailed – that the quantity of dust was sufficient to be offensive to people working in that mill and certainly was sufficient to be regarded, to use the words of the Act, as in substantial quantity. It follows, therefore, that it was the defendants' duty under section 63(1) to take all practicable measures to protect the persons employed from inhaling dust;
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> …In those circumstances I find the defendants in breach of section 63 as well as in breach of section 4. There is no doubt, the contrary is not argued, that there is a causal connection between the breaches and the injury sustained by the plaintiff and thus I find the defendants liable."

5.39 In the case of *Knox*, Simon Brown J preferred the approach of Boreham J. I agree. I can see no reason to believe that Parliament did not intend that exposure to dust which was "likely to be offensive" should not found a valid civil claim, provided of course that the claimant has suffered injury as a result of his exposure. Thus, I find that the claimants have succeeded in establishing that, throughout the period between 1947 and 1990, the defendants exposed their workers to dust and fume that were "likely to be offensive".

The issue of practicability

5.40 Section 47 of the 1937 Act and section 63 of the 1961 Act required a factory owner to take all practicable measures to protect workers against the inhalation of dust or fume which satisfied one or more of the pre-conditions discussed in the preceding paragraphs. The onus is on the defendants to plead and prove that all practicable measures were taken[166].

5.41 At the start of the trial, the defendants were contending that they had taken all measures that were "reasonable and practicable" save in relation to exposure to dust and fume emitted on the oven tops after the early 1970s. They conceded that there were measures they could have taken to protect men from exposure on the oven tops after that time. They contended that, otherwise, they had taken appropriate precautions. They said that they had made a large number of modifications and improvements in order to reduce exposure to dust and fume. The defendants argued that, in order materially to reduce the amount of dust and fume generated, it would have been necessary to re-design and rebuild major parts of the Phurnacite Plant. That, they said, would have been disproportionately expensive and would not have been "reasonable".

5.42 Section 47 of the 1937 Act and section 63 of the 1961 Act required the measures taken to be "practicable", not "reasonably practicable". The difference between the two concepts was examined in the cases of *Adsett v K and L*

[166] *Nimmo v Alexander Cowan & Sons Limited* [1968] AC 107

Steelfounders and Engineers Ltd[167] and *Moorcroft v Thomas Fowles & Sons Ltd*[168]. In *Adsett*, Parker J (as he then was) said at 141:

> "…It seems to me that "practicable" must impose a stricter standard than "reasonably practicable". Under "practicable" questions of cost may be eliminated, but what is to be done must still be possible, and it must, as I see it, be possible in the light of current knowledge and invention at the time."

5.43 In *Moorcroft*, Lord Parker CJ (as he had by then become) stated that "impracticable" meant "not possible" or "not feasible". He repeated his view that "practicable" must impose a stricter standard than "reasonably practicable". He went on to say:

> "It may be that certain matters one would take into consideration if the words were "reasonably practicable", such matters as the cost and the like, have to be eliminated."

5.44 In the event, having considered the evidence, the defendants conceded that there were measures that they could have taken to reduce exposure to dust and fume which they did not take. They also accepted that there were measures that they could have taken sooner. They therefore accepted that, to use Mr Walker's words, they were "unable to surmount the high hurdle of showing that it was impracticable" to reduce their workers' exposure to dust and fume. That was a realistic concession. It is quite clear from the description I have given of working conditions at the Phurnacite Plant that far more could have been done to reduce or to eliminate sources of dust and fume and to protect the defendants' workforce. I shall return to the issue of the measures that could have been taken when I consider the question of whether there was an irreducible minimum of dust and fume to which the claimants would have been exposed, whatever steps the defendants had taken.

5.45 I therefore find that, throughout their operation of the Phurnacite Plant, the defendants were in breach of their duty under section 47 of the 1937 Act or section 63 of the 1961 Act in respect of men working in the pitch bays, the briquetting buildings (by which I mean the dryer house, the buildings in which the pug, back end and presses were situated and press house 5 at briquetting plant 2) and the batteries.

5.46 As to the coal sample room and the main sample room, I am satisfied that, at times when there was dust visible in the air, that dust must have been of a "substantial quantity" and was probably also "likely to be offensive", particularly in the small area of the coal sample rooms. I find also that, in exhauster house 1, there would have been times (in particular, during cleaning operations), when the dust would have been of a "substantial quantity" and "likely to be offensive". The pungent fumes and volatilised substances produced by steam cleaning would also have been "likely to be offensive" and the latter would have been "likely to be injurious". Professor Jones' 'background' levels, estimated by reference to his modelling dispersion exercise, reveal significant levels of BSM in both exhauster houses (twice the ACGIH TLV in exhauster house 1 and five times the ACGIH TLV in exhauster house 2). As I have

[167] [1953] WLR 137
[168] [1962] 3AUER 741 at 746

already observed, I consider that his estimated exposure levels for exhauster house 1 under-estimate the levels of exposure for men employed in exhauster house 1.

5.47 I am also satisfied, having regard to the evidence and, in particular, Professor Jones' 'background' exposure levels, as derived from his modelling dispersion exercise, that the defendants were also in breach of their duties under section 47 of the 1937 Act or section 63 of the 1961 Act in respect of the workshops, where plant and equipment contaminated with pitch dust would have been repaired, and in the boiler houses at the briquetting plants. I do not consider that there is sufficient evidence to demonstrate that they were in breach of duty in respect of either the offices/canteen or the coal blending site.

5.48 The issue of breach of duty in the open areas of the Phurnacite Plant is more difficult and it is perhaps unfortunate that I did not hear detailed submissions about it. Professor Jones' 'exposure matrices' suggest an average external exposure level to BSM of more than twice the TLV and to BaP of not much below the level on the quenching car floor/ramps. There can be no doubt that there was a great deal of dust containing pitch deposited around the Phurnacite Plant and that the dust would have been blown about in the atmosphere and would at times have been offensive to men working in the outside areas.

5.49 The claimants contended that, insofar as workers were exposed to dust in the open areas of the Phurnacite Plant, the defendants would have been liable if their exposure could properly be attributable to breaches of section 47 of the 1937 Act and/or section 63 of the 1961 Act. I was referred to the decision of Irwin J in *Anderson*. Mr Anderson worked at a power station for a short period in the late 1940s. He was employed in the accounts department and was never involved in any of the industrial processes carried on at the power station. The boilers and much of the pipework at the power station were insulated with asbestos lagging material. The material was regularly removed and renewed, involving operations such as mixing, stripping, sawing and sweeping asbestos. Those operations produced large quantities of asbestos dust to which Mr Anderson was exposed as he walked around inside the power station. Years later, he developed a mesothelioma which it was conceded had been caused by exposure to asbestos at the power station. It was held that, although it could not be established that Mr Anderson had been close to any specific operation involving asbestos so that he was exposed to significantly higher levels of asbestos than the general atmosphere in the power station, he was entitled to rely on the breaches of section 47 of the 1937 Act that had undoubtedly occurred and had caused asbestos to enter the general atmosphere.

5.50 Mr Allan submitted that, by analogy with *Anderson,* the claimants in this litigation should be able to rely on the breaches of section 47 of the 1937 Act or section 63 of the 1961 Act which had occurred and which had caused the emission of dust containing PAHs into the general environment in the open areas of the Phurnacite Plant. It seems to me, however, that the position in this litigation is very different to that in *Anderson*. The exposure with which I am concerned here occurred outside the "workrooms" of the Phurnacite Plant, in the open air. The purpose of section 47 of the 1937 Act and section 63 of the 1961 Act was to ensure that dust and fume were removed from all workrooms. At least in the early years when the statutory provisions were in force, the only available means of removing dust and fume from inside workrooms would have been to vent the dust and fume to the open air. This would no doubt have changed over the years as the available extraction equipment became more sophisticated. However I heard no evidence about that. I note also that the provisions of the 1946 Regulations, which remained in force until October 1989, specifically provided for the venting of dust containing pitch to the open air. It seems to me difficult in those circumstances to say that the defendants were in breach of their duties under the 1937 or 1961 Acts and/or the Regulations for doing that.

5.51 In the circumstances, I am unable to find that there was a breach of section 47 of the 1937 Act or section 63 of the 1961 Act in respect of exposure to dust in the outside areas of the Phurnacite Plant.

Sections 4 of the 1937 and 1961 Acts

5.52 Sections 4 of the 1937 and 1961 Acts add nothing to the provisions of section 47 of the 1937 Act and/or section 63 of the 1961 Act and I do not propose to consider them further.

Section 5 of the 1959 Act and section 29(1) of the 1961 Act

5.53 The claimants also alleged breaches of section 5 of the 1959 Act and section 29(1) of the 1961 Act. Those sections required a factory owner to make and keep safe, so far as is reasonably practicable, every place at which any person had at any time to work. The sections add nothing to the provisions of section 47 of the 1937 Act and/or section 63 of the 1961 Act in relation to exposure to dust and fume. However, they are, or may be, relevant to the issue of dermal exposure to pitch and pitch dust.

5.54 The case of *Baker v Quantum Clothing Group Limited* [2011] 1 WLR 1003 established, *inter alia*, that a workplace could be "unsafe" for the purposes of section 47 of the 1937 Act and/or section 63 of the 1961 Act, not only because of its physical structures, but also by reason of the activities constantly and regularly carried on there. It also decided that safety is a relative concept which must be judged according to the general knowledge and standards of the times, by reference to what might reasonably have been foreseen by a reasonable and prudent employer. It confirmed that the primary burden is on the claimant to prove that his workplace was unsafe. If he is able to do that, the onus is then on the defendant to prove that he took all reasonably practicable measures to make and keep the workplace safe. For the purposes of section 5 of the 1959 Act and section 29(1) of the 1961 Act, the test is that of "reasonable practicability", which involves weighing the nature and potential consequences of a risk against the measures needed to meet it.

5.55 The requirement for an employee to have regular dermal contact with pitch and pitch dust, giving rise as it did to the known risk of skin lesions, including skin cancer, obviously rendered his place of work unsafe. The defendants did not seek to argue otherwise. Nor did they raise the defence of reasonable practicability. There were obvious ways for them to avoid such contact. The earlier introduction of liquid pitch or an effective system of mechanical shovelling of pitch would have eliminated or reduced the exposure of men working in the pitch bay and (if liquid pitch had been introduced earlier) would also have reduced the exposure of men working in those areas of the briquetting plant up to the point in the process when the liquid pitch was added. The provision of impermeable gloves and overalls would have had the same effect for men working at a later stage of the process. I am satisfied that, from the time when the Factories Act 1959 came into force until October 1989, when the

COSHH Regulations came into operation, the defendants were in breach of section 5 of the 1959 Act and section 29(1) of the 1961 Act. Before that time, they would have been in breach of their common law duty of care to workers who suffered substantial dermal exposure to pitch dust.

The 1946 Regulations

5.56 The claimants alleged, *inter alia*, that the defendants had been in breach of Regulations 4, 6, 7, 8, 10, 11, 13 and 17 of the 1946 Regulations. These Regulations relate to dust only. I heard little argument in relation to them. Regulations 6, 8, 10 and 11 imposed absolute duties.

5.57 Regulation 6 provided:

> "Elevators and chutes (including chutes feeding to or delivering from machines) used for conveying material in a state in which it is liable to give off dust, and any spaces through which material in such a state falls on discharge from an elevator or band-conveyor, shall be encased or enclosed throughout their length; and to prevent dust at the ends of the enclosure from escaping into the general air of the workplaces there shall be either mechanical exhaust ventilation arranged for the purpose or an adequate vent or vents in the enclosure and leading to the open air."

5.58 It is clear from the evidence that I have described in Section 2 that there was a great deal of dust emission from conveyors and transfer points both inside the briquetting plants and on the shuttle car and oven floors of the batteries, giving rise to undoubted breaches of Regulation 6.

5.59 Regulation 8 provided that:

> "Driers, disintegrators and heaters shall be so constructed and maintained as to prevent the escape of dust into the general air of the workplaces."

5.60 As I have described in Section 2 of this judgment, there were regular emissions of dust from the dryers both before the ESPs and cyclones were fitted and afterwards. On occasions, there were also emissions of dust from the disintegrators.

5.61 Regulation 10 provided:

> "Adequate mechanical exhaust ventilation shall be provided for pitch-cracking machines and at places where pitch is broken up on the floor of a workroom, so as to prevent the escape of dust into the general air of the workplaces."

5.62 There was no mechanical exhaust ventilation in the pitch bays, which were covered. The pitch crackers were enclosed but leaks would sometimes develop causing pitch dust to be emitted.

5.63 Regulation 11 stated:

> "Casings and enclosures required by these Regulations shall be maintained in good repair and in a dust-tight condition."

5.64 There was a good deal of evidence that casings and enclosures – in particular those covering the conveyors – were frequently in a damaged state and remained so for some time. As a result, emissions of dust occurred.

5.65 I am satisfied on the evidence that the defendants were in breach of all the Regulations I have referred to above. Indeed, they did not seek seriously to argue otherwise.

The COSHH Regulations

5.66 From October 1989, the COSHH Regulations replaced section 63 of the Factories Act 1961 and the 1946 Regulations. The COSHH Regulations are of limited relevance to the lead cases since they affect only Mr Middle, who was employed by the defendants until after Phurnacite production ceased in 1990. Between October 1989 and 1990, Mr Middle was employed as a rigger/plater in briquetting plant 2 and was exposed to large quantities of dust from the processes carried on there. The claimants contend that the defendants were in breach of Regulations 6-12 of the COSHH Regulations. I do not propose to deal with all those Regulations in detail. Suffice it to say that there was a clear breach of Regulation 7 which provides that:

> "7 (1) Every employer shall ensure that the exposure of his employees to substances hazardous to health is either prevented or, where this is not reasonably practicable, adequately controlled.
> (2) so far as is reasonably practicable, the prevention or adequate control of exposure of employees to a substance hazardous to health shall be secured by measures other than the provision of personal protective equipment.

Common law negligence

5.67 In the light of the findings that I have made in relation to breach of statutory duty, it is unnecessary for me to address the issue of common law negligence.

The irreducible minimum

5.68 The defendants argued that, even if all practicable measures had been taken to reduce dust and fume levels, there was nevertheless an irreducible minimum level which would inevitably have been generated by the Phurnacite manufacturing process. Men working at the Phurnacite Plant would have been exposed to that minimum level (the 'non-tortious' level) of dust and fume without any breach of duty on the part of the defendants. The defendants relied on a number of cases in which the court had identified an element of non-tortious exposure. The case of *Allen and others v British Rail Engineering Limited*[169] concerned four 'lead' vibration white finger claims in which the trial judge had reduced the damages assessed for Mr

[169] [2001] ICR 942

Allen's total injury to reflect, *inter alia*, the fact that, even had the defendant taken all proper precautions, he would still have been exposed to a non-tortious level of exposure which would have contributed to his total injury. Giving the judgment of the Court, Schiemann LJ set out the principles which had been established by the relevant case law. Amongst those principles were:

> "… (iv) The court must do the best it can on the evidence to make the apportionment and should not be astute to deny the claimant relief on the basis that he cannot establish with demonstrable accuracy precisely what proportion of his injury is attributable to the defendant's tortious conduct. (v) The amount of evidence which should be called to enable a judge to make a just apportionment must be proportionate to the amount at stake and the uncertainties which are inherent in making any award of damages for personal injury."

5.69 Schiemann LJ went on to approve the approach of the trial judge who had adopted a 'broad brush' approach to the assessment of non-tortious exposure. A similar approach had previously been taken by the Northern Ireland High Court in the case of *Bowman and others v Harland and Wolff plc*[170]. In the leading deafness case of *Thompson v Smiths Shiprepairers Limited*[171], there had been a period of non-tortious exposure to excessive noise before the defendants had the knowledge necessary to place them in breach of duty. In explaining how he had approached the issue of apportionment, Mustill J said at 443G-444B:

> "Thus, whatever the position might be if the court were to find itself unable to make any findings at all on the issue of causation and was accordingly being faced with a choice between awarding for the defendants in full, or for the plaintiffs in full, or on some wholly arbitrary basis such as an award of 50 per cent, I see no reason why the present impossibility of making a precise apportionment of impairment and disability in terms of time, should in justice lead to the result that the defendants are adjudged liable to pay in full, when it is known that only part of the damage was their fault. What justice does demand, to my mind, is that the court should make the best estimate which it can, in the light of the evidence, making the fullest allowances in favour of the plaintiffs for the uncertainties known to be involved in any apportionment. In the end, notwithstanding all the care lavished on it by the scientists and by counsel I believe that this has to be regarded as a jury question, and I propose to approach it as such."

5.70 The defendants argued that I should apply the same sort of 'broad brush' approach to the issue of apportionment in this case. Mr Walker submitted that I should adopt as the basis of such apportionment the evidence given by Mr Stear about working conditions at the Avenue Works, a coke plant operated by the NSFL. Mr

[170] [1992] ICLR 349
[171] [1981] 1 QB 192

Stear had been referred to a section of Professor Syred's Generic Report[172] in which Professor Syred had compared the results of personal sampling carried out on the batteries at the Phurnacite Plant with the results of sampling conducted at and around the ovens at other plants operated by NSFL.

5.71 Mr Stear observed that the "best" of the NSFL plants (i.e. the plant with the lowest exposure levels) appeared to be the Avenue Works. The sampling results showed that the levels of dust, BSM and BaP on the oven tops at the Avenue Works were between 25% and 50% of the levels at the Phurnacite Plant. He attributed the lower levels of exposure at the Avenue Works to better housekeeping and the provision of better seals on the oven lids/doors, together with a different system of charging the ovens (sequential charging) from the system in operation at the Phurnacite Plant. He said that the Avenue Works still had exposure levels in excess of the ACGIH TLV. However, those exposure levels "represented the best they could achieve". On the basis of that evidence, the defendants contended for a finding that the irreducible minimum level of exposure was 33% or, at the least, 25%.

5.72 The claimants' case was that no reduction at all should be made in respect of non-tortious exposure. They argued that the burden was on the defendants to show that they had taken all practicable measures to protect the claimants from inhaling dust and fume and that, even if they had taken all practicable measures, there would still have been some exposure which was unavoidable and therefore non-tortious. They said that the defendants had adduced no evidence on practicability and had not discharged that burden. They submitted that there were a large number of measures that the defendants could and should have taken to protect the claimants from inhaling dust and fume. I shall refer briefly to some of the measures that the claimants said could have been taken.

Measures to address the sources of fume and dust

5.73 The claimants contended that, if the defendants had complied with the 1946 Regulations, many of the sources of dust in the briquetting plants would have been entirely eliminated. Regulations 6, 8, 10 and 11 imposed absolute duties and it was therefore not open to the defendants to contend that it had not been practicable to eliminate all exposure to dust from those sources. Moreover, the measures that were taken should have been more effective. For, example, there should have been more and better designed ESPs, together with more effective extraction in the briquetting plants. Many of the measures which were eventually taken to improve conditions could have been taken much earlier. For example, the provision of liquid pitch at an earlier time would have eliminated the need for the pitch men to break up solid pitch and would also have improved conditions for men working in the briquetting buildings.

5.74 The evidence showed that the re-introduction into the Phurnacite manufacturing process of large quantities of dust and breeze (including very fine dust from the ESPs, together with dust and breeze from the presses, the trommel houses, the batteries and the screen houses) greatly exacerbated the dust problems in the briquetting plants. The dust from the ESPs was recycled purely as a means for disposing of it. It did not add value to the finished Phurnacite product. The claimants suggested that it should have been possible to dispose of the dust in some other way,

[172] Part 5 at Syred1/109-113

thus avoiding the many problems involved with storing, collecting and transporting the dust and re-introducing it into the Phurnacite manufacturing process. As for the remainder of the dust and breeze, measures should have been taken to devise a proper system for recycling them without the escape of dust. A system should have been devised for disposing of the large quantities of dust produced at various points on the raw ovoid conveyors.

5.75 The claimants submitted that there was also much that could have been done to improve conditions on the batteries. Better maintenance of the ovens (including doors and lids) and a properly scheduled programme of rebuilding of the ovens would have reduced leakages of fume and gas. The elimination of the practices of over-filling ovens and of using uncarbonised material to seal oven lids would have reduced emissions. Increased carbonising times would have had the same effect. Better maintenance of the elephants and the gas off-takes would have prevented leaks from those sources. The building of more quenching towers and/or the use on all the batteries of a system such as the 'Spruce' system would have reduced the amount of dust and grit given off during quenching.

Cleaning and housekeeping systems

5.76 The claimants also contended that the systems of cleaning and general housekeeping at the Phurnacite Plant could have been much improved. Many of the defendants' documents refer to inadequacies of those systems in all parts of the Phurnacite Plant, particularly the briquetting buildings and the oven floors. In August 1975[173], the Alkali Inspectorate advised management at the Phurnacite Plant that:

> "Housekeeping…has clearly not been an integral part of maintenance work. There are many points throughout the system where blockages have occurred, been removed and left to blow away…A major effort is required to achieve a reasonable standard of plant cleanliness and this can only be maintained if adequate facilities are provided."

5.77 Shortly afterwards, a regular cleaning gang was established to clear up spillages. However, in April 1986[174], the report of an inspection of a number of NSFL plants revealed that, although progress had been made at the Phurnacite Plant, it was still "in need of a lot of attention", with a number of "areas of concern" remaining. The claimants contended that, had the systems of cleaning and general housekeeping in both the indoor and outdoor areas of the Phurnacite Plant been better, this would have significantly improved the working conditions of those working there. Such systems would have required the provision of sufficient and suitable vacuum cleaning equipment, a point that the Alkali Inspectorate had made in August 1975[175].

The provision of respiratory protective equipment

5.78 The claimants contended that one measure that the defendants could and should have taken to protect their workers was to provide, from the early 1950s

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[173] CB3/297
[174] CB9/53
[175] CB3/290

onwards, suitable RPE of an 'approved' type. During the trial, I heard and read a good deal of evidence about the provision of RPE at the Phurnacite Plant. What follows is a brief summary of the main points of that evidence.

5.79 The defendants' case, as set out in their opening submissions, was that, from the 1950s, suitable dust respirators and masks had been provided for the use of men working at the Phurnacite Plant. However, as the trial progressed, it became clear that, until about 1980, the only type of mask regularly worn at the Phurnacite Plant consisted of a gauze pad on a metal frame, generally known as a 'Martindale mask'. That type of mask was designed to protect the wearer against 'nuisance' dust only and did not afford adequate protection against the fine dust and fume encountered at the Phurnacite Plant.

5.80 In November 1957[176], Dr Jenkins, NCB divisional medical officer for Wales, informed Dr Rogan, chief medical officer of the NCB, in response to a request about the use of dust respirators at patent fuel plants, that Martindale masks were worn by workers at the Phurnacite Plant whilst cleaning out "pits" (presumably the pits under the conveyors in the briquetting plants). He said that, otherwise, there was no general use of respirators at patent fuel plants, nor was there intended to be any such use, since dust sampling had indicated that working conditions at such plants were "not dangerous" (by which he meant that there was no risk of pneumoconiosis). Dr Rogan[177] responded by advising Dr Jenkins that the Martindale masks were "not much good" and that, when further supplies of the masks were required, they should be replaced by respirators that complied with NCB specifications. There is no evidence that a different type of RPE was in fact provided for workers at the Phurnacite Plant until some considerable time later. Indeed, Martindale masks appear to have been in more general use at the Phurnacite Plant from the mid-late 1960s. They continued to be supplied for the use of men working at the Phurnacite Plant until production of Phurnacite ceased in 1990. The defendants now concede that neither the Martindale masks, nor the paper masks which were also provided at some time, afforded adequate protection against the dust and fume emitted at the Phurnacite Plant.

5.81 The evidence of Mr Foster (an assistant manager at the Phurnacite Plant from 1970 until 1972) was that ori-nasal masks with filters were introduced at the Phurnacite Plant in the early 1970s. (It seems likely that he was referring to the 'Baxter Pneu-seal' respirators, which became available in 1974.) Mr Foster said that, when the respirators were introduced, it was left to the individual worker to decide whether to wear any RPE and, if so, whether to wear a filter mask or a Martindale or paper mask. It is clear that the filter masks were not widely used. It seems that many workers found the Martindale masks comfortable and easy to use and would choose to wear them in preference to a filter mask. The evidence of most of the witnesses was that, before 1980/1981, they had never worn any RPE except for a Martindale or paper mask. Many men employed in areas where exposure to dust and fume was highest (e.g. the oven tops) did not wear any RPE at all.

5.82 By late 1970, the defendants had become aware of the publication of the American studies[178] which showed increased risks of respiratory cancer in workers

[176] CB1/114
[177] CB1/115
[178] Lloyd *et al* and Redmond *et al*

employed on coke ovens. It was recognised that similar risks might exist for men working on the Phurnacite ovens. Representatives from the NCB visited the USA and were aware that coke oven workers in the USA wore respirators. The Factory Inspectorate were pressing for action on the provision of RPE at the coke and other plants operated by NSFL. In late 1972[179], there was a meeting between representatives of the Factory Inspectorate and the British Steel Corporation (BSC), who also operated coke ovens, together with Dr Morley, technical director of the NCB Coal Products Division, and a representative of CPL. At that meeting, the Factory Inspectorate made clear that they would require the introduction and regular use of respirators.

5.83 There was reluctance on the part of some members of the NCB management to disclose to the workforce and the Unions the potential risks associated with work on coke ovens and the ovens at the Phurnacite Plant. Although the Environmental Control Committee recommended in May 1972[180] that the NCB Coal Products Divisional Board should consider how best to inform employees of the potential risks, and, in the summer of 1972, drafts were prepared of letters that might be sent to the Unions, managers and other relevant organisations, it does not appear that those letters were ever sent. In February 1973, concerns were expressed[181] that disclosure of the potential risks would give rise to expensive demands for 'condition money'. The evidence strongly suggested that the first time the defendants gave their workers any formal warning about the potential risks associated with working on the Phurnacite ovens was in 1981[182]. That warning, which was directed only at workers employed on the batteries, was coupled with an instruction to wear the RPE which by then was provided for their use.

5.84 Meanwhile, in January 1973, following the meeting with the Factory Inspectorate in December 1972, Dr Morley wrote a draft paper in which he accepted that NCB policy must be to conform to the guidance given by the Factory Inspectorate on respirators. The draft paper contained a suggested policy on the provision and use of RPE and referred to the need to alert employees to the potential hazards and to educate them in the use of RPE. This paper was the subject of controversy amongst the NCB's management[183] and Dr Morley's suggested policy was not adopted. By February 1973, Dr Morley was instead suggesting[184] that, together with BSC, who were facing similar pressure from the Factory Inspectorate, the NCB should "…resist, if *[it]* could, any policy for using respirators, pending the outcome of investigations".

5.85 In January 1973[185], a meeting of the CPL management considered the various types of RPE that were on the market. The Factory Inspectorate were advocating one of two types of powered respirator that were currently available, i.e. the Martindale powered respirator or a similar model made by Siebe Gorman. It was believed that both types of respirator would probably offer 100% protection if properly maintained. However, there were concerns on the part of the CPL management that the powered respirators would be unsuitable for use on the oven tops. It was decided that non-powered 'half mask' respirators were "more likely to be acceptable" to the men who

[179] CB3/49
[180] CB2/272
[181] e.g. CB3/70
[182] CB3/18
[183] CB3/43
[184] CB3/71
[185] CB3/53

would have to wear them. It was recognised that the half mask respirators would provide less protection than powered respirators and that they could not be worn for long periods (probably no more than an hour at a time at most). Nevertheless, a decision was taken to introduce half mask respirators at one plant in the first instance as a "pilot scheme". It is clear from the documentary evidence dating from early 1973[186] that the NCB/NSFL management were strongly opposed to the introduction of powered respirators. Meanwhile, mention was made at the meeting of a prototype 'airstream' helmet which was currently being developed by a company named SMRE. The airstream helmet was fitted with a face visor, which would supply filtered air to the wearer's breathing zone. It was suggested that the NCB Coal Products Division Board might wish to support the development of this type of helmet for use at their carbonisation plants.

5.86 In May 1974[187], it was reported that a number of 'Baxter Pneu-seal' and 'Martindale Y' half mask respirators were to be provided for use on carbonisation plants, including the batteries at the Phurnacite Plant. It appears that they were not to be issued to each man working at or near the ovens but instead were to be made available "on request". The 'Baxter Pneu-seal' and 'Martindale Y' respirators were on the NCB's list of 'approved' respirators. It was intended that all unapproved masks should be withdrawn from the stores when the new respirators were provided although it is clear that, at least at the Phurnacite Plant, this was never done. By September 1974[188], 200 'Baxter Pneu-seal' respirators had been supplied to the Phurnacite Plant.

5.87 It was planned that, when the half mask respirators had been supplied at their plants, managers and medical staff would give 'presentations' to the consultative councils for the relevant regions with a view to encouraging use of the respirators. The idea was that members of the consultative councils would pass the information down to each plant's Consultative Committee and that in that way the information would be transmitted to individual workers. At a meeting of members of the medical staff of the NCB Medical Service in November 1974, Dr Archibald, assistant chief medical officer for the NCB Coal Products Division, expressed concern at the continued reluctance of the NCB to divulge to its workforce "all the information available on the dangers associated with coke oven top work". He was obviously concerned that he should not be compromised by any misleading or incomplete information that might be presented in the course of the 'presentations', at which he had been invited to be present. At the same meeting, he expressed the view that the NCB had afforded the issue of RPE "a low priority" as a result of which implementation of the decision to provide respirators had been slow.

5.88 In January 1976[189], the 'Baxter Pneu-seal' respirators were reported to be in use by men working in "areas of high discomfort" at the Phurnacite Plant , although not in general by men employed on the oven tops. It seems that the reason for this was that the respirators tended to cause chafing of the skin and that fine abrasive dust was able to enter the mask. It appears that the 'Baxter Pneu-seal' respirators were unpopular and that they quickly fell out of use altogether. In June 1976[190], it was reported that the 'Baxter Pneu-seal' and 'Martindale Y' were not used by many men

[186] e.g. CB3/62 at paragraph 10
[187] CB3/176
[188] CB3/194
[189] Syred5/136
[190] CB4/151

at any of the plants where they were available. They were giving rise to complaints of skin irritation. It does not seem that any steps were taken to address these problems or to provide an alternative type of RPE for men exposed to dust and fume.

5.89 It is clear from the documents that, by mid 1976, it was hoped that the problem of RPE would be solved by the entry onto the market of the new type of airstream helmet which had first been referred to at the meeting in January 1973. In February 1976, the NCB's Joint Working Party on the Environment at the Carbonisation Works was told that the NCB were having discussions with Racal Amplivox (who had taken over from SMRE development of the airstream helmet) about the requirements of men working on coke and Phurnacite ovens. Representatives from Racal Amplivox (Racal) had already visited a BSC coke oven to observe the working conditions there. It was hoped that prototype models would be ready for trial on the ovens by July or August 1976.

5.90 Meanwhile, in June 1976[191], a meeting took place between representatives of NSFL the British Coke Research Association, BSC and the HSE, including the Factory and Alkali Inspectors. At the meeting, the Factory Inspector emphasised that the immediate protection of oven workers was "essential". A clear indication was given that the Factory Inspectorate would be taking all necessary measures to ensure that appropriate provision was being made. At a meeting of the Environmental Control Committee two days later[192], it was reported that the Factory Inspectorate accepted that NSFL would not enforce the wearing of respirators, although they expected NSFL to comply with their duty of providing respirators and encouraging their use.

5.91 The prototype Racal airstream helmet was presented at a meeting of the NSFL Joint Working Party on the Environment at the Carbonisation Works (which comprised members of both management and the Unions) in October 1976[193] and was well received. Twenty helmets had been ordered by NSFL for trial at their carbonisation plants, including the Phurnacite Plant. A few of the first batch of helmets were issued to the Phurnacite Plant in late December 1976 and trials showed that they gave very effective protection against dust and fume. The trials conducted by BSC (which had taken place rather earlier than those conducted by NSFL) had also proved successful with around 85% of the workforce reported to be "quite happy" to wear the helmet. By early October 1976, BSC had already decided to order 2,000 of the helmets and had drawn up procedures for servicing them.

5.92 By March 1977[194], NSFL had acquired a further 50 Racal airstream helmets and were conducting more trials. Trials at three plants (which did not include the Phurnacite Plant) had included the personal sampling of exposure levels of men wearing the helmets. The results were promising in that they showed that an exposure level to BSM of less than the TLV of 0.2 mgm^{-3} was achievable if the visor was positioned over the worker's face (i.e. in the 'down position) for 75% of the shift. The workers at two of the three plants were generally happy to wear the helmets. However, the workers at the third plant had stopped wearing them. There were a number of complaints about the helmets, including the fact that the visors tended to become covered with dust and to suffer abrasion damage when attempts were made to

191 CB4/178
192 CB4/204
193 CB4/261
194 CB5/17 *et seq*.

rub off the dust. At that time, it was decided to ask the manufacturers to attempt to resolve the problems with the helmet; meanwhile, it was considered premature to make a decision to introduce the Racal airstream helmets into operational use. It was noted that the costs of purchasing and servicing the helmets would be very high.

5.93 At a meeting in April 1977, chaired by a representative of the HSE and attended by, amongst others, representatives from BSC and NSFL, BSC reported that 1,200 of the 2,000 helmets they had purchased had been issued and 85% of coke oven operatives had said they would wear them. Mr Launder, divisional chief scientist of NCB Coal Products Division, commented on the high cost of purchasing, maintaining and replacing the helmets. He observed that tests had shown that the visors were used by workers for only between 25% and 50% of the time. The helmets hindered men working in confined spaces. He said that NSFL was examining ways in which the helmets could be made cheaper and more durable. A few days' later, Mr Launder reported[195] in more detail about the current position and advised that a further trial of the 50 additional helmets purchased should be conducted at one NSFL carbonisation plant with a view to seeking a reduction in the costs of maintaining the helmets. That trial went well. Personal sampling of exposure levels showed that wearing a helmet resulted in considerable reductions in exposure to dust, BSM and BaP and the workers appeared ready to accept them. Ten of the 50 Racal airstream helmets were sent to the Phurnacite Plant in June 1977 for testing. The results indicated an 89% reduction in total dust exposure on the oven tops and an 82% reduction in the briquetting plants.

5.94 By January 1978, the general manager of one of the NSFL plants where the Racal airstream helmets had been trialled was becoming concerned at the delay in implementing the wider provision of the helmets. In a letter to Mr Howson, then managing director of NSFL, he said that:

> "... a certain amount of disillusionment is creeping in that the Company is not interested in extending the use of the helmet even though it is a very good protection for the men."

5.95 He suggested that NSFL should purchase two helmets for each plant in order to keep up interest in the ongoing investigational work and to "squash the suggestion that *[NSFL]* is deliberately going slow."

5.96 At a meeting of the Executive Committee of NSFL in February 1978[196], it was reported that the Racal airstream helmets had now been developed to a generally acceptable standard and that many men were anxious to have the opportunity to wear them. Provision of the helmets would however be very costly. Nevertheless, it was recognised that NSFL would come under considerable pressure from the Factory Inspectorate if steps were not taken to introduce the helmets. In Wales, NSFL was said to be "under intolerable pressure" to supply the helmets to their workers. There were undoubtedly "tremendous advantages" to be gained from wearing the helmets and it was natural that men who benefited from wearing helmets wanted to have a helmet personally allocated for their use. The Committee Chairman invited general managers to submit their requirements for helmets for onward transmission to the Board. In May 1978[197], it was decided not to order sufficient helmets for all the

[195] CB5/39
[196] CB5/321
[197] CB6/16

workers who required protection. Instead, NSFL intended to purchase an additional 250 helmets only and to "introduce them progressively to meet the demand for them".

5.97 There was extensive discussion of the Racal airstream helmets at a meeting between representatives of BSC and NSFL in August 1978[198]. It was reported that, of the 2,000 helmets originally purchased by BSC, 75% were already in use operationally and 85- 95% of the men to whom they had been issued were using them. Plans were going ahead for the introduction of the helmets to those plants which were not already using them. BSC were generally satisfied with the helmets. In contrast, Mr Launder reported that there were only a total of 70 helmets in use at all NSFL plants at that time and that it had not yet been decided to go ahead with a full scale distribution to all works. A large scale trial was ongoing at one coke plant where, in general, the men had taken well to the helmet, particularly when their working conditions were poor. NSFL were concerned about the high costs of maintaining the helmets. Those costs were also of concern to BSC.

5.98 In February 1979[199], the NSFL Environmental Control Committee decided that the 300 Racal airstream helmets "already ordered" (I assume this was the original 50 helmets plus the 250 helmets ordered later) should continue to be issued to NSFL plants and adequate maintenance systems for the helmets should be provided and evaluated. Meanwhile, some work should be done on identifying the circumstances in which workers would need to use the helmets. By April 1979[200], about 100 of the 300 helmets held by NSFL still remained unissued. The Phurnacite Plant had been issued with only 26 helmets and only 14 of those were in use. It was reported that the HSE were becoming concerned at the contrast between the progress being made by BSC in providing Racal airstream helmets for their workers and the apparent lack of urgency displayed by NSFL. By contrast, BSC had almost completed the issue of its 2,000 helmets. The HSE had indicated on two separate occasions that they were not satisfied with the rate at which NSFL was proceeding and had issued a "stern warning" that they were prepared, if necessary, to take steps to enforce the provision of helmets at coke ovens owned by NSFL.

5.99 There had been no change to the initial findings that the helmets were effective and they were in general acceptable to the workers who had worn them. Mr Gregory, group technical manager (coking), proposed that NSFL should purchase a sufficient number of additional helmets for issue to the oven top men working at all their coke plants, together with the Phurnacite and Homefire plants. It was anticipated that 990 helmets would be required for this purpose; 172 of those would be required for the Phurnacite Plant. Mr Gregory's proposal was put to a Meeting of the directors of NSFL on 27 April 1979[201]. The directors were unwilling to accept the views of the Factory Inspectorate and instead resolved to carry out further trials on the 100 undistributed helmets remaining. Meanwhile, it was decided that no more helmets should be purchased.

5.100 The Factory Inspectorate continued to press for the provision of Racal airstream helmets and, by August 1979, they had requested the allocation of 120 helmets to the Phurnacite Plant. At a meeting of the NSFL Environmental Control

[198] CB6/81
[199] CB6/277
[200] CB6/264
[201] CB6/298

Committee in August 1979[202], it was proposed that helmets should be issued to the Phurnacite Plant on a gradual basis rather than in one batch of 120. In October 1979, at an Accountability meeting between the NSFL Board and Mr Lloyd, manager of the Phurnacite Plant, Mr Lloyd said that he had tried to obtain some of the Racal airstream helmets in response to a request by the Factory Inspectorate which had been concerned about the high levels of dust on the oven tops. However, when he did so, he was informed that the decision to proceed with distributing the helmets was to be delayed pending a discussion between the managing director of NSFL and the HSE.

5.101 At the same meeting, reference was also made to trials of a disposable mask (the '3M mask') which were apparently being conducted by the IOM. The results of those trials would not be known for some time. It was said that the 3M masks were cheap and were in use at premises operated by BSC. Mr Howson, managing director of NSFL, suggested that a number of the 3M masks should be purchased and that the Factory Inspectorate should be informed that this had been done. Some concern was expressed that this apparent change of course might cause difficulties. NSFL had persuaded workers to wear the Racal airstream helmets and it now seemed that they would not be issued with them. However Mr Howson referred to the "massive problem" of maintaining the helmets which BSC were facing. He considered that the 3M masks should be tried out although he recognised that there might be some objections to wearing them.

5.102 Meanwhile, NSFL's policy was to issue Racal airstream helmets at those plants where pressure from the Factory Inspectorate was greatest. On 30 November 1979[203], Mr Wood, safety manager for CPL, reported that he had had a meeting with the Factory Inspectorate who were now satisfied that NSFL were progressing at a "satisfactory pace". He said that the Factory Inspectorate had agreed to the use of 3M masks at the Phurnacite Plant on a trial basis in preference to Racal airstream helmets. The 3M masks were to be issued shortly. At a meeting of the Wales Regional Health and Safety Committee in December 1979[204], Mr Lloyd expressed concern that, having introduced the Racal airstream helmet with considerable publicity, NSFL was now performing a *volte-face* in favour of the 3M mask. Mr Wood referred to evidence of "wearer resistance" to the helmets which had, he said, arisen after the "initial enthusiasm". That was disputed by the Union representatives present, who said that they were not aware of any resistance in Wales to the wearing of the helmets; indeed, all the helmets at the Phurnacite Plant and the other Welsh plant where the helmets were available were in use. Mr Wood said that NSFL were not "shutting the door" on the Racal airstream helmet and the current programme of issue would be completed. Further decisions would be taken after completion of trials of the 3M masks at the Phurnacite Plant and elsewhere. At an Accountability Meeting with the NSFL Board in February 1980[205], Mr Lloyd reported that the 3M masks were suitable for the briquetting plants but had "not been well received" on the batteries. Four Racal airstream helmets were currently in use and there were no plans to extend their use at present. Mr Howson said that testing of the 3M masks should continue. Meanwhile, a decision on the general provision of Racal airstream helmets would be deferred for the time being.

[202] CB7/52
[203] CB7/85
[204] CB7/79
[205] CB7/93

5.103 In his Annual Review of Safety during the year to March 1980[206], Mr Wood observed that the Racal airstream helmet had not proved the "panacea for all ills" that many had expected it to be. He said that the process of issuing and providing them for the use of oven workers was continuing "at locations of highest risk". There had been some "user resistance" to wearing the 3M masks in hot locations where considerable facial discomfort due to perspiration had been reported. By April 1980[207], the 3M masks had won the "seal of approval" from the IOM and were the only disposable respirator approved for use with asbestos fibres. However, there continued to be reports of an uncomfortable amount of sweating when wearing a 3M mask and of difficulty breathing through the mask when working hard in hot conditions. The complaints had come mainly from men working on the batteries at the Phurnacite Plant. By contrast, the cleaners in the briquetting plants thought the 3M masks were a great improvement on the previous "traditional" dust respirators (presumably the Martindale masks). Mr Wood observed that NSFL policy was that any worker could request a Racal airstream helmet if he wished, but they would not be issued routinely. He considered that, eventually, about half of all oven top workers would choose to wear a Racal airstream helmet.

5.104 By the end of 1980, a decision had been made to distribute the Racal airstream helmets at the Phurnacite Plant. A meeting in August 1980 between the Board and the acting plant manager recorded that Racal airstream helmets had been delivered to the Phurnacite Plant and were in the process of being issued to the men. However, in November 1980 there were still not a sufficient number of Racal airstream helmets available for all the oven top workers. The plant manager, by then Mr Dawes, reported at a meeting with the Board[208] that 60 helmets were coming from another NSFL plant whilst a further 20 helmets were being purchased. Mr Dawes noted that the HSE wanted everyone working on the batteries to wear a Racal airstream helmet.

5.105 At a meeting of the Joint Safety, Health and Environment Committee in January 1981[209], a Union representative reported on a recent meeting between the HSE and Union officials. The HSE had emphasised the importance of wearing RPE and had spoken about the risks associated with the environment at the Phurnacite Plant. The officials had agreed "with some enthusiasm" to the wearing of RPE on and around the batteries. Following the meeting, the HSE had issued a formal Improvement Notice requiring the issue and wearing of RPE, i.e. the Racal airstream helmet or its equivalent. It was probably at about this time that a written warning was sent out to all men who worked on the oven tops. Mr Dawes' evidence was that, when the Racal airstream helmets became available and the risks were explained to the men working on the oven floor, they were welcomed by the men. He said that, from 1981, the helmets were in routine use. In his report to the Board for the four weeks up to 28 February 1981[210], Mr Dawes reported that the Improvement Notice had been complied with satisfactorily.

5.106 At a meeting of the NCB Coal Products Division Works Safety Health and Environment Committee in March 1982[211], Mr Green, deputy safety manager for CPL, said that, from that time on, the use of suitable RPE by everyone working on or

[206] CB7/104
[207] CB7/107
[208] CB7/239
[209] CB7/266
[210] CB7/286
[211] CB8/106

visiting the batteries would be enforced. 'Suitable RPE' meant the Racal airstream helmet for battery workers and the 3M mask for men making visits of shorter duration. The witness evidence (in particular the evidence of Mr Harris, Mr Brian Jones and Mr Middle) confirmed that, shortly after the issue of Racal airstream helmets to all oven workers, their use became mandatory.

5.107 Thereafter, there were some continuing problems with the Racal helmet in certain circumstances. Dust and fume would blow up the front of the helmet, as a result of which the men would have to lift up the face visor to clear the dust and fume away. On occasion also, the helmets would become distorted when exposed to extreme heat[212]. There was also an initial shortage of spare parts for the helmets but this problem appears to have been resolved by June 1984[213]. In general, however, the Racal airstream helmets were a success and the evidence was that, once they were issued, they were routinely used by the men working on the ovens. The overall effect of the Racal helmets was to protect the wearer against all but a small proportion of the dust and fume to which he would otherwise have been exposed.

5.108 The evidence was that Racal airstream helmets were not provided for men who did not come within the category of full-time oven top workers, even if they spent a substantial amount of their time working on or around the ovens. Racal airstream helmets were not routinely supplied to supervisory staff or to peripatetic workers such as painters, who were required to work on the oven floor at times. They were not provided for the use of quenching car attendants.

5.109 Racal airstream helmets were not available either for use in other parts of the Phurnacite Plant. They were not provided, even on request, to men working in the briquetting plants. 3M masks were provided for use in parts of the Plant other than the oven tops and there is no reason to suppose that they were not suitable for such work. However, it was not suggested that use of 3M masks was ever made generally compulsory, save for a few specific jobs. Mr Middle's evidence was that men performing very dusty work (e.g. working inside an elevator) were required to wear 3M masks. In general, however, it appears to have been left to each individual to decide whether and in what circumstances he should wear a mask.

5.110 Bearing in mind the extent of the dust and fume produced at the Phurnacite Plant, it is surprising and disturbing that the defendants had not instituted a practice of providing and encouraging the use of RPE many years before they did. In the 1950s, there were NCB–approved respirators which, although not as effective as the models that were subsequently developed, would nevertheless have afforded significant protection against dust and fume. Such respirators could have been worn without undue discomfort in the briquetting buildings and other parts of the Phurnacite Plant and their use should have been enforced. Even if they had been uncomfortable to wear throughout a shift on the oven tops, they could have been worn at times of maximum exposure, e.g. when poking or charging the ovens. Until production at the Phurnacite Plant ceased in 1990, the defendants continued to provide workers at the Phurnacite Plant with the gauze Martindale masks which, as Dr Rogan had pointed out more than 20 years earlier, were ineffective in protecting the wearer against anything but nuisance dust.

[212] CB8/159
[213] CB8/243

5.111 It took over a decade from the time when the defendants became aware of the evidence from the USA about the risks associated with coke oven emissions before they finally provided and enforced the use of appropriate RPE for men working full-time on the oven tops. This is despite the fact that they must have realised that the need for adequate respiratory protection was urgent, especially since they were having little or no success in reducing the level of dust and fume emissions from the batteries and other parts of the Phurnacite Plant and the problem of the clustering of ovoids (and the consequent need for poking) was increasing.

5.112 The lengthy period of delay was caused in part by the defendants' reluctance to alert their workforce to the potential dangers from the emissions and in part by their concerns about the costs of implementing a proper regime of RPE. I accept that the Racal airstream helmet as first designed required some modification and that there were inevitably 'teething problems' when it was first introduced. However, those considerations should not have prevented its earlier introduction and, in the meantime, interim measures should have been taken to ensure that their workers had at least some protection. It was not until the HSE issued an Improvement Notice that the wearing of Racal airstream helmets was made compulsory for oven top workers.

5.113 Even then, the use of the helmets was severely restricted. No explanation has been given for this; it seems likely that it was by reason of the cost of providing the Racal airstream helmets more widely. For most workers at the Phurnacite Plant, it was not compulsory to wear any form of RPE; they were left to decide for themselves whether to wear RPE. It is clear from the authorities[214] that, in order to fulfil its statutory duty under section 47 of the 1937 Act and section 63(1) of the 1961 Act, a defendant must not only provide suitable RPE but must also take steps to induce its employees to wear it. Thus, the mere fact that 3M masks were available at the Phurnacite Plant after about 1980 did not prevent the defendants from being in breach of their duty beyond that date to a claimant who did not choose to wear one.

Other protective measures

5.114 Other protective measures could have been introduced or improved. These would not have reduced the inhalation of harmful dust and fume but would have reduced the amount of dermal exposure to dust and other substances containing PAHs.

5.115 Barrier cream had always been provided for the use of workers at the Phurnacite Plant but it was available only in the shower area. Men generally applied barrier cream at the start and end of their shifts but the evidence shows that the cream soon wore off, especially when men were performing hot or strenuous work and there was little or no opportunity to re-apply barrier cream during the course of the shift. There was no provision for the men to take barrier cream with them to their place of work or to be allowed time to re-apply it at regular intervals.

5.116 In the early years, workers at the Phurnacite Plant wore their own clothes to work and were responsible for laundering them. At some time, probably in the 1960s, the NCB began to supply sets of blue overalls to be worn when working. In the mid-1970s, these were replaced by orange overalls, together with sets of underwear, and arrangements were made by NSFL for them to be laundered weekly. The men usually

[214] e.g. *Crookall v Vickers-Armstrong Ltd* [1955] 1 WLR 659

had three sets of overalls, with one being worn, one spare and one at the laundry. The overalls were eventually laundered through the Plant on a weekly basis. It is clear from the evidence that the claimants' work clothes, and later their overalls, became contaminated with pitch, coal, dust and other substances which sometimes soaked through to the skin beneath.

5.117 The overalls, when provided, were not impermeable and did not protect the wearer from the ingress of dust and/or pitch. A number of witnesses described how fine dust would get inside their overalls. Photographs[215] of men wearing the overalls show that the overalls were often open at the neck, making it easy for dust to get inside the top of them and to come into contact with the wearer's upper body. There seems to have been no appreciation at management level of the importance of providing work wear that offered proper protection against dust and other contaminants. It should have been possible substantially to reduce the men's exposure to those substances by the provision of impermeable overalls but this was not done.

5.118 A range of different types of gloves were supplied for use by workers at the Phurnacite Plant. However, the evidence was that, for some types of work, none of the gloves were suitable due to the intricate nature of the work being undertaken. It may well be that alternative types of gloves could have been identified that would have been suitable for more intricate work. However, I did not hear sufficient evidence to form a concluded view about this.

Discussion and conclusions about the 'irreducible minimum'

5.119 The evidence shows that there was much that the defendants could and should have done to reduce the exposure of their employees to dust and fume. The single measure that would have produced the most significant reduction in exposure would have been the provision, from the early years, of the most effective type of respirator currently available. I consider that RPE, coupled with all the other measures that I have referred to, should have made it possible to eliminate, or reduce to a very low level, the exposure to dust and fume of the men working in many – if not all – parts of the Phurnacite Plant.

5.120 The defendants did not rely on the defence of impracticability. Such a defence was not in any event available in relation to some provisions of the 1946 Regulations which imposed an absolute duty to prevent the escape of dust. The defendants did not adduce any evidence about the levels of exposure to which workers at the Phurnacite Plant would inevitably have been exposed, whatever protective measures had been put in place. They relied solely on the evidence of Mr Stear about conditions at the Avenue Works, to which I have already referred. That evidence was an extremely flimsy basis on which to found an argument that there was an irreducible minimum exposure at all, let alone an irreducible minimum exposure of 25% or 33%. I have no detailed information about conditions at the Avenue Works or about the measures that had been taken to reduce or prevent emissions of dust and fume there. However, the Avenue Works were under the same ownership as the Phurnacite Plant and, having regard to my findings about the poor working conditions at the Phurnacite Plant, I consider it highly unlikely that the conditions at the Avenue Works were exemplary. I do not consider that the sampling results from the Avenue Works afford any guide to

[215] e.g. CBP34,38, 48,87& 88

what might have been an irreducible minimum of dust and fume at the Phurnacite Plant. That leaves me without any evidence on this topic.

5.121 It may be that, in certain areas of the Phurnacite Plant, at certain times and when performing certain jobs, some small degree of dust and/or fume exposure was inevitable even if all the proper precautions had been taken. However, I am satisfied that, on most occasions, exposure could have been wholly, or virtually wholly, avoided. I bear in mind that, in cases such as *Allen* and *Thompson*, judges have been encouraged to make the best estimate they can of the non-tortious element of exposure, using a 'broad brush' approach. In this case, however, it seems to me that there is so little material on which such an estimate could be based that any estimate would be no more than a guess. In the circumstances, I do not consider it appropriate to make a finding that there was a minimum exposure level of exposure at the Phurnacite Plant that was unavoidable.

SECTION 6

LEGAL CAUSATION

The issue

6.1 In the current litigation, the claimants sought to persuade me to decide the cancer cases on the basis that the claimants' occupational exposure had made a material contribution to their cancers. They contended that they should succeed in establishing liability by the application of the principle established in *Bonnington Castings v Wardlaw*[216], even in cases where they would clearly not be able to succeed in establishing a 'doubling of risk'. The defendants urged me to decide the cancer cases (at least the lung and bladder cancer cases) by applying the 'doubling of risk' test.

The law

The basic principle

6.2 It is a basic principle that a claimant will only succeed in establishing liability in an action for personal injuries if he can prove on the balance of probabilities that the defendant's tortious conduct caused or materially contributed to the injury of which he complains. The 'conventional' way of proving causation is by establishing that, but for the breach of duty, the relevant injury would not have occurred (the *'but for'* test).

Material contribution

6.3 Particular problems can, however, arise, when determining the issue of causation in cases of disease resulting from exposure (usually occupational exposure) to harmful agents. One such problem arose in the case of *Bonnington*. The claimant in that case developed pneumoconiosis as a result of the inhalation of silica dust, part of which was attributable to the defendant's breach of duty and part of which was non-tortious. The House of Lords held that, on the facts of the case, the tortious exposure to silica dust had made a 'material contribution' to the claimant's disease so that the defendant was liable to compensate him for the whole of his injury.

6.4 As to the meaning of a 'material contribution' Lord Reid stated at 621:

> "What is a material contribution must be a question of degree. A contribution which comes within the exception de minimis non curat lex is not material, but I think that any contribution which does not fall within that exception must be material. I do not see how there can be something too large to come within the de minimis principle but yet too small to be material."

6.5 Pneumoconiosis is a 'divisible' disease, i.e. it is dose related, the severity of the disease being dependent upon the quantity of dust inhaled. It should be noted that, in *Bonnington*, the defendant had not argued that, if it was found liable, its

[216] [1956] AC 613

liability should extend only to that part of the claimant's injury which was attributable to the silica dust to which it had exposed him in breach of duty. Therefore, there was no apportionment as between tortious and non-tortious exposure and the claimant was awarded damages on a 100% basis.

6.6 Since *Bonnington,* there have been a number of decisions involving divisible conditions (such as industrial deafness, vibration white finger and certain types of lung disease) in which liability for the injury has been apportioned as between different defendants and/or as between tortious and non-tortious exposures to the causative agent.

6.7 The *Bonnington* principle has been applied in a range of cases, not all of which have concerned occupational disease. *Bailey v MOD*[217] was a clinical negligence case. The claimant was operated upon for a gallstone problem. Following that operation there was a negligent lack of adequate care. The claimant developed acute pancreatitis which was not a consequence of the defendant's negligence. However, a few days after her operation, the claimant was in a weakened state, partly as a result of the defendant's negligence and partly due to the pancreatitis. Whilst she was in that state, the claimant aspirated her vomit, resulting in a cardiac arrest which, in turn, caused her to suffer hypoxic brain damage. Referring to the trial judge's finding that the defendant's negligence had made a material contribution to the injury, Waller LJ (with whom the other members of the Court of Appeal agreed) said at paragraph 36:

> "That is not an application of the 'but for' test as Lord Rodger made clear in *Fairchild*."

6.8 He went on at paragraph 43:

> "It seems to me thus respectfully that Lord Rodger in *Fairchild* accurately summarises the position when he says in paragraph 129 that in the cumulative cause case such as *Wardlow* the 'but for' test is modified."

6.9 And at paragraph 46:

> "In my view one cannot draw a distinction between medical negligence cases and others. I would summarise the position in relation to cumulative cause cases as follows. If the evidence demonstrates on a balance of probabilities that the injury would have occurred as a result of the non-tortious cause or causes in any event the claimant will have failed to establish that the tortious cause contributed. Hotson exemplifies such a situation. If the evidence demonstrates that 'but for' the contribution of the tortious cause the injury would probably not have occurred the claimant will (obviously) have discharged the burden. In a case where medical science cannot establish the probability but can establish that the contribution of the negligent cause was more than negligible, the 'but for' test is modified and the claimant will succeed."

[217] [2008] EWCA 883

The Fairchild exception

6.10 The case of *Fairchild v Glenhaven Funeral Services Ltd et al*[218] was concerned with the position where a claimant had developed mesothelioma (a type of cancer uniquely associated with exposure to asbestos dust) after successive tortious exposures to asbestos with different employers. Cancer is an indivisible injury; once a cancer develops, its severity is not affected by the extent of exposure to carcinogens. Given the state of medical knowledge at the time, it was not possible for the claimant to prove on the balance of probabilities that his mesothelioma had resulted from asbestos fibres inhaled during the course of his employment with any one of his former employers. Accordingly, applying the conventional '*but for*' test of causation, his claim would inevitably have failed. Nor would he have been able to show on the balance of probabilities that any one of his exposures to asbestos had made a material contribution to his mesothelioma.

6.11 Mesothelioma is a particularly unpleasant form of cancer and, given the fact that many workers who contract the disease have been exposed to asbestos successively by a number of different employers, the inability to prove causation in such cases was perceived to cause real injustice. In *Fairchild*, the House of Lords decided that, in such circumstances, a modified approach to the proof of causation was justified, requiring a claimant to prove only that each defendant's tortious conduct had materially increased his risk of contracting mesothelioma and that the risk had materialised. This 'modified approach' has come to be known as 'the *Fairchild* exception'.

6.12 *Fairchild* did not resolve the issue of whether the liability of each defendant whose tortious conduct had materially increased the risk of mesothelioma was joint and several, or whether such a defendant was liable only for the contribution which his asbestos had made to the claimant's risk of developing the disease. In *Barker v Corus UK Ltd et al*[219], both the judge at first instance and the Court of Appeal held that, where the *Fairchild* exception applied, each defendant whose tortious acts were found to have materially increased the claimant's risk of developing mesothelioma was jointly and severally liable for the mesothelioma and for the injury, loss and damage resulting therefrom. The House of Lords disagreed. They found that the defendants' liability was several and should be attributed according to each defendant's relative degree of contribution to the risk, measured by reference to factors such as the duration and intensity of the claimant's asbestos exposure during his employment with each defendant.

6.13 The effect of the decision in *Barker* was subsequently reversed by the enactment of section 3 of the Compensation Act 2006 (the 2006 Act). This provided that, in such cases, the defendants' liability was joint and several, thus enabling a claimant to recover full compensation from any one of the defendants whose tortious conduct had been found to have materially increased the risk of him developing mesothelioma.

6.14 *Fairchild* dealt only with the position where the claimant's exposure to asbestos had occurred as a result of tortious exposure during his employment with

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[218] [2003] 1 AC 32
[219] [2006] 2 AC 572

more than one defendant. However, it is now clear that the *Fairchild* exception also applies where a claimant has had both tortious and non-tortious exposures to asbestos dust. Non-tortious exposure would most commonly arise from inhalation of asbestos in the general atmosphere.

6.15 In the judgment of Lord Nicholls in *Fairchild*[220], there was a warning of the dangers of extending the *Fairchild* exception to cover cases other than mesothelioma claims. In *Sienkiewicz, (administratrix of the estate of Enid Costello deceased) v Greif (UK) Ltd et al*[221], Lord Brown also expressed concern at the prospect of the creation of any further "special rules regarding the principles governing compensation for personal injury[222]". In the same case, Lord Phillips referred to the possibility that, in the future, the Supreme Court might limit the effect of the *Fairchild* exception by identifying exceptions to the 'material increase in risk' test or might abolish the *Fairchild* exception altogether and revert to the conventional approach to the balance of probabilities in mesothelioma cases. He did not suggest that there was any possibility of extending the *Fairchild* exception to cover other circumstances or diseases.

6.16 The issue of possible extension of the *Fairchild* exception was considered by the Court of Appeal in the *Atomic Veterans* case[223]. That case involved claims by ten lead claimants from a group of over 1,000 claimants (mainly former servicemen) who alleged that they had suffered various types of cancer as a result of exposure to ionising radiation in the course of a series of atmospheric tests of thermonuclear devices in the Pacific Ocean region in the 1950s. The evidence was that there were a number of potential causes for the claimants' conditions other than ionising radiation. At the time of the limitation hearing, the claimants plainly could not satisfy the *'but for'* test of causation. It was not suggested that evidence was likely to emerge that their exposure to radiation had been so high as to have doubled the risk already present from other potential causes.

6.17 The claimants suggested that they would be able to rely on expert evidence to the effect that their exposure to radiation had materially increased their risk of developing their various conditions. They recognised that, if they were to succeed in establishing causation on the basis of a material increase in risk, there would have to be an extension of the scope of the *Fairchild* exception. However, they submitted that there was no reason why such an extension should not be allowed for reasons of policy. When considering the broad merits of the cases for the purposes of limitation, the judge at first instance was prepared to contemplate the possibility that, in the circumstances of the *Atomic Veterans* case, an extension to the *Fairchild* exception might be created. However, the Court of Appeal[224] concluded that there was no foreseeable possibility of such an extension in a case where there were multiple potential causes, some of which had not even been identified.

6.18 The *Atomic Veterans* case went to the Supreme Court[225] where Lord Phillips observed[226] that, in the light of the Supreme Court's observations in *Sienkiewicz*, the

[220] Paragraph 43
[221] [2011] 2 AC 229.
[222] Paragraph 70
[223] *Ministry of Defence v AB and otherl* [2010] EWCA Civ 1317
[224] *Ministry of Defence v AB & Ors* [2010] EWCA Civ 1317
[225] [2012] UK SC9
[226] at paragraph 157

Court of Appeal's conclusion that the *Fairchild* exception would not be extended was plainly correct. It does not appear that there is any appetite in the appellate courts for extending the *Fairchild* exception to cases involving diseases other than mesothelioma.

The 'doubling of risk' test

6.19 Section 108(1) of the Social Security Contributions and Benefits Act 1992 (the 1992 Act) provides, *inter alia*, that industrial injuries benefits shall be payable in respect of any "prescribed disease", i.e. a disease which is recognised to be due to the nature of the applicant's employment. Section 108(2) states that a disease may be prescribed in relation to any workers if the Secretary of State is satisfied that it ought to be treated, having regard to its causes and incidence and any other relevant considerations, as a risk of the workers' occupations and not as a risk common to all persons and the disease is such that, in the absence of special circumstances, the attribution of particular cases to the nature of the employment can be established or presumed with "reasonable certainty".

6.20 The IIAC advises the Secretary of State about which diseases should be prescribed. When deciding whether there is a sufficient link between a disease and a specific occupation, the IIAC applies two tests. First, it looks for clinical features of the disease which might allow it to be attributed to occupation in some cases. An example of this might be if the symptoms arising from the disease improve or deteriorate according to whether the worker is away from or attending work. Second, the IIAC requires epidemiological evidence of a 'doubling of risk', i.e. evidence that the disease is twice as likely to occur in the occupation compared with the general population. Despite the reference to "reasonable certainty" in the 1992 Act, documents[227] produced by the IIAC suggest that it evaluates causation by reference to the balance of probabilities.

6.21 Primary carcinoma of the lung caused by working in certain asbestos-related occupations has been a prescribed disease for many years. Until 2006, the prescription criteria provided that an award of industrial injuries disablement benefit for asbestos-related lung cancer was dependent on the presence of asbestosis or diffuse pleural thickening, as well as lung cancer. During the 1980s, there were a number of common law claims for asbestos-related lung cancer in which an issue arose as to whether, in a case where the claimant had been exposed to asbestos but had not developed asbestosis or diffuse pleural thickening, his lung cancer had been caused by asbestos exposure. All the claims save one failed because the claimant had not been able to show evidence of asbestosis or diffuse pleural thickening.

6.22 In April 2006, the prescription criteria were revised. The requirement for the presence of asbestosis or diffuse pleural thickening was removed and was replaced by a requirement that the applicant had worked for a specific number of years in one of a number of industries involving the manufacture or use of asbestos. After that time – and perhaps borrowing the principle of 'doubling of risk' from the IIAC – many common law claims for asbestos-related lung cancer were settled on the basis that the claimant was able to establish by means of expert evidence that his asbestos exposure had 'doubled the risk' which he would otherwise have had of developing lung cancer.

[227] e.g IIAC Report: *Lung cancer in oven workers.* September 2011. CB8/163 at page 8, paragraph 14: Morgan/54

6.23 The case of *John Shortell (executor of the estate of John Joseph Shortell and litigation friend of Eileen Shortell) v BICAL Construction Ltd*[228] was the first claim for lung cancer arising from asbestos exposure to come before the courts for many years. The deceased died of lung cancer, having been exposed to asbestos for much of his working life with the defendant. He had had no other asbestos exposure but had been a fairly heavy smoker. Cigarette smoking is, of course, a common cause of lung cancer. The epidemiological evidence was that asbestos and cigarette smoke have a multiplicative effect on risk, such that, when both factors are present, the risk of contracting lung cancer is 50 times greater than the risk that would be present in a non-smoker who is not exposed to asbestos.

6.24 In *Shortell*, it was conceded by the defendant that, if the claimant could prove on the balance of probabilities that the risk factor created by its breach of duty had more than doubled the deceased's relative risk of contacting lung cancer, the claimant would succeed on the issue of primary liability. Mackay J heard expert engineering, epidemiological and medical evidence and found that the lifetime burden of asbestos sustained by the deceased had had the effect of more than 'doubling of risk' of lung cancer which would otherwise have existed, so that the claimant had succeeded in establishing causation on the balance of probabilities.

6.25 *Novartis Grimsby Ltd v John Cookson*[229] was a case involving carcinoma of the bladder, allegedly caused by tortious exposure to aromatic amines used in the manufacture of azo dyes. The claimant had been a moderate cigarette smoker for about 20 years. It is known that cigarette smoking increases the risk of developing bladder cancer. It was accepted by the parties that both occupational exposure to aromatic amines and exposure to the carcinogens contained in cigarette smoke (in particular, amines) would have an additive - if not a multiplicative - effect. The argument between the parties was about the relative potency of the effects of smoking and occupational exposure. In essence, the argument was whether the occupational exposure was sufficient to have caused or materially contributed to the development of the cancer.

6.26 The claimant's medical expert stated in evidence that he considered that the claimant's occupational exposure to aromatic amines had more than doubled the risk of developing bladder cancer to which he had already been subject as a result of his smoking. At trial, the Recorder accepted that evidence. However, his finding in favour of the claimant on causation was not based on the 'doubling of risk'. Instead, he invoked the principle in the case of *Bonnington* and held that, since the medical experts had agreed that occupational exposure to aromatic amines and smoking were at least additive factors in the causation of bladder cancer, the occupational exposure must have made a material contribution to the development of the claimant's carcinoma.

6.27 Before the Recorder, the defendant had argued that *Bonnington* applied only where the relevant disease was divisible and had been caused by the cumulative effect of tortious and non-tortious exposure. The defendant submitted that, in such a case, it could properly be said that the tortious component of the exposure had made a material contribution to the disease. Such cases would now be subject to

[228] unreported 16 May 2008
[229] [2007] EWCA Civ 1261

apportionment of damages. That was very different from the position in *Novartis*, where the disease was indivisible and had been triggered by the effect of two different types of exposure. The defendant submitted that it could not be said that either of the exposures had made the disease more severe. Therefore it could not be said that either exposure had "contributed" to the disease. Each exposure had contributed only to the risk that the disease would develop. The claimant meanwhile had argued that *Bonnington* remained good law, although it was conceded that it was usually applied to divisible diseases and was then subject to apportionment.

6.28 In *Novartis,* the Court of Appeal considered that it had been unnecessary for the Recorder to make a finding based on *Bonnington* since his finding of a 'doubling of risk' had been sufficient to establish causation. Giving the leading judgment, Smith LJ observed that it was not certain whether the principle in *Bonnington* applied only to divisible conditions where the various exposures had contributed to the severity of the condition, or whether the principle applied also to indivisible conditions where the exposures had contributed only to the risk that the disease would develop. However, because the issue of causation in *Novartis* could be determined by the 'doubling of risk' test, it was unnecessary to consider that issue.

6.29 The Court of Appeal returned to the issue of material contribution in the *Atomic Veterans* case when considering the claimants' contention that they might be able to establish that their exposure to ionising radiation had made a material contribution to their cancers. In rejecting that contention, Smith LJ said at paragraph 150:

> "… we accept that, at least so far as cancers are concerned, the claimants cannot rely on proving that the radiation exposure has made a material contribution to the disease, as in *Bailey* and *Bonnington Castings*. This principle applies only where the disease or condition is 'divisible' so that an increased dose of the harmful agent worsens the disease. As is well known, in *Bonnington*, the claim succeeded because the tortious exposure to silica dust had materially aggravated (to an unknown degree) the pneumoconiosis which the claimant might well have developed in any event as the result of non-tortious exposure to the same type of dust. The tort did not increase the risk of harm; it increased the actual harm. Similarly in *Bailey*, the tort (a failure of medical care) increased the claimant's physical weakness. She would have been quite weak in any event as the result of a condition she had developed naturally. No one could say how great a contribution each had made to the overall weakness save that each was material. It was the overall weakness which led to the claimant's failure to protect her airway when she vomited with the result that she inhaled her vomit and suffered a cardiac arrest and brain damage. In those cases, the pneumoconiosis and the weakness were divisible conditions. Cancer is an indivisible condition; one either gets it or one does not. The condition is not worse because one has been exposed to a greater or smaller amount of the causative agent."

6.30 In *Sienkiewicz*, the deceased had sustained light exposure to asbestos dust in the course of her employment with the defendants. Her only other known exposure to asbestos dust was that which she would have encountered in the general environment. The judge at first instance found that the deceased's occupational exposure to asbestos dust had increased by a factor of 18%, the risk to which she was in any event subject as a result of environmental exposure. He found that the claimant could not fulfil the 'doubling of risk' test, so that her case on causation must fail.

6.31 In the Court of Appeal, the claimant argued that the judge had been wrong to apply the 'doubling of risk' test. It was contended that the effect of *Fairchild*, *Barker* and section 3 of the 2006 Act was that, in a mesothelioma case, even if there were not multiple asbestos exposures, a claimant had to prove only that his occupational exposure to asbestos dust had materially increased the risk of him developing a mesothelioma. The judge had therefore been wrong to apply the more stringent 'doubling of risk' test.

6.32 The defendant's case was that the *Fairchild* exception did not apply in circumstances where, as in *Sienkiewicz*, there had been only one occupational exposure to asbestos and therefore the claimant did not face the impossible task of proving that any one period of tortious exposure had caused her mesothelioma. In a case with only one occupational exposure, the claimant should be required to prove causation on ordinary principles.

6.33 Giving the leading judgment in the Court of Appeal, Smith LJ referred to the 'doubling of risk' test and to the cases of *Shortell* and *Novartis*. She said at paragraph 23:

> "In my view, it must now be taken that, saving the expression of a different view by the Supreme Court, in a case of multiple potential causes, a claimant can demonstrate causation by showing that the tortious exposure has at least doubled the risk arising from the non-tortious cause or causes."

6.34 The Court of Appeal accepted the claimant's argument that, in a case of mesothelioma, the 'doubling of risk' test should not be applied. They concluded that, by enacting section 3 of the 2006 Act, Parliament had laid down a rule that causation in a mesothelioma case could be established by proof of a material increase in risk. This precluded a defendant from averring, in a mesothelioma case, that the claimant had to satisfy the 'doubling of risk' test. They held that the judge should have applied the test of material increase of risk. If he had done so, he would inevitably have held that the deceased's occupational exposure to asbestos had materially contributed to her risk of developing mesothelioma. The appeal was therefore allowed.

6.35 The Supreme Court in *Sienkiewicz* upheld the decision of the Court of Appeal, but disagreed about the effect of the 2006 Act. They found that section 3(1)(d) specified what was to be the effect where a defendant had been found liable in tort for materially increasing the risk. They held that whether and in what circumstances liability in tort will attach to a defendant who has materially increased the risk of a victim contracting mesothelioma remains a question of common law. Thus, it was necessary to consider whether the claimant had succeeded in establishing causation according to ordinary common law principles.

6.36 In his judgment in *Sienkiewicz*, Lord Phillips devoted considerable time to considering the application and validity of the 'doubling of risk' test. He began by discussing the cases of *Shortell* and *Novartis*. He concluded that, in *Shortell,* it had been unnecessary for the judge to rely on the 'doubling of risk' test. He considered that the case fell within the principles set out in *Bonnington*. At paragraph 75 of his judgment, he said:

> "Applying the *Bonnington* test of causation, the issue was whether the asbestos to which the victim had been exposed had made a material contribution to the cause of the victim's lung cancer. The expert evidence, given by both medical and epidemiological experts, but based in the case of each, I suspect, on epidemiological data, was that asbestos and cigarette smoke not merely combined cumulatively to cause lung cancer, but that they had a synergistic effect in doing so. This evidence was enough, as I see it, to satisfy the *Bonnington* test of causation, as the victim had been exposed to both significant quantities of asbestos fibres and to significant cigarette smoke."

6.37 Since lung cancer, from which the claimant in *Shortell* was suffering, is an indivisible condition, it does not seem to me that Lord Phillips' observations can be reconciled with the views of the Court of Appeal as expressed in the *Atomic Veterans* case.

6.38 Lord Phillips went on to observe that, in *Novartis*, the Court of Appeal had not found it necessary to decide whether the case fell within the *Bonnington* principle. He expressed no view about this although since *Novartis*, like *Shortell*, involved an indivisible injury with two competing causes which were said to have acted cumulatively, it seems likely that he would have considered that the *Bonnington* test applied in that case also.

6.39 In *Sienkiewicz* Lord Phillips accepted that, if a defendant is responsible for an exposure which has more than doubled the risk of the claimant's disease, it follows that on the balance of probabilities he has caused the disease. However, he observed that these were statistical probabilities and the issue in *Sienkiewicz* was whether a statistical approach to determining causation should be applied in a mesothelioma case. Before going on to consider the position in cases of mesothelioma, he made some observations about the wider picture.

6.40 At paragraphs 90-93 of his judgment, Lord Phillips addressed the question whether the 'doubling of risk' test can be applied in multiple cause cases involving diseases other than mesothelioma. He observed that he could see no scope for the application of the 'doubling of risk' test in cases where two agents have operated cumulatively and simultaneously in causing the onset of a disease. In such a case, the rule in *Bonnington* would apply. Where the disease is indivisible (as with lung cancer), a defendant who has tortiously contributed to the cause of the disease will be liable in full. Where the disease is divisible (such as asbestosis), the defendant will be liable in respect of the share of the disease for which he is responsible.

6.41 At paragraph 91, Lord Phillips went on to deal with the position where the initiation of the disease is dose related, and there have been consecutive exposures (one non-tortious and one tortious) to an agent or agents that cause the disease. He said that the position would depend upon which exposure came first in time. Where it was the tortious exposure, it is axiomatic that this will have contributed to causing the disease, even if it is not the sole cause. Where the non-tortious exposure came first, there may be an issue as to whether this was sufficient to trigger the disease or whether the subsequent, tortious, exposure contributed to the cause. Lord Phillips then observed:

> "I can see no reason in principle why the "doubles the risk" test should not be applied in such circumstances, but the court must be astute to see that the epidemiological evidence provides a really sound basis for determining the statistical probability of the cause or causes of the disease."

6.42 At paragraph 93, Lord Phillips went on to say that, where there are competing alternative (rather than cumulative) potential causes of a disease or injury, he could see "no reason in principle" why epidemiological evidence should not be used to show that one of the causes was more than twice as likely as all the others put together to have caused the disease or injury.

6.43 Lord Phillips then went on to consider whether the 'doubling of risk' test could be applied in mesothelioma cases. He discussed in some detail the adequacy of the epidemiological evidence available in cases of mesothelioma. He concluded (at paragraph 106) that there are special features about mesothelioma and the gaps in the knowledge about it that rendered it inappropriate to decide causation on epidemiological data as to exposure. Thus, he did not consider that the application of the 'doubling of risk' test was appropriate in such cases. He concluded that the judge should have applied the *Fairchild/Barker* 'material increase in risk' test.

6.44 In *Sienkiewicz*, Lord Phillips and other members of the Supreme Court referred at some length to the potential problems associated with using statistical and/or epidemiological evidence as the sole basis for a decision on causation. Lord Phillips observed (at paragraph 83) that a relative risk of just over two (i.e. just 'doubling of risk') is a "tenuous basis" for concluding that the statistically probable cause of a disease is also the probable biological cause. The balance of probabilities would be a very fine one and the epidemiological data may not be reliable. However, there may be other features of the case, such as characteristics of the claimant, which will also be a factor in causation. Lord Rodger expressed similar reservations. However, he emphasised that he did not intend to discourage the use of epidemiological evidence or to depreciate its value in cases where a claimant has to prove his case on the balance of probabilities. He said at paragraph 163:

> "That epidemiological evidence used with proper caution, can be admissible and relevant in conjunction with specific evidence related to the individual circumstances and parties is, however, common ground and clearly right. What significance a court may attach to it must depend on the nature of the epidemiological evidence, and of the particular factual issues before the court."

6.45 Lady Hale expressed considerable reservations about the use of the 'doubling of risk' test, although she accepted that statistical probabilities have a part to play in assisting judges to reach their own conclusions about where the balance of overall probabilities lies. Lord Mance also expressed concern at the prospect of a court relying on epidemiological evidence alone in order to make a decision as to whether a particular defendant was negligent or causatively responsible. He observed at paragraph 191:

> "That epidemiological evidence, used with proper caution, can be admissible and relevant in conjunction with specific evidence related to the individual circumstances and parties is, however, common ground and clearly right. What significance a court may attach to it must depend on the nature of the epidemiological evidence, and of the particular factual issues before the court."

6.46 It is to be noted that the *dicta* of members of the Court relating to the 'doubling of risk' test and the use of statistical and epidemiological evidence other than in cases of mesothelioma must be regarded as having been *obiter*.

Discussion and conclusions on legal causation

6.47 As I have already observed, it appears impossible to reconcile the Court of Appeal's analysis of the law relating to material contribution in the *Atomic Veterans* case with Lord Phillips' observations about the *Shortell* case in *Sienkiewicz.* Any hope that the Supreme Court might seek to clarify the position in their judgments in the *Atomic Veterans* case was unfounded. In that case, Lord Phillips did not make any reference to the observations of the Court of Appeal on the application of *Bonnington*. The only member of the Court to refer to *Bonnington* was Lord Mance who observed that, before the judge at first instance, the claimants':

> "…hope was to invoke the principle or an extension of the principles in *Bonnington* … and/or *Fairchild* … That was and is, however, a hope without prospect of success."

6.48 In *Sienkiewicz*, Lord Phillips observed that he could see no scope for the application of the 'doubling the risk' test in cases where two agents had combined "cumulatively and simultaneously" to cause the onset of a disease. In such a case, the rule in *Bonnington* would apply. Where the disease was indivisible (as with lung cancer), a defendant who had tortiously contributed to the cause of the disease would be liable in full. Where the disease was divisible (as with asbestosis), the defendant would be liable in respect of the share of the disease for which he was responsible.

6.49 By contrast, the Court of Appeal in the *Atomic Veterans* case concluded that it was only in cases of divisible injury that the *Bonnington* principle applied. It is true that the type of injury suffered by the claimant in *Bonnington* was in fact divisible. However, it was not treated as such by the parties or the court; they approached the injury as though it was an indivisible injury. Similarly, the Court of Appeal in the *Atomic Veterans* case regarded the 'injury' in the case of *Bailey* as having been the claimant's weakened state which had led to her cardiac arrest and brain damage. They regarded that injury as divisible. Yet, it seems to me that the 'injury' in *Bailey* was in reality the claimant's brain damage, which was indivisible. The defendant's negligence had made an unquantifiable contribution to the weakness that had led to the development of that brain damage. If that is right, the fact that an injury is indivisible does not necessarily preclude the application of the *Bonnington* principle. That would accord with the view of Lord Phillips in *Sienkiewicz*.

6.50 I have concluded that, in considering whether *Bonnington* has any application to the claims for lung and bladder cancer in this litigation, I should focus on three generic issues. First, I should consider whether it is possible for the claimants to establish to the required standard (without recourse to the ‘doubling of risk’ test) that the occupational exposure made any contribution at all to their cancer.

6.51 Second, if the claimants can succeed in surmounting that first hurdle, I should decide whether the occupational exposure is capable of being considered as one of a number of “cumulative causes” of their cancer. In the cases of *Bailey* and *Sienkiewicz*, Waller LJ and Lord Phillips clearly related the application of *Bonnington* to cases where the breach of duty was one of a number of “cumulative” or “cumulative and simultaneous” causes of the relevant injury.

6.52 Third, if I find that the occupational exposure was capable of being considered one of a number of cumulative causes of the claimants’ cancer, I must decide whether there is any basis on which the claimants can establish that the contribution made by the occupational exposure to the development of their cancer was ‘material’.

6.53 In the event that I decide that the *Bonnington* principle does not apply to the claims, I must go on to consider whether it would be appropriate instead to apply the ‘doubling of risk’ test. In doing so I should bear in mind the observations of the Supreme Court about the care necessary when using epidemiological evidence to establish causation.

6.54 I shall consider those various issues at Section 8 of this judgment in the context of the claims for lung cancer. Before doing so, I shall say something about the process of carcinogenesis.

SECTION 7

CARCINOGENESIS

The expert evidence

7.1 The evidence on carcinogenesis came from, for the claimants, Dr Bojan Flaks and Dr Robin Rudd and, for the defendants, Dr Stephen Falk and Professor Jones.

7.2 Dr Flaks is a former experimental pathologist and toxicologist with a special interest in the mechanisms of chemical carcinogenesis. He provided some useful background information about such matters as the relevant carcinogens. However, his analysis of the relevant epidemiological and other evidence lacked the rigour of the other three experts.

7.3 Dr Rudd is a consultant physician with specialist accreditation in respiratory medicine and medical oncology. He is a leading expert in his field and a very experienced and impressive witness in cases of occupational respiratory disease.

7.4 Dr Falk is a consultant clinical oncologist at the Bristol Oncology Centre whose areas of interest include lung cancer and skin cancer. He impressed me as a fair and balanced witness with an excellent knowledge of the relevant epidemiology. I have already referred to Professor Jones' qualities as a witness. He has no medical qualifications but demonstrated an impressive knowledge of the relevant epidemiology.

The general process

7.5 The following description of the carcinogenic process is drawn mainly from the evidence of Dr Rudd, and is not controversial. The dispute relates to the legal consequences of the nature of the process.

7.6 The human body is composed of a vast number of cells of different types. The cells are constantly dividing and dying. Each cell contains genetic information in the form of DNA. In order to proliferate and form tumours, cells must first undergo a number of changes to their physiology. Dr Rudd identified those changes as self sufficiency in growth signals; insensitivity to signals which inhibit growth, evasion of programmed cell death; limitless potential to replicate; ability to stimulate angiogenesis (i.e. new blood vessel formation) and ability to invade tissues and metastasise to distant parts of the body.

7.7 Those physiological changes are brought about by mutations, i.e. genetic modifications resulting from changes in DNA. Mutations arise spontaneously all the time in the course of the normal cell division which is necessary to maintain the integrity of the tissues of the body. They can be caused by random errors in DNA replication during cell division and also as a result of naturally occurring environmental agents such as ultraviolet radiation (UVR) in sunlight and ionising radiation. They can also be caused by endogenous genotoxins, i.e. chemicals produced by the body which are capable of causing mutations. The frequency of random mutations increases with age. Some mutations render the cell incapable of multiplying and cause it to die without passing on the mutation. Mutations which survive are usually dealt with by the natural mechanism of DNA repair which can act to repair the damage to the cell or to eliminate the damaged cell. If that repair mechanism fails and the affected cell goes on to replicate in the usual way, it will pass the mutation on to its 'progeny' which will in turn pass it on to the next generation of cells.

7.8 Carcinogens are exogenous genotoxins, which may cause direct damage to a cell by mutation or may act indirectly by increasing the frequency of DNA damage or by interfering with DNA repair mechanisms, or in both or multiple ways. It is believed that cancers arise by means of a process consisting of between four and seven independent 'events'. Each 'event' involves one or more mutations which result in changes to the cell such as activation of oncogenes or the de-activation of tumour suppressor genes which are involved in cell cycle control, cell signalling and DNA repair. This is known as the 'multi-stage model of carcinogenesis'. 'Oncogenes' are genes which, when mutated, actively promote carcinogenesis. Tumour suppressor genes are genes which, when mutated, fail in their normal function of regulating cell growth, thus allowing the uncontrolled growth which is characteristic of cancer cells.

7.9 The mutations which are necessary to transform a normal cell into a malignant cell do not occur all at once, but happen sequentially over long periods, probably decades in most cases. Mutations cause damage to many cells over the years but cells which do not acquire the 'full house' of changes necessary to cause cancer do not cause the body any serious harm. Eventually, however, a single cell may acquire the 'full house' and is transformed into a malignant cell which has the potential to proliferate and cause a tumour. However, even then, the development of a tumour is by no means inevitable. Most malignant cells (and their progeny) are eliminated by the body's natural defence mechanisms. Some malignant cells become dormant. In order to enable a tumour to form, a malignant cell will have to acquire the ability to initiate angiogenesis, producing blood vessels to supply the tumour with essential nutrients. Not all malignant cells acquire the ability to do this. It is only when the tumour has grown large enough for angiogenesis to become established that the eventual emergence of a clinically evident tumour becomes inevitable.

7.10 The experts agreed that carcinogenesis is fundamentally stochastic, i.e. random. This means that it is impossible to predict whether or not any particular cell will develop into a malignant cancer. The experts agreed also that exposure to a carcinogen increases the risk of an individual developing cancer but does not influence the severity of the disease should it occur.

Chemical carcinogenesis

7.11 Most chemical carcinogens are unreactive until they undergo processing by enzymes in the body which 'mistake' them for the molecules upon which they normally act. The normal function of enzymes is to detoxify or render harmless potentially damaging agents. In the case of carcinogens, however, the enzymes render the agents more dangerous, producing ultimate carcinogens which damage DNA.

7.12 Some carcinogens (known as 'complete carcinogens') are capable of bringing about all the changes necessary to cause cancer. Other chemical agents (known as 'initiators') can initiate the carcinogenic process, but require the action of other agents to complete it. There are many other chemical agents which can act indirectly (e.g. by interfering with DNA repair mechanisms), thereby increasing the frequency of survival of cells which have undergone mutations naturally or as a result of the action of other carcinogens. Agents which contribute to carcinogenesis, but are not capable of producing the genetic changes necessary to cause cancer when acting alone, are referred to as 'promoters'. A 'complete' carcinogen acts as both an 'initiator' and a 'promoter'.

7.13 Most cancers result from multiple exposures to a combination of initiating and promoting agents over a protracted period. These result in the gradual accumulation of mutated cells which have varying proportions of the genetic changes necessary to transform a normal cell into a malignant cell. Even after exposure to a carcinogen ceases, there remain cells which have undergone these mutations and which form a pool of cells with increased probability of eventual acquisition of the 'full house' of changes necessary for malignant transformation as a result of random mutations and/or the act of other carcinogens.

Tobacco carcinogenesis

7.14 Over 300 carcinogens have been identified in tobacco smoke or in its water soluble components which leach into saliva. The most important of these carcinogens are tobacco specific nitrosamines (TSNs) and PAHs. Among the PAHs, BaP is the most extensively studied compound and its ability to induce lung tumours upon local administration or inhalation has been convincingly established.

7.15 PAHs are metabolised to compounds which combine chemically with DNA and which interfere with DNA replication. BaP is metabolised through various pathways and many genetic abnormalities associated with lung cancer have been identified as resulting from the action of metabolites of BaP. The different enzymes in the body act on BaP in different ways, producing a number of chemicals which can assist carcinogenesis by various means. Some of the chemicals produced are capable of causing DNA damage, whereas others are capable of promoting the growth of tumours without causing DNA damage.

SECTION 8

THE CAUSATION OF LUNG CANCER

8.1 Three of the lead claimants, Mr Carhart, Mr Davies and Mr Griffiths, have claims for lung cancer. All three men were smokers or former smokers.

The expert evidence

8.2 The expert evidence relating to lung cancer came mainly from Dr Rudd, Dr Falk and, in relation to the epidemiological evidence, Professor Jones. Dr Flaks provided some background evidence.

The risks associated with coke oven plants

8.3 The experts considered the epidemiological evidence relating to the risks of lung cancer associated with exposure to coke oven emissions. Those risks will not of course be identical to the risks associated with exposure to emissions at the Phurnacite Plant. However, they are the closest match available. The experts agreed that the epidemiological studies from the USA (in particular the studies by Lloyd *et al* and Redmond *et al)* showed clear evidence of an increase in the risk of lung cancer amongst coke oven plant workers. They also agreed that there was a dose response relationship for exposure by inhalation to either BSM or BaP. As I have explained previously, BaP and BSM are not the only carcinogenic agents contained in dust and fume produced at coke plants or at the Phurnacite Plant. They are used as indicators of the presence of carcinogenic materials. The fact that various epidemiological studies have measured the amount of exposure to BaP or BSM and have revealed evidence of a relationship between one or both of those substances and the risk of lung cancer does not imply that the risk is all attributable to BaP or BSM. Other carcinogenic substances may also have had an effect. Similarly, tobacco smoke contains many carcinogenic materials. Although TSNs and PAHs are considered to be the most significant of those materials, the possibility exists that other carcinogenic substances contained in tobacco smoke could play a part in the development of lung cancer.

8.4 The findings of the coke oven studies provided evidence for a relationship between the risk of lung cancer and work on coke ovens. That risk appears to be related to the presence of PAHs in the fumes emitted from the coke ovens. PAHs will not be present in other parts of coke plants. By contrast, however, the use of pitch at the Phurnacite Plant meant that workers in parts of the Plant other than the oven tops will have been exposed to dust and fume containing PAHs. The experts accepted that, for the purpose of assessing the risk of lung and bladder cancer, it was appropriate to take into account all exposure to PAHs at the Phurnacite Plant, whether in the form of dust or fume.

8.5 Professor Jones expressed his overall conclusions about the effects of the epidemiological evidence thus:

> "In my view there is a clear generic link between employment in coal carbonisation and the potential for an increased risk of lung cancer. That is to say, contaminants that may enter the workplace in these types of processes will, if inhaled in sufficient

> quantity, lead to an increase in the risk of developing lung cancer. Thus, notwithstanding the generally weak evidence for an increased risk of lung cancer in the study carried out specifically at the [Phurnacite Plant] … one must assume that occupational exposures at the plant can have increased the risk of lung cancer in at least some of the more highly exposed employees."

8.6 I did not understand either Dr Rudd or Dr Falk to disagree with Professor Jones' views as expressed in that passage.

8.7 The study[230] referred to by Professor Jones was conducted by the Institute of Occupational Medicine (IOM). The study (the 1987 IOM study) reviewed the mortality data from the Phurnacite Plant over a 17-year period from 1967 to 1983. The number of deaths observed was slightly greater than the number expected. There were more deaths than expected from cancers in general. For lung cancer, there were 17 deaths as against the 11.7 deaths that would have been expected. The small numbers meant that the results fell below statistical significance, i.e. the probability that the result occurred by chance was less than 95%.

Calculations of 'doubling of risk'

8.8 Both Dr Rudd and Professor Jones undertook calculations of the cumulative exposure to BaP that would be required to double the relative risk of developing lung cancer. 'Relative risk' is the ratio of the risk of disease or death among the exposed population to the risk among the unexposed population. A relative risk of one indicates that there is no association between the exposure and the risk of disease or death. A relative risk of two indicates that the exposure has doubled the chance that the risk of disease or death will materialise. A relative risk of more than two means that the statistical likelihood is that, if the risk does materialise, the exposure will have caused it to do so.

8.9 Dr Rudd based the calculations in his original Generic Report on a meta-analysis of epidemiological studies undertaken for the HSE by Dr Ben Armstrong, a well known expert in the field, together with colleagues from the London School of Hygiene and Tropical Medicine (the Armstrong meta-analysis)[231]. The Armstrong meta-analysis reviewed all the relevant published evidence from epidemiological studies in order to obtain an estimate or estimates of the relationship with lung cancer and to identify sources of variation in this relationship. Using data contained in the Armstrong meta-analysis, Dr Rudd calculated that the cumulative exposure to BaP required in order to more than double the risk of lung cancer was 442 μgm^3 years.

8.10 Professor Jones noted that the Armstrong meta-analysis included studies in which the BaP exposure had been estimated rather than measured and where the estimates of BaP exposure were based on assumptions that he regarded as debatable. For the purposes of his calculations, therefore, he used only those studies for which actual exposure measurements were available. In addition, he used two studies that

[230] Smith TA, Hurley JF *et al*. *Mortality study of workers at a patent fuel plant.* Institute of Occupational Medicine report TM/87/20. 1987: Falk 3/1
[231] Armstrong B; Hutchinson E; Fletcher T. *Cancer risk following exposure to polycyclic aromatic hydrocarbons (PAHs); a meta-analysis*. Research Report 068. Health and Safety Executive 2003: Jones 2/97.

had been published since the Armstrong meta-analysis had been reported. On the basis of that data, he calculated that a cumulative exposure to BaP of 270 μgm^3 years (i.e. considerably lower than the level calculated by Dr Rudd) would result in a ‘doubling of risk’. At their joint meeting, Dr Rudd accepted that Professor Jones’ calculations were likely to be more reliable than his own and the figure of 270 μgm^3 years was agreed. Because the figure for risk was agreed by the experts, there was not a great deal of discussion at trial about the calculations of risk. In his first Generic Report, Professor Jones described in some detail the way in which he carried out his calculations[232] in the individual cases. Dr Rudd did not dispute the method adopted by Professor Jones. Dr Falk also accepted Professor Jones’ calculations and considered that they provided a useful measure of risk for causation purposes.

8.11 The Armstrong meta-analysis took no account of other risk factors to which the BaP-exposed subjects included in the studies would have been exposed. The most obvious such risk would be smoking. Smoking is the major cause of lung cancer in the industrialised world. The authors of the meta-analysis considered that the fact that most of the studies they reviewed were not controlled for smoking was unlikely to cause major bias since previous studies had shown that, when comparing one group of manual workers with another, smoking rates as between those who had and had not been exposed to the substance giving rise to the risk were unlikely to differ much. The effect of this is that, if an individual has had exposure to BaP in excess of the agreed figure of 270 μgm^3, it would imply that, on the balance of probabilities, a lung cancer would not have occurred without the BaP exposure, regardless of past smoking history.

The competing views

8.12 Dr Rudd and Professor Jones agreed that, where an individual has inhaled BSM or BaP as a result of both smoking and occupational exposure, there is likely to have been an interaction between the two exposures. This interaction would, they agreed, have had a multiplicative, or near multiplicative, effect on increasing the risk of lung cancer.

8.13 Dr Rudd went further and expressed the view that, in any individual case where a lung cancer has developed, both exposures will on the balance of probabilities have contributed materially to the carcinogenic process which resulted in the development of the cancer. Professor Jones did not agree. He accepted that both exposures would have contributed to the risk of a lung cancer developing. However, he did not consider that it was possible to determine whether one, both or neither of the exposures had actually been involved in the causal sequence of formation of an individual cancer.

8.14 Dr Rudd’s evidence was that every exposure to a carcinogen will play a part in the carcinogenic process going on in an individual’s body. This can happen in a variety of ways. It may cause the DNA within a cell to be damaged by mutation. The damaged cell may then go on to produce one or more generations of damaged cells. It may contribute to the production of a secondary carcinogen which will go on to cause damage to a cell. The carcinogen may cause the ultimate change which converts a non-malignant tumour into a malignant tumour. It may interfere with the body’s repair mechanisms. It may assist in promoting the growth of a tumour once formed.

[232] Jones1/38-45 and 90-102.

The greater the quantity of the carcinogen to which the individual is exposed, the greater the number of those separate processes that will occur. The processes will result in the existence of multiple cells which have undergone changes that give them the potential to acquire the 'full house' necessary to become malignant and, if the circumstances are right, to form a tumour. In many of those cells, the carcinogenic process will be aborted by the elimination or repair of the damaged cell. But the potential for a cancer to develop is nevertheless increased.

8.15 Dr Rudd said that, if an individual has been exposed to a significant amount of a carcinogen, then, on the balance of probabilities, some part of that carcinogen will have contributed materially, whether directly or indirectly, to the development of any cancer from which that individual suffers, provided that the cancer is of the type for which the carcinogen is a recognised risk factor. Indeed, he went further and said that that would be so even when the individual has been exposed to another potent carcinogen, such as cigarette smoke. In that event, provided that the exposure is more than *de minimis*, both carcinogens will on the balance of probabilities have made a direct or indirect contribution to the development of the relevant cancer.

8.16 Dr Rudd suggested that the difference of opinion between himself and Professor Jones lay in their respective views of what was meant by 'causation'. In expressing his view, he was reflecting his belief that the carcinogens from both the occupational exposure and smoking would have contributed to DNA damage in multiple cells, one of which cells had eventually acquired all the mutations necessary to become cancerous. Carcinogens from both occupational exposure and smoking would also have contributed to the promotion of growth of the tumour once it had formed. He observed that he did not consider that it was "meaningful" to suggest that one or other source alone was responsible for the cancer.

8.17 Dr Rudd accepted that, in any individual case, it was not possible to say what had 'caused' the ultimate step that had resulted in the formation of the malignant cell leading to a cancer. Causation in medicine is, he said, attributable by reference to information about risk factors. If a heavy smoker dies of lung cancer with no other known risk factors, his death will be attributed to smoking. It may be that, in fact, his lung cancer was caused by inhaling general pollution or by some other carcinogen to which, unknown to his medical advisers, he had been exposed. However, since smoking is known greatly to increase the risk of lung cancer, the smoker's death can be attributed to lung cancer with a reasonable degree of medical certainty.

8.18 Dr Rudd said that, from the medical perspective, even where the relative risk of developing lung cancer as a result of BaP in an individual case is less than doubled, the BaP exposure may still reasonably be considered to have made a material contribution to the causation of the cancer, on the basis that the occupational exposure, together with the tobacco-derived carcinogens to which the individual has been exposed, will have played a material part in the carcinogenic process. He explained:[233]

> "If a person is deriving a substantial dose of, for example, BaP from smoking and from his occupation, even if that exposure has not been sufficient to double his risk of lung cancer, that exposure may nevertheless have been contributing to the DNA

[233] TD15/118/6-13

> damage which is present and to the development of the mutations which are necessary for cancer to emerge and to the promotion of the growth of the tumour after it has been initiated."

8.19 Dr Rudd explained that, if it were possible to look back at the origins of a malignant cell, one would see a cell which had acquired some DNA damage (a mutation), but had survived. Subsequently it had been subject to further mutations until it acquired a 'full house' and became malignant. Some of the mutations may not have been caused directly by carcinogens. Some might have been caused by a secondary carcinogen to which the primary carcinogens had contributed. Some may have been caused by factors unrelated to the carcinogens. He accepted that, even when an individual had been exposed to carcinogens, it was "theoretically possible" that none of the mutations which had produced an individual malignant cell had been caused by those carcinogens. However, where there had been substantial exposure to carcinogens, he considered that the odds against all the mutations having occurred coincidentally, without any involvement of the carcinogens, would be very long indeed.

8.20 Dr Rudd said that he considered it most appropriate medically to conclude that all the carcinogenic activity which contributed to the DNA damage (i.e. which contributed to the production of potentially malignant cells, one of which eventually survives) should be considered to have contributed to the eventual emergence of that one malignant cell. This approach was, he said, appropriate even where different carcinogens were involved. He said that where, as with the claimants in this litigation, the major carcinogen from both smoking and occupational exposure is the same (i.e. PAHs), it is even more plausible that both exposures should have contributed to the process.

8.21 Dr Rudd was asked why, if his thesis was correct, there had been any need for the *Fairchild* exception. His response was that, in *Fairchild*, he and the other experts had been instructed to consider from what source the asbestos fibre(s) that had caused the final step in the production of the malignant cell had come. They were unable to do so; hence the impossibility of establishing causation and the necessity for the creation of the *Fairchild* exception. He said that the expert evidence in *Fairchild* was given in the light of the knowledge of carcinogenesis at that time. Judgment at first instance was given in *Fairchild* in February 2001) and, since then (understanding of the molecular basis of carcinogenesis has progressed considerably. Dr Rudd said that, if he were asked the same questions now as he had been asked in *Fairchild*, he would say that it was probable that the asbestos fibres from each source had contributed to the carcinogenic process.

8.22 Dr Rudd said that, in order to assess the extent of the contribution made by a carcinogen, it is necessary to refer to the epidemiological evidence and to look at risk factors. He made clear that the issue of the magnitude of the increase in risk that should be considered sufficient to establish whether the contribution made by the carcinogen had been 'material' was a matter for the court. From the medical point of view, even very light exposure might contribute to the carcinogenic process. However, a court might consider that the exposure had been so light that it should not attract an award of damages. He did not offer an opinion as to the size of risk that should be accepted by the court as constituting a 'material' contribution for the purposes of establishing legal causation.

8.23 Professor Jones accepted the general description of the multi-stage process of carcinogenesis given by Dr Rudd. However, he considered that, in the absence of evidence supporting the 'doubling of risk', any attempt to say that an occupational carcinogen had actually contributed to the chain of causal events that led to a particular cancer developing was, in scientific terms, "a step too far". He said that it was not possible to say, in relation to a lung cancer which developed in an individual who had been exposed to PAHs at the Phurnacite Plant, that the mutations that had led to the formation of that cancer had or had not been influenced by the carcinogens contained in tobacco smoke and/or by the occupational exposure to PAHs. It is, he said, possible for a cancer to develop without any apparent 'cause', in the sense of an external agent. Even if a carcinogen had been involved in the process of tumour formation, its involvement may have been at a very early stage and may have had only a small effect on the risk of a tumour developing. Professor Jones did not consider that it could properly be said that the malignant cell had necessarily been exposed to either, both or neither of the carcinogens. It might have been; it might not.

8.24 Professor Jones accepted that both smoke-derived carcinogens and occupational carcinogens would have contributed to the carcinogenic process in the sense of creating an increased population of cells with different numbers of DNA changes caused by mutations. However, he did not believe that it was possible to say, in relation to any cell that became malignant, that it had been affected by either carcinogen. He said that the individual's occupational exposure to carcinogens would have increased the risk of developing lung cancer faced by that individual, and by all other individuals with the same smoking history. However, it could not be said with any confidence in relation to that specific individual that the causal chain of his lung cancer had been influenced by occupational exposure.

8.25 Dr Falk agreed with Professor Jones that it was impossible to determine whether or not a specific carcinogen had caused one or more changes in a cell which had ultimately become malignant. He accepted when it was put to him in cross-examination that it was likely, where an individual has had major exposure to two different carcinogens, that both carcinogens will have contributed at some stage to the multi-stage process that caused the cancer. However, he emphasised that it would not be possible to ascertain scientifically the extent of the contribution, i.e. whether it could properly be termed 'material'.

8.26 Dr Falk said that, in cases where the exposure to an occupational carcinogen was not sufficient to double the risk of the development of lung cancer, the exposure would have the effect of increasing the risk. Where exposure to a carcinogen is associated with a small increase in risk, it would be difficult to say that exposure to that carcinogen had 'caused' the risk to materialise. Since the changes that occur within the cells are largely random in nature, it cannot be said that the exposure 'caused' or even 'contributed to' a specific cancer.

Personal susceptibility

8.27 Dr Rudd said that, in the present case, the risk posed by occupational exposure to PAHs would be increased in certain individuals by the effect of personal susceptibility. There is no dispute that there are variations in personal susceptibility to carcinogens, including those in tobacco smoke. However, the experts differed in their views about the incidence and effects of personal susceptibility.

8.28 The relative risk factor calculated by reference to a cohort of individuals will be an average, reflecting the spectrum of susceptibility of those individuals. Within the cohort will be individuals who are more susceptible than average (i.e. who will have a higher than average risk) and others who are less susceptible than average (i.e. who will have a lower than average risk). Dr Rudd considered it probable that the individuals who actually develop lung cancer are those who are more susceptible and who have higher than average risk factors. He conceded that the effect could not be quantified. However, susceptibility was, he said, a factor that should be taken into consideration. He said that it tended to support his view that an estimated risk factor of less than double the risk might reasonably be regarded as sufficient to establish causation. If the individual who has developed a cancer can be assumed to be of more than average susceptibility, a smaller amount of the occupational carcinogen (i.e. an amount which would ordinarily give rise to a risk factor of less than double) will have been required to cause the cancer in that individual, when compared with the average individual.

8.29 Dr Rudd said that it was only if the proportion of more susceptible individuals in the population was very small that it would not be the case that the majority of cancers would develop in more susceptible individuals. He said that it is known that there are approximately equal proportions of people who are less susceptible than average and more susceptible than average to tobacco smoke. Therefore, it is to be expected that, in a cohort of individuals who have been exposed both to smoking-derived carcinogens and BaP, more cases of lung cancer will occur among the more susceptible individuals than among the less susceptible individuals.

8.30 Dr Flaks' evidence was that – somewhat counter-intuitively – in a group exposed to a carcinogen, it is not necessarily the most susceptible individuals who develop the cancers. He attributed this to the stochastic nature of the carcinogenic process.

8.31 Dr Rudd accepted that, if the two carcinogens under consideration were different, it would not be appropriate to assume that an individual would necessarily be susceptible to both carcinogenic agents. However, in the Phurnacite cases, BaP was common to both smoking and occupational exposure, so the susceptibility to both types of exposure was likely to be the same. Dr Flaks' evidence was rather different. He said that animal studies suggested that it was likely that the TSNs in tobacco smoke are more important lung carcinogens than PAHs.

8.32 Professor Jones did not agree that those individuals who develop lung cancer are necessarily more susceptible than average. He said that such a conclusion involved making assumptions about relative sensitivities to occupational and non-occupational carcinogens and about the proportion of more susceptible individuals in the population. Professor Jones accepted that, within the population, there is a spectrum of different degrees of susceptibility to a specific carcinogen. However, he did not accept that varying susceptibility was the only factor in determining who developed lung cancer and who did not. He said that, since cancer is a stochastic process, chance is a factor. Nor did he accept that the division of the population into individuals of greater and lesser susceptibility was apparently equal, as Dr Rudd had described. More fundamentally, however, Professor Jones suggested that it was inappropriate to take personal susceptibility into account when considering causation in an individual case. To do so would, he said import a degree of 'double counting' which would be unduly favourable to the claimant.

8.33 Professor Jones did not accept that the operative carcinogens contained in cigarette smoke and in the dust and fume to which workers at the Phurnacite Plant were exposed were necessarily the same. He said that both tobacco smoke and the dust and fume produced at the Phurnacite Plant contained a large number of different carcinogens. It could not be assumed that BaP had been the only operative substance in each case. If it had been, its effect would not have been multiplicative (or nearly so), as he and Dr Rudd had agreed. Instead, it would have been additive. Professor Jones agreed that, if different carcinogens were playing a part, it is likely that the carcinogens resulting from the two exposures would have acted at different stages of the carcinogenic process.

Exposure by inhalation

8.34 The experts agreed that inhalation exposure was the dominant factor in determining the risk of lung cancer. It was not in dispute that, for the purposes of lung cancer, it was inhalable - rather than respirable - dust that was the relevant agent. Most lung cancers arise in the major bronchi, into which all inhalable dust will penetrate.

Dermal exposure

8.35 Dr Rudd considered that measurement of the risks posed by inhalation of occupational carcinogens was likely to be an under-estimate of the total risk to an individual since workers at the Phurnacite Plant probably sustained more dermal exposure to pitch than was average for the cohorts included in the Armstrong meta-analysis. Dr Flaks also considered that dermal exposure was an important factor. Both experts accepted that there was no means of quantifying dermal exposure.

8.36 Professor Jones said that the assumption that workers at the Phurnacite Plant had had greater dermal exposure to carcinogens than the other groups of workers included in the Armstrong meta-analysis was purely speculative. In any event, he did not believe that there was any significant evidence to support a link between dermal exposure to PAHs and an increased risk of lung cancer.

The parties' cases

The claimants' case

8.37 The claimants' case was that they had established, in each of the lung cancer cases, that the claimant's occupational exposure had made a material contribution to the development of his cancer. Thus, it was not necessary for him to show that there had been a 'doubling of risk' as a result of the occupational exposure. A much lower level of risk would be required in order to establish that the contribution made by the exposure had been 'material'.

8.38 The claimants contended that any analysis of causation in this case must start with a finding as to whether the court was dealing with a case of competing causes or multiple causes. As an example of a case involving competing causes, Mr Allan cited *Wilsher v Essex Area Health Authority*[234]. In that case, a premature baby developed

[234] [1988] AC 1074

retrolental fibroplasia (RLF), causing blindness. The claimant's case was that the condition had been caused by the negligent administration of an excessive amount of oxygen. However, there were four other potential causes, all non-negligent. There was no satisfactory evidence that the excessive oxygen, rather than the other potential causes, was likely to have caused the claimant's RFL. The claimant was therefore unable to establish that the defendant's negligence had caused or materially contributed to his injury.

8.39 Mr Allan argued that, given the medical basis on which it was decided, *Fairchild* was also a case involving competing causes. He said that the evidence of the medical experts in *Fairchild* was that the claimant's mesothelioma might have been caused by a single asbestos fibre or a few fibres or many fibres; none of these possibilities was more probable than the others. If the cause was a single fibre[235], it was impossible to prove which defendant had been responsible for exposing the claimant to that fibre. Thus, the need arose for the *Fairchild* exception. If the evidence had been that a large number of asbestos fibres had contributed to the formation of the mesothelioma, the court would have been able to conclude that the asbestos fibres to which he had been exposed by all the defendants had played a part.

8.40 Mr Allan submitted that, in the light of the evidence relating to carcinogenesis, I should not view this as a case of competing causes. He said that the evidence suggested that it was probable that carcinogens resulting both from smoking and from occupational exposure to PAHs (in particular BaP) had contributed to the evolution of the claimants' lung cancers. That contribution will not necessarily have been made by bringing about the very last stage in the multi-stage process. The contribution may have taken a number of different forms during the period (often many years) for which the multi-stage process was in operation. Mr Allan pointed out that the agreed medical evidence is that the effect of the two carcinogens is likely to have been multiplicative, or nearly multiplicative. There is also dermal exposure to take into account.

8.41 Thus, Mr Allan did not accept that it was necessary for a claimant to prove that his risk had been more than doubled in order to establish causation. He argued that, in any event, the 'doubling of risk' test is inappropriate in a case of this kind where the court is not dealing with competing causes. He pointed out that the 'doubling of risk' test has a limited history and attracted a considerable amount of criticism (albeit *obiter*) in *Sienkiewicz*, when the members of the Supreme Court pointed out the potential dangers of placing too great a reliance upon epidemiological data and upon minute calculations of relative risk in order to apply the 'doubling of risk' test. He accepted that the extent to which the experts consider that the relevant occupational carcinogens have increased the risk of lung cancer is a relevant factor in the consideration of causation. However, he said that it should not be the sole test.

8.42 Mr Allan submitted that I should find as a fact that multiple factors were involved in the development of the claimants' cancer, the two obvious candidates being smoke-derived carcinogens and occupational exposure to carcinogens and that I should also find that, on the balance of probabilities, both factors will have played a part in the development of the claimants' cancers. It then becomes a legal question whether or not the contribution is sufficient to found causation and it is for the court

[235] The 'single fibre' theory is now recognised as no longer valid: paragraph 102 *Sienkiewicz*

to determine what level of contribution should be regarded as 'material' for these purposes.

8.43 Mr Allan submitted that I should find, in each case of lung cancer, that the tortious occupational exposure had materially contributed to the development of the claimant's cancer. He reminded me of Dr Rudd's evidence that, "when there had been substantial exposure to carcinogens, the odds against all the mutations having occurred entirely coincidentally would be very long indeed".

The defendants' case

8.44 Mr Walker submitted that each individual claimant must prove that the defendants' tortious act had been the, or at any rate an, operative cause in the development of his injury. He said that, in cases (other than mesothelioma cases) where the claimant has been able to prove no more than an increase in risk, the court's approach has been to require the claimant to satisfy the 'doubling of risk' test. If the claimant can prove that the defendant's tortious act has more than doubled the risk of the outcome of which he complains, he will have proved on the balance of probabilities that the tortious act caused that outcome. If he cannot satisfy the test, his claim will fail.

8.45 Mr Walker posed the question whether the 'doubling of risk' test has survived the case of *Sienkiewicz*. He said that the observations of the members of the Supreme Court on the point were not unanimous and were in any event *obiter* and were made in the context of a mesothelioma case. He pointed out that Lord Phillips had given approval to the 'doubling of risk' test in circumstances where there are competing alternative causes, subject to his observations about the quality of the available epidemiological evidence. He argued that this was one of those cases where the application of the 'doubling of risk' test was appropriate.

8.46 Mr Walker submitted that the application of the *Bonnington* principle was inappropriate in the circumstances of this litigation. He invited me to accept the evidence of Professor Jones and Dr Falk that the effect of the claimants' occupational exposure to carcinogens would have been to increase their risk of developing cancer. Their view was that it was not possible to say with any confidence that the occupational exposure had made a material contribution to the cancer that developed. He suggested that Dr Rudd's evidence had been somewhat inconsistent. In his evidence he had on several occasions[236] used the word "may" (as in "may have been contributing") to describe the activity of the occupational carcinogen. That, Mr Walker said, reflected the fact that it was not possible to say whether the occupational exposure had played a part in the development of the claimants' disease.

8.47 Mr Walker argued that it is not possible to determine, in relation to any specific cancer, that an occupational carcinogen - rather than a smoking-derived carcinogen or some other factor - has caused all or any of the changes which brought about the development of a cancer. The chance that the occupational carcinogen played some part in the process will vary according to the amount of the occupational carcinogen to which the claimant has been exposed. Therefore, it is only when one can be satisfied that the extent of the occupational exposure has been sufficient to

[236] See for example the passage quoted at paragraph 8.18 of this judgment.

double the risk of the cancer developing that it is possible to find, on the balance of probabilities, that the occupational carcinogen contributed to the cancer.

8.48 Mr Walker said that, if the court were to accept the claimants' submissions on causation, the result would be that, in every case where a claimant was able to establish tortious exposure to a carcinogen greater than *de minimis* and had developed a cancer, he would be able to establish causation. He would be able to do so even when the carcinogen was shown statistically to have increased his risk of developing a cancer by only a small amount, and notwithstanding the presence of other carcinogens (such as those derived from smoking) which had been demonstrated statistically to give rise to a far greater risk than the carcinogen to which the claimant had been exposed tortiously. Moreover, if the principle were to be applied in cases of cancer, there would be no reason why it could not be extended to cases involving other conditions also.

Discussion and conclusions

8.49 As far as I am aware, the arguments on causation advanced on behalf of the claimants in this case have never previously been argued before a court. They are based on the emerging understanding of the process of carcinogenesis. Whilst there was plainly some knowledge of the mechanism of carcinogenesis by the early 2000s (as evidenced by the diagram dating from 2001 to which Dr Rudd referred in his Generic Report), I accept that the possible implications of that mechanism on the issue of causation were not recognised until considerably later. If they had been recognised at that time, I have little doubt that they would have been deployed in argument in *Fairchild*.

8.50 The three lead claimants with claims for lung cancer were exposed to carcinogens, both from their occupational exposure at the Phurnacite Plant and as a result of their smoking. In addition, each would have been subject to other factors, such as environmental exposure to carcinogens (albeit usually at a low level) and endogenous features unconnected to any exposure to carcinogens. All these factors are likely to have played some part in the carcinogenic processes going on in the claimants' bodies, processes which are, by their nature, wholly random.

8.51 In their Joint Statement, Dr Flaks and Professor Jones agreed:

> "Because of the stochastic nature of carcinogenesis, the question of whether a particular human cancer has or has not been caused by (for example) occupational exposure can only be addressed in terms of likelihood; occupational exposure to a carcinogenic chemical will increase the likelihood of cancer occurring in an exposed individual, and if exposures are high enough will cause a discernable increase in the number of cancers occurring in an exposed population. For any particular individual, the cancer may have arisen as a result of the action of an occupational carcinogen in some combination with that of environmental exogenous agents and/or endogenous factors, or through the action of environmental and endogenous factors alone. Any scientific assessment of causation can only result in an expression,

either quantitative or qualitative, of the likelihood that an occupational carcinogen has been the "cause".

In general, the chain of causation for a particular case is likely to involve action by a combination of exogenous and endogenous agents at different steps of the process. For an individual case in which there has been occupational exposure to carcinogens, exogenous factors acting in the chain of causation may originate from either environmental or occupational exposure, or from both."

8.52 That passage underlines the fact that it is not possible to say, in relation to any individual cancer, which factor or factors have caused or contributed to its development. Dr Rudd accepts that, but points out that the same is true when reaching a conclusion about the causation of any cancer. It is only possible to reach a conclusion medically on the basis of an assessment of risk.

8.53 Dr Rudd has no means of assessing the likelihood that occupational exposure has in fact contributed to the lung cancer suffered by any individual claimant. He said that, when there has been substantial exposure to carcinogens, both occupational and from cigarette smoking, the "odds" against all the mutations necessary to produce a cancer having occurred entirely coincidentally without any contribution by those carcinogens would be "very long indeed". However, it seems to me that the only way to assess what those odds really are - and whether, on a balance of probabilities, the occupational carcinogen has made a contribution in any individual case - is by reference to the risk factors revealed in the relevant epidemiological material.

8.54 If I were to accept Dr Rudd's evidence that the claimants' occupational exposure to carcinogens had made a contribution to their cancer, I would need then to consider the nature of that contribution. Having regard to the evidence about the mechanism of the carcinogenic process, I question whether the term "cumulative" can really be applied to the part played by the claimants' occupational exposure to carcinogens when taken in conjunction with their exposure to the carcinogens contained in cigarette smoke and with the other factors that might have played a part in the development of their cancers. In respect of a cancer suffered by any individual claimant, the occupational carcinogen might or might not have contributed and, if it did contribute, it might have played a very minor or an extremely major role. Moreover, other factors – smoking-related, environmental and endogenous – might have been the sole cause of the cancer, might have played no part in its development or might have played a more minor or a more major role than the individual's occupational exposure to carcinogens. To describe the action of an individual claimant's occupational exposure to carcinogens as one of a number of "cumulative causes" of his cancer does not seem to me accurately to represent its role. It is a very different situation from *Bonnington*, where the additional dust exposure caused by the defendant's breach of duty plainly had a cumulative effect by adding to the claimant's total dust exposure or from *Bailey*, where there was clear medical evidence that the defendant's negligence had added to the claimant's weakness which had in turn resulted in her cardiac arrest and consequent brain damage.

8.55 In *Shortell*, there was evidence of the multiplicative effect of exposure to both asbestos and cigarette smoking and Lord Phillips accepted that the claimant's exposure to asbestos had been a "cumulative cause" of her cancer and had therefore made a material contribution to it. There appears to have been no discussion in that case about the biological mechanism by which it was suggested that the asbestos and cigarette smoking exposure had acted "cumulatively".

8.56 In *Sienkiewicz*, the Supreme Court did have evidence about the carcinogenic process, derived from the judgment of Rix LJ in *Employers' Liability Insurances "Trigger" Litigation*[237]. However, the focus of attention in *Sienkiewicz* was directed to the process by which a single carcinogenic agent (asbestos) caused mesothelioma.

8.57 Having regard to the evidence about the carcinogenic process given to me, it does not seem to me that, in *Shortell*, the asbestos and cigarette smoke can properly be said to have acted cumulatively to cause the claimant's cancer. The multiplicative effect described in *Shortell* referred, not to the biological mechanism which took place in order to cause the cancer, but to the greatly increased effect on risk produced by exposure to a combination of the two carcinogens. It seems to me that the court in *Shortell* was really being told, not that asbestos and cigarette smoke had combined cumulatively to <u>cause</u> the claimant's lung cancer, but that asbestos and cigarette smoke had combined cumulatively to <u>increase the risk</u> of lung cancer. Therefore it seems to me that the judge at first instance was right to decide the case on the basis of 'doubling of risk'.

8.58 The claimants suggested that the potential for their occupational exposure to carcinogens to have acted cumulatively with their exposure to carcinogens as a result of their smoking was increased by the fact that the carcinogens from both sources were the same, namely PAHs. It is true that the claimants would have been exposed to PAHs from both sources. However, cigarette smoke contains many other carcinogens, including TSNs which, according to Dr Flaks, are probably the most potent carcinogens contained in cigarette smoke. (I note that, in *Novartis*, it was alleged that the claimant had been exposed to aromatic amines in the course of his work and that his occupational exposure, together with the amines (TSNs) to which he had been exposed as a result of his smoking, had caused his bladder cancer.). The dust and fume to which the claimants were exposed at the Phurnacite Plant will also have contained other carcinogens in addition to PAHs. Therefore, it seems to me that it would be unwise to place significant reliance on the fact that some of the carcinogens were common to both the claimants' occupational exposure and their smoking. As Professor Jones pointed out, the fact that their combined effects on risk are multiplicative or nearly so, strongly suggests that different carcinogens were at work. If the carcinogens from both sources had been identical, one would have expected their effects on risk to have been additive, rather than multiplicative.

8.59 Even if I were to accept that it is more probable than not that occupational exposure to carcinogens made a contribution – whether directly or indirectly – to the development of an individual claimant's cancer, I would then face the difficulty of assessing whether that contribution was 'material'. In *Bonnington*, Lord Reid said that any contribution that was not *de minimis* is 'material'. That view has prevailed ever since. However, the claimants appeared to accept that, in the context of this litigation, the threshold of anything more than *de minimis* was unrealistic and they suggested that I should set the bar rather higher.

[237] [2010] EWCA Civ 1096

8.60 Dr Rudd suggested that it would be necessary for the court to examine the risk factors and to make a judgment as to where the line of materiality should be drawn, according to the court's view as to whether it would be reasonable to compensate an individual for a specific level of increased risk. For example, I would have to decide whether it was reasonable to find that, where there had been occupational exposure to carcinogens which gave rise to, say, a 15% increase in the risk of developing lung cancer, the occupational carcinogens had made a 'material contribution' to the claimant's cancer. Whereas a lesser risk would not Such an exercise would involve an arbitrary decision on my part as to where to draw the line. I cannot envisage on what basis I could decide where to make the distinction between what is and is not 'material', other than by reference to the test propounded by Lord Reid, which is in any event binding on me. Nor do I know how I could decide at what level of risk it would be 'reasonable' to compensate a claimant. It does not seem to me that it would be permissible for me to carry out such an exercise.

8.61 All these considerations lead me to the conclusion that it cannot be right to approach the cases of lung cancer – nor indeed those of bladder cancer – by applying the *Bonnington* principle. Moreover, to adopt the claimants' arguments would, as the defendants have pointed out, have potentially far-reaching effects. It would mean that, in any case of cancer where a claimant could establish tortious exposure to a carcinogen that was 'material' (according to whatever measure of materiality the court chose to adopt) the claimant would succeed in establishing causation and would be entitled to 100% damages. Whilst I have some sympathy with the predicament of claimants who may have difficulty in establishing a link between occupational exposure to carcinogens and the development of their cancers, I cannot accept that such a result would be fair to potential defendants who would be required to pay full damages in many cases in which occupational exposure had played a small part or, perhaps, no part at all.

8.62 In view of my conclusions on the material contribution argument, I must look for another way of approaching the case. The obvious alternative – and that urged on me by the defendants – is the application of the 'doubling of risk' test. It is plain that the majority of members of the Supreme Court in *Sienkiewicz* considered that the test can be used in appropriate circumstances although there was obvious concern about over-reliance on epidemiological evidence alone.

8.63 In this litigation, I have the benefit of a wealth of witness and other evidence about the working conditions at the Phurnacite Plant and the extent of the exposure to dust and fume of the men working there. I have previously referred to this evidence and also to the available evidence about exposure levels at the Phurnacite Plant. Although the latter evidence has its limitations, it accords well with the witness evidence and I am satisfied that it represents a reasonably accurate picture of the exposure levels of the relevant lead claimants. The expert witnesses who dealt with the issue of lung cancer were all impressive and had an excellent knowledge of the relevant epidemiological material. The meta-analysis on which Dr Rudd and Professor Jones based their (eventually agreed) assessment of the level of exposure to BaP required in order to more than double the risk of lung cancer was undertaken by a well respected researcher and is generally considered to be authoritative. All these factors encourage me in the belief that the 'doubling of risk' test is an appropriate approach in the circumstances of this litigation.

8.64 The claimants suggested that it would be appropriate to find causation proved in an individual case even if the claimant's occupational exposure to carcinogens had been at a level which would not give rise to a 'doubling of risk'. This was on the basis that a claimant who develops cancer must have a greater than average susceptibility and would therefore require less occupational exposure than that which would be required to produce a 'doubling of risk' in order to develop a cancer. I do not accept that contention for the reasons given by Professor Jones. I note also that Dr Flaks did not accept that it was necessarily the most susceptible individuals who developed cancer.

8.65 Nor do I consider that the fact that a claimant has had extensive dermal exposure to PAHs is a reason to find causation proved in an individual case of lung or bladder cancer where the claimant's occupational exposure by inhalation has been at a level which would not give rise to a 'doubling of risk'. There is no convincing evidence of a link between dermal exposure and lung or bladder cancer and in any event no way of quantifying that exposure.

SECTION 9

THE CAUSATION OF BLADDER CANCER

The expert evidence

9.1 The expert evidence relating to the causation of bladder cancer came primarily from Mr Bo Pettersson, consultant urological surgeon, for the claimant, and Professor Stephen Jones for the defendants. Parts of Dr Flaks' evidence about carcinogenesis were also relevant. Mr Malcolm Bishop, retired consultant urological surgeon, reported on condition, prognosis and life expectancy in the cases of Mr Jenkins and Mr Richards, the two lead claimants with claims for bladder cancer. However, Mr Bishop declined to express a view on causation, on the ground that it (and, in particular, the relevant epidemiology) was outwith his expertise as a consultant urological surgeon. Indeed, he went further than that, asserting that causation issues should be dealt with solely by specialist cancer epidemiologists and occupational hygienists, not by urologists.

9.2 Mr Pettersson disagreed with that view. He has a special interest in urological oncology and considers that a knowledge of the relevant epidemiology is one of the necessary "tools of his trade". He said that such knowledge enabled him to advise his patients on issues like the relative prospects of success of the various forms of treatment available and the steps to be taken to prevent a recurrence of a cancer. He said that it was sometimes relevant for him to be able to advise patients about the probable cause of their cancer. He considered that he was well qualified to give evidence on the issue of causation, both generically and in the individual cases of Mr Jenkins and Mr Richards.

9.3 I do not accept Mr Bishop's assertion that no consultant urological surgeon is qualified to give evidence on causation in a case such as this. It may well be that many clinicians do not have a detailed knowledge of the latest research papers, reviews and analyses in their field of practice. They will probably have a general knowledge about new developments and types of treatments gleaned from the medical media, without having examined the original published material. Their knowledge may be sufficient for their own day-to-day professional practice but plainly would not equip them to give expert evidence on a topic (such as causation) that required a good understanding of the relevant epidemiology. It appears that Mr Bishop would fall into this category. That being the case, he was right to acknowledge that fact.

9.4 However, other clinicians will make a practice of keeping abreast of every important new development in their field of practice. They will read and evaluate carefully each new paper as it is published and will re-assess their understanding of the subject matter in the light of each new development. Very often, such practitioners will perform research and will themselves publish peer-reviewed papers. Clinicians in this category will often have the expertise necessary to give evidence based on the relevant epidemiological evidence. Moreover, unlike experts without the experience of practice in the relevant field, they will be able to view the epidemiological evidence in the context of their clinical knowledge and experience.

9.5 When a clinician (or indeed any other expert witness) professes expertise in a subject and gives evidence about it, it is for the court to assess the extent of his/her expertise and the weight to be placed on that evidence. In Mr Pettersson's case, his knowledge of the relevant epidemiology appeared very superficial. I gained the impression that he had not read the relevant papers with any degree of care (if at all) until a late stage in these proceedings, probably just before the Joint Meeting with Professor Jones. I have no doubt that his knowledge of the literature is sufficient to enable him properly to advise his patients on the types of treatment available to them, the likely outcomes and matters of that kind. However, issues such as whether or not bladder cancer can be caused by exposure to the type of substances present in the dust and fume emitted at the Phurnacite Plant or whether a man who gave up smoking years before still has an increased risk of bladder cancer are more complex and less relevant in day-to-day practice. I was not confident that Mr Pettersson had a sufficiently good knowledge of the relevant literature to be able to express an authoritative opinion on its various strengths and weaknesses. By contrast, as I have previously observed, Professor Jones, although not medically qualified, had an excellent knowledge and grasp of the relevant epidemiology.

The disease

9.6 The three most common cancers amongst males in the UK are prostate, lung and colorectal cancer. They are significantly more numerous than bladder cancer, which is the fourth most common. Bladder cancer is significantly more common in men than in women.

9.7 Most bladder cancers do not cause death. Seventy per cent of patients with bladder cancer have superficial tumours which are not life-threatening and can be removed. However, such tumours frequently recur and regular cystoscopic examinations are required after their removal in order to ensure that any recurrence is detected and treated as early as possible. The remaining 30% of patients have muscle-invasive disease which carries with it a high risk of death from metastasis. Such disease is treated radically, by surgery and/or radiotherapy, unless it has metastasised too far for treatment to be effective.

9.8 The major known causes of bladder cancer are occupational exposure to carcinogenic chemicals and cigarette smoking. However, many bladder cancer cases have no identifiable cause. The experts estimated the proportion of such cases at between about 25% (Mr Pettersson) and about 50% (Mr Bishop) of all bladder cancer cases. Whichever is right, it is plain that a significant proportion of bladder cancer cases have no identifiable cause.

9.9 Bladder cancer has a long latent period and can develop many years after exposure to the carcinogenic agent that is believed to have caused it. Mr Bishop suggested a typical latency period of 15-25 years whilst Mr Pettersson's opinion was that the latent period generally lay between about 15 and 40 years.

The epidemiological evidence

9.10 The first issue to be determined is whether there is epidemiological evidence to support the proposition that bladder cancer can be caused by exposure to substances of the kind which the relevant claimants encountered at the Phurnacite Plant.

9.11 It was conceded on behalf of the claimants that they could not point to a specific study within the medical literature which established beyond doubt the link between bladder cancer and exposure to dust and/or fume of the type encountered at the Phurnacite Plant. However, they argued that there was evidence in the literature that made it very likely that such a link did in fact exist.

The evidence relating to the Phurnacite Plant

9.12 As I have already explained, the manufacturing process carried on at the Phurnacite Plant was unique and cannot be directly compared with processes carried out in any other industry. Much of the evidence I heard in relation to the issue of causation of bladder cancer related to processes in other industries that were in some respects similar to those carried out at the Phurnacite Plant. There was considerable debate about the extent of the similarities and differences between the various processes and the nature of the dust and fume emissions produced by them.

9.13 The experts agreed that, whilst employed at the Phurnacite Plant, the claimants had been exposed by way of inhalation, ingestion and dermal contact to a combination of coal and pitch dust and to a number of PAHs, including BaP.

9.14 I have already referred at Section 8 of this judgment to the study that examined mortality from various types of cancer at the Phurnacite Plant, published in 1987 by the IOM[238] (the 1987 IOM study). The 1987 IOM study investigated the mortality amongst male workers employed at the Phurnacite Plant on 1 January 1967 over a 17-year period to December 1983. As at 31 December 1983, 479 of the 609 subjects were still alive and 130 had died. The 1987 IOM study showed more deaths from cancer than would have been expected to occur. The specific sites of cancer were the lungs (17 observed; 11.7 expected), the stomach (6 observed; 3.7 expected), the bladder (3 observed; 1.3 expected) and the prostate (2 observed; 1.1 expected).

9.15 The authors of the 1987 IOM study concluded that, since the evidence of a connection between coal carbonisation and lung cancer was well established, the excess of lung cancer deaths at the Phurnacite Plant was likely to have been caused by occupational exposure. However, they went on to observe that the position with cancers at other sites (including the bladder) was "less clear". The numbers of deaths were small and the results were not statistically significant. Nevertheless, they observed that, in view of the evidence of other studies linking bladder cancer with coal tar products, the excess number of bladder cancer deaths at the Phurnacite Plant might also be work-related. The report of the 1987 IOM study noted that the three men who had died of bladder cancer had all worked in the briquetting plants or on the batteries. They had not been employed in the by-products plants or the pitch bays.

9.16 The claimants' case was that, although the excess number of bladder cancer deaths found in the 1987 IOM study was not statistically significant, the result raised (as the authors had observed) a real possibility of an occupational link. 'Statistical significance' is a measure of the likelihood that a particular result occurred by chance. The measure conventionally used is a 95% 'confidence interval', i.e. a range of values within which there is a 95% probability that the result has not occurred by chance. However, even when a result does not reach that high level of probability, the possibility that it occurred by chance may be small. Thus, despite the fact that the

[238] Smith, Hurley *et al* (1987): Jones 8/5

three deaths of bladder cancer in the 1987 IOM study did not reach the conventional level of statistical significance, Dr Flaks calculated that the possibility that the result had occurred by chance was only about 10%.

9.17 Professor Jones did not disagree with Dr Flaks' calculation as a mathematical exercise. However, his view was that the number of deaths from bladder cancer in the 1987 IOM study was too small to enable any reliable conclusions to be drawn. If there had been only one fewer death, the possibility that the result had occurred by chance would have been very much higher.

Comparison with the coke production industry

9.18 The most obvious industry with which to compare the manufacture of Phurnacite is the coke production industry. I have previously discussed the similarities and differences between the two industries. What they had in common was the process of carbonisation which, in both cases, was carried out in ovens at high temperatures. The carbonisation of coke produces CTPVs, as did the carbonisation of Phurnacite. However, there were differences between the respective temperatures at which the carbonisation of coke and of Phurnacite took place and between the length of time required to complete carbonisation in each case. Furthermore, pitch was used as a binding agent in the manufacture of Phurnacite, but not in the production of coke.

9.19 There have been a number of studies dealing with mortality from cancer in coke production plants[239], none of which showed statistically significant evidence of a link between coke production and bladder cancer.

9.20 The defendants submitted that, since the coke production plant studies showed a clear link between exposure to CTPVs from coke ovens and lung cancer, the absence of any evidence of such a link with bladder cancer suggests that no such link exists. However, the claimants argued that the mortality studies provided no information about the number of diagnoses of (as opposed to deaths from) bladder cancer amongst individuals who had been exposed to CTPVs whilst working on coke ovens. Since lung cancer is a much more common disease than bladder cancer and only a minority of bladder cancers result in death, it is, they say, not surprising that the studies do not show an excess number of deaths from bladder cancer.

9.21 I was referred to only one study[240] that dealt with morbidity (i.e. the number of diagnosed cases) as well as mortality (the number of deaths). That study looked at cancers amongst men working in a Norwegian coke production plant. It showed a slightly increased number of bladder cancer cases diagnosed amongst men working in the plant (5 cases observed; 4.5 expected), but the difference was not statistically significant. In their conclusions, the authors noted that their study had two limitations – a small cohort of subjects and a short follow-up time. They advised that, because of those limitations, the results should be interpreted with caution. Thus, the study is of limited value.

[239] Those cited by Professor Jones were Buck and Reid (1956); Redmond *et al* (1976); Hurley, Cherrie et al (1991; BSC) & Chau Bertrand *et al* (1993)
[240] Bye, Romundstad *et al* (1998)

Comparison with the aluminium smelting industry

9.22 Aluminium is smelted by reducing alumina (aluminium oxide) in large electrolytic cells or electrolytic baths (known as 'pots'). A steel shell lined with carbon constitutes the negative electrode or cathode. The positive electrode or anode is a mixture of coke and either petroleum pitch or coal tar pitch, which is suspended over the electrolytic bath. In the Söderberg process of aluminium smelting, the coke and pitch mixture is fed as a paste into the anode compartment. In the electrolytic bath, the alumina is dissolved in molten cryolite which reduces its melting point so as to enable the electrolytic cell to be operated effectively at temperatures around 950°C (a similar temperature to that used for the carbonisation of Phurnacite). During the electrolysis process, the alumina is reduced to molten aluminium and deposited at the cathode where it is siphoned off. Meanwhile, because of the heat of the electrolytic bath, the anode slowly breaks up into particles and gases containing, *inter alia*, PAHs.

9.23 Large scale studies carried out in the aluminium smelting industry have demonstrated a substantially increased risk of bladder cancer due to occupational exposure. Most of the smelting at the aluminium plants studied was done by the Söderberg process. A Canadian study published in 1984[241] found an unusually high incidence of bladder cancer amongst individuals working at aluminium reduction plants. Exposure to PAHs, of which BaP served as an indicator, seemed to be the causative factor. The 'relative risk' was found to be as high as 12.38 for workers with 20 or more years of BaP exposure, i.e. the risk of developing bladder cancer for such workers was 12.38 times that of controls without any relevant exposure. As Professor Jones observed, this is a very high relative risk and, if it were carried through to the coke production industry, one would have expected to see some increased mortality from bladder cancer in the coke production studies. It does not appear that this size of relative risk was reproduced in later studies of the aluminium smelting industry.

9.24 Another Canadian study published in 1995[242] looked at the incidence of bladder cancer amongst approximately 16,000 individuals who had worked at a major aluminium reduction plant, mainly using the Söderberg process. The individuals had all worked at the relevant plants for more than a year during a 30-year period starting in January 1950. The study identified an increased risk of bladder cancer, especially amongst men who had worked on the Söderberg process. A strong association between the risk of developing bladder cancer and cumulative exposure to CTPVs (measured as BSM or BaP) was observed. The authors found that BaP cumulative exposure was a better indicator of risk than BSM cumulative exposure. However, they made clear that it should not necessarily be assumed that either BaP or PAHs in general were the causal agent. They suggested that it was possible that the operative substances might be aromatic amines such as 2-naphthylamine, which are known to cause bladder cancer in humans and which are emitted during the Söderberg process. Nitro-PAHs were identified as another possible causal agent.

9.25 As a result of these studies and others like them, the link between exposure to the substances emitted during the Söderberg process and the risk of bladder cancer is now well recognised. Although the aluminium smelting studies have not identified an entirely consistent link with an excess incidence of lung cancer, the study by

[241] Theriault, Tremblay *et al* (1984).: Pettersson 3/276
[242] Tremblay, Armstrong *et al* (1995) Jones 8/128

Tremblay, Armstrong, *et al* (1995) found an association between lung cancer and employment on the Söderberg process.

9.26 The claimants contended that the similarities between the substances emitted during carbonisation at the Phurnacite Plant and those produced by the Söderberg process provided strong support for the contention that the processes carried on at the Phurnacite Plant also gave rise to an increased risk of bladder cancer. The aluminium smelting studies – unlike the coke production studies – examined the incidence of bladder cancer, rather than mortality. Thus, they had revealed the increased risk of bladder cancer which had not been evident from the coke production studies.

9.27 Professor Syred's evidence was that, although petroleum coke (rather than coal) was used in the Söderberg process, the coke had a low volatility content, as did the coal used in the carbonisation of Phurnacite. However, the most important similarity between the two processes was the presence of pitch. The 'cooking' times and temperatures for both processes were similar and Professor Syred suggested that they would have produced similar levels of BSM and BaP.

9.28 Professor Jones considered that there were more differences than similarities between the two processes. He said that the petroleum coke used in the Söderberg process was a completely different material from the coal used at the Phurnacite Plant and would have contained a number of different chemical constituents, some of which may have been carcinogenic. He accepted that, if coal tar (rather than petroleum) pitch was used in the Söderberg process, pitch would have been a common factor. (I note that the report of the study by Tremblay, Armstrong *et al*, (1995) referred to the use of petroleum pitch[243].) However, he said that the "chemical environments" of the two processes were quite different. During the Phurnacite carbonisation process, the only materials present were coal and pitch, heated largely in the absence of air. In the Söderberg process, molten cryolite, alumina and aluminium were also present and the oxidation and reduction reactions were significantly more complex than the Phurnacite carbonisation process. In addition, the Söderberg process involves the gradual heating of the anode paste which sinks to the bottom of the anode compartment, emitting volatiles as it gains heat. More paste is then poured in and heats up quickly, giving rise to further emissions. Professor Jones suggested that this was very different from the process at the Phurnacite Plant, where the ovoids were carbonised in a sealed oven, and emissions occurred only at the point when the oven was opened, by which time most of the CTPVs would have been burned off.

9.29 Professor Jones considered that men working on the Söderberg process would have been exposed to a range of potentially hazardous substances which would not necessarily have been present during the carbonisation of Phurnacite. He referred in particular to the possibility, raised in the study by Tremblay, Armstrong, *et al*, (1995), that 2-naphthylamine or nitro-PAHs might have been the causal agent. Professor Jones accepted that, although no relevant analysis had been undertaken, it was "quite likely" that aryl amines, which are known to be potent carcinogens, were present to some degree in emissions from the ovens at the Phurnacite Plant. He also accepted that it was possible that 2-naphthylamine might have been present in those emissions. However, neither the presence of 2-naphthylamine nor that of nitro-PAHs had been confirmed.

[243] Jones8/130

Comparison with carbonisation plants in the gas production industry

9.30 The claimants also sought to draw an analogy between the carbonisation processes carried on at the Phurnacite Plant and in the coal carbonising plants at gas works.

9.31 The eminent epidemiologist, Sir Richard Doll, carried out a series of studies[244] into the mortality rates and causes of death of men who were, or had in the past been, employed as gas workers in the UK. The studies published in 1965 and 1972 focused in particular upon men who had worked regularly in carbonising plants. The 1965 study examined mortality between 1953 and 1961. An excess risk for lung cancer was observed amongst men who had had heavy exposure to dust and fume in carbonising plants. There was a small increased risk from bladder cancer although it did not quite reach statistical significance. The 1972 study added a further four years' data to the previous study. The new data provided confirmation that exposure to the products of coal carbonisation could give rise to lung cancer and, according to the authors, "left little doubt" that the risk of bladder cancer was also increased. The authors noted that the fumes emitted during coal carbonisation at gas works contained significant quantities of the known carcinogens, 2-naphthylamine and 1-naphthylamine, which would have been inhaled by the men working there and absorbed as a result of contact between tar and their skin. They suggested that individuals who developed bladder cancer were likely to have had "unusually heavy exposure". However, they cautioned that 2-naphthylamine and 1-naphthylamine were not the only substances present in tar fumes that were capable of causing bladder cancer.

9.32 Coal gasification is no longer carried out in the same way as previously and the number of studies relating to the process is limited. The object of coal gasification was to remove by-products from the coal which necessitated the use of lower grade coal than that used to make Phurnacite. Professor Jones described the studies by Doll *et al* as "the only substantial evidence for a link between occupational exposure in coal carbonisation and an increase in the risk of bladder cancer" although, bearing in mind the lack of other similar studies and the differences between coal gasification and the Phurnacite carbonisation process, he considered that caution should be exercised in drawing an analogy between the two.

9.33 An International Agency for Research on Cancer (IARC) Working Group evaluated the carcinogenicity of coal gasification in 1984[245]. They concluded that there was 'limited' evidence that exposure to coal tar from the destructive distillation of coal gave rise to bladder cancer. For the purpose of IARC's work, the term 'limited' in the context of human carcinogenicity has a specific meaning, namely:

> "A positive association has been observed between exposure to the agent, mixture or exposure circumstance and cancer for which a causal interpretation is considered by the Working Group to be credible, but chance, bias or confounding could not be ruled out with reasonable confidence,"

[244] Doll (1952); Doll, Fisher *et al* (1965) and Doll, Vessey *et al* (1972)
[245] IARC 1984a Flaks1/64

Views expressed in the literature

9.34 The claimants contended that their case as to the link between PAHs (in particular BaP) and bladder cancer derived considerable support from a number of authoritative publications which, whilst acknowledging that the causal relationship was not as clear as that between PAHs and lung cancer, nevertheless accepted that there was cogent evidence of such a relationship.

9.35 The claimants relied first on a review published in 1997 by Boffetta *et al*[246]. In the Abstract, the authors stated:

> "Epidemiologic evidence on the relationship between polycyclic aromatic hydrocarbons (PAHs) and cancer is reviewed. High occupational exposure to PAHs occurs in several industries and occupations. Covered here are aluminium production, coal gasification, coke production … Heavy exposure to PAHs entails a substantial risk of lung, skin and bladder cancer, which is not likely to be due to other carcinogenic exposures present in the same industries. The lung seems to be the major target organ of PAH carcinogenicity and increased risk is present in most industries and occupations listed above. An increased risk of skin cancer follows high dermal exposure. An increase in bladder cancer risk is found mainly in industries with high exposure to PAHs from coal tars and pitches. Increased risks have been reported for other organs… "

9.36 In their Conclusions, the authors observed that the increase in bladder cancer risk was less consistent than that demonstrated for lung and skin cancers. They said that a pattern could be identified, pointing towards industries with high PAH exposure from coal tar and pitch, such as aluminium production, coal gasification and tar distillation.

9.37 Mr Pettersson also referred in his Report to a review by Bosetti, Boffetta *et al* (2007)[247] on which the defendants also placed reliance. The authors reviewed the results from studies conducted on workers exposed to PAHs in various industries, namely aluminium production, coal gasification, coke production, iron and steel making, the manufacture of coal tar and related products, and the production of carbon black and carbon electrodes. They concentrated on examining studies that had been reported since the review by Bofetta *et al* (1997), although their results also took account of earlier studies. They noted that the studies of coke production showed no evidence of an increased risk of bladder cancer. By contrast the Norwegian studies of aluminium production had confirmed an excess risk for cancer of the bladder but did not show any association for lung cancer. They observed that the "cause-effect inference" remained "unclear" in aluminium production, given the small excess risk and the limited data on relative risk associated with dose and duration of exposure. They referred to the "modest" excess risks of bladder cancer for most industries (except coal gasification where the relative risk had been reported by Doll *et al* at

[246] Boffetta *et al* : Pettersson 1/[92]
[247] Pettersson1/125

2.39). They observed that the possibility that the apparently excess risk was due to some bias or confounding factor could not be completely ruled out.

9.38 The claimants also relied on a review and meta-analysis of published reports of occupational epidemiological studies concerning the relationship between exposure to PAHs and cancers of the lung and bladder, carried out on behalf of the HSE in 2003[248] (the 2003 HSE review). The authors of the review noted that there was "little independent evidence" for an association of bladder cancer with PAHs in coke ovens or other industries except for the aluminium production industry. However, they observed that the small numbers of cases examined in the studies, especially for mortality studies, "limited power".

9.39 At section 4.2 of the 2003 HSE review, the authors stated:

> "Results for bladder cancer were more uncertain than for lung cancer, due mainly to the much smaller number of cases in this rarer cancer. Although our results support a PAH-bladder cancer association, there is less evidence for a PAH-bladder cancer causal association than there is for lung cancer. Only for the aluminium production industry was the evidence for an association strong. On the other hand the data from the other industries were weak rather than negative – and were compatible with a generic PAH risk of the same magnitude per unit BaP across all cohorts.
>
> As we commented in the Introduction, previous reviews have similarly concluded that there is a much stronger weight of evidence that PAH causes lung cancer than that it causes bladder cancer. One recent review … noted specifically that the evidence was confined to the aluminium production industry. Other co-exposures, in particular aromatic amines and nitro-PAH…known to be present in small concentrations in aluminium potrooms, have been suggested as alternative causal agents. However, it is unclear why these would not also be present in other PAH-exposed workplaces.
>
> If we do assume a causal association, the absence of significant heterogeneity between studies suggests focusing for quantitative risk estimation on the overall mean URR of 1.33."

9.40 The claimants also relied on a report on the burden of occupational cancer in Great Britain written for the HSE in 2007[249] (the 2007 HSE report). That report in turn drew on information contained in a paper by Siemiatycki, Richardson *et al* (2004)[250] (the Siemiatycki paper), describing the work done by IARC in evaluating the evidence of carcinogenicity for a variety of substances encountered in the workplace.

[248] Armstrong, Hutchinson *et al* (2003). Petterson 1/26
[249] Rushton, Hutchings *et al* (2007). JS/91
[250] JS/163A

9.41 The Siemiatycki paper contained a Table[251] showing occupations or industries that had been evaluated by IARC as "definitely", "probably" or "possibly" giving rise to an excess of risk of bladder cancer amongst workers. The Table included the aluminium production industry, where the substances suspected of producing the carcinogenic effect were identified as "pitch volatiles, aromatic amines". They were categorised as "definitely" giving rise to an excess risk of cancer. In 1987, IARC classified the evidence for an association between aluminium production and lung and bladder cancer as "strong". For the coke production industry, the suspected substance was coal tar fumes. They were categorised as "definitely" giving rise to an excess risk of cancer in humans. In 1987, IARC classified the evidence for an association between coke production and skin cancer and lung cancer as "strong", whereas that for bladder and kidney cancer was deemed to be "suggestive".

9.42 The Siemiatycki paper reported that coal tars and pitches used in, *inter alia*, the production of refined chemicals and coal tar products (patent-fuel); coke production; coal gasification and aluminium production were classified by IARC in 1987 as having "sufficient" evidence of carcinogenicity in both humans and animals. IARC classified the evidence of an association as "strong" for skin cancer and "suggestive" for both lung and bladder cancer[252].

9.43 The authors of the 2007 HSE report referred to the studies indicating an increase in the risk of bladder cancer amongst workers exposed to CTPVs for long periods in the aluminium industry. They refer to the "particularly high" exposures to PAH experienced by workers on the Söderberg process. They noted that the identity of the causative agent in that process was unknown. They also referred to the studies relating to coal gasification by Doll *et al* and to the high exposure to PAHs of men working on the tops of coke ovens. They noted that the large studies conducted by Lloyd *et al* (1970)[253] in the USA and by Costantino *et al* (1995)[254] in Canada had not shown any evidence of an increased risk of bladder cancer amongst coke oven workers.

The parties' cases

9.44 The claimants argued that there is clear epidemiological evidence of a causal link between high levels of exposure to dust and fume containing PAHs in industries such as coal gasification and aluminium smelting and an excess risk of both lung and bladder cancer. A similar link has also been demonstrated between the coke production industry and lung cancer. The similarities between the processes carried out in those industries and the carbonisation of Phurnacite make it probable that exposure to dust and fume containing PAHs produced by Phurnacite carbonisation (which are known to give rise to an excess risk of causing lung cancer) are also capable of causing bladder cancer. The claimants relied on the review by Boffetta *et al* (1997), the 2003 HSE review, the 2007 HSE report and the work of IARC as providing strong support for the existence of a causal link between exposure to high levels of PAHs and the risk of bladder cancer.

9.45 The defendants contended that the epidemiological evidence does not support the claimants' case. In particular, they referred to the absence of evidence of an

[251] JS/163K Table 6a
[252] JS/163D Table 3
[253] Jones7/1
[254] Jones2/301

association between bladder cancer and work on the carbonisation process in the coke production industry. They relied on the differences between the Söderberg process and the Phurnacite carbonisation process, as enumerated by Professor Jones. They suggested that, if the processes were analogous, an obvious excess of deaths from bladder cancer in the coke production industry could be expected. However, such an excess was not evident from the epidemiological evidence. They submitted that it was possible that the carcinogenic substance responsible for causing bladder cancer in the Söderberg process was not present in the emissions created by the Phurnacite carbonisation process and/or the coke production process or not present in sufficient quantities. They argued that there were so many differences between the Söderberg process and the Phurnacite carbonisation process that it was impossible to conclude on a balance of probabilities that, because the Söderberg process gave rise to an excess incidence of bladder cancer, this would also be the case for the Phurnacite carbonisation process.

Discussion and conclusions on the epidemiological evidence

9.46 There is no doubt that the epidemiological evidence suggests an association between exposure to PAHs, in particular BaP, and an excess incidence of bladder cancer. However, the possibility that some other causative agent, such as 2-naphthylamine, 1-naphthylamine and/or nitro-PAHs, is responsible for the high incidence of bladder cancer in the coal gasification and aluminium smelting industries (a possibility which has been canvassed in some of the studies dealing with those industries[255]) remains a real one and cannot be discounted.

9.47 Whilst it is quite possible that substances such as 2-naphthylamine, 1-naphthylamine and/or nitro-PAHs were present in the dust and fume emitted from the Phurnacite ovens, this fact has not been confirmed. If the relevant substances were present, it is impossible to say whether the quantities emitted during the carbonisation process would have been comparable to those given off during the Söderberg or coal gasification processes. Furthermore, there are, as Professor Jones pointed out, significant differences between the Söderberg process and the Phurnacite carbonisation process. In particular, I accept Professor Jones' evidence that the gradual process of emission of fume that occurs in the course of the Söderberg process may present a hazard that was not present in the Phurnacite carbonisation process.

9.48 The epidemiological studies relating to the coke production industry do not assist the claimants. I fully accept the limitations of the various studies and it may well be that, had they studied morbidity as well as mortality, a causal link with bladder cancer would have been observed. However, the fact is that no positive support can be derived from any of those studies. As for the 1987 IOM study of mortality at the Phurnacite Plant, the number of bladder cancer deaths (three) is too small for any reliable conclusions to be drawn.

9.49 Having considered all the evidence, I find that, although the epidemiology suggests that it is possible that the fumes emitted during the carbonisation process at the Phurnacite Plant may have contained sufficient quantities of one or more substances (whether BaP, PAHs in general and/or 2-naphthylamine, 1-naphthylamine and/or nitro-PAHs) capable of giving rise to an increased risk of bladder cancer, the

[255] e.g. the studies by Doll *et al* ; the Tremblay, Armstrong *et al* study (1995) and the 2007 HSE report

epidemiological evidence, taken on its own, falls short of establishing that fact on a balance of probabilities.

9.50 For the reasons set out at Sections 6 and 8 of this judgment, I do not accept the claimants' submissions that, by reason of the mechanism of carcinogenesis, I should find that the PAHs to which the relevant claimants were exposed made a material contribution to the development of their bladder cancer. I consider that the claimants would be able to succeed only if they were able to establish that their exposure to PAHs had doubled the risk of them developing cancer. Therefore, if my view on the strength of the epidemiological evidence relating to bladder cancer were different, it would be necessary to go on to consider the extent of the increase in risk attributable to occupational exposure.

9.51 Unlike the position with lung cancer, the experts did not attempt any estimate of the extent of any increase in the risk of bladder cancer as a result of exposure to BaP or any other carcinogenic substance. That would be difficult to do, not least when one considers that as many as 25%-50% of bladder cancers have no identifiable cause. I have no other material on which to assess the increased risk. Mr Pettersson did not give evidence about this issue. Professor Jones' final position was that it was possible that there was some increased risk caused by exposure to PAHs at the Phurnacite Plant, but he was unable to quantify that possible risk. I do not see how I could do so either.

9.52 It is important to bear in mind that, even if the epidemiological evidence were strong enough to establish the potential for an increased risk of bladder cancer, this would apply only to men who had spent a long time working on the Phurnacite ovens. The evidence from the Söderberg and coal gasification processes was that it was the men with long exposure to the dust and fume from the 'cooking' processes who were liable to develop bladder cancer. A claimant such as Mr Jenkins, who spent only about 17 months working on the batteries (and only part of that time on the oven tops) would not come into that category. Mr Jenkins spent most of his time at the Phurnacite Plant working in the by-products plant. Mr Richards is in a different position. He worked in the by-products plant for about 8½ years. However, he spent almost 16 years working as a process foreman on the batteries and, as I have found, had a significant amount of exposure to dust and fume from the ovens.

9.53 There is no suggestion, either from the literature relating to the Phurnacite Plant or elsewhere, that employment at the by-products plants attached to the various industries under evaluation carried with it an increased risk of bladder cancer. Of the three men at the Phurnacite Plant referred to in the 1987 IOM study, who died from bladder cancer, none had worked in the by-products plant.

The effects of smoking

9.54 All the relevant experts agreed that smoking increases the risk of bladder cancer. They also agreed that, upon cessation of smoking, the risk decreases. What was not agreed, however, was whether, many years after an individual has ceased smoking, he remains at an increased risk of bladder cancer as a result of his past smoking history. This is significant in the cases of Mr Jenkins and Mr Richards, since both men gave up smoking a long time before their first bladder cancer developed. I have found that Mr Jenkins gave up smoking about 36 years before his first tumour appeared, having smoked for 20 years, and that Mr Richards gave up about 38 years before his first episode of bladder cancer, having smoked for 16 years.

9.55 In their Joint Statement, Mr Pettersson and Mr Bishop agreed that the medical literature provided "persuasive evidence" for a significant fall in the incidence of bladder cancer as early as four years after discontinuing cigarette smoking. They also agreed that, after 15-20 years of non-smoking, the increased risk due to smoking had reduced to such an extent that it was negligible. However, they were both "inclined to the view" that the relationship between tobacco smoke and industrial carcinogens was likely to be complex and that, as a result, the "normal" reduction in cancer risk after ceasing to smoke might be disturbed. Thus, where there had been occupational exposure to a carcinogen, a previous history of smoking might still have played a part in the development of a bladder cancer which appeared as many as 15 years or more after cessation of smoking and/or exposure to the carcinogenic substance.

9.56 Professor Jones did not agree that, in an ex-smoker, the risk of developing bladder cancer would ever reduce to that of a person who had never smoked. He relied on a paper by Brennan, Bogiuot *et al* (2000)[256] ('the Brennan paper') in support of his view that, even 30 years after an individual has stopped smoking, his risk of developing bladder cancer is still increased. The Brennan paper was a combined analysis of 11 case-control studies, carried out in six European countries, comprising a total of 2,600 male bladder cancer cases. The purpose of the analysis was to measure the relationship between cigarette smoking and bladder cancer in men.

9.57 In his original Report, Mr Pettersson cited two papers (one being the Brennan paper, and the other a short summary document[257]) in support of his contention that, after 15 years of smoking cessation, the risk of bladder cancer is reduced to or virtually to the level of an individual who has never smoked. The summary document merely contained a statement that "[a] decreased risk of bladder cancer approaching that of a non-smoker is seen approximately 15 years after smoking cessation", together with a reference to another study[258], which was not included in Mr Pettersson's references. In his Joint Statement with Professor Jones, Mr Pettersson mentioned a number of other papers, one[259] of which showed a low relative risk of bladder cancer for ex-smokers who had ceased smoking 15 or more years ago. However, the evidence about the effects of long-term cessation of smoking centred around the Brennan paper.

9.58 The authors of the Brennan paper found that there was a linear increasing risk of bladder cancer with increasing duration of smoking, from a relative risk or 'odds ratio' of 1.96 after 20 years of smoking to an odds ratio of 5.57 after 60 years of smoking (i.e. after 60 years of smoking, the risk to the smoker was more than fivefold that of a non-smoker). A dose relationship was observed between the number of cigarettes smoked per day and the incidence of bladder cancer. However, that relationship was observable only up to a threshold limit of 15-20 cigarettes per day, after which no further increase in the incidence of bladder cancer was apparent.

[256] Pettersson 1/8
[257] Fielding *et al* (1985) Pettersson1/226
[258] Wigle, Mao *et al* (1980)
[259] Wynder *et al* (1977) Pettersson3/303

9.59 The effects of stopping smoking were illustrated in *Table VI* of the Brennan paper[260]. An immediate decrease in the risk of bladder cancer was observed for men who gave up smoking. The extent of the decrease varied according to the length of time for which the men had smoked. The results shown in *Table VI* suggested that a man who had smoked for between 1 and 19 years and had given up smoking more than 24 years previously still had a relative risk of developing bladder cancer of 1.68 when compared with a lifelong non-smoker, whereas a man who had given up smoking at the same time but had smoked for more than 39 years had a relative risk of 3.25 when compared with a lifelong non-smoker. *Table VI* did not contain any data showing the magnitude of risk for a man who had given up smoking more than 35 years previously. Both Mr Jenkins and Mr Richards fell into that category.

9.60 The claimants contended that some of the information contained in *Table VI* was anomalous and confusing. For example, *Table VI* suggested that a man who had smoked for between 1 and 19 years and had given up smoking 5-9 years previously, had a relative risk when compared with a lifelong non-smoker of 0.61, i.e. less than the risk of the non-smoker. That was to be contrasted with the relative risk of 1.68 of the man who had smoked for between 1 and 19 years and had given up smoking more than 24 years previously. There were other similarly surprising values in *Table VI*. In oral evidence, Mr Pettersson described the Brennan paper as giving "very confusing" results which could not be relied upon.

9.61 By contrast, the defendants submitted that the Brennan paper was highly informative. Professor Jones acknowledged that there may not have been complete consistency between the studies analysed in the Brennan paper; for example, the varieties of tobacco smoked may have been different in some countries and that may have caused some variation in results. However, the combined number of bladder cases was large, enabling the authors to separate out the effects of the number of cigarettes smoked and the duration of smoking of both current and ex-smokers. He considered that the Brennan paper was the most informative study available dealing with the effects of smoking cessation on the risk of bladder cancer. Professor Jones explained the apparent anomalies in *Table VI* as the effects of chance. He pointed out that the wide confidence intervals used in *Table VI* were an indication that a high degree of statistical fluctuation in the results was to be expected. He considered that, taken overall, the results showed that the risk of bladder cancer reduced significantly from about four years after stopping smoking, after which it began to decline more gradually as the number of years' cessation of smoking increased. He considered that the rate of decline towards the end of the 25-year period covered by the study suggested that the increased risk caused by smoking would never disappear entirely.

Discussion and conclusions

9.62 It seems to me that, although the data contained in the Brennan paper have some limitations, they constitute the best available evidence about the effects on the risk of bladder cancer after a long period of smoking cessation. The data do not support the contention that the effects of smoking disappear entirely with the passage of time. Taken at face value, they suggest that a man (such as Mr Richards) who had smoked for 16 years, would have a relative risk factor of 1.68 compared with a lifelong non-smoker if he had given up smoking 25 years previously. Presumably his relative risk factor would have reduced somewhat by the time he had given up for 38

[260] Pettersson 1/144

years. A man (like Mr Jenkins), who had smoked for 20 years and had given up 25 years previously, would have a risk factor of 2.33 compared with a lifelong non-smoker. Again, that would presumably be less if he had ceased smoking as long as 36 years previously.

9.63 On the basis of the available evidence, I find that, after 38 years of non-smoking, Mr Richards would have had a relative risk of no more than about 1.5 attributable to his past smoking when compared with a lifelong non-smoker, whilst Mr Jenkins would have had a relative risk of about 2.

SECTION 10

THE CAUSATION OF SKIN CANCER

10.1 Two of the lead claimants, Mr David Jones and Mr David Middle, have claims for skin cancer.

The expert evidence

10.2 The expert evidence about skin cancer came from Dr Flaks and Dr August, for the claimants, and from Dr Falk, for the defendants. Dr August is a consultant dermatologist. As he made clear, his focus is on the treatment of his patients, not on understanding how their skin conditions came about. I have no doubt that he is very skilled in the diagnosis and treatment of skin cancer. However, he is not – and does not claim to be – an expert in the field of epidemiology and this inevitably affected his ability to speak authoritatively about issues of causation.

10.3 As a clinical oncologist, Dr Falk treats a number of different types of cancer. At the height of his involvement with skin cancer, the disease accounted for approximately 20% of his practice. Over the past few years, with the increasing tendency to specialisation and the decline in the use of radiotherapy, the proportion of his time spent treating skin cancer has reduced to about 5%. However, he demonstrated an excellent knowledge of the up to date epidemiological literature on the topic and made an impressive witness.

The disease

10.4 Skin cancer is a cancer of the cells in the outermost layer of the skin (the epidermis). There are two main types of skin cancer, namely malignant melanoma of the skin and non-melanoma skin cancer (NMSC). In this case, I am concerned only with NMSC.

Non-melanoma skin cancer

10.5 NMSC is a very common type of cancer in humans. The majority of NMSCs are classified either as basal cell carcinomas (BCCs) or squamous cell carcinomas (SCCs). BCCs are sometimes known by the name, ‘rodent ulcers’. In the UK, BCCs are about three or four times more common than SCCs. There is some evidence that the gap between BCCs and SCCs is narrowing and that the number of BCCs and SCCs may almost reach parity in countries with high levels of sun exposure.

10.6 BCC and SCC have very different courses. If not diagnosed and treated early, a SCC is capable of locally infiltrative growth together with spread to regional lymph nodes and to distant organs (the process known as ‘metastasis’). The overall risk of metastasis from SCC is, however, relatively low and survival rates from SCC are high. By contrast, BCC spreads only very locally and is rarely if ever fatal. It can however, be disfiguring if not diagnosed and treated appropriately. Both SCC and BCC are found more frequently in men than women and the incidence of both types of cancer increases with age.

10.7 There was some dispute between the experts about whether BCC and SCC can be regarded as clinically distinct diseases. Dr Flaks suggested that the distinction was largely an artificial one, based on histopathological appearances rather than on the genesis of the tumour. Dr Falk did not agree. His evidence was that BCC and SCC are generally believed to be clinically distinct tumours. They have different appearances and behave in a different way, particularly in relation to growth and spread. He accepted that, even when histology is carried out, there can be difficulty in distinguishing between the two types of tumour. However, more subtle changes within the cells, detectible only by electron microscopy studies and immunohistochemical techniques which are now available, show that the tumours are quite distinct.

The causes of non-melanoma skin cancer

10.8 NMSC may be caused by a number of factors, including exposure to UVR, immunosuppression and chemical carcinogens.

Ultraviolet radiation

10.9 The most common risk factor for NMSC is exposure to UVR from sunlight. UVR is a known mutagen which is capable of inducing DNA damage that can lead to a subsequent cancer. It is also known to alter the skin's immune response, rendering the skin more susceptible to tumour formation. It seems likely that UVR is both an initiator and promoter of carcinogenesis. The incidence of both BCC and SCC rises with exposure to sunlight. However, whereas the increased risk of BCC appears to reach a plateau after a certain level of exposure to sunlight, there is a proportionately greater effect of increasing solar exposure on SCC risk. Incidents of sunburn give rise to a disproportionate risk of BCC.

10.10 Certain skin types are recognised as being more vulnerable than others to the effects of UVR. Dermatologists categorise individuals into one of six skin types. Type I individuals classically have red or fair hair, with pale skin which does not tan and is very vulnerable to UVR. Type II individuals have light brown hair and pinkish skin which has the ability to develop some tan and is vulnerable to intense sunlight. Type III individuals have darker hair and skin and are less prone to sunburn, with correspondingly less vulnerability to UVR. Types IV, V and VI are Mediterranean, Asian and Afro-Caribbean respectively and are at much less risk of NMSC from UVR.

10.11 Exposure to UVR can also cause pre-malignant lesions known as actinic or solar keratoses. These take the form of dry rough patches on the skin, caused by an accumulation of keratin brought about by the action of sunlight. I was told that the roughened surface of an actinic keratosis is very distinctive. If left untreated, these lesions can develop into SCCs. BCCs, however, arise *de novo*, without pre-malignant lesions. Exposure to UVR can also cause the development of what are known as the stigmata of photo ageing; the most common of these are erythema (reddening), actinic freckles (liver spots), elastosis (yellowing of the skin) and telangiectasis (small thread veins).

10.12 Repeated exposure to UVR is required to induce an excess of NMSC and the latent period is long.

Immunosuppression

10.13 Immunosuppression is also a recognised risk factor for the development of NMSC. The risk of developing NMSC is very significantly greater for transplant patients than for the general population. In this group of patients, SCC is more common than BCC. Patients with immunosuppression secondary to human immunodeficiency virus (HIV) infection have a more modestly elevated risk of developing NMSC; they do not have the altered ratio as between SCC and BCC which is typical of transplant patients. SCC which arises as a result of immunosuppression has a more aggressive course than usual, with a higher rate of recurrence, metastasis and death.

Chemical carcinogens

10.14 A number of chemicals are known to be carcinogenic to skin. These chemicals include pitch and tar related products.

10.15 Dermal exposure to pitch can cause a number of effects. The most immediately obvious is a yellow staining of the skin, which can be difficult to remove, even by repeated showering. Individuals who have been exposed to pitch can also develop phototoxicity. The skin may become reddened and the individual may suffer discomfort, even pain, on exposure to sunlight. Pitch exposure can also cause acne and comedones (blackheads). These effects are not necessarily precursors to the development of skin cancer. They are, however, indicators that the affected individual has had a significant exposure to pitch.

10.16 Exposure to pitch is well known to cause non-malignant lesions such as papilloma or pre-cancerous lesions such as keratoacanthoma, sometimes described as ‘acanthoma’ and also known (when associated with pitch exposure) as ‘pitch warts’. If not removed, a pitch wart may go on to develop into a SCC.

10.17 The increased risk of developing NMSC due to the carcinogenic effects of coke production is well established and there is no dispute between the experts that pitch and tar related products can give rise to SCC. The issue is whether they can also cause BCC, the type of tumour diagnosed in the cases of Mr David Jones and Mr Middle.

10.18 Dr Falk accepted that, if a man who had worked at the Phurnacite Plant and had a history of very extensive exposure to pitch and/or tar had developed SCC (rather than BCC) it would be reasonable to say, on the basis of the available medical literature, that his exposure had been a ‘major cause’ of his SCC. However, the literature did not support such a link with BCC.

The literature

10.19 In order to determine whether there is evidence of an association between BCC and exposure to pitch and tar related products, it is necessary to examine the available literature. That literature, much of which was published some considerable time ago, rarely distinguished between SCC and BCC. One reason for that was the difficulty of making a clinical differentiation between the two conditions. Diagnosis by visual examination is not always reliable. Until the last two decades, histological examination of skin lesions was not routinely practised in all parts of the UK and many lesions were removed without a firm diagnosis of either SCC or BCC being made. Even when histological examination was undertaken, it was not always possible to distinguish between BCC and SCC without more sophisticated techniques, which were not available until recently.

10.20 Where the type of NMSC was identified in the literature, it tended to be SCC, rather than BCC. For example, in 1948, Dr Philip Ross reported[261] on the types of malignant lesions in his clinical practice which appeared to be related to pitch and tar. In 1953, Dr Fisher undertook a review of skin cancer in tar workers[262]. Both doctors discussed the risk of SCC; neither mentioned BCC.

Prescription

10.21 SCC has been a prescribed disease for many years when associated with occupations involving the use, or handling of, or exposure to substances including tar, pitch, bitumen and soot. In 1981, the IIAC considered whether BCC should also be prescribed. The IIAC concluded that it should not be prescribed since it had many causes other than occupational exposure, including exposure to the sun. In 2002, however, the IIAC advised the Secretary of State that the prescription should be revised so as to identify the relevant prescribed disease as "primary carcinoma of the skin", i.e. to include BCC, as well as SCC. That advice was followed in 2003. The documents I have seen gave no explanation of the reasoning behind the IIAC's decision and I heard no evidence about this matter.

The Phurnacite Plant study

10.22 In the early 1960s, researchers at the Cardiff Royal Infirmary and the Welsh National School of Medicine, Cardiff, carried out a study[263] (the Phurnacite Plant study) at "a local patent fuel plant" (plainly the Phurnacite Plant). The Phurnacite Plant study compared the skin lesions suffered by 144 workers who had had exposure to pitch with the skin lesions suffered by 263 controls selected from patients attending the dermatological out-patients department at the local hospital. Both subjects and controls were examined in 1963, then re-examined two years later. The incidence of SCC was 2.8% amongst the pitch workers, compared with 0.4% in the controls. In the pitch workers, lesions developed on the scrotum, as well as on areas of the body that would have been exposed whilst working, such as the hands and face.

10.23 The incidence of BCC incidence amongst the pitch workers was only 0.7% (i.e. one case), compared with a much higher rate of 12.5% in the controls. It was acknowledged by the authors of the study that the very high incidence of BCC in the control group must reflect the fact that the controls had been selected from a group of individuals who, since they had been referred to hospital with skin problems, would have a significantly higher risk of skin cancer than the general population. The numbers of subjects and controls involved in the Phurnacite Plant study were small. The experts agreed that no conclusions could be drawn from the one case of BCC that was observed.

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[261] Ross, P: *Occupational skin lesions due to pitch and tar.* British Medical Journal. 364-369 1948: Falk2/323

[262] Fisher R: *Skin cancer in tar workers* 1954. Occupational Medicine (London) 3(4):315-318. Falk2/17

[263] Hodgson, GA & Whiteley, H.J. *Personal susceptibility to pitch*. Brit.J.Industr.Med.,1970, 27,160-166: Flaks5/43

The incidence of basal cell carcinoma in the general population

10.24 The incidence of BCC in the general population is not easy to determine and was the subject of considerable controversy at the trial. Historically, cases of BCC have not been well documented, partly because of the difficulty of distinguishing between SCC and BCC. Other factors may also have played a part. England has a system whereby new cases of cancer are recorded at one of a number of cancer registries situated in different areas of the country. The information collected by the registries is used for compiling statistics and for other purposes related to public health. GPs pass information about diagnosed cases of cancer to local authorities who supply the information for their area to the appropriate registry. Until recently, some registries did not collect data for NMSC, in particular BCC.

10.25 Over time, it has become clear that the recording of NMSC is variable as between the cancer registries covering different areas. In 2010, the South Wales Public Health Observatory published a study of the reporting of NMSC over the three-year period 2004-2006. The authors compared the recorded age-standardised incidence rates of NMSC according to the information held by the various local authorities. No distinction was made between SCC and BCC. The range was extremely wide – from five cases to 260 cases per 100,000 people. The authors identified those local authorities with rates of up to 50 cases per 100,000 people. They considered that there was obvious under-reporting of NMSC in the areas covered by those authorities, which were situated mainly in the Thames Valley and the South East.

10.26 The study then attempted to estimate the extent of the under-reporting by seeking to establish a ratio between cases of NMSC and malignant melanoma and applying that ratio in the areas of under-reporting. Data from the West Midlands and South West areas, which were judged to have the best quality data about NMSC, were used to establish the ratio. In the South West, 36 of the 45 local authorities had a ratio of seven cases of NMSC to ten cases of malignant melanoma. Similar results were obtained in the West Midlands. That ratio was used to calculate the 'true' number of new NMSC cases in those areas which had been identified as under-reporting. This exercise suggested that 9,043-14,625 (i.e. 20%-25%) cases of NMSC per annum had gone unrecorded in those areas. A comparison of the rates of BCC and SCC for the West Midlands and South West suggested a ratio of between three and five cases of BCC to one case of SCC. This in turn suggested that, of those cases that had gone unreported, 6,782-12,139 were BCC cases and 2,260-3,656 were cases of SCC.

10.27 The study confirmed that, at least in the mid-2000s, there was significant under-reporting of both BCC and SCC in some areas. It should be noted that this was a study which looked at the differing numbers of NMSC cases which had actually been reported by GPs to local authorities and then to the various registries. It may be that, in some areas, GPs were failing to diagnose cases of skin cancer. It may be that they were diagnosing cases but failing to report them. What the study could not and did not reveal, however, was the extent to which patients were failing to bring to the attention of their GPs skin lesions which were in fact cases of NMSC.

10.28 I was referred to an Australian study[264] which suggested that, even in that country, where the risk of skin cancer has been well known for many years, there is a significant degree of under-reporting of the condition. A cohort of 2,926 subjects was examined for skin abnormalities in 1987 and again in 1992. During the intervening five-year period, 273 of the 2,926 subjects had self-reported to their doctors and had been diagnosed with skin cancer. Nevertheless, when dermatologists actually examined the subjects' skin again in 1992, a further 532 unreported cases of NMSC were identified and confirmed by histological examination. Even allowing for the fact that some of the subjects might have postponed consulting their doctor because they knew that they would be undergoing a further skin examination in any event, this suggested a surprisingly high level of under-reporting of NMSC.

10.29 In 1988, the Department of Dermatology at the South West Wales Cancer Institute carried out a population-based epidemiological study of NMSC incidence over a six-month period in West Glamorgan, South Wales. Ten years later, the study was repeated. The results were published in 2000[265] ('the South Wales study'). The skin cancer figures came from the local cancer registry. The cases of skin cancer comprised diagnoses of NMSC most of which had in the main been confirmed by histopathology reports. Those cases in which there had been no histological confirmation had been diagnosed by experienced consultant dermatologists. Therefore, the quality of the data relating to the registered cases was good. Cases of NMSC were counted by reference to the number of individual patients (some with multiple cancers), rather than the number of individual cancers.

10.30 The comparison of the results of the exercises carried out in 1988 and 1998 identified a significant rise in the crude incidence of NMSC over the ten-year period. In 1988, there had been 173.5 individuals per 100,000 population per annum with NMSC. By 1998, that figure had risen to 265.4 individuals per 100,000 population per annum, i.e. a rise in incidence of 52%. The incidence of individuals with BCC had increased by 66% to 224 per 100,000 population per annum and the incidence of individuals with SCC had increased by 16% to 441 per 100,000 population per annum. The crude figures were then adjusted to take account of the world standard population for age and sex so as to enable the incidence of NMSC in West Glamorgan to be compared with the incidence on NMSC in other parts of the world. After that adjustment, the 1998 incidence figure was 129.9 individuals per 100,000 population per annum for men and women together with NMSC. That was appreciably higher than most Northern European countries at that time, as was the figure for BCC (128 men with BCC per 100,000 male population and 105 women with BCC per 100,000 female population).

10.31 The increase in the incidence of NMSC (especially of BCC) demonstrated in the South Wales study may be attributable to a number of factors: a real increase in the number of cases, many resulting from sun exposure which had occurred years before; previous under-diagnosing of NMSC, in particular of BCC; and/or previous under-reporting by patients to their GPs of skin lesions which were in fact BCC. In the decade from 1988 to 1998, there was an increase in public awareness of the dangers of sun exposure and of the prevalence of skin cancer which might well have

[264] English, DR, Kricker A, Heenan, P *et al*. *Incidence of non-melanocytic skin cancer in Geraldton, Western Australia.* 73, 629-633 (1997). Falk3/317
[265] Holme SA, Malinovszky K, Roberts DL. *Changing trends in non-melanoma skin cancer in South Wales*. 1988-98, *British Journal of Dermatology* 2000 : 143:1224-1229: Falk3/337

led to a greater degree of reporting. What the South Wales study does not tell us, however, is how much under-reporting by patients still existed in 1998.

The Letzel and Drexler study

10.32 Much of the argument between the parties centred round a German study reported in 1998[266] by Dr Letzel and Dr Drexler (the 1998 study). That study was up-dated in 2007[267] (the updated study) by Dr Voelter-Mahiknecht and others, including the authors of the 1998 study. When referring to the 1998 study and the updated study collectively, I shall call them 'the Letzel and Drexler study'.

10.33 Dr Flaks referred in his Generic Report to the 1998 study (but not to the updated study), observing that it had identified a number of cases of BCC, as well as of SCC. Dr August took up the reference in his individual Reports in the cases of Mr Middle and Mr David Jones (he did not produce a Generic Report) and reproduced the brief details of the 1998 study given by Dr Flaks. I do not get the impression that Dr August had read the 1998 study at that time (and he seemed unaware that it had been updated) although, by the time he gave oral evidence, he agreed that it was "the only decent plank" for his proposition that pitch and tar were capable of causing BCC. In his Generic Report, Dr Falk referred to the updated study and discussed its contents in some detail, raising a number of the points that he subsequently made in his oral evidence.

10.34 The 1998 study examined 606 workers (the subjects) employed at one of the world's largest tar refineries, in Germany. The subjects had all, over a period of 50 years between 1946 and 1996, been diagnosed as suffering from tar-induced dermatosis. Germany has a scheme for recognising and compensating for occupationally-related diseases similar to that in the UK. Malignant skin tumours (including both SCC and BCC) and their preliminary stages (including tar-induced dermatosis) have for a long time been prescribed diseases for the purposes of the German system. The 1998 study was intended, *inter alia*, to explore what kind of tar-induced skin tumours had been diagnosed in the subjects, which regions of the body were mainly affected by the tumours and how long the latent period was from exposure to the development of the tumours. It is to be noted that the authors of the Letzel and Drexler study were not seeking to discover whether or not BCC was an occupationally-related condition. They accepted without question that it was.

10.35 The 1998 study found, amongst the 606 subjects, 380 SCCs, 218 BCCs and 182 keratoacanthomas or pitch warts. It must be noted that those were the numbers of actual lesions observed, not the number of subjects with skin lesions. 151 of the subjects developed one or more SCCs and 98 subjects developed one or more BCCs. Some subjects had both BCCs and SCCs. In all, 207 (34.2%) out of the 606 subjects developed at least one SCC or one BCC. The ratio of SCCs to BCCs was 1.7 SCCs to one BCC, i.e. different from the usual pattern of more BCCs than SCCs.

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[266] Letzel S, Drexler H. *Occupationally related tumors in tar refinery workers.* Journal of the American Academy of Dermatology. Volume 39, Number 5, Part 1: Flaks6/47

[267] Voelter-Mahiknecht S, Scheriau R, Zwahr G et al. *Skin tumours among employees of a tar refininery: the current data and their implications.* International Archive of Occupational Environmental Health 2007. 80:485-495: Falk3/84

10.36 In the updated study extending to 2002, the number of subjects had increased to 618 and the number of cancerous lesions found had increased to 393 SCCs, 298 BCCs and 194 keratoacanthomas. 155 of the subjects had SCCs and 120 had BCCs. The number of SCCs per patient was between 0 and 41 and the number of BCCs per patient was between 0 and 20. The ratio of SCCs to BCCs was 1.32 SCCs to one BCC. The authors of the 1998 study had observed that the ratio of BCCs to SCCs in Germany was then known to be about ten to one. (This ratio is significantly different from the ratio in the UK which is about three or four BCCs to one SCC.) They commented:

> "Bearing in mind the known ratio of basal cell to squamous cell carcinomas in Germany (about 10:1) the reversal of the relationship to 1:1.7 is particularly noteworthy, which makes the induction of basal cell carcinomas seem less important."

10.37 The authors of the updated study pointed out that the reversal of the ratio would have been even more marked if there had not been early intervention to excise pre-cancerous lesions, thus preventing them from progressing to develop into SCCs.

10.38 Amongst the subjects of the updated study, the average age at the time of the first manifestation of skin cancer was 54.9 years for SCC. In the general population, the age of those diagnosed with their first SCC is usually between 60 and 80 years. Amongst the subjects of the updated study the average age of manifestation of BCC was 62.7 years, which corresponded with the median age of manifestation (63 years) in the general population of Germany.

10.39 In the 1998 study, it was found that the location of the BCCs observed (mainly on the face) did not differ greatly from that seen in the general population. SCCs were, however, found in some unusual sites. They were observed more frequently than usual on the upper lip and the forearms. Twenty SCCs were found on the scrotum; no BCCs were observed at that site.

10.40 In the updated study, the distribution of SCCs remained somewhat different from the general population. The location of BCCs was similar to that of the general population, i.e. on areas of skin exposed to the sun. However, there was a slight difference. The authors reported that, in the general population, BCCs are rarely found on the outer surface of the auricle of the ear whereas, in the updated study, 7% of BCCs amongst the subjects were found in that position.

10.41 All the experts agreed that the Letzel and Drexler study was a good quality study covering as it did 56 years and a relatively large cohort of subjects. Most of the NMSCs observed had been subjected to histological examination, presumably for the purpose of claiming compensation under the Government scheme. Thus, the accuracy of the diagnosis of the type of NMSC is likely to have been reasonably reliable in most cases.

10.42 The Letzel and Drexler study did, however, have two obvious defects, which were acknowledged by its authors. First, the study involved early intervention which may have affected the results. The subjects' skin was inspected regularly for lesions. As a result, any lesions that formed were removed very early. This could potentially have resulted in the identification of more lesions than would have been found in a normal population where observation would depend on individual patients seeking medical advice. The fact that pre-cancerous lesions were excised promptly will have prevented some NMSC from progressing as they might have been permitted to do in other circumstances. This would have had the effect of reducing the number of SCCs which developed, but not the number of BCCs, since the latter do not have a pre-cancerous phase.

10.43 The second obvious defect in the Letzel and Drexler study was that, because the authors were unable to identify a suitable control group, no comparison could be made between the incidence of the different types of skin tumour amongst the cohort of subjects with the incidence amongst members of the local population who had not been exposed to tar but otherwise possessed similar characteristics. In addition, the total number of workers at the tar refinery was not known. The authors of the updated study accepted that these factors meant that the information in the study could not be used as a basis for reaching conclusions about the incidence of SCC or BCC.

10.44 The claimants' case was that, despite the defects in the Letzel and Drexler study, the number of cases of BCC identified in that study could be explained only by the effect of exposure to tar-related products. Dr August had calculated that the annual incidence of BCC found in the Letzel and Drexler study was about 5.13 times more than would have been expected if the incidence of BCC in Germany were similar to that found in the South Wales study. He recognised that the lack of controls was a weakness of the Letzel and Drexler study but could see no reason why the risk of BCC in Germany should not be similar to that found in South Wales. He observed that the findings of the Letzel and Drexler study suggested that the risk of BCC amongst persons exposed to pitch was significantly increased.

10.45 Dr Falk accepted that it was biologically plausible that there might be an increased incidence of BCC - as well as an increased incidence of SCC - related to exposure to pitch and tar. That view was based on indirect evidence derived from the effects of other agents, in particular immunosuppression and the initiator/promoter action of UVR-induced damage, both of which are known to cause an increased risk of both SCC and BCC. He emphasised, however, that such indirect evidence was different from saying that a direct link has been proven. He did not accept that there was any reliable epidemiological evidence which supported an increased incidence. In particular, he did not accept that the Letzel and Drexler study provided such evidence. He agreed that the number of cases of BCC observed in the study was greater than might have been expected and he acknowledged that its findings raised the possibility that a relationship between pitch exposure and BCC existed. However, he said that, without further investigation by means of a properly designed case controlled study, it was impossible to confirm or refute that possibility.

10.46 Dr Falk cited the following reasons for his view:

(a) Without an appropriate control group taken from the local population, it was impossible to determine whether there was a true increase in the incidence of BCC amongst the subject cohort. There may have been special factors in the local population which gave rise to a generally increased incidence of BCC. In the absence of controls, this could not be determined. It was not valid to compare a group of German tar refinery workers (the Letzel and Drexler study) with the population of West Glamorgan (the South Wales study).

(b) In the Letzel and Drexler study, diagnoses of skin cancer did not depend on self-reporting by patients. The subjects' skin was inspected regularly and any abnormalities were dealt with promptly. Early histological examination is likely to lead to a greater incidence of diagnosis of skin tumours. Dr Falk said that, in normal circumstances, there is likely to be a significant degree of under-reporting of BCCs. They can be very slow growing and, in normal circumstances, may not be reported to a doctor for many years, if ever. The usual age at which patients first report a BCC is between 60 and 80 years. A person of that age may regard a lesion on his/her skin as part of the ageing process and may not report it. He/she may have other, more disabling, medical conditions and may die before his/her BCC has become sufficiently troublesome to cause him/her to consult a doctor about it. Even if a BCC is reported to a GP, it may be removed without any histological examination being undertaken, and therefore without any reliable diagnosis having been made.

Dr Falk also said that epidemiological studies investigating the incidence of NMSC which are based on information collected about cases of skin cancer can, by definition, take no account of cases that are not reported to GPs, or those which are reported to GPs but are not then reported by them to the appropriate public body. Dr Falk said that the South Wales study had been entirely dependent on data originating from clinicians who had treated patients with NMSC. There will inevitably have been a degree of under-reporting, particularly of BCC.

Dr Falk accepted that there was now a greater awareness of the risk of skin cancer and a greater willingness on the part of the public to seek medical advice generally and about skin lesions in particular. Thus, the level of under-reporting is generally much less than it was in the past. Nevertheless, he considered it likely that the incidence of NMSC (particularly BCC) was less than suggested by the publicly held data. The extent of under-reporting could not be quantified. Whatever its extent, however, there was bound to be a significant difference in incidence between a population whose skin was examined regularly and a population who had to report any skin abnormalities themselves. Dr Falk said that this factor alone was likely to lead to a finding of higher numbers of skin cancers amongst the German tar refinery workers than within the local population or any other population that might be comparable.

(c) NMSC are usually associated with those parts of the body that are frequently exposed to the UVR in sunlight, such as the head area and hands. Dr Falk said that, if the BCCs observed in the Letzel and Drexler study had been caused by exposure to tar products, he would have expected them to appear at sites of the body not generally associated with BCC. SCCs caused by occupational exposure are frequently found on the scrotum. In the absence of known occupational exposure, SCCs are not normally found at that site. The Letzel and Drexler study noted that, at some of the subjects, SCCs and keratoacanthomas had been observed at sites (the upper lip and forearm) not usually associated with such lesions. By contrast, the BCCs had been confined to sites at which they occur in the general population, save for a small number observed on the subjects' ears. Dr Falk accepted that, if there were a synergistic effect between exposure to tar and exposure to UVR which gave rise to BCC, that would account for the coincidence between the distribution of BCCs in the Letzel and Drexler study and their distribution in the general population. He agreed that the coincidence of distribution could also be explained if there had been heavy exposure to tar at the relevant sites, but little exposure to sunlight.

(d) Dr Falk said that he would also have expected new cases of BCC caused by occupational exposure to have occurred at a lower average age than in the general population. In the updated study, the average age at which SCCs developed was younger (55 years) than the age range amongst the general population (60 to 80 years). However, the average age for the development of BCC was the same at about 63 years.

(e) Dr Falk said that, if the incidence of BCC had been increased as a result of exposure to pitch or tar products, he would nevertheless have expected the ‘usual’ ratio of BCC to SCC to be maintained. In the Letzel and Drexler study, however, the ratio was reversed. If there had not been early intervention, the ratio would have been weighted towards SCC even more markedly since early intervention will have prevented some SCCs from developing at all.

10.47 Dr August did not accept that the incidence of BCCs as reported in the Letzel and Drexler study would have been significantly affected by the regime of regular skin inspections. Nor did he accept that there was any significant degree of under-reporting of BCCs generally. He believed that the vast majority of the BCCs suffered by the subjects of the Letzel and Drexler study would have been reported by them to their doctors in any event. He said that BCCs do not resolve spontaneously. If they are left untreated, they will almost invariably progress and will destroy the tissue around them. They cannot therefore be ignored. The only effect of regular examinations would have been to bring forward the diagnoses by a short time. Dr August did accept however that there might still be some under-reporting by GPs of BCCs which they had diagnosed and removed.

Discussion and conclusions

10.48 The Letzel and Drexler study is at the heart of the claimants’ case on the causation of skin cancer. I have scrutinised it carefully, together with the experts’ evidence about it. In doing so, I have borne in mind the need, emphasised by members of the Supreme Court in *Sienkiewicz*, to ensure that, if conclusions are to be founded on epidemiological evidence, that evidence provides a sound basis for those conclusions.

10.49 The authors of the Letzel and Drexler study were at pains to emphasise that, because it had not been possible to identify an appropriate control group, the study could not be used to calculate the incidence of any of the skin lesions described therein. That, however, is in effect what the claimants are seeking to do in this case. They invite me to draw conclusions from a comparison of the incidence of BCC amongst a group of tar workers in Germany between 1946 and 2002 with the incidence of BCC amongst the population of West Glamorgan during two six-month periods in 1988 and 1998. I accept Dr Falk’s evidence that the exercise is not a valid one. It may or may not be that the incidence of BCC in the general population in Germany is, as the claimants suggest, very similar to that in South Wales. I have heard no evidence on the point. In particular, I have no knowledge at all of conditions in the area of Germany in which the relevant tar refinery was situated or of any special factors that may have affected the incidence of BCC there. (For example, the local population may be abnormally fair-skinned.) I note that, according to the 1998 study, the ratio of BCC to SCC in Germany was said, in 1998, to be ten BCCs to one SCC. That is significantly different from the ratio quoted for the UK (three or four BCCs to one SCC). It may be that the incidence of BCC in Germany is different from that in the UK for some specific reason. I have no evidence about the matter.

10.50 Even if the incidence of BCC identified in the South Wales study can validly be compared with the incidence amongst the German tar workers, I have considerable doubts about Dr August's conclusion that the incidence of BCC amongst the latter cohort was more than five times the incidence amongst the population of West Glamorgan. First, it seemed to me that he was using the total number of BCCs identified (218) in the 1998 study, rather than the number of individuals who had developed BCCs (98). The incidence of BCC in the South Wales study was calculated on the latter basis. Thus he was not comparing like with like.

10.51 Second, he was comparing the crude number of BCCs found amongst the German tar refinery workers (divided by 50 to produce a figure for annual incidence) with the standardised incidence figure calculated in the South Wales study. Again, that was not comparing like with like. The crude incidence figure of 230 cases of BCC in men out of a population of 100,000 per annum found in West Glamorgan in 1998 was much larger than the standardised incidence rate for men, which was calculated at 128 cases per annum. We do not know what the standardised incidence rate for the German tar workers would have been.

10.52 Third, I am not confident that Dr August's method of producing an annual incidence rate can be regarded as epidemiologically sound. His workings were not explained in evidence.

10.53 Dr August also sought to compare the incidence of BCC identified in the Letzel and Drexler study with the incidence as reported in a recent edition of a leading textbook[268]. Dr August quoted that incidence as 0.1% between the ages of 40 and 49 and 0.2% between 50 and 59 years. Once again, I am not confident that this is a valid comparison. I have been unable to ascertain from the short extract I have seen whether the textbook is referring to the incidence of individuals developing BCC or the incidence of the development of tumours. I am not sure why Dr August confined his comparison to persons under the age of 60 when the average age at which BCC develops is 63, I have no information about the age of the data contained in the textbook. Dr Falk's evidence was that they were "not recent". Since there has been a significant recent increase in the incidence of BCC (which the textbook estimates at 50% over the past two decades), the age of the data is important.

10.54 I did not regard Dr August's failure to accept that the early intervention which occurred in the Letzel and Drexler study would have had an effect on the apparent incidence of BCC as realistic. That failure was linked to his reluctance to acknowledge that there was or ever had been any significant degree of under-

[268] Bolognia JL *et al*. *Dermatology*, Second Edition.

reporting of BCC by patients. In his practice, Dr August will have seen patients whose BCC has reached the point where they have considered it necessary to seek medical advice and have been referred to him. He will not see, or know of the existence of, patients who have not reported their condition to a doctor because it is not causing them problems and they do not regard it as significant. I accept Dr Falk's evidence on this matter. The Australian study to which he referred (albeit the data are now 20 years old) provided a striking illustration of the extent of under-reporting of both BCC and SCC in a relatively risk-aware population. Without the appropriate epidemiological evidence, there is no way of quantifying the degree of under-reporting. However, I am satisfied that it is significant and that the fact that the subjects of the Letzel and Drexler study underwent regular skin examinations would have had the effect of increasing the number of BCC cases from that which would have been diagnosed in any event.

10.55 Dr Falk examined the Letzel and Drexler study for differences in the pattern of BCC incidence that would distinguish it from the pattern observed in the general population. Such differences might provide support for the hypothesis that the apparently increased BCC incidence amongst the subjects of the study was caused by occupational exposure, rather than the effects of UVR or some other non-occupational factor. I accept his evidence that, had occupational exposure been the explanation, one would have expected there to be a difference in the age at which BCC first developed. I regard it as significant that the average age at which SCC was diagnosed amongst the subjects of the Letzel and Drexler study was younger than the age for diagnosis amongst the general population. By contrast, the average age for the diagnosis of BCC remained unchanged. I am less persuaded by the fact that the sites where BCC developed on the subjects' bodies were largely similar to those where they develop in the general population. I accept that that might be accounted for by other factors. Nor did I understand why Dr Falk would necessarily have expected the usual BCC to SCC ratio to be maintained if occupational exposure had caused the increased incidence in the number of cases of BCC. After all, SCC and BCC are known to behave differently and a reversal in the ratio between them has been observed amongst transplant patients who are at a higher risk of both SCC and BCC. It is, however, noteworthy that the authors of the 1998 study considered that the reversal of the ratio made the induction of BCC by tar seem "less important".

10.56 The claimants placed some reliance upon the fact that BCC falls within the skin cancers that are prescribed diseases in Germany and that, since 2003, it has been included within the disease "primary carcinoma of the skin" prescribed in the UK. The problem is that I have seen no evidence as to why this is so. It may be, as Dr Falk suggested, that BCC (as well as SCC) was originally prescribed in Germany because of the difficulties in distinguishing between BCC and SCC. However, that would not account for its continued prescription and cannot be the reason for the relatively recent decision to include BCC within the disease prescribed in the UK. It may be that the latter occurred because reliance was placed on the Letzel and Drexler study. Dr Falk was plainly puzzled by the definition introduced in the UK in 2003; he observed that it did not even distinguish between NMSC and melanoma. In the absence of evidence about the basis on which BCC was included within the list of prescribed diseases in both Germany and the UK, it does not seem to me that I can properly infer that this was done for reasons solidly based on reliable epidemiological evidence. If such evidence existed, I would have expected the experts to have referred me to it.

10.57 On the basis of the evidence before me, I am unable to conclude on a balance of probabilities that BCC can be caused or materially contributed to by exposure to pitch or tar related products. I accept that, as Dr Falk has fairly said, such a relationship is plausible and that it is quite possible that it exists. However, possibility – even strong possibility – is not sufficient for these purposes. It follows therefore that the claims of former employees at the Phurnacite Plant who have developed BCC must fail.

10.58 The position with SCC is very different. The evidence of an association between SCC and exposure to pitch and tar-related products is very strong. In relation to claimants with claims for SCC, it will be necessary to assess their history of exposure to pitch and tar-related products, together with any other risk factors such as their exposure to UVR, their skin type, the condition of their skin, and the opinions of the medical experts. It will then be necessary to consider, in cases of SCC where there has been a significant amount of dermal exposure to pitch and/or tar-related products, whether the evidence supports a finding that, on the balance of probabilities, that exposure has caused the claimant's SCC.

SECTION 11

RESPIRATORY DISEASE

The expert evidence

11.1 The expert evidence relating to non-malignant respiratory disease came from Dr Rudd and Professor Jones. Dr Rudd has extensive experience of the clinical assessment and management of non-malignant respiratory disease. The defendants instructed Dr John Moore-Gillon, a consultant chest physician. He and Dr Rudd agreed on all matters relating to respiratory condition, prognosis and life expectancy in the lead cases involving respiratory disease. Dr Moore-Gillon did not give oral evidence. Professor Jones is, of course, not medically qualified but he had a good knowledge of the relevant epidemiology and provided some useful evidence. In relation to all medical issues, however, Dr Rudd's opinion must prevail.

The cases

11.2 The cases of non-malignant respiratory disease were those involving Mr Carhart, Mr Griffiths, Mr Middle, Mr Richards and Mr Robson. All the men except Mr Middle were smokers or former smokers.

The relevant diseases

Chronic bronchitis

11.3 Chronic bronchitis (CB), is defined by the Medical Research Council (MRC) as the production of sputum on most days for at least three months in the year for at least two successive years. Occupational exposures to dust and fume cause CB by direct action on the airways. The condition is dose-related, i.e. the greater the extent of the exposure, the more severe the CB is likely to be.

Chronic obstructive pulmonary disease

11.4 Chronic obstructive pulmonary disease (COPD) is a functional definition based on the observation, on lung function testing, of fixed and irreversible obstruction to expiratory airflow (i.e. the rate at which air can be exhaled from the lungs) due to narrowing of the airways. A key physiological measure that is used to diagnose and assess the severity of COPD is the 'forced expiratory volume in one second', abbreviated as FEV_1. This is the volume of air that an individual can expel from fully inflated lungs, using maximum effort, in one second. A related measure is the 'forced ventilatory capacity' (FVC). This is the total volume of air that can be exhaled by an individual in emptying fully inflated lungs.

11.5 The ratio of FEV_1 to FVC represents the percentage of an individual's FVC that he is able to blow out in the first second of expiration. If the airways are narrowed by COPD, it is more difficult to blow air out and the rate of air flow is reduced. The proportion of the FVC that can be blown out in the first second is reduced. The FEV_1 is thus reduced, whilst the FVC either remains the same or is reduced to a lesser extent than the FEV_1. Thus the FEV_1/FVC ratio falls if COPD is present. A reduction in the ratio FEV_1/FVC is generally regarded as the most reliable indicator of obstruction. Although FEV_1 alone is sometimes used, this value may also be reduced by other lung conditions which restrict the size of the lungs without causing obstruction to airflow. In either case the effect of gender, age, height and weight on these parameters must be taken into account, using one or another of the standard predictive equations for 'normal' lung function that are available for this purpose.

11.6 The underlying conditions that give rise to COPD are emphysema and/or small airways disease.

Causation of chronic bronchitis and chronic obstructive pulmonary disease

11.7 CB and COPD are independent phenomena which can occur either separately or together. The most common cause of both CB and COPD is smoking. There is however clear epidemiological evidence of a relationship between exposure to certain types of dust and fume and the development of CB and/or COPD.

Smoking

11.8 Epidemiological work reported in 1976[269] established that there is a wide spectrum of rates of decline in FEV_1 in the population of smokers. The study established that, in non-smokers, the average annual decline in FEV_1 was around 15ml whereas in smokers it was 30ml. There was a dose response relationship whereby heavier smokers tended to experience a more rapid decline in FEV_1. However, in smokers the rate of decline was highly variable, indicating variation in individual susceptibility to the effects of smoking. Susceptibility to CB also varied. In less than 20% of smokers the decline was rapid enough to result in the development of disabling COPD. After smoking ceased, the rate of decline in FEV_1 with age reverted to the rate in non-smokers. However, the decline attributable to smoking which had already occurred was irreversible.

Occupational exposure in coal mining and coke production

11.9 Having reviewed the epidemiological evidence, Dr Rudd and Professor Jones agreed that both smoking and coal dust can cause damage to lung function and can increase the prevalence of COPD in a population of smokers and/or those occupationally exposed to coal dust. They agreed also that the effects of smoking and coal dust combine additively to reduce lung function. However, this additive effect has a near multiplicative effect on the prevalence of a given level of functional deficit in an exposed population. They further agreed that, in broad terms, a cumulative exposure to coal dust of 200 mg^{-3} would be sufficient to double the risk of a disabling loss of lung function. A disabling loss of lung function is defined as FEV_1 less than 65% of that which would be predicted. They agreed that this would depend to some extent on age.

11.10 Dr Rudd and Professor Jones also referred to recent epidemiological studies which have confirmed previous suspicions that there is a relationship between occupational exposure to dust and fume in coke plants and the development of COPD. They agreed that work on coke ovens involves occupational exposure that can result in damage to lung function.

[269] Fletcher CM, Petor, Tinker C, Speizer F (1976). *The Natural History of Chronic Bronchitis and Emphysema.* Oxford University Press:

11.11 Dr Rudd and Professor Jones referred in particular to a series of studies of the respiratory function of workers in the coke ovens at an Australian steelworks. The first study (the 2002 Wu study[270]) related to research carried out between 1978 and 1990. That research was followed up between 1990 and 2000 and was reported in 2004 (the 2004 Wu study[271]). The 2002 Wu study looked at 1377 male subjects who had at some time worked in relatively highly exposed positions near coke ovens; each subject had at least one set of lung function measurements. Individual monitoring data for exposure were not available so years of work in coke oven operations was used as a surrogate for exposure. The study stated that, during the years 1983-1985, the average exposure for certain categories of workers considered to be amongst the highest exposed was 0.19 mg m^{-3} BSM. Multiple regression analysis was used to assess the effect on lung function of occupational exposure and smoking. This showed a significant reduction in FVC for those employed in the most highly exposed group, as well as for those who smoked.

11.12 For subjects with a history of one or more years of coke oven work, each year of working in the most exposed group was associated with reduction in FEV_1 of around 9ml and in FVC of around 12ml. The ratio FEV_1 /FVC was not significantly affected. For ex-smokers, FEV_1, FVC and FEV_1/FVC ratio were lower for each year of past smoking by around 13ml, 8ml and 0.3% respectively.

11.13 The 2004 Wu study was a longitudinal study. In this study, the analysis was limited to 580 male coke oven workers with at least two sets of lung function measurements between October 1978 and July 1990. Each year of work in the most highly exposed group was found to increase the FVC decline by about 0.7 ml per year. After the exclusion of 111 subjects without a detailed work history, that finding was confirmed and each year of exposure in that group was also found to increase the FEV_1 decline by around 0.8ml per year. The estimated effect of one year's occupational exposure in that group was found to be equivalent, in terms of reduction in FEV_1, to an estimated 2.1 pack-years' smoking. (A pack year is defined as 20 cigarettes smoked every day for one year.) An increase in the odds ratio for symptoms of CB was observed for those who had been employed in the highest exposed group. The findings were consistent with the 2002 Wu study.

11.14 The Wu studies did not assess individual exposures in coke oven workers, so a quantitative dose response relationship between exposure levels and COPD had not been identified. A study reported in 2006[272] (the Hu study) compared about 800 coke oven workers at two coking plants in China with a control group who had no occupational exposure to dust and fume. The authors of the study measured exposure levels to coke oven emissions and estimated a cumulative level of exposure for each worker, based on estimated mean exposure levels and the number of years worked. They identified three levels of estimated cumulative exposure to coke oven emissions, measured by reference to BSM.

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[270] Wu J, Kreis IA, Griffiths D et al. *Cross sectional study on lung function of coke oven workers*: *lung function surveillance systems from 1978 to 1990*. Journal of Occupational Environmental Medicine 2002:59:8116-23: Rudd 2/11

[271] Wu J, Kreis IA, Griffiths D et al. *Respiratory symptoms and lung function of coke oven workers: a lung function surveillance systems from 1990 to 2090*. Journal of Occupational Environmental Medicine 2004:46:906-915: Rudd 2/1

[272] Hu Y, Chen B *et al. Increased risk of chronic obstructive pulmonary disease in coke oven workers*: *interaction between occupational exposure and smoking.* (2006) Thorax 61(4): 290-295: Jones 3/136

11.15 The Hu study found that FVC, FEV, FEV_1/FVC ratio and FEV_1% predicted (i.e. the FEV_1 as a percentage of the predicted value for the individual) all reduced significantly with cumulative BSM exposure. The mean FVC, FEV_1 and FEV_1% predicted values were lower in the exposed groups than the control group. There was a significant dose response relationship between cumulative BSM exposure level and CB or COPD after adjustment for gender, height and smoking. The risks of CB and COPD associated with the highest exposure level were broadly comparable with those associated with the highest smoking category. There was a strong and statistically significant interaction between cumulative BSM exposure and cigarette smoking in causing COPD, i.e. the effect of both hazards combined was more than the sum of the effects of each hazard alone. For example, the odds ratio for COPD from high BSM exposure alone was 5.92, for the highest category of smoking (more than 300 cigarette years) alone it was 7.51 but, for the combination of high exposure and heavy smoking, it was 58.12. The Hu study confirmed the finding in the Wu studies of an increased odds ratio for symptoms of CB with increasing exposure to BSM.

The implications for the Phurnacite Plant

11.16 Dr Rudd and Professor Jones agreed that the Wu and Hu studies established a link between employment in coke oven work and an increase in COPD, a reduction in lung function and an increase in the prevalence of CB. However, the studies did not identify the causative factor(s) that gave rise to the link. Professor Jones suggested that the link might be considered to apply to work on the ovens at the Phurnacite Plant, but not necessarily to work in, for example, the briquetting plants or in the pitch bay.

11.17 Dr Rudd considered that, by analogy with coal mining, dust exposure was plainly relevant to the development of COPD. However, the Wu and Hu studies had established a link between the BSM contained in coke oven emissions, rather than dust levels. He said that it was probable therefore that the fume from the ovens would also have contributed to the development of COPD in Phurnacite Plant workers. He said that, so far as CB is concerned, the dust derived from coal and pitch, together with the chemicals contained in fume from the ovens, would have acted as irritants and would have contributed to the development of CB. I accept his evidence on these points.

11.18 The question then arose as to how the effects of exposure to dust and fume at the Phurnacite Plant should be quantified. Both experts noted that the estimated exposure levels for BSM in the Wu studies were significantly lower than the exposure levels estimated by the experts as having been present at the Phurnacite Plant. If the loss of lung function observed in the Wu studies were interpreted as a loss per unit of exposure to BSM, the losses of lung function resulting from work on the Phurnacite Plant ovens would be so large as to be wholly inconsistent with the apparent lack of excess mortality from non-malignant respiratory disease amongst the Phurnacite Plant workforce. Thus, some other method had to be devised.

11.19 Dr Rudd's preferred solution was to take a 'broad brush' approach. He noted that the Wu and Hu studies had demonstrated that exposure to fumes from coke ovens had an effect on lung function which was approximately equal to the effects of smoking. He therefore proposed that one year's work at the Phurnacite Plant should be equated to one year of average smoking. In each of the individual cases, he apportioned the causation of the individual's respiratory disease between smoking and occupational exposure to dust and fume. He allowed one unit per annum for occupational exposure, half a unit for each year of light (less than 15 cigarettes a day) smoking, one unit for each year of average (15-25 cigarettes a day) smoking and one and a half units for each year of heavy (more than 25 cigarettes a day) smoking.

11.20 Dr Rudd explained that he considered that this 'broad brush' approach was appropriate because of his concerns about the difficulty of making any accurate estimate of the quantity of dust to which an individual claimant had been exposed at the Phurnacite Plant. He noted also that the epidemiological studies did not deal with the relationship between the development of COPD/CB and exposure levels to dust (as opposed to fume) in coke plants. He considered that there was so much uncertainty involved that it was not possible to make any accurate mathematical assessment of the loss of lung function which was likely to result from the estimated levels of exposure for the Phurnacite workers. His view was that his 'broad brush' approach was likely to be more accurate

11.21 Professor Jones accepted that Dr Rudd's approach was reasonable for those periods when an individual had worked on the oven tops. However, he did not regard it as appropriate for work in other areas of the Phurnacite Plant. In his Generic Report, he set out in considerable detail[273] his approach to quantifying the effects of exposure to dust and fume at the Phurnacite Plant. For the purposes of quantifying the effect of exposure to dust, he used a figure of 0.76 ml per g h m^{-3} as representing the loss of FEV_1 for each gram hour per cubic metre of cumulative exposure to dust. This figure was based on epidemiological evidence relating to the effects of coal dust. It was significantly lower than the figure (1.25 ml per g h m^{-3}) adopted by Turner J in the BCRDL lead cases. Professor Jones' figure represented the average effect found by the relevant studies. By contrast, the figure used by Turner J was selected as representing the effect on a typical susceptible individual. He had concluded that it was susceptible individuals who suffered a significant decrement of lung function as a result of coal dust exposure. The claimants contended that, if Professor Jones' approach were to be followed, I should use the same figure as Turner J for the loss of lung function attributable to the effects of dust.

11.22 The figure of 0.76 ml per g h m^{-3} is derived from data relating solely to coal dust and therefore does not take any account of exposure to pitch dust containing PAHs or other irritants. Furthermore, it relates only to the respirable fraction of dust. Thus, if the figure were to be used to calculate the probable loss of lung function of men who worked in the briquetting plants, it would be necessary to estimate the level of the respirable dust to which they were exposed there. Professor Jones used the calculations for the respirable fraction of total dust contained in his Generic Report when quantifying the loss of lung function likely to result from exposure to dust in the briquetting plants.

11.23 As to work on the ovens, Professor Jones considered it appropriate to use the figure (derived from the Wu studies) of 10ml loss for every year of work on the ovens. He used the figure (again derived from the Wu studies) of 13 ml loss for each year's smoking, regardless of whether the individual's smoking had been light, average or heavy.

[273] At Jones 1/60-81

Discussion and conclusions

11.24 I am satisfied that Dr Rudd was correct when he said that the estimated exposure levels to dust are vulnerable to error so that making precise calculations of loss of lung function based upon them is an exercise which is inherently unreliable. This is particularly so in relation to the estimated exposure levels to respirable dust. I have already referred at Section 4 of this judgment to the paucity of evidence about the proportion of respirable dust contained within the total dust emitted in various areas of the Phurnacite Plant and to the considerable difficulties of determining that proportion with any degree of certainty. It was plain from Professor Jones' evidence that there were a number of different ways of assessing the proportion of respirable dust and that the result of the assessments varied significantly according to the method of assessment. Indeed, Professor Jones acknowledged that it was not satisfactory to make such an assessment on the limited data available[274]. Moreover, Professor Jones' calculations are based on the epidemiology relating to coal mine dust, and take no account of the fact that the claimants at the Phurnacite Plant were exposed to a 'cocktail' of irritant dust and fume, of which coal dust was only a part.

11.25 It seems to me that Dr Rudd's 'broad brush' approach is likely to be at least as accurate and, given that Professor Jones' calculations did not take any account of different levels of smoking intensity, very possibly more so.

11.26 I do not, however, accept that it would be appropriate to find that one year's occupational exposure at the Phurnacite Plant would produce the same loss of lung function as a year's average smoking, wherever that occupational exposure occurred. I am satisfied that that is appropriate for work on the oven floor and the shuttle car floor where workers were exposed to a good deal of fume from the ovens, as well as dust. For other areas of the Phurnacite Plant, I must make a judgment, taking into account the evidence I have heard about the conditions in each area.

11.27 I consider that a fair and reasonable approach is to allocate units for occupational exposure as follows:

For every year on the oven and shuttle floors	1 unit
For every year in the briquetting plant	0.90 units
For every year on the quenching car floor, the ramps, in the screen house, in the pitch bays	0.75 units
For every year in the coal sampling rooms	0.50 units

11.28 Those values will have to be discounted as appropriate for periods when a claimant was working in a capacity other than as a process operative or in a job (such as that of a fitter) which I have assessed as having equivalent exposure to that of a process operative working in the same area.

11.29 In the cases of Mr Carhart, Mr Richards and Mr Robson, where there are claims for COPD, I have calculated their occupational exposure units in accordance with the approach I have described. Those calculations are set out at Appendix B of my individual judgments in their claims.

[274] E.g. at TD25/271/1-2

SECTION 12

LIMITATION

12.1 In the cases of all but two of the lead claimants, the defendants alleged that the claims were time-barred by the provisions of sections 11 and 14 of the Limitation Act 1980 (the 1980 Act) and that, in the event that the defendants' contentions on knowledge were accepted, it would not be equitable for the court to use its discretion pursuant to section 33 of the 1980 Act to allow the claims to proceed.

The Law

Date of knowledge

12.2 The provisions relating to date of knowledge are contained in sections 11 and 14 of the 1980 Act. The combined effect of section 11(3) and (4) is that an action for personal injuries cannot be brought more than three years after the date on which the cause of action accrued or (if later) the date of knowledge of the person injured.

12.3 If the proceedings were not issued within three years of the date when the cause of action arose, the onus is on the claimant to establish a date of knowledge within the three years preceding the date of the issue of proceedings. If the defendants wish to contend for a date of knowledge prior to the three-year period immediately preceding the issue of proceedings, the onus is on them to prove that the claimant had actual or constructive knowledge by that date.

12.4 Date of knowledge is defined by section 14, the relevant parts of which provide:

> "(1) …in sections 11 and 12 of the Act, references to a person's date of knowledge are references to the date on which he first had knowledge of the following facts –
>
> (a) that the injury in question was significant; and
>
> (b) the injury was attributable in whole or in part to the act or omission which is alleged to constitute negligence, nuisance or breach of statutory duty;
>
> *((c) and (d) are not relevant for present purposes)…"*

What is a significant injury?

12.5 Section 14(2) defines what is a "significant" injury for the purposes of section 14(1)(a):

> "For the purposes of this section an injury is significant if the person whose date of knowledge is in question would

> reasonably have considered it sufficiently serious to justify his instituting proceedings for damages against a defendant who did not dispute liability and was able to satisfy a judgment."

The test for "attributability" of the injury

12.6 Section 14(1)(b) requires that the person whose knowledge is in question must have knowledge that the relevant injury is attributable in whole or in part to the act or omission which is alleged to constitute negligence, nuisance or breach of duty. In *Nash v Eli Lilly & Co*[275], the Court of Appeal approved the "reasonable possibility" test when determining the issue of attributability. At 797H-798A, Purchas LJ quoted with approval the words of Sir David Croom-Johnson in *Guidera v NEI Projects (India) Ltd*[276]:

> "The stark strength of the word "knowledge" does not stand alone. It is knowledge that attribution is merely possible, a real possibility and not a fanciful one, a possible cause as opposed to a probable cause of the injury."

12.7 In *Broadley v Guy Clapham & Co*[277], the Court of Appeal stated that it was not necessary for the claimant to know that the acts or omissions of the defendant constituted negligence. Section 14(1)(b) simply requires that the court:

> "… should look at the way the [claimant] puts his case, distil what he is complaining about and ask whether he had, in broad terms, knowledge of the facts on which that complaint is based."

12.8 In *Dobbie v Medway Health Authority*[278], the Court of Appeal emphasised that a claimant did not need to have sufficient knowledge to enable counsel to draft a fully particularised Statement of Claim, but had only to know "the essential thrust of the case", that is to say, that the injury was "capable of being attributed to what compendiously could be called the defendant's fault". In his judgment, Sir Thomas Bingham MR said:

> "Time starts to run against the claimant when he knows that the personal injury on which he founds his claim is capable of being attributed to something done or not done by the defendant whom he wishes to sue. This condition is not satisfied where a man knows that he has a disabling cough or shortness of breath but does not know that his injured condition has anything to do with his working conditions. It is satisfied when he knows that his injured condition is capable of being attributed to his working conditions, even

[275] [1993] 1 WLR 782
[276] (unreported) Court of Appeal 30 January 1990.
[277] [1994] 4 All ER 439
[278] [1994] 1 WLR 1234

> though he has no inkling that his employer may have been at fault."

12.9 The principles governing determination of date of knowledge were summarised in *Spargo v North Essex District Health Authority*[279]. In *Spargo,* the claimant had been diagnosed (mistakenly as the treating doctor later acknowledged) with brain damage and had been confined to a psychiatric hospital for six years. Having consulted a solicitor, she first obtained an unfavourable medical opinion. Subsequently, she received a favourable second opinion and commenced proceedings, claiming that she had suffered injury as a result of having been given the wrong treatment and that, had she been properly treated, she would have been cured. The judge held that her date of knowledge arose only when she received an expert opinion definitely linking her injuries with the misdiagnosis and that the claim was therefore made within the three years before the commencement of proceedings. The Court of Appeal reversed the judge's decision, finding that the claimant had known about her injury many years previously and about the causally relevant omission and about the link between the two.

12.10 In his judgment at 129, Brooke LJ said:

> "(1) The knowledge required to satisfy section 14(1)(b) is a broad knowledge of the essence of the causally relevant act or omission to which the injury is attributable;
>
> (2) "Attributable" in this context means "capable of being attributed to", in the sense of being a real possibility;
>
> (3) A plaintiff has the requisite knowledge when she knows enough to make it reasonable for her to begin to investigate whether or not she has a case against the defendant. …
>
> (4) On the other hand she will not have the requisite knowledge if she thinks she knows the acts or omissions she should investigate but in fact is barking up the wrong tree; or if her knowledge of what the defendant did or did not do is so vague or general that she cannot fairly be expected to know what she should investigate; or if her state of mind is such that she thinks her condition is capable of being attributed to the act or omission alleged to constitute negligence, but she is not sure about this, and would need to check with an expert before she could be properly said to know that it was."

Constructive knowledge

12.11 For the purposes of sections 11 and 14 of the 1980 Act, a person's knowledge is not confined to what he/she actually knows. In addition, he/she is deemed to have

[279] [1997] 8 Med LR 125 (CA)

other knowledge (constructive knowledge) which he/she might reasonably have been expected to acquire. Section 14(3) provides that:

> "... a person's knowledge includes knowledge which he might reasonably have been expected to acquire –
> (a) from facts observable or ascertainable by him, or
> (b) from facts ascertainable by him with the help of medical or other appropriate expert advice which it is reasonable for him to seek;
> but a person shall not be fixed under this subsection with knowledge of a fact ascertainable only with the help of expert advice so long as he has taken all reasonable steps to obtain (and, where appropriate, to act on) that advice."

12.12 In the leading case of *A v Hoare and ors*[280], the House of Lords considered, *inter alia*, the approach to be adopted by a court when considering when a claimant had acquired the requisite knowledge under section 14. At paragraph 34 of his judgment, Lord Hoffmann said:

> "Section 14(2) is a test for what counts as a significant injury. The material to which that test applies is generally "subjective" in the sense that it is applied to what the claimant knows of his injury rather than the injury as it actually was. Even then, his knowledge may have to be supplemented with imputed "objective" knowledge under section 14(3). But the test itself is an entirely impersonal standard: not whether the claimant himself would have considered the injury sufficiently serious to justify proceedings but whether he would "reasonably" have done so. You ask what the claimant knew about the injury he had suffered, you add any knowledge about the injury which may be imputed to him under section 14(3) and you then ask whether a reasonable person with that knowledge would have considered the injury sufficiently serious to justify his instituting proceedings for damages against a defendant who did not dispute liability and was able to satisfy a judgment".

12.13 Thus, the test for constructive knowledge is objective. Essentially, a person must act reasonably in acquiring and using the information he/she has or could reasonably ascertain to establish knowledge of the significance of his/her injury and its attribution to a relevant act or omission of the defendant. In *Adams v Bracknell Forest Borough Council*[281] (a case about dyslexia), Lord Hoffmann endorsed the "reasonable curiosity" test which had been applied by the Court of Appeal in *Forbes v Wandsworth Health Authority*[282]. At paragraph 43, he stated:

> "… [in losing his leg, the claimant] thought he had simply suffered a misfortune. Stuart-Smith LJ [in Forbes] was prepared to accept that one might not be able to say that such

[280] [2008] UKHL 6
[281] [2005] 1 AC 76
[282] [1997] QB 402

> an attitude was unreasonable but thought that section 14(3) would fail in its purpose unless it was assumed that a reasonable victim of an injury such as the loss of a leg will display some curiosity about why it should have happened. He pointed out that otherwise the limitation period could be indefinitely extended. Until three years after the date of knowledge was found to have passed, the plaintiff had an absolute right to sue. This could be unjust to defendants who, contrary to the policy of the Act, would be vexed with stale claims. On the other hand, tightening up the requirements of constructive knowledge need not involve injustice to a [claimant] because the discretion under section 33 gave the court power to allow him to sue when it was equitable to do so. But section 33, unlike section 14, allowed the court to consider fairness to both sides."

12.14 Lord Hoffmann went on at paragraph 47[283]:

> "In my opinion, section 14(3) requires one to assume that a person who is aware that he has suffered a personal injury, serious enough to be something about which he would go and see a solicitor if he knew he had a claim, will be sufficiently curious about the causes of the injury to seek whatever expert advice is appropriate."

12.15 In *Hoare*, Lord Hoffmann drew a distinction between a finding as to the acquisition of knowledge by a claimant for the purposes of the 1980 Act and a finding as to what steps the claimant ought reasonably to have taken. At paragraph 37, he observed:

> "…section 14 makes time run from when the claimant has knowledge of certain facts, not from when he could have been expected to take certain steps. Section 14(2) does no more than define one of the facts by reference to a standard of seriousness."

12.16 At paragraph 38, he observed:

> "Section 14(2) is simply a standard of seriousness applied to what the claimant knew or must be treated as having known. It involves no inquiry into what the claimant ought to have done. A conclusion that the injury would reasonably have been considered sufficiently serious to justify the issue of proceedings implies no finding that the claimant ought reasonably to have issued proceedings. He may have had perfectly good reasons for not doing so. It is a standard to determine one thing and one thing only, namely whether the injury was sufficiently serious to count as significant."

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[283] In *London Strategic Health Authority v Whitson* [2010] EWCA Civ 195, it was noted that these observations were *obiter*

12.17 Lord Hoffmann made clear that the issue of what steps a claimant should have taken, and in particular whether he could reasonably have been expected to institute proceedings, is an issue to be considered under section 33 of the 1980 Act.

The claimant who develops different injuries at different times

12.18 In the *Atomic Veterans* case[284], the Court of Appeal considered the position where a claimant develops one injury which he/she believes is capable of being attributed to the defendant's breach of duty, and later develops a different injury which is attributable to the same cause. Giving the judgment of the court, Smith LJ said at paragraph 82:

> "It is well established that a claimant can bring only one action for personal injuries arising from a particular tort whenever those injuries arise: see Brunsden v Humphrey [1884] 14 QBD 141 per Bowen LJ at 148, affirmed by Lord Hoffmann in Rothwell v Chemical & Insulating Co Ltd [2008] 1 AC 281 at 291E. It follows that once a claimant has a cause of action and has knowledge of it (that is he has knowledge of a significant injury and that it is capable of being attributed to the relevant acts or omissions), time begins to run against him. He must then bring his claim in respect of all the consequences of that tort, relying, if he believes that there might be later medical developments, on a claim for provisional damages under section 32A of the Senior Courts Act 1981. If he brings his claim and it proceeds to judgment, it would seem that there is nothing he can do if he develops a further condition as a result of the same tort unless that condition is covered in the provisional damages order. Paradoxically, if the claimant delays bringing his claim in respect of the first significant injury and waits until he has developed a second condition, he will be able to claim in respect of both if he can persuade the court to exercise its section 33 discretion in his favour."

12.19 The Court of Appeal also considered the point at which a belief of a claimant about the attributability of his/her condition could properly be termed 'knowledge'. Smith LJ continued at paragraph 92:

> "92. So, in a case where the claimant's state of mind is more accurately described as one of belief rather than knowledge, it seems to us that what matters is whether his state of belief is such as to make it reasonable to expect him to begin to investigate further. In general that assessment will have to be made by reference to the things that he has said and done. For example, if he says that, at such and such a time, he had a firm belief that his illness had been caused by radiation, it would obviously be reasonable to expect him to begin investigating. If he said that he had a firm belief that his

[284] *Ministry of Defence v AB and others* [2010] EWCA Civ 1317

> illness could have been caused by radiation, that would also, we think, be enough. In cases in which there is no such direct evidence, it would be relevant to consider how he acted. For example, if a claimant applied for a war pension alleging that his condition had been caused by radiation at the tests, it seems to us that it would be difficult to avoid the conclusion that his belief in the causal connection was sufficient to make it reasonable that he should investigate the possibility that he had a viable common law claim.
>
> 93. We note that, in Halford, Lord Donaldson MR suggested that a belief would have to be reasonable before it could amount to knowledge. With great respect, we do not think that the belief needs to be objectively reasonable. We think that what matters is the claimant's subjective state of mind. If a claimant comes to believe that there is a causal connection between his condition and the matters complained of, it will matter not from where he has derived that belief, even it were from an incompetent expert adviser or from a newspaper article which was not based on sound research. If the belief were of such strength that it was reasonable to expect him to start investigating his claim, it would amount to knowledge within section 14."

The discretion to allow a statute-barred action to proceed

12.20 In the event that I find that the claimant's date of knowledge arose more than three years before the commencement of proceedings, I must consider whether it would nevertheless be equitable to allow his/her claim to proceed under the provisions of section 33 of the 1980 Act.

12.21 Section 33(1) provides:

> "If it appears to the Court that it would be equitable to allow an action to proceed having regard to the degree to which:–
>
> (a) the provisions of section 11 ... of this Act prejudice the [claimant] or any person whom he represents; and
>
> (b) any decision of the Court under this subsection would prejudice the defendant or any person whom he represents
>
> the Court may direct that those provisions shall not apply to the action, or shall not apply to any specified cause of action to which the action relates."

12.22 Section 33(3) requires the Court to have regard to:

> "... all the circumstances of the case and in particular to –
>
> (a) the length of, and the reasons for, the delay on the part of the [claimant];

> (b) the extent to which, having regard to the delay, the evidence adduced or likely to be adduced by the [claimant] or the defendant is or is likely to be less cogent than if the action had been brought within the time allowed by section 11 ... ;
> (c) the conduct of the defendant after the cause of action arose, including the extent (if any) to which he responded to requests reasonably made by the [claimant] for information or inspection for the purpose of ascertaining facts which were or might be relevant to the [claimant's] cause of action against the defendant;
> (d) the duration of any disability of the [claimant] arising after the date of the accrual of the cause of action;
> (e) the extent to which the [claimant] acted promptly and reasonably once he knew whether or not the act or omission of the defendant, to which the injury was attributable, might be capable at that time of giving rise to an action for damages;
> (f) the steps, if any, taken by the [claimant] to obtain medical, legal or other expert advice and the nature of any such advice he may have received."

12.23 The burden of showing that it would be equitable to disapply the limitation period lies on the claimant. The court's discretion under section 33 is wide and unfettered. In resolving an application under section 33, the court must make a decision of which the inevitable effect is either to deprive the defendant of an accrued statute-bar defence or to prevent the claimant's action against the defendant from proceeding. In choosing between these outcomes, the court must be guided by what appears to it to be equitable and must have regard to all the circumstances of the case, in particular, the six matters listed in subsection 33(3).

12.24 In *Cain v Francis*[285], the Court of Appeal emphasised that the phrase "it would be equitable to allow the action to proceed" is "at the heart" of section 33. "Equitable" here means "fair and just". Having reviewed the history and purpose of the limitation regime, Smith LJ (with whom the other members of the Court of Appeal agreed) referred to the context of section 33. At paragraph 68, she said:

> "… The context is that the claimant had the right to pursue his cause of action which he has lost by the operation of section 11. The defendant, on the other hand, had an obligation to pay the damages due; his right was the right to a fair opportunity to defend himself against the claim. The operation of section 11 has given him a complete procedural defence which removes his obligation to pay. In fairness and justice, he only deserves to have that obligation removed if the passage of time has significantly diminished his opportunity to defend himself (on liability and/or quantum). So the making of a direction, which would restore the defendant's obligation to pay damages, is only prejudicial to him if his right to a fair opportunity to defend himself has been compromised."

[285] [2008] EWCA Civ 1451

12.25 The court rejected the suggestion that the financial prejudice to the defendant of having to pay damages in the event that the claim was permitted to proceed was a relevant consideration.

12.26 At paragraph 73, Smith LJ went on:

> "It seems to me that, in the exercise of the discretion, the basic question to be asked is whether it is fair and just in all the circumstances to expect the defendant to meet this claim on the merits, notwithstanding the delay in commencement. The length of the delay will be important, not so much for itself as to the effect it has had. To what extent has the defendant been disadvantaged in his investigation of the claim and/or the assembly of evidence, in respect of the issues of both liability and quantum? But it will also be important to consider the reasons for the delay. Thus, there may be some unfairness to the defendant due to the delay in issue but the delay may have arisen for so excusable a reason that, looking at the matter in the round, on balance, it is fair and just that the action should proceed. On the other hand, the balance may go in the opposite direction, partly because the delay has caused procedural disadvantage and unfairness to the defendant and partly because the reasons for the delay (or its length) are not good ones."

12.27 She continued by referring at paragraph 74 to the period of delay to be taken into account:

> "Although the delay referred to in section 33(3) is the delay after the expiry of the primary limitation period, it will always be relevant to consider when the defendant knew that a claim was to be made against him and also the opportunities he has had to investigate the claim and collect the evidence: see *Gwentoys*. If, as here, a defendant has had early notification of a claim and every possible opportunity to investigate and to collect evidence, some delay after the expiry of three years will have had no prejudicial effect."

12.28 I shall bear these principles in mind when considering the issue of limitation in the individual cases.

History of events

12.29 Before dealing with the parties' generic contentions on limitation, it is necessary to consider the relevant history of events. Much of the history is derived from the evidence of Mr Gareth Morgan (partner of Hugh James) who has conduct of the litigation for the claimants and of Mr Carl Dray (partner of Nabarro), who acts for the defendants. Both Mr Morgan and Mr Dray provided witness statements and gave oral evidence.

12.30 The claimants accepted that workers at the Phurnacite Plant would have been aware from the outset of their employment at the Plant that the inhalation of coal dust in underground mining could cause respiratory disease. The claimants also accepted that workers at the Phurnacite Plant would have been aware of the potential for skin lesions (including skin cancer) as a result of exposure to pitch. However, the awareness that there was a link between lung and/or bladder cancer would have come significantly later.

12.31 I have already referred to research conducted in the late 1960s in the USA which provided compelling evidence of an association between exposure to coke oven emissions and lung cancer. That research prompted the start of the 1987 IOM study of mortality at the Phurnacite Plant which I have discussed in Sections 8 and 9 of this judgment. Work on the study began in 1967 and, in November 1968, all industrial workers at the Phurnacite Plant who had been employed there on 1 January 1967 were invited to participate in the study. Work on the study continued until 1983. The work was based mainly on documentary records, but participants in the study were invited to take part in a survey of respiratory symptoms in November 1968. About 78% of those who had been invited to participate in the study did so. The researchers involved in the study visited the Phurnacite Plant from time to time to discuss their preliminary and final findings with members of management and Union representatives. The final results of the study were published in 1987. Although they showed more deaths from lung, stomach and bladder cancer than would have been expected, the numbers were small and the results did not reach statistical significance.

12.32 The results of the 1987 IOM study were reported to the NUM Coke Man's Area. I have no information about how the Union responded to the results, nor whether they informed their members. There is evidence that, some years later, in 1996, the Union were asking for a follow-up study to be undertaken with a view to ascertaining whether there was any basis on which former Phurnacite workers might be able to claim damages. No such follow-up study was ever undertaken.

12.33 I have already described the long standing concerns of residents who lived near the Phurnacite Plant about pollution emanating therefrom. Those concerns were reflected in articles in local and national media, dating from 1970 onwards. It is clear that the concerns were not confined to the nuisance caused by the emissions. They also extended to concerns about the risks to health. In the early 1970s, the concerns appeared to focus on the possibility of the emissions causing non-malignant respiratory disease such as CB. A newspaper article from February 1972 referred to the ongoing monitoring of the lung function of children at a nearby school and also to the 1987 IOM study which was then in its early stages. In the event, the monitoring exercise did not disclose any excess incidence of lung function problems.

12.34 It is clear that the concerns continued. Another article in the local press published in 1979 referred to a three-day picket of the Phurnacite Plant mounted by local residents the previous year. Again the health hazard referred to in the article was non-malignant respiratory disease. However, researchers at Swansea University in 1981 conducted a series of video-recorded interviews with three workers at the Phurnacite Plant (two of them Union officials) as part of the "Phurnacite Project". Those interviews contained references to the possibility of a cancer risk from the Phurnacite Plant. Since only short summaries of the interviews are available, it is not known precisely what those risks were perceived to be. It may be that the workers had been involved in, or received information about, the ongoing IOM study and were aware of the nature of the risks being investigated. Concerns about the risks of cancer associated with the Phurnacite Plant appear to have surfaced more generally amongst the local community in the mid-1990s.

12.35 The Phurnacite Action Group (PAG) was founded in 1995 with the aim of campaigning to secure compensation for former Phurnacite workers and their families. PAG was formed by Mr Malcolm Cook, himself a former worker at the Phurnacite Plant, who had become concerned at the number of deaths from cancer amongst his former workmates. In 1996, the Independent newspaper carried a report[286] about an investigation into local cancer deaths being carried out by a doctor at the request of the local Member of Parliament. The media, including the BBC, carried further stories about possible risks to health in the late 1990s and early 2000s. PAG was later replaced by another group, the Phurnacite Justice Action Group (PJAG), whose efforts led eventually to the launching of the current litigation.

12.36 Before the start of this litigation, there had been a number of other attempts to pursue claims in respect of injuries alleged to have been caused by occupational exposure to dust and fume at the Phurnacite Plant.

The case of Albert Evans

12.37 The only one of those claims to be pursued to a conclusion was the case of Albert Evans. Mr Evans had worked at the Phurnacite Plant as a fitter between January 1961 and January 1984. In 1996, Hugh James, who were instructed by Mr Evans, obtained a medical report in Mr Evans' case. The report stated that Mr Evans had "asthmatic bronchitis largely of occupational origin" and suggested that the Phurnacite Plant had been "the main causative occupation". Particulars of Claim were issued in March 1997. A Defence was filed, denying breach of duty and causation and raising the limitation defence.

12.38 During 1997 and 1998, the British Coal Corporation conducted a search for documents which resulted in extensive disclosure. Amongst the numerous documents disclosed were the Minutes of the NSFL Environmental Control Committee meetings from their first meeting in 1973 up to 1983, and the summary of personal sampling results from 1971 to 1983 which I have referred to in this judgment as *Table 6.4*. Other documents relating to matters such as emissions from the Phurnacite Plant, the steps taken to reduce those emissions and the provision of masks and respirators were also found and disclosed. By the time disclosure took place in 1998, the Phurnacite Plant had been closed down for several years. Because Mr Evans' employment at the Phurnacite Plant had ceased in January 1984, the documents disclosed in his case were restricted to those which had come into existence before the end of 1983. All the documents disclosed in Mr Evans' claim were available in the current litigation.

12.39 Mr Evans' case proceeded towards trial. Both parties instructed experts, including consultant chemists, who met and provided a Joint Statement. In April 2002, the claim was settled for £40,000. Mr Evans' claim was funded by legal aid. It was a case of asthma, involving specific asthmagens to which it was alleged that Mr Evans had been exposed. It was, therefore, of a wholly different character to the claims involved in this litigation.

[286] DLBB/88

Cases dealt with by Smith Llewelyn Partnership, Swansea

12.40 In July 1996, a firm of solicitors based in Swansea, Smith Llewelyn Partnership (SLP), attended a meeting of PAG. Following that meeting, SLP had received instructions in connection with a number of potential claims. On 4 October 1996, they issued a writ on behalf of Mrs Linda Kirwan, a former cleaner at the Phurnacite Plant, claiming damages for personal injuries allegedly suffered as a result of her employment at the Phurnacite Plant between 1976 and 1986. The writ was served on the second defendant, CPL, in February 1997.

12.41 In a letter dated 4 March 1997, written to CPL's solicitors, Nabarro (then known as Nabarro Nathanson), SLP said that they acted for a significant number of claimants who fell into three broad categories. The first category (of whom Mrs Kirwan was said to be one) consisted of former employees at the Phurnacite Plant who had developed medical conditions allegedly caused by exposure to "chemical waste" there. The second and third categories related to local residents who had been exposed to emissions from the Plant and to children who had suffered burns as a result of chemical residues left at the site after the Plant had been demolished. SLP told Nabarro Nathanson that the writ in Mrs Kirwan's case had been served "to protect the limitation of actions". They proposed that, in view of the fact that she was one of a number of claimants, the case should proceed by way of generic proceedings, with a general extension of time being given for service of the Statement of Claim in Mrs Kirwan's case. A few weeks later, SLP wrote a further letter to Nabarro, informing them that Mrs Kirwan wished to discontinue her claim and suggesting that the parties should have a discussion about how to progress the remaining claims.

12.42 That discussion does not appear to have taken place, the defendants understandably taking the view that they should await the formal notification of intended proceedings before taking any action.

12.43 In October 1998, SLP wrote a letter before action to Nabarro, referring to a number of claimants (both former Phurnacite Plant workers and local residents) for whom they acted and who were suffering from various types of cancer, alleged to have been caused by occupational exposure at the Phurnacite Plant. That letter was followed on 28 April 1999[287], by a writ claiming damages on behalf of Mr Howard Bew and a number of other former workers at the Phurnacite Plant. By that stage, SLP had obtained legal aid certificates on behalf of 17 claimants.

12.44 No Particulars of Claim were ever served in the action and, in April/May 2000, the Legal Services Commission (LSC) discharged[288] the legal aid certificates previously granted to the 17 claimants. The claimants complained to their Member of Parliament who made representations on their behalf to a Parliamentary Secretary at the Lord Chancellor's Department. In a letter dated 14 June 2000[289], the Parliamentary Secretary explained that the LSC considered that the number of claimants, coupled with the relatively low value of their claims, did not satisfy the cost-benefit ratio which was a prerequisite for funding.

[287] CLB/3
[288] E.g. GMM/82
[289] GMM/84

12.45 The Parliamentary Secretary went on to explain that another firm of solicitors, Randalls, had attended a meeting with the LSC and SLP. Randalls had indicated that they were instructed by the NUM to act for 100 potential Phurnacite claims. They had agreed to provide details of their clients and to discuss a possible cost sharing agreement. It was hoped that the addition of the Randalls cases might be sufficient to satisfy the cost-benefit ratio. However, Randalls had not provided the required information and the legal aid certificates previously granted to SLP's clients had therefore been discharged. The Parliamentary Secretary suggested that consideration might be given to pursuing the claims under conditional fee agreements (CFAs). It is not known whether the NUM support for the Randalls claimants had extended to the provision of any funding. In any event, Randalls do not appear to have taken any further steps to progress the claims in which they were instructed.

Claims dealt with by other firms of solicitors

12.46 A number of other firms of solicitors intimated to the defendants that they were instructed in claims by former Phurnacite workers. In 1996, Browell, Smith and Goodyear (BSG), a firm of Newcastle solicitors, informed the defendants that they were instructed in three potential claims involving cancers alleged to have been caused by occupational exposure at the Phurnacite Plant. BSG were NUM solicitors but it is not known whether the claims received any financial support from the NUM. BSG did not pursue them.

12.47 In 1999, Robertsons, a firm based in Cardiff, informed the defendants that they had received instructions in 53 potential claims for non-malignant respiratory disease and various types of cancer allegedly caused by occupational exposure at the Phurnacite Plant. It is known that, at one stage, the claims being conducted by Robertsons were being "supported" by the NUM (Coke Man's Area) but whether that support extended to the provisions of any funding for the claims is not clear. Some time later, Robertsons informed the defendants that they were not proceeding with the claims. In February 2001, Charles Crookes and Jones, a firm of solicitors from Caerphilly, informed the defendants that two of the former Robertsons claims had been transferred to them. It is not known whether any funding was available for those claims but they were not pursued at that time. Raleys, a firm of NUM solicitors, were instructed in one potential claim by the widow of a former Phurnacite Plant worker who had died of stomach cancer but they advised against pursuing the claim. Another firm of solicitors, Thompsons, had investigated a number of claims for respiratory disease suffered by former Phurnacite workers. They carried out investigations, including inspecting documents and instructing engineering and medical experts. In about 2006, they decided not to pursue the claims further. In oral evidence, Mr Dray said that, in addition to the claims identified by the claimants, he believed that five or six potential Phurnacite claims had been notified to the British Coal Corporation in or about 1996, although no proceedings had been issued in any of those cases.

The involvement of Hugh James

12.48 Hugh James' first involvement with potential claims by former workers at the Phurnacite Plant came when they were instructed in Mr Evans' claim.

12.49 By September 1995, proceedings had been issued in about 100 claims by coal miners for non-malignant respiratory disease allegedly caused by exposure to dust underground. In November 1995, Turner J (as he then was) was appointed to manage the claims, which became known as the BCRDL. The trial of the lead cases in the BCRDL took place between October 1996 and January 1998 and the Claims Handling Agreement (CHA) was finally agreed in September 1999.

12.50 The period for registering claims in the BCRDL ran from 1999 until the 'cut-off' date of 31 March 2004. During that period, a number of claims for non-malignant respiratory disease were registered in the BCRDL on behalf of men who had worked at the Phurnacite Plant. Some of those men had spent some time working underground and some time employed at the Phurnacite Plant. Others had never worked underground and were seeking to claim solely in respect of their employment at the Phurnacite Plant. The terms of the CHA did not require the defendants to compensate men who were alleging that their respiratory disease had been caused solely by their exposure at the Phurnacite Plant. Such claims were in general 'parked' within the BCRDL, pending a decision as to whether and how they should be dealt with. Some of the claims were settled under the BCRDL despite the fact that the claimants had not worked underground. This happened either because of an error or in circumstances where, because the BCRDL was at one point proceeding very slowly, the defendants elected to make interim bereavement awards to workers' widows without investigating their claims. However, the majority of claims which involved employment at the Phurnacite Plant alone remained 'parked' in the BCRDL until the commencement of the current litigation. Hugh James were instructed in some of those claims.

12.51 Hugh James did not consider it practicable to pursue the claims for non-malignant respiratory disease that had been registered in the BCRDL – or the other similar claims in which they were instructed – as unitary common law actions. They were aware from their previous experience of group litigation against these defendants that, because of the large number of potential Phurnacite claims, any individual claim action would be resisted and would in all probability proceed to a full contested trial. They were aware (as has indeed proved to be the case) that the process of investigation and trial of even a single claim would require extensive resources. By contrast, the damages in most of the cases were likely to be modest. Hugh James did not consider that the claims would be financially viable, whether as unitary actions or group litigation, making it highly unlikely that either the LSC or a Union would fund the claims. That view altered only when Hugh James began to receive instructions from a large number of individuals with potentially valuable claims for cancer allegedly caused by occupational exposure at the Phurnacite Plant.

12.52 Before 2004, Hugh James had not been involved in any of the potential claims for cancer. In 2004, solicitors from Hugh James met members of PJAG, which had by that time replaced PAG. Following that meeting, Hugh James received instructions in a number of potential claims by former Phurnacite workers for cancer, as well as for non-malignant respiratory disease. I was told that, shortly after the meeting, Hugh James first began to examine the generic issues surrounding the possible connection between exposure to dust and fume at the Phurnacite Plant and the development of cancer. They opened the first individual file for a cancer claim by a former Phurnacite worker in January 2005. Between January and July 2005, they received instructions on behalf of 137 former employees of the Phurnacite Plant who had potential cancer claims. The schedules of costs disclosed by the claimants for the purpose of the costs capping hearings confirm that work on the Phurnacite claims began in earnest in 2005. Between 2001 and the beginning of 2005, Hugh James had spent only a total of 64 hours carrying out work on generic Phurnacite issues. In

2005, they did over 100 hours' work and the time spent increased markedly in the years that followed.

12.53 Preliminary investigations then took place, the potential claimants were interviewed and technical and medical evidence was obtained. By February 2007, the initial investigations had been completed and Hugh James began to take steps to obtain funding for the proposed litigation. In March 2007, a case plan was submitted to the LSC in support of an application for legal aid funding. In April 2007, discussions began with 'after-the-event' (ATE) insurers. Meanwhile, Hugh James notified the defendants' solicitors of the proposed litigation and proceedings were issued in four cancer claims (including two of the lead claims involving Mr Carhart and Mr Jenkins) where the primary limitation period was about to expire. Those claims were stayed, with the permission of the court.

12.54 In 2007, Capita, who were by that time acting as the first defendant's claims handlers for the purposes of the BCRDL, indicated their intention to strike out the 'parked' Phurnacite claims pursuant to the strike out procedures contained in Orders made in the BCRDL. Hugh James requested Capita not to strike out the Phurnacite claims. In April 2008, they informed Nabarro that preparations were under way for a group action which would include claims for non-malignant respiratory disease. In July 2008, it was agreed that those BCRDL claims that related solely to employment at the Phurnacite Plant should be identified and placed on a Schedule which should then be put before the court for directions as to their future conduct. That was done and those Phurnacite claims that were identified were managed within the BCRDL until the commencement of the current litigation.

Funding of the litigation

12.55 Funding by means of CFAs was introduced in July 1995. At first, it was not possible for claimants to recover the 'additional liabilities' consequent on a CFA, i.e. the success fee payable to the claimants' lawyers and the premium paid for ATE insurance. The Access to Justice Act 1999 (the 1999 Act), which came into force in 2000, had the effect of taking most personal injury claims out of the scope for legal aid. Such claims were thereafter to be funded by CFAs. The 1999 Act provided that successful CFA-funded claimants could recover from their unsuccessful opponent the 'additional liabilities' that had previously been irrecoverable.

12.56 Since, initially, ATE insurance was not available for multi party actions, such actions remained eligible for legal aid if the potential claimants could show a wider public interest in the litigation. An independent committee, the LSC Multi Party Action Committee, was set up to determine such applications. Over time, ATE insurers began to provide cover for some multi party actions.

12.57 In April 2007, Hugh James applied to the LSC for legal aid for the Phurnacite claims. The application went to the LSC Multi Party Action Committee which refused it in December 2007. An appeal was lodged and, on 24 April 2008, short term funding was granted to allow further investigations to be carried out. In September 2008, a funding certificate was issued, limited to the making of an application for a GLO, the registration of claims and to enable compliance with the generic pre-action protocol. That certificate was never extended. Following receipt of legal aid funding, Hugh James sent a letter of claim to the defendants on 30 September 2008.

12.58 Negotiations for ATE insurance had been under way since April 2007. The negotiations had not started earlier because of the extensive investigations into the prospects of success of the action that were necessary before a potential insurer could be approached. Those negotiations were complicated by the fact that, in their response to the letter of claim, dated 4 December 2008, the defendants raised an issue as to whether they were the correct defendants. The position was not clarified finally until a court hearing in May 2009. The GLO was made on 22 July 2009. Also in July 2009, the defendants agreed that, for Phurnacite claims alleging respiratory disease alone or alleging both respiratory disease and cancer, the date of registration in the BCRDL should be deemed to be date of issue of proceedings for the purposes of this litigation. Thereafter, the negotiations with insurers were concluded and an ATE insurance policy was issued on 3 August 2009.

12.59 In 2007 and 2008, there were ongoing discussions about possible contributions to the funding of the litigation that might be made by the NUM and/or the Union of 12.59 Democratic Mineworkers. In the event, no funding was provided by either Union although, in May 2008, a third Union, the National Association of Colliery Overmen and Deputies, confirmed that they were prepared to make £50,000 available to support two of their members with potential cancer claims.

12.60 The claimants relied on the history of claims by former Phurnacite workers which I have described. That history was not encouraging from the point of view of a potential claimant. All but one of the claims had foundered before, or shortly after, the commencement of proceedings. In a number of cases, legal aid had been granted initially on a limited basis but had then been withdrawn. It is not clear whether any of the claims had received financial backing from a Union but, if they had, the financial support did not extend to funding of the commencement of proceedings. Even after the introduction of CFAs in 1995, no firm of solicitors had been prepared to pursue a Phurnacite claim on a CFA. The only claim that had been pursued to a conclusion was that of Mr Evans. That was an entirely different type of claim and had plainly been suitable to be pursued as a unitary action with the benefit of legal aid.

12.61 The claimants submitted that I should view the issue of limitation in the light of this history. They submitted that, if I find in any individual case that the claimant's knowledge arose more than three years before the commencement of proceedings and that it would have been reasonable for him/her to consult solicitors earlier than he/she in fact did, I should have regard to what would have happened if he/she had done so and, in particular, whether it is likely, having regard to the potential funding difficulties, that proceedings would have been commenced earlier than they actually were. The claimants contended that, in reality, it would not have been feasible to proceed with a unitary claim, whether for non-malignant respiratory disease or cancer, earlier than the late 2000s. Such a claim could have been expected to be strongly contested and would, being a 'test' case, have involved the expenditure of huge resources for which funding would not have been available.

Prejudice

12.62 The defendants contended that the evidence adduced in this litigation (in particular, the evidence available to them) was bound, by reason of the passage of time, to be significantly less cogent than would have been the case had the actions been commenced within the primary limitation period. The defendants referred in particular to the effect of delay on the availability of witnesses and the availability of documentation. They contended that the claimants had failed to act promptly and reasonably and that the funding problems described by the claimants would have been no bar to the claims proceeding.

The availability of witnesses

12.63 The dates of employment at the Phurnacite Plant of the lead claimants span the period 1948 to 1991. Five of the eight lead claimants began work at the Phurnacite Plant in the late 1940s or 1950s, i.e. more than 50 years ago. The defendants said that any potential witnesses who held a middle or senior management position at that time were likely by now to be either dead or too infirm to give evidence.

12.64 Mr Dray gave evidence about the attempts made by the defendants to trace witnesses for the purposes of this litigation. He said that he had instructed a claims investigator to trace management grade witnesses who had been employed at the Phurnacite Plant or who had occupied senior management roles in CPL or NSFL between 1941 and 1991. The investigator had identified 77 potential witnesses who had worked at the Phurnacite Plant, of whom 49 could not be traced, five were known to be dead, four were too ill to be interviewed, six were unwilling to assist, two were claimants in the current litigation and one was living abroad. Of the remaining ten potential witnesses, seven had provided witness statements.

12.65 Amongst the former senior management staff at CPL or NSFL, the investigator had identified 40 individuals, of whom 23 were known to be dead, 11 could not be traced and two were unwilling to assist. Of the remaining four, one had provided a witness statement but the other three did not have sufficient knowledge of the Phurnacite Plant to provide any useful evidence. Mr Dray attributed much of the difficulty in tracing potential witnesses to the fact that their full names were often not known and many had surnames which are very common in Wales.

12.66 In his oral evidence, Mr Dray was asked whether the defendants had identified as potential witnesses, Mr Glanville Harris (former deputy works chemist, shift superintendent and ovens assistant manager) and Mr Brian Jones (former shift superintendent, section manager and environmental manager, who worked at the Phurnacite Plant from 1971 until after the Phurnacite Plant ceased production in 1990). Mr Harris and Mr Brian Jones gave evidence for the claimants; both had held managerial and/or supervisory roles at the Phurnacite Plant. Mr Dray said that the defendants had not identified Mr Harris. He said that they had identified Mr Brian Jones but had decided not to interview him on the ground that he and Mr Baylis (a witness identified by the defendants) "were likely to give exactly the same sort of evidence". Also, by the time the defendants became aware of Mr Brian Jones' existence, the defendants were aware that he had been interviewed by the claimants' solicitors. Mr Baylis had been employed at the Phurnacite Plant as a shift manager for only a short period between 1974 and May 1977. Between 1963 and 1974, he had visited the Phurnacite Plant from time to time in the course of his job of providing technical support for coal products processing plants. After May 1977, he worked as assistant manager, and afterwards manager, of the Homefire works in Coventry. By contrast, Mr Brian Jones had been employed at the Phurnacite Plant for over 20 years and had an extraordinary knowledge of the Phurnacite Plant's history and processes.

12.67 Mr Dray explained that, in order to identify potential witnesses, searches were made in colliery yearbooks and in the disclosed documents. Efforts were then made to trace telephone numbers for the individuals identified. Witnesses who were traced and interviewed were asked whether they could provide details of other potential witnesses. It was suggested to Mr Dray that, since all the surviving former supervisors and managers at the Phurnacite Plant would have been members of employment pension schemes, one way of reaching potential witnesses would have been to ask the administrators of those schemes to send out letters asking for anyone who believed they could help to come forward. Mr Dray accepted that it would have been possible to do that, but acknowledged that no such action had been taken.

12.68 The defendants contended that the delay in bringing proceedings had also made the task of evidence gathering very difficult. They pointed out that, of the 236 claims registered in the litigation, 89 are made on behalf of former workers at the Phurnacite Plant who have died. Of those 89 men, 23 died in the 1990s and 44 have died since 2000, 17 of those 44 deaths having occurred since 2006. In the lead actions, 32 witness statements were served. By the time of the trial, eight of the makers of those statements had either died or become too ill to give evidence. The defendants contended that they were thereby deprived of the opportunity of challenging much of the evidence about the claimants' working conditions and, as a result, had suffered prejudice.

12.69 The defendants also pointed to specific gaps in the evidence in relation to some of the individual lead claims. I shall refer to those gaps in my individual judgments.

The availability of documents

12.70 The defendants contended that the delay in bringing the claims has resulted in certain important documents no longer being available. They referred in particular to the following categories of document:-

> (a) *Records of personal sampling results*
> *Table 6.4* contains a summary of the results of personal sampling carried out at the Phurnacite Plant in the period from 1971 to 1983. The figures in *Table 6.4* are average figures for the personal sampling of one or two workers in each location conducted over four days. For some of the sampling exercises, reports of the exercises are available, showing the individual day's sampling results for each worker who had participated in the sampling exercise. However, reports are not available for all the sampling exercises that were undertaken. In addition, the defendants complained that the paper records which were made by the team undertaking the sampling had not survived. Those paper records would, they said, have contained notes about potentially suspect samples and/or about unusual weather and other conditions that might have affected the sampling results.
>
> Also, no personal sampling results for the period from 1984 until the cessation of Phurnacite production in 1990 have survived. As I explained in Section 3, those results should have included - in addition to the levels of total dust, BSM

and BaP – measurements of the average levels of respirable dust to which the workers sampled had been exposed during the four-day sampling exercise.

The defendants were unable to say when the samplers' paper records, the reports of the individual sampling exercises and/or the results of personal sampling carried out from 1984 onwards had been lost or destroyed.

(b) *Committee Minutes*
Mr Dray referred in his evidence to the fact that the defendants had not been able to find complete sets of the Minutes of all the relevant Committees, although he acknowledged that the court had a "good selection" of Minutes.

(c) *Documents relating to the defendants' preparations for the introduction of the COSHH Regulations 1988*
The COSHH Regulations 1988 came into force in October 1989, shortly before the cessation of production at the Phurnacite Plant. It appears that the documents relating to the defendants' preparations for the introduction of the Regulations cannot be found. Mr Dray acknowledged that the documents related to only a short period in the life of the Phurnacite Plant. Of the lead claimants, only Mr Middle's claim involves allegations of breach of the COSHH Regulations

(d) *Training records, overtime records and medical records in some of the individual claims*

12.71 I shall refer to these as appropriate in my individual judgments.

12.72 Mr Dray was asked whether any steps had been taken to preserve existing documentation at the time when the earlier claims (e.g. that of Mr Evans and those of Mrs Kirwan and others) were intimated to CPL in October 1996). Mr Dray said that the usual practice would have been to give instructions to the company responsible for archiving the relevant documents to preserve them. He assumed that the usual practice had been followed in 1996.

Discussion and conclusions

Date of knowledge

12.73 The date of knowledge in any individual case will depend on the specific facts and circumstances of that case. I shall deal with those facts and circumstances in the individual judgments. However, those facts and circumstances must be viewed against the background of local awareness of the pollution emitted at and from the Phurnacite Plant and its possible consequences.

12.74 There can be no doubt that there was a high degree of local concern about the pollution caused by the Phurnacite Plant. It is clear from the documents that those concerns were present as long ago as the 1950s. Before 1990, it seems that the concerns focused mainly on the potential for non-malignant respiratory disease as a result of exposure to the emissions from the Phurnacite Plant.

12.75 I am satisfied that knowledge of the possible attributability of lung and/or bladder cancer would in general have come rather later. Some workers at the Phurnacite Plant would have become aware of the possibility that there might be a link between various types of cancer and occupational exposure at the Phurnacite Plant during the period (between 1967 and 1983) that work was being done on the 1987 IOM study. However, I am satisfied that it was only some time after the publication of the study, in about 1990, that there was a general awareness amongst workers at the Phurnacite Plant and the local community that, where a worker had developed a cancer of the lung, there was a real possibility that it was attributable to his employment at the Phurnacite Plant. The evidence relating to the risk of bladder cancer was rather more equivocal but there is no doubt that some Phurnacite workers and their families were aware of the possible link between bladder cancer and occupational exposure at the Phurnacite Plant.

Section 33

12.76 I have dealt in this judgment with the issue of limitation after those Sections of the judgment in which I have set out my conclusions in relation to exposure, breach of duty and causation. That is because, when writing my judgment, I have found it convenient to deal with the issues in that order. Despite the way in which my judgment is structured, however, I make it clear that, when considering limitation issues, I have not taken into account any findings in favour of the claimants that appear in the earlier Sections of my judgment. When reaching my conclusions, I have applied the principles I have discussed earlier in this Section.

12.77 For the purposes of section 33 of the 1980 Act, I must have regard to the degree to which the parties would be prejudiced by any decision I might make, having regard to all the circumstances of the case and, in particular, the matters identified in section 33(3). The discussion that follows relates to generic issues only. It will be necessary to consider the specific facts and circumstances in each individual case.

12.78 It is necessary first to consider the issue of delay. The length of, and reasons for, the delay will be specific to each individual case and must be considered separately.

12.79 In some cases, at least part of the delay is likely to have consisted of a period after the claimant first consulted solicitors and before proceedings were commenced. Some of the individual claims may have passed through the hands of one or more firms of solicitors before eventually reaching Hugh James. It is clear that, before Hugh James put in place the funding arrangements for the current litigation, no other firm of solicitors had succeeded in obtaining the funding necessary to advance claims on behalf of former Phurnacite Plant workers, whether by way of a group or a unitary action. (The case of Mr Evans, commenced in 1993 and conducted with the benefit of legal aid funding, was quite different in character, as demonstrated by the fact that it was settled by the defendants). Union backing on the scale necessary properly to investigate and pursue such an action was not forthcoming. Legal aid was unavailable or available only to a very limited extent. And, before 2000, CFAs were not financially viable in large actions, because of the non-recoverability of 'additional liabilities'.

12.80 Even after 2000, it was not easy to obtain funding for claims on behalf of former Phurnacite workers and their families. In 2000, the LSC discharged the legal aid certificates previously granted to 17 potential claimants on the basis that the relatively low value of the claims, when compared with the high costs of investigating and pursing them, did not satisfy the relevant cost-benefit ratio. The same type of cost-benefit analysis would inevitably have been carried out by any prudent solicitor when deciding whether to enter into a CFA, and by any potential ATE insurer.

12.81 Mr Morgan's evidence was that, in the early 2000s, when he and his partners considered whether they could progress the Phurnacite claims in which they had been instructed, they had reached the conclusion that litigation, whether by group or unitary action, was not financially viable because of the relatively low value of the claims. In effect, therefore, they came to the same conclusion as the LSC had done in the SLP claims. Hugh James have considerable experience of group litigation, in particular group litigation against these defendants. They were aware that the Phurnacite claims would be defended, in all probability to a contested trial and they made their assessment of the viability of the claims with that in mind. Their view about the viability of the claims only changed in 2005, when the number of claims and their potential value increased significantly.

12.82 I am satisfied that, when considering the reasons for delay in an individual case, any actual difficulties with obtaining funding must be taken into account. Those difficulties did not arise as a result of any fault on the part of the claimants or their advisers. Nor, of course, were they attributable to fault on the part of the defendants. They merely form part of the explanation for delay.

12.83 In 2005, Hugh James began seriously to investigate the Phurnacite claims with a view to assessing the prospects of success of a group action. Such an assessment was necessary in order to enable the claimants' legal advisers to decide whether to enter into CFAs, for the purposes of obtaining ATE insurance and also in order to have any prospect of obtaining funding from the LSC and/or any other source. In the event, the investigations took more than three years and a letter before claim was not sent to the defendants until September 2008.

12.84 Detailed investigations were required, including the interviewing of potential claimants and witnesses, the obtaining of expert and medical evidence, the examination of documents and any technical and epidemiological data that was then available, and the obtaining of counsel's advice. That work was bound to take some considerable time. Further time was spent trying to obtain the necessary funding. It may be, as Mr Morgan candidly acknowledged, that some aspects of the investigatory work could have been accomplished quicker than they were. However, I do not find that there was any significant delay on the part of Hugh James or that any delay that did occur can properly be regarded as culpable.

12.85 I have accepted that I should consider the evidence about the funding difficulties actually faced by claimants in the Phurnacite litigation when examining the reasons for delay in an individual case. The claimants urged me to use the evidence about funding difficulties in another way also. They contended that I should consider the position as to funding that would have existed if an individual claimant had instructed a solicitor at or shortly after the time that he/she acquired 'knowledge' for the purposes of the 1980 Act. Thus, if I were to find that a claimant had developed COPD and had the requisite knowledge by 1990 but did not consult a solicitor, the claimants said that I should go on to consider whether it would have been feasible for that claimant to have pursued a claim at that time. The claimants suggested that I should conclude in that example that, in 1990, it would not have been realistic for a claimant to have pursued a unitary claim for damages for COPD allegedly caused by occupational exposure at the Phurnacite Plant. In 1990, it had not yet been established that coal dust could cause COPD; that was not established until 1998, when judgment was given in the lead BCRDL cases. Indeed, the contention that coal dust could cause COPD had been rejected only the year before in the case of *Tanner v National Coal Board*[290]. The claimants argued that the prospects of success and the likely costs of the action would have been such that the claimant would not have been able to proceed at that time. He/she would not have been able to pursue his/her claim to trial until the late 2000s when the number and potential value of the Phurnacite claims was sufficient to make them viable. Thus, the claimants argued, the defendants have not been prejudiced by the claimant's failure to act earlier.

12.86 Whilst I have some sympathy with the submission made by the claimants, I do not feel able to accept it. If a claimant did actually consult a solicitor and was advised that he/she could not proceed by reason of a lack of funding, then that would plainly be a relevant factor in considering the reasons for delay. However, I consider that it is a step too far to speculate about what might or might not have happened in the entirely hypothetical situation that a claimant who did not in fact consult solicitors had done so. The course of events that would have followed if the claimant had consulted solicitors after acquiring knowledge would have depended on a whole range of factors, many of which may not now be capable of being ascertained. If the court were to attempt to reconstruct events in this way, it would be necessary for the parties to adduce detailed evidence about the circumstances at the relevant time, the type(s) of funding that may or may not have been available and what the likely course of events would have been. This would impose an additional burden on the parties and the court and would add to the complexity of decision-making in limitation cases.

12.87 The next issue to be addressed is the effect, if any, of the delay on the evidence available at trial.

12.88 There is no doubt that, with the passage of time, potential witnesses who might have assisted both parties will have died or become too ill to give evidence. I include within the term 'witnesses' those former Phurnacite workers in respect of whom claims have been made. Some of those workers will have made witness statements before their deaths; others will not.

12.89 It is true also that former employees who were in middle or senior management positions in the 1950s and 1960s are likely to have been older than the workers who commenced employment at the Phurnacite Plant at that time. Thus, there is likely to have been a higher attrition rate amongst those who might have been potential witnesses for the defendants than amongst potential witnesses for the claimants.

[290] Unreported 20 December 1989

12.90 The question is whether the defendants would have been in a significantly better position to defend the claims if witnesses who are now unavailable had been able to give evidence. No specific witnesses were identified by the defendants as causing them particular prejudice by their absence; they merely pointed to the small number of witnesses they have been able to trace.

12.91 I am not persuaded that the defendants have taken all the steps that they might have done to identify and trace potential witnesses. The attempts made by them to identify and trace witnesses were very superficial. They did not employ the obvious expedient of attempting to communicate with former supervisory and management staff through the relevant pension schemes. Furthermore, even when they became aware of the availability of a potential witness of management grade such as Mr Brian Jones, with his lengthy period of service at the Phurnacite Plant and his considerable knowledge of the processes carried on there, they elected not to interview him. That decision was not consistent with a real intention to gather as much evidence as possible about working conditions at the Phurnacite Plant. In the event, the defendants chose to rely on the evidence of only five of the nine witnesses from whom they had obtained witness statements. Thus, even when the defendants had been able to trace and interview witnesses, they judged that it was not in their interests to rely on them.

12.92 A great deal of evidence was available about working conditions at the Phurnacite Plant, from both the witnesses and the mass of contemporaneous documentation. There were 30 lay witnesses, whose evidence is summarised at Section 2 of this judgment. Many of them had an excellent recollection of the processes carried out at the Phurnacite Plant and were able to give highly detailed accounts about the working conditions there. In general, those accounts were very consistent with each other. The disclosed documents contain many accounts of sources of dust and fume emissions identified in the course of Plant inspections, pollution surveys, correspondence from the Alkali Inspector and the like. There is overall consistency between the conditions described by the witnesses and the information contained in the documents. Such is the consistency of the overall picture that I am driven to the conclusion that, whenever the defendants had begun their search for witnesses and however thorough that search had been, it is in the highest degree improbable that they would have identified a witness or witnesses who would have given evidence about the working conditions at the Phurnacite Plant such as to change the outcome of the issues to be determined in this litigation.

12.93 I come now to the documentation. The defendants' primary submissions related to the fact that some of the documents containing the results of the sampling of exposure levels to dust, BSM and BaP carried out at the Phurnacite Plant were no longer available. They argued that the missing data would adversely affect the court's ability to determine accurately the exposure levels of individual claimants and they emphasised the importance of that exercise, particularly in claims where the claimant was seeking to prove causation by reference to the 'doubling the risk' test.

12.94 The first issue to determine is the nature and extent of the missing documents. I have reviewed at Section 3 of this judgment the sampling results that have survived. They consist of:

(a) the results of static sampling exercises for respirable dust conducted on three occasions during the 1950s and 1960s;

> (b) the results (contained in *Table 6.4)* of personal sampling of exposure levels for dust, BSM and BaP carried out between 1971 and 1983;
> (c) reports compiled following some (but not all) of the personal sampling exercises referred to at (b), giving the results for each individual whose exposure levels were measured (as opposed to the average exposure levels recorded in *Table 6.4*); and
> (d) the results of various *ad hoc* sampling exercises carried out from time to time in different locations at the Phurnacite Plant between 1971 and 1983.

12.95 There is no evidence to suggest that any static sampling of exposure levels was conducted at the Phurnacite Plant before 1971, other than the three exercises for which the results are available. It is virtually certain that no personal sampling took place until 1971. As I discussed in Section 3, there seems to have been a gap in both personal sampling and static sampling between 1972 and 1975. The reason for this is unknown. There is no reason to believe that there were any further *ad hoc* static and/or personal sampling exercises conducted between 1971 and 1983 other than those for which the results are available.

12.96 Not all the reports compiled following the personal sampling exercises carried out between 1971 and 1983 have survived. These reports showed the results relating to each individual sample taken during the relevant sampling exercise. The defendants voiced serious concern at the outset of the proceedings about the fact that these reports were not available. (At that stage, they appeared to believe that none of them were available.) In the event, however, the technical experts paid little attention to the individual reports, preferring instead to focus on the average data contained in *Table 6.4.*

12.97 Also unavailable were the paper records completed by members of the team responsible for conducting the personal sampling exercises. According to Dr Choo Yin, those paper records would have contained details of the individuals whose exposure levels were sampled, together with notes about any sampling results that seemed to be “not quite right” and about weather conditions and other matters that might have affected the sampling results. Dr Choo Yin seemed to think the paper records were kept in the Plant laboratory for some time at least. However, it is not known whether the records were retained for more than a short period and, if so, when they were discarded or lost. There is no way of knowing, for example whether they would have still been in existence in 1990, when the Phurnacite Plant ceased production.

12.98 In any event, I consider it unlikely that the paper records would have yielded a significant amount of useful information. Dr Choo Yin said that, when he and his team regarded a sample as “not quite right”, they would discard it, as well as making a note in their paper records. Thus, if there was a suspect result, it would not have formed part of the data contained in *Table 6*.4. I did not get the impression that suspect results occurred very frequently and I consider it unlikely that, even if the paper records had been available, the average exposure levels recorded in *Table 6.4* would have been affected.

12.99 The evidence is that the programme of regular personal sampling of exposure levels continued after 1983, although the incidence was reduced to once a year. The results of the six or seven personal sampling exercises carried out between 1983 and 1990 are missing. When those results were disposed of or lost is not clear. It seems unlikely that they were still in existence in 1997, when proceedings were commenced in Mr Albert Evans' case. If they had been, one would have expected them to have been preserved in accordance with the usual practice described by Mr Dray. If they were not in existence in 1997, the most likely time for them to have gone astray was at the time the Phurnacite Plant was closed down, shortly after 1990.

12.100 Is it likely that the missing sampling results would have assisted the defendants in their defence of the claims? First of all, the results would only have assisted them in cases where the claimant had been employed after 1983 in an area where personal sampling was carried out. Second, the results would only have assisted the defendants if they had shown average exposure levels which were lower than those recorded for the period up to 1983. None of the experts suggested that it was likely that exposure levels would have decreased during the 1980s. Descriptions of the working conditions given by witnesses who worked at the Phurnacite Plant during the 1980s did not suggest that there was any material improvement in those conditions during that period. In all the circumstances, I consider it highly unlikely that the defendants would have been assisted had the additional sampling results been available. Indeed, they may well have been in a worse position.

12.101 In general, there was a wealth of documentation describing conditions at the Phurnacite Plant. It is true that the number of documents dating from the 1940s and the early 1950s was small by comparison with the volume of documentation which was available for the later years. That may in part have been a reflection of the fact that, in earlier years, fewer Committees were in existence and less paper was generated. However, it is likely that some documents from that period have been lost. It is not possible to say when that occurred. It may have been many years ago. Nevertheless, I am quite satisfied that the documents which were available, coupled with the witness evidence, were sufficient to give a generally accurate picture of the working conditions at the Phurnacite Plant throughout the period for which it was in operation. I regard it as highly unlikely that, if the missing documents had been available, they would have materially affected the overall effect of the existing evidence.

12.102 As to the documents relating to the preparations made by the defendants for the introduction of the COSHH Regulations 1988, these are of limited relevance in this litigation. The Regulations came into operation only in October 1989, very shortly before production at the Phurnacite Plant ceased. In any event, the important factor, when deciding whether there was a breach of any of the COSHH Regulations must be the evidence about the conditions in which the defendants' employees were required to work, rather than evidence about the preparations made by the defendants for the introduction of the Regulations.

12.103 The absence of documents such as training records, overtime records and medical records in an individual claim is a matter that I shall consider in my individual judgments in the lead cases. It will also be necessary in the individual cases to consider the extent to which the claimant acted promptly and reasonably once he/she acquired the relevant knowledge and to examine the steps, if any, taken by the claimant to obtain medical, legal or other advice and the nature of any such advice he/she may have received, before carrying out the balancing exercise necessary in order to reach a conclusion as to whether it would be fair and just to permit the action to proceed.

APPENDIX A

Parameter	Yr	Mo*	Pitch man	PRESS HALL I Press	PRESS HALL I Pug	PRESS HALL I Back	PRESS HALL II Press	PRESS HALL II Pug	PRESS HALL II Back	OVENS Shuttle	OVENS Tops	OVENS Quench	OVENS Wharf
Dust (mg/m^3)	71	-/-/9	3.5							11.4	7.8	3.6	
	72	-/-/7								4.8	9.6	2.6	1.5
	75	8/8/6	6.1	9.0	2.5	5.4	9.0	28.1	30.1	31.1	20.9	6.8	5.9
	75	10/12/10	6.0	19.3	19.3	15.5	31.5	23.6	13.7	13.4	13.1	5.8	3.3
	76	4/4/1	6.1	6.8	22.0	20.5	14.9	16.1	34.4	41.9	14.4	4.3	3.4
	76	8/8/6	6.7	14.0	20.4	59.2	16.9	12.8	29.0	29.0	16.0	4.4	11.6
	76	11/11/10	10.2	10.4	12.0	14.1	8.1	18.3	17.7	8.1	15.0	4.5	1.3
	77	3/5/4	2.4	8.9	12.1	9.9	14.7	12.4	11.5	5.6	22.4	6.9	1.9
	78	3/3/5		11.6	11.4	9.5	24.4	8.4	25.7		18.6	6.9	2.1
	79	6/6/6		27.9	32.6	21.0	21.1	3.6	13.0		18.2	3.4	
	80	5/5/4		11.4	42.1	62.0	30.9	145.3	28.2	203.4	17.3	4.2	
	80	10/10/9		10.3	21.6	19.7	21.1	30.0	25.7	16.1	19.4	3.0	
	81	5/5/4		18.3	16.8	35.5	9.8	23.6	13.4	17.2	16.7	4.1	
	81	11		15.3	21.5	16.6							
	82	7/3/5		11.3	15.8	14.3	20.6	17.8	22.6	20.3	22.7	5.6	
	82	-/-/10								24.1	11.7	7.4	
	83	-/-/3								18.9	15.5	6.8	
BSM (mg/m^3)	71	-/-/9	1.9							0.9	1.3		
	72	-/-/7								0.9	1.9	0.2	0.7
	75	8/8/6	1.1	0.7	0.1	0.1	1.2	0.8	0.3	5.0	1.7	0.8	0.4
	75	12/12/10	3.7	0.9	1.5	1.6	14.7	2.6	1.0	1.7	2.4	0.7	0.2
	76	4/4/1	0.6	0.3	1.2	2.2	1.9	1.4	4.9	9.7	2.4	0.6	0.8
	76	8/8/6	3.4	2.1	2.8	0.3	3.4	4.0	5.5	3.5	2.1	0.9	1.2
	76	11/11/10	3.5	1.7	0.8	1.6	1.0	1.9	1.0	2.3	2.6	0.8	0.2
	77	5/5/4	0.9	1.0	1.2	1.3	1.7	1.1	1.3	1.8	2.6	0.7	0.2
	78	3/3/5		0.9	0.7	1.0	1.4	0.8	1.2		1.9	0.7	0.2
	79	6/6/6		2.0	2.8	1.5	3.1	0.5	1.8		3.3	0.9	
	80	5/5/4		1.9	1.9	1.3	4.0	6.6	2.4	23.9	3.0	0.7	
	80	11/10/9		2.4	3.0	1.9	4.2	7.4	1.9	2.7	2.8	0.3	
	81	5/5/4		1.2	1.0	1.7	0.6	1.9	0.7	6.0	4.9	0.8	
	81	11		1.0	1.0	0.8							
	82	7/3/5		0.6	0.6	0.8	1.6	1.1	0.8	1.2	2.0	0.4	
	82	-/-/10								1.9	2.0	0.8	
	83	-/-/3								2.4	3.9	0.7	
B(a)P (ug/m^3)	71	-/-/9	15.1							13.9	17.7		
	72	-/-/7								6.0	31.0	1.5	2.9
	75	8/8/6	2.2	1.1	0.1	0.2	1.1	6.9	0.4	53.5	14.3	2.8	1.6
	75	12/12/10	27.7	6.9	4.8	6.1	64.0	3.9	6.3	28.5	31.0	8.2	5.2
	76	4/4/1								7.3	18.5	1.5	0.7
	76	8/8/6	134.0	23.4	36.5	127.6	46.9	99.8	56.1	36.8	42.8	6.8	20.6
	76	11/11/10	90.5	9.9	6.3	13.1	11.5	58.6	14.2	57.7	81.7	5.2	1.2
	77	3/5/4	13.4	6.3	3.3	3.7	17.1	15.6	16.4	5.7	43.7	24.1	1.5
	78	3/3/5		6.9	2.4	1.9	10.6	2.3	6.0		15.2	5.6	0.6
	79	6/6/6		6.9	6.4	3.4	10.6	0.6	3.0		36.4	14.5	
	80	5/5/4		4.4	4.6	3.9	17.4	14.5	22.0	103.4	24.9	4.8	
	80	10/10/9		4.5	2.1	3.4	5.1	1.4	3.8	32.9	39.2	1.5	
	81	5/5/4		6.3	2.2	6.3	1.8	ND	1.0	89.7	34.1	2.1	
	81	11		6.3	5.6	4.6							
	82	7/3/5		3.4	3.3	5.0	15.0	7.9	17.0	21.1	41.2	3.0	
	82	-/-/10								11.2	35.7	2.1	
	83	-/-/3								37.7	43.7	9.8	

* Note: First month is for Press Hall I, Second month Press Hall II, Third month oven de

APPENDIX B

Exposure levels to 31/12/74, "on-plant" concentrations

	Offices / canteen	Average external	Coal yard / tipplers	Coal sampling	Boiler House	Workshops	Exhauster House 1	Exhauster House 2	Pitch bay	Briquetting	Oven and shuttle floors	Quench, ramp and screens
Respirable dust (mg m^{-3})	0.043	0.47	0.13	1.5	0.12	0.54	0.4	1	1.5	3.5	3.9	0.72
Total dust (mg m^{-3})	0.22	2.8	0.9	10	1	2.5	2.4	4.8	5.9	21	24.2	4.5
Benzene soluble matter (mg m^{-3})	0.043	0.47	0.13	0.13	0.12	0.54	0.4	1	2.1	1.9	3.2	0.6
Benzo[α]pyrene (μg m^{-3})	4.3	4.7	1.3	1.3	1.2	5.4	4	10	47	13	35	5.5
Oven years	0	0	0	0	0	0	0	0	0	0	1	1

Exposure levels to 31/12/74 due to atmospheric emissions ("background concentrations")

	Offices / canteen	Average external	Coal yard / tipplers	Coal sampling	Boiler House	Workshops	Exhauster House 1	Exhauster House 2	Pitch bay	Briquetting	Oven and shuttle floors	Quench, ramp and screens
Respirable dust (mg m^{-3})	0.043	0.47	0.13	0.13	0.12	0.54	0.4	1	0.5	0.5	0.72	0.72
Total dust (mg m^{-3})	0.22	2.8	0.9	0.9	1	2.5	2.4	4.8	6	6	4.5	4.5
Benzene soluble matter (mg m^{-3})	0.043	0.47	0.13	0.13	0.12	0.54	0.4	1	0.5	0.5	0.6	0.6
Benzo[α]pyrene (μg m^{-3})	4.3	4.7	1.3	1.3	1.2	5.4	4	10	5	5	5.5	5.5
Oven years	0	0	0	0	0	0	0	0	0	0	0	0

Exposure matrices applied to calculations for all claimants

Exposure levels 1/1/75 onwards, "on-plant" concentrations

	Offices / canteen	Average external	Coal yard / tipplers	Coal sampling	Boiler House	Workshops	Exhauster House 1	Exhauster House 2	Pitch bay	Briquetting	Oven and shuttle floors	Quench, ramp and screens
Respirable dust (mg m^{-3})	0.04	0.42	0.09	1.5	0.086	0.5	0.34	0.88	1.5	3.5	3.9	0.72
Total dust (mg m^{-3})	0.15	2.1	0.3	10	0.41	2.4	1.73	4.3	5.9	21	24.2	4.5
Benzene soluble matter (mg m^{-3})	0.04	0.42	0.09	0.09	0.086	0.5	0.34	0.88	2.1	1.9	3.2	0.6
Benzo[α]pyrene (μg m^{-3})	0.4	4.2	0.9	0.6	8.6	5	3.4	8.8	47	13	35	5.5
Oven years	0	0	0	0	0	0	0	0	0	0	1	1

Exposure levels 1/1/75 onwards due to atmospheric emissions ("background concentrations")

	Offices / canteen	Average external	Coal yard / tipplers	Coal sampling	Boiler House	Workshops	Exhauster House 1	Exhauster House 2	Pitch bay	Briquetting	Oven and shuttle floors	Quench, ramp and screens
Respirable dust (mg m^{-3})	0.04	0.42	0.09	0.09	0.086	0.5	0.34	0.88	0.3	0.3	0.7	0.7
Total dust (mg m^{-3})	0.15	2.1	0.3	0.3	0.41	2.4	1.73	4.3	2.7	2.7	3.4	3.4
Benzene soluble matter (mg m^{-3})	0.04	0.42	0.09	0.09	0.086	0.5	0.34	0.88	0.3	0.3	0.6	0.6
Benzo[α]pyrene (μg m^{-3})	0.4	4.2	0.9	0.9	0.86	5	3.4	8.8	3	3	5.5	5.5
Oven years	0	0	0	0	0	0	0	0	0	0	0	0

ERNEST NOEL CARHART

1. Ernest Noel Carhart was born on 16 October 1926. He died on 29 June 2005 aged 78 years.

The claim

2. The claim is brought by Mr Carhart's widow, Audrey Lilian Carhart (the claimant), on behalf of his estate under the Law Reform (Miscellaneous Provisions) Act 1934 and on her own behalf, as his dependant, pursuant to the Fatal Accidents Act 1976. It is alleged that, as a result of the dust and fume containing PAHs to which he was exposed during his employment at the Phurnacite Plant, Mr Carhart developed lung cancer which caused his death. There are also claims in respect of COPD and CB alleged to have been caused by exposure to dust at the Phurnacite Plant.

The defendants' case

3. The defendants admit that they were in breach of their duty towards Mr Carhart until 1981, after which he was issued with and began to wear a Racal airstream helmet when carrying out his work.

4. The defendants accept that Mr Carhart developed lung cancer which was the underlying cause of his death. However, they contend that the claimant cannot prove to the required standard that Mr Carhart's lung cancer was caused by his occupational exposure to PAHs. The defendants accept also that Mr Carhart probably suffered from a minor degree of COPD which is likely to have been caused by a combination of occupational exposure to dust and fume at the Phurnacite Plant. They do not accept that he developed CB.

5. Although the defence of limitation pursuant to both the Limitation Act 1939 and the Limitation Act 1980 was pleaded in the Individual Defence in Mr Carhart's claim, in the event the defendants did not pursue their arguments on limitation in his case.

Damages

6. Damages in Mr Carhart's case have been agreed, subject to the issues of breach of duty, causation and apportionment. Damages for pain, suffering and loss of amenity have been agreed in the sum of £67,500 and special damages in the sum of £43,699.77. The total damages are therefore £111,199.77, exclusive of interest.

7. Insofar as Mr Carhart's claim for non-malignant respiratory disease is concerned, the defendants contend that, in the event that Mr Carhart establishes that he is entitled to damages for COPD and/or CB, those damages should be subject to apportionment to exclude the effects of any exposure to dust which may have occurred before nationalisation of the Phurnacite Plant in 1947. It is agreed that there should be apportionment to exclude from compensation that part of his COPD and CB, if proved, which can properly be attributed to his smoking. The defendants also contend that there should be apportionment to reflect any exposure to dust and fume which would inevitably have occurred without breach of duty on the defendants' part (i.e. the 'irreducible minimum').

Employment history

Period of employment

8. Mr Carhart was employed at the Phurnacite Plant continuously from February 1948 until 21 December 1985 when he took early retirement: a total of just less than 38 years. Before that, he had worked at the Phurnacite Plant for a few months in 1943/1944 prior to completing his National Service. It is not contended that he had any exposure to PAHs, dust and/or fume other than at the Phurnacite Plant.

The witnesses

9. In April 2001 Mr Carhart made a witness statement for the purposes of a claim in the BCRDL. That claim was denied because he had not worked underground. In his witness statement, he set out some brief information about his employment history and working conditions. After Mr Carhart's death, the claimant made a witness statement in March 2011 for the purposes of this claim, but she was able to say little about her late husband's work. Evidence about Mr Carhart's working conditions was derived mainly from two of his former colleagues, Mr Pugh and Mr Brian Jones.

10. Mr Pugh was employed at the Phurnacite Plant between 1946 and 1985, save for five years between 1955 and 1960, when he was performing National Service. He worked mainly on batteries 1 and 5, with some overtime in the briquetting plants. He was a process foreman from 1970 until 1985. He knew Mr Carhart well. He made a witness statement in February 2011; unfortunately, by the time of the trial, he was unfit to give oral evidence. Mr Brian Jones was employed by the defendants from 1971 until after the cessation of Phurnacite production at the Plant in 1990. He was a shift superintendent between 1971 and 1984. Thereafter he worked in various management capacities. He made a lengthy witness statement for the purpose of these proceedings (mainly in connection with the claim of Mr Robson); he also gave oral evidence. He worked closely with Mr Carhart between 1971 and 1977 and it is clear from his evidence that he regarded Mr Carhart as a highly conscientious and experienced employee. Also relevant to Mr Carhart's claim was the evidence of Mr Richards, another of the lead claimants, who was a process foreman for some time. He provided a detailed witness statement and gave oral evidence.

Summary of evidence

11. Briefly summarised, the evidence of Mr Carhart's post-1947 working history at the Phurnacite Plant was as follows:

1948-1950

12. The records show that Mr Carhart re-commenced work at the Phurnacite Plant on 9 February 1948. The evidence about Mr Carhart's employment from that time until 1953 is somewhat uncertain. In his witness statement, he described working initially for about 18 months as a yard labourer. He related how he had to work in the pitch bay, clearing up the pitch pits and using power tools to break up solid pitch residues. He described spending four or five days at a time cleaning out naphthalene residue from storage tanks. Mr Pugh recalled Mr Carhart cleaning out tar tanks, although this may

have been a little later in his career. It is clear from a document completed by Mr Carhart in 1971 that he also worked as a crane assistant at some time between 1948 and 1950.

13. I accept that, during his time as a yard labourer, it is probable that Mr Carhart spent about 25% of his time working in the pitch bay and other areas with a significant exposure to dust containing pitch. For the remaining 75% of his time, he worked in the open areas of the Phurnacite Plant.

1950-1953

14. Although Mr Carhart did not mention the fact in his witness statement, it appears that, after his time as a yard labourer, he went on to work as a general labourer (or 'spare man') in briquetting plant 1. In an internal application form for the post of superintendent which he completed in 1971[291], Mr Carhart stated that, between 1948 and 1953, he had worked in the briquetting plant (that would be briquetting plant 1) on the coal tipplers and as a back end man and a press man. It seems to me highly likely that the information given by him in 1971 was more accurate than the different accounts of his work history contained in other documents which came into existence later. I have assumed that he worked in briquetting plant 1 from 1 July 1950 until 30 June 1953.

1953-1962

15. In the same internal application form, Mr Carhart stated that he had moved to the carbonisation plant in 1953. That would fit in with Mr Pugh's evidence that Mr Carhart was already working on battery 1 before he (Mr Pugh) left the Phurnacite Plant to do National Service in 1955. Mr Pugh's recollection was that he (i.e. Mr Pugh) was working on the ramps at some point before he left the Phurnacite Plant whilst Mr Carhart was a quenching car attendant. From that time on, Mr Carhart worked in various capacities on the batteries, including as a charging car operator, a gas man, a quenching car attendant and in the screen house.

16. I find that it is probable that Mr Carhart spent about a year working as a quenching car attendant and that, thereafter, his time was divided between the oven floor (50%), the quenching car floor (25%) and the screen house (25%).

1962-1977

17. From 1962 onwards, Mr Carhart's working history is reasonably clearly documented. Between 16 October 1962 and 1977, he worked as a process foreman with responsibility for batteries 1 and 2. (During the period from 1968 to 1973, when battery 2 was being rebuilt, he was also responsible for at least part of battery 3). Between 1970 and 1977, Mr Carhart and Mr Pugh were both performing the same job although they worked on different shifts. From 1966 to 1981, Mr Richards was a process foreman, also on batteries 1, 2 and 3. From 1966 until 1977, Mr Richards and Mr Carhart were doing the same job, again on different shifts.

18. Mr Pugh, Mr Brian Jones and Mr Richards all gave different assessments of the average time during a shift that a process foreman would spend working in the various areas of the batteries. They were able to give average times only since every day's work

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was different and the process foreman's programme would depend entirely on what problems arose during his shift and in what area the problems occurred. However, it was common ground between the witnesses that most problems occurred on the oven floor, as a result of which a process foreman would spend more time there than in the other working areas. On occasion, he might spend virtually a whole shift dealing with problems on the oven floor whilst, at other times, he might be required to spend a significant amount of time dealing with issues which arose elsewhere in the carbonisation plant.

19. Mr Pugh's evidence was that, on average, a process foreman would spend 80% of his time on the oven floor and 10% of his time on the quenching car floor, with the remaining 10% divided between the ramps and the screen house. Mr Brian Jones estimated that Mr Carhart would have spent up to 70% of his time on the oven floor and 20% on the quenching car floor, with the remaining 10% of his time split between the ramps, the screen house and the by-products plant. Neither Mr Pugh nor Mr Brian Jones made any mention of time spent on administration. Mr Richards estimated that, over an eight-hour shift, he spent an average of three to four hours on the oven floor, 30-45 minutes on the quenching car floor and in the screen house, 10-15 minutes on the shuttle car floor and 15 minutes on the ramps. The remaining hour would be spent doing administrative tasks in the foreman's office/canteen. In oral evidence, Mr Richards suggested that he would sometimes spend as long as one and a half hours in the office/canteen at lunchtime, eating his meal and completing his paperwork.

20. I cannot accept the evidence of Mr Pugh and Mr Jones that, when Mr Carhart was a process foreman, he would have spent his entire working time on the batteries. It may be that, in giving their estimates of the percentage of time spent in the various working areas, they were referring only to the time actually spent performing active duties and were leaving the administrative part of the process foreman's job out of account. Be that as it may, I find that, as Mr Richards' evidence made clear, a proportion of Mr Carhart's usual eight-hour shift (and of any overtime he worked) must have been spent on administrative work of various kinds. No two process foremen will have organised their working day in precisely the same way and I find that Mr Carhart probably did not devote as much time to administrative duties as did Mr Richards. Nevertheless, I am satisfied that he must have spent an average of at least one and a half hours of his shift (i.e. about 20%) away from the working areas of the batteries, doing administrative work in the foreman's office/canteen, conferring with colleagues and walking between the two batteries or between the batteries and the office/canteen. Of the remaining 80% of his time, I find that 65% was spent on the oven floor, 10% on the quenching car floor and 5% split between the screen house, the ramps and the shuttle car floor.

1977-1985

21. Mr Carhart was promoted to chief heater foreman in 1977. I have assumed that this occurred on 1 March 1977. He continued to work in that capacity until his retirement on 21 December 1985. Mr Pugh's evidence was that, as chief heater foreman, Mr Carhart would have spent all his time working on the oven floor. Mr Brian Jones said that he would have spent 60% of his time on the oven floor and 40% on the quenching car floor. Neither of those witnesses suggested that Mr Carhart would have spent any time carrying out administrative duties. Mr Richards did not given any evidence relevant to Mr Carhart's work as a chief heater foreman.

22. I find that, when he was working as a chief heater foreman responsible for all the batteries, Mr Carhart would have spent more time walking between the batteries and doing administrative work. As a consequence, he would have spent about two hours (i.e. 25% of his shift) away from the working areas. Of the remaining 75%, I find that that 50% was spent on the oven floor and 25% on the quenching car floor.

23. The Table below summarises my findings in relation to Mr Carhart's working history at the Phurnacite Plant.

TABLE 1

PERIOD	JOB TITLE	OTHER INFORMATION
9 Feb 1948 -30 Jun 1950	Yard labourer	75% in open areas; 25% pitch bay or areas with similar exposure
1 Jul 1950 -30 Jun 1953	Labourer/ spare man, briquetting plant 1	
I Jul 1953 -30 Jun 1954	Quenching car attendant, battery 1	
I Jul 1954 -15 Oct 1962	Process operative, battery 1	50% oven floor; 25% quenching car floor; 25% screens
16 Oct 1962 -29 Feb 1977	Process/oven foreman on batteries 1 and 2	65% on oven floor; 10% on quenching car floor & 5% split between the screen house, ramp floor & shuttle floor 20% in foreman's office/canteen and open areas
1 Mar 1977 -21 Dec 1985	Chief heater foreman responsible for all batteries	50% on oven floor; 25% on quenching car floor 25% in foreman's office/canteen and open areas. One year on strike in this period

24. I have already concluded at Section 4 of my generic judgment that both a process foreman and a chief heater foreman would have had 75% of the exposure level of a process operative.

Respiratory protective equipment

25. The evidence of Mr Pugh, Mr Brian Jones and Mr Richards was that, although Racal airstream helmets were issued to process operatives working on the oven tops in the early 1980s, they were not issued to process foremen. However, the evidence of Mr Carhart himself was that he wore a helmet with an air supply and visor (which, from the description, must have been a Racal airstream helmet) when working as a process foreman and chief heater foreman on the oven tops. I accept his evidence on this point although I find (and the defendants appear to accept) that he did not start to wear the helmet until somewhat later than he believed, i.e. until about 1981. I have concluded in Section 5 of my generic judgment that, even after the Racal airstream helmets were provided, the defendants continued to be in breach of duty in respect of work on the oven tops although, since Mr Carhart wore a Racal airstream helmet, he would have been exposed to only about 10% of the fumes to which he would have been exposed when he was not wearing RPE.

Overtime

26. No overtime records were available in Mr Carhart's case. In accordance with the conclusions I reached at Section 4 of my generic judgment, the average overtime levels, as calculated by Professor Syred, should be used when considering Mr Carhart's exposure to dust for the purpose of assessing what proportion of his non-malignant respiratory disease was attributable to occupational exposure to dust and fume. Overtime should be disregarded when assessing his exposure levels to PAHs for the reasons set out in Section 4.

Exposure levels

27. All three experts used the personal sampling results set out in *Table 6.4*[292] as the basis for calculating the extent of Mr Carhart's exposure to dust, BSM and BaP. Their assessments of his exposure levels are set out in the Table below:

TABLE 2

Expert	Total Dust (mg y m^{-3})	Respirable Dust (mg y m^{-3}) *(x 1.84)*	BSM (mg y m^{-3})	BaP (µg y m^{-3})
Syred	685	324	88	1123
Stear	243	n/a	30	372
Jones	516.1	79.3 *(145.91)*	46.6	469.3

28. For the purposes of Mr Carhart's claim for lung cancer, the most significant figure is that for his exposure to BaP.

29. The significant disparities between the experts' assessments were to a large extent explained by their differing assumptions about Mr Carhart's pattern of work during his time as a process foreman and chief heater foreman and the extent of his exposure to dust and fume during that time when compared with the exposure of process operatives working in the same areas. In addition, Mr Stear assumed much lower levels of exposure on the batteries before 1975 than after that date. This inevitably brought his estimate of Mr Carhart's exposure levels well below those of the other two experts.

Assessment of overall exposure levels

30. I have already indicated that, in general, I accept Professor Jones' approach to the assessment of exposure levels. Therefore, once I had reached some provisional conclusions about my findings of fact in Mr Carhart's case, I invited Professor Jones to re-work his calculations on the basis of those provisional conclusions. This was not an exercise that I could have performed myself and it was undertaken by Professor Jones with the consent of the parties. I asked him to provide more detail of his workings than he had given previously in the event that it was necessary for me to make any adjustments to his calculations consequent upon any further findings that I might make. Both parties have had the opportunity to comment on the additional material from Professor Jones and have done so. Save for his calculations in respect of respirable dust (which, having regard to my conclusions at Sections 4 and 11 of my generic judgment, I do not adopt), no criticism of his methodology was raised over and above that which has been discussed in my generic judgment.

[292] Syred1/131

31. Professor Jones' re-worked calculations are attached to this individual judgment at Appendix A. Briefly summarised, his estimates of Mr Carhart's exposure between 1948 and 1985 are, for total dust 553.7 $mgym^{-3}$, for BSM 56.5 $mgym^{-3}$ and for BaP 604.6 μgym^{-3}. Those figures take into account the fact that, from 1981 until his employment ended in 1985, Mr Carhart would have used a Racal airstream helmet when working on the oven tops. They make no deduction for any 'irreducible minimum' for the reasons I have discussed in Section 5 of my generic judgment.

32. Professor Jones' figures include a relatively small amount of exposure to dust, BSM and BaP during the periods when Mr Carhart was employed in the open areas of the Phurnacite Plant or the offices/canteen. I have found that the defendants were not in breach of duty during those periods. However, since that small amount of exposure will not affect the outcome of the case, I have not re-calculated Professor Jones' figures to exclude it. I have excluded the dust exposure for those periods when calculating Mr Carhart's occupational exposure units for the purpose of determining what proportion of his COPD was caused by his occupational exposure to dust.

33. Professor Jones estimated Mr Carhart's lung cancer causation probability, on the basis of a multiplicative interaction between smoking and occupational exposure, at 69.1% for BaP. His estimate of excess relative risk for BaP was 2.24.

34. I accept Professor Jones' figures as the best available estimates of Mr Carhart's exposure levels during the period for which the defendants operated the Phurnacite Plant. However, for the reasons set out in Section 3 of my generic judgment. I consider that, overall, the estimates will tend to under-estimate rather than over-estimate his exposure to BSM and BaP.

The medical issues

35. The medical evidence in Mr Carhart's case came from Dr Rudd and Dr Falk.

Smoking

36. Dr Rudd's estimate of Mr Carhart's smoking history, based on references in his medical notes, is that he was light smoker (i.e. less than 15 cigarettes a day) for 66 years. On the evidence, Dr Rudd's estimate appears fair and reasonable and I accept it.

37. Dr Rudd and Dr Falk agreed that Mr Carhart's smoking history substantially increased his risk of developing lung cancer and of consequent death. Dr Rudd estimated his baseline risk of lung cancer as a result of smoking at 12%. Dr Falk assessed the risk as slightly higher, namely at 15%.

Lung cancer

38. The immediate cause of Mr Carhart's death was peritonitis due to a perforated duodenal ulcer. However, Dr Rudd and Dr Falk agreed that the peritonitis was attributable to his underlying condition of lung cancer. Mr Carhart suffered respiratory symptoms due to his cancer from early 2004 although he had been experiencing weight loss for some months before that. Dr Rudd's evidence, which I accept, was that, in the absence of lung cancer, Mr Carhart's life expectancy would have been 3.8 years at the time of his death.

39. I discussed the causation of lung cancer at Section 8 of my generic judgment. I am satisfied that the agreed exposure to BaP for the 'doubling of risk' (270 μym^{-3}) is soundly based and that the exposure levels assessed by Professor Jones are reasonably accurate, albeit probably an under-estimate of Mr Carhart's actual exposure. Since Professor Jones has calculated that Mr Carhart's exposure to BaP amounted to 604.6 μym^{-3}. I find that the claimant has established that Mr Carhart's risk of developing lung cancer was significantly more than doubled and that she has thereby succeeded in establishing the causation of his lung cancer.

Chronic obstructive pulmonary disease

40. Problems" for six or seven years prior to April 2001, i.e. since about 1994. He described how he had shortness of breath on exercise. The parties agreed that these symptoms were attributable to mild COPD. Dr Rudd estimated Mr Carhart's disability as a result of COPD at about 5% from 1994.

41. I have concluded at Section 11 of my generic judgment that Dr Rudd's 'broad brush' approach to quantifying the contribution made to a claimant's COPD by exposure to dust at the Phurnacite Plant is the appropriate method to adopt in the circumstances of this litigation. I have accepted Dr Rudd's evidence that a year's work on the oven floor was equivalent to a year's average smoking and, using that correlation as a basis, I have calculated Mr Carhart's total occupational exposure units at 22.3. My calculation is at Appendix B to this individual judgment.

42. The apportionment as between smoking and occupational exposure is as follows:

Light smoking for 66 years	*33 units*
Exposure to dust at the Phurnacite Plan	
Total exposure units	*22.3 units*
Occupational exposure responsible for 22.3 ÷ (22.3 + 33)	*= 40% of causation*

43. I therefore find that 40% of Mr Carhart's **respiratory** disability of 5% (or a disability of 2%) was attributable to his occupational exposure to dust at the Phurnacite Plant between 1948 and 1985. His exposure to dust during his previous short period of employment at the Phurnacite Plant may have made some contribution to his condition. However I am satisfied that the contribution would have been so minor as not to be material and I make no deduction in respect of it.

Chronic bronchitis

44. In her witness statement, the claimant said that, whilst working at the Phurnacite Plant, Mr Carhart developed a productive cough which persisted to the time of his death. The claims questionnaire signed by Mr Carhart in September 2000 stated that he had suffered from a productive cough whilst still at work (although his answer also suggested that he had been working underground which was never the case). I note, however, that Mr Carhart himself described in the witness statement made in support of his BCRDL claim how he had consulted his GP in 2000 complaining of a persistent cough. He suggested that his chest problems had started in the mid to late 1990s. He made no mention of a more long standing problem.

45. Mr Carhart's GP records contain no handwritten or computerised records dating from before 1987, i.e. they commence after he ceased work at the Phurnacite Plant. As a result, it is not possible to see whether there were any occasions whilst he was working at the Phurnacite Plant when he attended his GP complaining of symptoms suggestive of CB. Certainly, there is nothing in the later medical records that would suggest that he had suffered from a regular productive cough during his employment there. In the circumstances, I am not persuaded on a balance of probabilities that Mr Carhart suffered from CB at the time of, or by reason of, his employment at the Phurnacite Plant.

Conclusion

46. The claimant's claim therefore succeeds in respect of Mr Carhart's lung cancer and COPD, but fails in relation to CB. Damages in his case have been agreed at £119,310.75, inclusive of interest.

APPENDIX A

Ernest Noel Carhart

Occupancy matrix

From	To	Job factor	Fractional occupancy						Annual hours
			Canteen / offices	Average external	Pitch bay	Briquetting	Oven and shuttle floors	Quench, ramp and screens	
09/02/1948	30/06/1950	1	0	0.75	0.25	0	0	0	2407
01/07/1950	30/06/1953	1	0	0	0	1	0	0	2407
01/07/1953	31/12/1953	1	0	0	0	0	0	1	2407
01/01/1954	30/06/1954	1	0	0	0	0	0	1	2407
01/07/1954	15/10/1962	1	0	0	0	0	0.5	0.5	2407
16/10/1962	31/12/1974	0.75	0.2	0	0	0	0.6667	0.1333	2407
01/01/1975	28/02/1977	0.75	0.2	0	0	0	0.6667	0.1333	2407
01/03/1977	31/12/1980	0.75	0.25	0	0	0	0.5	0.25	2407
01/01/1981	28/02/1984	0.75	0.25	0	0	0	0.5	0.25	2407
01/03/1985	21/12/1985	0.75	0.25	0	0	0	0.5	0.25	2407

Ernest Noel Carhart

Exposure estimates

From	To	Job	Plant	Resp dust mg y m^{-3}	Tot dust mg y m^{-3}	BSM mg y m^{-3}	BaP µg y m^{-3}	Oven years	Resp excl ovens mg y m^{-3}
09/02/48	30/06/50	Yard labourer	Pitch bay	1.13	4.46	1.25	28.05	0.00	1.13
09/02/48	30/06/50	Yard labourer	Plant external average	1.07	6.35	0.84	8.42	0.00	1.07
01/07/50	30/06/53	Labourer / spare man, briquetting	Briquetting	13.29	79.76	5.70	38.97	0.00	13.29
01/07/53	31/12/53	Quench operator, battery 1	Quench, ramp and screens	0.46	2.86	0.30	2.76	0.50	0.00
01/01/54	30/06/54	Quench operator, battery 1	Quench, ramp and screens	0.45	2.81	0.30	2.71	0.49	0.00
01/07/54	15/10/62	Process operative, battery 1	Oven and shuttle floors	20.48	127.08	13.26	145.08	4.15	0.00
01/07/54	15/10/62	Process operative, battery 1	Quench, ramp and screens	3.78	23.63	2.49	22.80	4.15	0.00
16/10/62	31/12/74	Oven foreman, batteries 1 and 2	Canteen / offices	0.13	0.68	0.10	10.50	0.00	0.13
01/01/75	28/02/77	Oven foreman, batteries 1 and 2	Canteen / offices	0.02	0.08	0.02	0.17	0.00	0.02
16/10/62	31/12/74	Oven foreman, batteries 1 and 2	Oven and shuttle floors	32.02	198.74	20.75	224.84	6.10	0.00
01/01/75	28/02/77	Oven foreman, batteries 1 and 2	Oven and shuttle floors	5.66	34.67	3.67	39.79	1.08	0.00
16/10/62	31/12/74	Oven foreman, batteries 1 and 2	Quench, ramp and screens	1.48	9.28	0.98	8.95	1.22	0.00
01/01/75	28/02/77	Oven foreman, batteries 1 and 2	Quench, ramp and screens	0.26	1.54	0.17	1.58	0.22	0.00
01/03/77	31/12/80	Heater foreman	Canteen / offices	0.05	0.18	0.04	0.38	0.00	0.05
01/01/81	28/02/84	Heater foreman	Canteen / offices	0.04	0.15	0.03	0.32	0.00	0.04
01/03/85	21/12/85	Heater foreman	Canteen / offices	0.01	0.04	0.01	0.08	0.00	0.01
01/03/77	31/12/80	Heater foreman	Oven and shuttle floors	7.53	46.16	4.89	52.98	1.44	0.00
01/01/81	28/02/84	Heater foreman	Oven and shuttle floors	0.62	3.80	0.40	4.36	1.18	0.00
01/03/85	21/12/85	Heater foreman	Oven and shuttle floors	0.16	0.97	0.10	1.12	0.30	0.00
01/03/77	31/12/80	Heater foreman	Quench, ramp and screens	0.87	5.13	0.58	5.27	0.72	0.00
01/01/81	28/02/84	Heater foreman	Quench, ramp and screens	0.71	4.22	0.47	4.34	0.59	0.00
01/03/85	21/12/85	Heater foreman	Quench, ramp and screens	0.18	1.08	0.12	1.11	0.15	0.00

Ernest Noel Carhart

Notes on exposure estimates

From	To	Job	Plant	Comments
09/02/48	30/06/50	Yard labourer	Pitch bay	Exposure levels as per exposure matrix
09/02/48	30/06/50	Yard labourer	Plant external average	
01/07/50	30/06/53	Labourer / spare man, briquetting	Briquetting	Exposure levels as per exposure matrix
01/07/53	31/12/53	Quench operator, battery 1	Quench, ramp and screens	Exposure levels as per exposure matrix
01/01/54	30/06/54	Quench operator, battery 1	Quench, ramp and screens	
01/07/54	15/10/62	Process operative, battery 1	Oven and shuttle floors	Exposure levels as per exposure matrix
01/07/54	15/10/62	Process operative, battery 1	Quench, ramp and screens	
16/10/62	31/12/74	Oven foreman, batteries 1 and 2	Canteen / offices	Exposure levels as per exposure matrix
01/01/75	28/02/77	Oven foreman, batteries 1 and 2	Canteen / offices	
16/10/62	31/12/74	Oven foreman, batteries 1 and 2	Oven and shuttle floors	Factor of 0.75 applied to exposures attributed to the plant
01/01/75	28/02/77	Oven foreman, batteries 1 and 2	Oven and shuttle floors	
16/10/62	31/12/74	Oven foreman, batteries 1 and 2	Quench, ramp and screens	
01/01/75	28/02/77	Oven foreman, batteries 1 and 2	Quench, ramp and screens	
01/03/77	31/12/80	Heater foreman	Canteen / offices	Exposure levels as per exposure matrix
01/01/81	28/02/84	Heater foreman	Canteen / offices	
01/03/85	21/12/85	Heater foreman	Canteen / offices	
01/03/77	31/12/80	Heater foreman	Oven and shuttle floors	Factor of 0.75 applied to exposures attributed to the plant. Factor of 0.1 for RPE use post 1/1/81. Absence for 1 year due to strike.
01/01/81	28/02/84	Heater foreman	Oven and shuttle floors	
01/03/85	21/12/85	Heater foreman	Oven and shuttle floors	
01/03/77	31/12/80	Heater foreman	Quench, ramp and screens	Factor of 0.75 applied to exposures attributed to the plant. No adjustment for respiratory protection. Absence for 1 year due to strike.
01/01/81	28/02/84	Heater foreman	Quench, ramp and screens	
01/03/85	21/12/85	Heater foreman	Quench, ramp and screens	

Ernest Noel Carhart
Estimates of FEV_1 loss and lung cancer causation probability

Summary exposure estimates

Period	Resp dust mg y m^{-3}	Tot dust mg y m^{-3}	BSM mg y m^{-3}	BaP µg y m^{-3}	Oven y	Resp excl ovens mg y m^{-3}
Pre 1/1/1954	16.0	93.4	8.1	78.2	0.5	15.5
Post 1/1954	74.5	460.3	48.4	526.4	21.8	0.3
Total	90.4	553.7	56.5	604.6	22.3	15.7

Estimates of FEV_1 loss (ml)

	FEV_1 loss ml
Due to dust	22
Due to time in ovens	223
Total	245

Estimates of excess relative risk

	Multiplicative ERR		Submultiplicative ERR	
	BSM	BaP	BSM	BaP
Pre 1.1.54 exposures	0.27	0.29	0.16	0.22
Post 1.1.1954 exposures	1.60	1.95	0.97	1.47
Total	1.87	2.24	1.13	1.69

'Multiplicative ERR' is excess relative risk calculated on the assumption that the interaction between smoking and exposure is wholly multiplicative; 'submultiplicative ERR' is excess relative risk calculated on the assumption that the interaction between smoking and exposure is intermediate between multiplicative and additive (page 39 of my generic report refers).

'BSM' and 'BaP' refer respectively to the use of risk coefficients derived by using benzene soluble matter or benzo[α]pyrene as markers of risk (pages 36 and 37 of my generic report refer).

Estimates of lung cancer causation probability

	Multiplicative CP		Submultiplicative CP	
	BSM	BaP	BSM	BaP
All exposures	65.1%	69.1%	53.0%	62.9%
Exposures post 1.1.1954	55.8%	60.2%	45.4%	54.7%

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APPENDIX B
CARHART

PERIOD	AREA	% TIME SPENT	EXPOSURE UNIT	DEDUCTION FOR NON-PROCESS JOB	RPE	NO. OF EXPOSURE UNITS
9/2/48-30/6/50 (2.39 years)	Pitch bay	25%	0.75	N/A	N/A	0.45
1/7/50-30/6/53 (3 years)	Briquetting plant	100%	0.90	N/A	N/A	2.70
1/7/53-30/6/54 (1 year)	Quenching car floor	100%	0.75	N/A	N/A	0.75
1/7/54-15/10/62 (8.33 years)	Oven floor	50%	1.00	N/A	N/A	4.17
	Quenching car floor and screens	50%	0.75	N/A	N/A	3.12
16/10/62-29/2/77 (14.37 years)	Oven and shuttle floors	67%	1.00	75%	N/A	7.22
	Quenching car floor, ramps and screens	13%	0.75	75%	N/A	1.05
1/3/77-31/12/80 (3.84 years)	Oven floor	50%	1.00	75%	N/A	1.44
	Quenching car floor	25%	0.75	75%	N/A	0.72
1/1/81-21/12/85 (3.97 years, excluding strike)	Oven floor	50%	1.00	75%	10%	0.15
	Quenching car floor	25%	0.75	75%	N/A	0.56
				Total exposure units		**22.33**

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RAYMOND DAVIES

1. Raymond Davies was born on 23 December 1936. He died on 30 January 2000 aged 63 years.

The claim

2. The claim is brought by Mr Davies' daughter, Ms Janice King (the claimant), on behalf of his estate under the provisions of the Law Reform (Miscellaneous Provisions) Act 1934. It is alleged that, as a result of the dust and fume containing PAHs to which he was exposed during his employment at the Phurnacite Plant, Mr Davies developed lung cancer which caused his death.

The defendants' case

3. The defendants admit that they were in breach of duty towards Mr Davies until 1980/1. After that time, respiratory protection in the form of a 3M mask became available for his use and they say that there was no breach of duty on their part - from that time. The defendants accept that Mr Davies developed and died from lung cancer. However, they contend that the claimant cannot prove to the required standard that Mr Davies' lung cancer was caused by his occupational exposure to PAHs.

4. The defendants contend also that Mr Davies' claim is statute-barred under the provisions of the 1980 Act.

Damages

5. Damages in Mr Davies' case have been agreed, subject to the issues of breach of duty, causation and limitation. Damages for pain, suffering and loss of amenity have been agreed in the sum of £35,000 and special damages in the sum of £1,772.42. The total damages are therefore £36,772.42, exclusive of interest.

Employment history

Period of employment

6. Mr Davies was employed at the Phurnacite Plant continuously from 1959 until the end of 1986, when he was made redundant: a period of about 27 years. It is not contended that he had any exposure to PAHs other than at the Phurnacite Plant.

The witnesses

7. There is no evidence from Mr Davies himself. His widow, Mrs Phyllis Davies, who died in 2007, made a witness statement in 2005 but she was able to say little about Mr Davies' working conditions. The claimant also made a witness statement and gave oral evidence. However, the main sources of evidence about Mr Davies' employment history and working conditions were Mr Hodges and the late Mr Turner.

8. Mr Turner was employed at the Phurnacite Plant between 1956 and 1985. As a plate layer in the mid-1960s, he was responsible for instructing Mr Davies in some aspects of his work. From 1975, Mr Turner was a maintenance foreman. He was

appointed chief maintenance foreman in about 1982. He was responsible for supervising members of the painting gang, including Mr Davies. Mr Turner made a detailed witness statement in March 2011, but died before the start of the trial. As might be expected of such a senior employee, Mr Turner's witness statement demonstrated an excellent knowledge of the workings of the Phurnacite Plant and the conditions there. I consider that his evidence about Mr Davies' employment was generally reliable. Mr Hodges worked at the Phurnacite Plant between about 1972 until 1990. For the first eight years or so, he was employed on the batteries. From 1980 to 1987 he worked as a painter in the same gang as Mr Davies. They would frequently, although not always, work on the same job. Mr Hodges gave oral evidence. The fact that he worked alongside Mr Davies for seven years meant that he had a particularly good understanding of Mr Davies' daily working conditions.

Summary of evidence

9. Briefly summarised, the evidence of Mr Davies's working history at the Phurnacite Plant was as follows:

1959-1964

10. The evidence about Mr Davies' employment during this period is not entirely clear. He began work as a general labourer or 'spare man'. In her witness statement, Mrs Davies' said that his first job was on the ovens. However, the defendants' records show that Mr Davies was trained as a back end man and a pug man. If that is right, Mr Davies must have undergone training in one of the briquetting plants. Mr Hodges' evidence was that it was unlikely that Mr Davies would initially have worked as a spare man on the batteries, only to transfer later to the briquetting plants. Mr Turner said the same. I therefore consider it probable that Mrs Davies' recollection was faulty and that Mr Davies spent the first five years of his employment working in one of the briquetting plants. His job changed in the mid-1960s, I have assumed that this occurred in 1965.

1965-31 December 1986

11. During this period (save for a time when he was absent from work through illness and a further year when he was on strike), Mr Davies worked as one of a gang of four painters. In the defendants' documents, he is consistently described as having been a "rough brush painter". Mrs Davies also described him as a "rough brush painter" in her witness statement, although she may merely have adopted the term which she had been told appeared in the defendants' documents. Both Mr Hodges and Mr Turner were adamant that Mr Davies was not a rough brush painter. Rough brush painters were in effect labourers who did a little unskilled painting. Mr Hodges and Mr Turner said that Mr Davies was a member of the "painting gang", who carried out skilled painting work, together with the necessary preparatory work, and undertook no labouring duties. I am satisfied that, whatever his title might have been, Mr Davies carried out the duties described by Mr Hodges and Mr Turner.

12. The painters would carry out various regular tasks on the batteries. On each battery there were girders, situated about 10-12 feet above the oven floor and just below the shuttle car floor. Some of the girders bore painted signs, identifying the weight that could be safely lifted using the girders. Due to the amount of dust, grit and fume on the oven floor, the girders corroded so rapidly that the signs had to be re-painted monthly. The painters would use ladders to gain access to the girders. Each girder would be

covered with a thick layer (Mr Hodges estimated two inches) of dust which the painters would have to remove before cleaning the girder with a wire brush and re-painting the sign.

13. Two sets of metal handrails ran the length of each battery on the oven floor and there was a third set on the shuttle car floor. There were also metal handrails running down the flights of steps in the batteries. These metal handrails corroded rapidly and required re-painting regularly. Mr Turner's evidence, which I accept, was that it would take three or four months to complete the process of cleaning, preparing and painting the handrails on the oven floors of all the batteries. That would still leave the handrails in other parts of the batteries to be done. I accept Mr Turner's evidence that all the handrails on each of the batteries were re-painted every two years. However, I find that it is probable that certain handrails, which were subject to particularly bad corrosion, would be re-painted more frequently. That would account for Mr Hodges' evidence that they were re-painted every six to eight months. Insofar as Mr Hodges' oral evidence suggested that the task of painting handrails took far less time than he had suggested in his witness statement, I am satisfied that this must have been based on a misunderstanding, possibly between a "battery" (or block) of ovens and a battery building. It is quite clear from the photographs that the task of painting the handrails would have taken a considerable amount of time.

14. The painters would also re-paint the large washers and nuts securing the tie rods at each end of the batteries. They would also use compressed air tools to remove dust and rust from the quenching cars, a task which would take a month at a time. They would paint the levers used to change the points on the rail tracks on the shuttle car, oven and quenching car floors.

15. Whilst the painters were working on the oven floor of the batteries, the processes of charging, discharging and (when necessary) poking clustered ovoids out of the ovens would continue as usual and the painters would be exposed to dust and fume from those processes. They would also be exposed to dust and fume in the atmosphere from all the other sources I identified in Section 2 of my generic judgment. They would not work in the immediate vicinity of an oven that was being discharged and would stand at the end of the battery to avoid the steam produced when the quenching of ovoids was going on. They would also try to avoid working next to an oven that was being charged. However, all these processes were going on continually on the oven floor and it would have been completely impracticable for the painters to arrange their work so as to avoid exposure to dust and fume. I accept Mr Hodges' evidence that, at times, they would be working only a few feet from men who were poking the ovens. In windy conditions, dust and fume would have been blown about and they may have inhaled dust and fume even if they were working some distance away from their source. I note that Mr Hodges had previously worked on the oven floor of a battery. His evidence was that a painter's exposure on the oven floor was not as intense as that of a process operative working on the ovens. In cross-examination, he agreed with Mr Walker that a painter's exposure would be "a small fraction" of the exposure of the process operatives carrying out work in the Phurnacite Plant; however, he went on to say that, when working in the briquetting plants, a painter's exposure would have been the same as that of the process operatives working there.

16. I have already referred to the evidence about Mr Davies' exposure to dust and fume when working on the oven floor. Whilst working on the shuttle car floor, he would have been exposed to dust emitted at the transfer points of the raw ovoid conveyors and from the charging of the raw ovoid bunkers. I find that, on the shuttle car floor, his

exposure would have been much closer to that of the process operatives employed there than when he was working on the oven floor. However, I take account of the fact that he would not have been charging the raw ovoid bunkers himself and that part of the work of painting handrails at shuttle car floor level was performed in the open air.

17. On the quenching car floor, Mr Davies would have had exposure to dust which had accumulated in the quenching cars and on the cabin occupied by the quenching car operators. The use of compressed air tools would have caused the dust to fly up and would have increased his exposure. However, he did not have to poke the ovens or work in close proximity to ovens that were discharging.

18. In the briquetting plants, the painters had to paint various kinds of metalwork, including girders. All the metalwork was covered by an accumulation of dust which had to be removed before the metalwork could be painted. This would be done by brushing the dust off the metalwork and shovelling it away. The painters also had to paint metal cages, trays and other metalwork situated under the conveyors. These tasks, which could take days to complete, involved working in confined areas where a great deal of fine dust had accumulated. That dust had to be removed before painting could begin. Mr Hodges described how, when he had been working in the briquetting plants, his overalls would be black and he would resemble a miner who had worked a shift underground. On occasion, the painters would have to work inside the ESPs, which Mr Hodges described as particularly dusty and unpleasant. As a painter, Mr Davies would also have spent some time working in exhauster houses 1 and 2, the screen houses and also, probably, the trommel houses. Although his exposure in some of those areas would probably not have been as heavy as in the briquetting buildings, I consider that it would be fair to treat it as such since, when working inside the ESPs or in confined areas under conveyors, his exposure is likely to have been significantly greater than that generally encountered by process operatives working in the briquetting plants. His exposure in the exhauster and boiler houses would have been less severe.

19. The work of a painter was one of those peripatetic jobs in respect of which there was an issue between the experts about how the worker's exposure to dust and fume would have compared with those of the process operatives working in the same areas. I discussed this topic at Section 4 of my generic judgment.

20. In his calculations of exposure levels, Professor Syred assumed that, wherever Mr Davies worked, he would have been exposed to the same levels of dust and fume as the process operatives carrying out their duties in that area. Thus he assumed that, when working on the oven floor of the batteries, Mr Davies would have had the same levels of exposure as the men responsible for charging and poking the ovens. Professor Jones initially adopted the same approach but, for the reasons I explained at Section 4, he later revised his calculations to assume that Mr Davies would have experienced 30% of the exposure levels of the process operatives working around him. Professor Jones made no distinction between Mr Davies' work on the batteries and in the briquetting plants, but applied the 30% to all the places where he had worked. He did however concede that, if I were to accept that Mr Davies sometimes worked only a few feet from where ovens were being poked, his exposure levels on the oven floor might well have been more than 30% of the levels experienced by the men regularly employed on the ovens.

21. In his calculations, Mr Stear assumed that Mr Davies' exposure was only 5% of that of the process operatives who regularly worked in the areas where he was employed from time to time. He calculated Mr Davies' exposure by taking 5% of the average

exposure levels for all areas of the Phurnacite Plant, using the date from *Table 6.4*. He assumed that, for the remainder of his time, Mr Davies was exposed only to 'background' exposure levels for the Phurnacite Plant, as calculated in Professor Jones' modelling dispersion exercise.

22. Having considered all the evidence, I find that Mr Davies spent approximately 20% of his working time painting areas such as the canteen, showers, offices and workshops. Of the remaining 80% of his time, I find that he would have spent 30% on the batteries, and 50% in the briquetting plants. Of the 30% of his time on the batteries, I find that Mr Davies would have spent 18% on the oven floor, 9% on the shuttle car floor and 3% on the quenching car floor.

23. Of the 50% of his time spent working in the briquetting plants, I consider it probable that Mr Davies would have spent 40% of his time in the briquetting buildings, press house 5, the ESPs or in other areas with similar exposure levels. The remaining 10% of his time would have been divided as to 5% in the exhauster houses and 5% in the boiler houses.

24. I am satisfied that it is not appropriate to assume that the relationship between a painter's levels of exposure to dust and fume and the levels of exposure experienced by process operatives employed in the areas where the painter was from time to time required to work would have been the same wherever he was carrying out his painting duties. I consider that the relationship would have varied, depending on whether the painter was working on the batteries or in the briquetting plants.

25. Doing the best I can, I estimate that, whilst working on the batteries, Mr Davies would have been exposed to 50% of the levels of dust and fume which would have been encountered by the process operatives working there. During his time in the briquetting plants, I accept Mr Hodges' evidence that Mr Davies would have had similar levels of exposure to the process operatives who worked there. I have described how there were considerable amounts of dust throughout the buildings in the briquetting plants. Although, as a painter, he would not have been working on or in the close vicinity of moving machinery, his own work would inevitably have involved a good deal of disturbance of dust. It was no doubt for that reason that Mr Turner described the job of a painter as "one of the worst roles at the plant".

26. The Table below summarises my findings in relation to Mr Davies' working history at the Phurnacite Plant.

TABLE 1

PERIOD	JOB TITLE	OTHER INFORMATION
1959 (1 year)	Spare man, briquetting plant	100 % briquetting plants
1960-1964 (4 years)	Back end man; pug man, briquetting plant	100% briquetting plants
1965 (1 year)	Painter	18% on oven floor; 9% on shuttle floor; 3% on quenching car floor. 40% in briquetting buildings or similar; 5% in exhauster houses and 5% in boiler houses. 10% canteens/offices; 10% workshops.
1 Jan 1966- 19Mar 1969	Absent from work	
20 Mar 1969- 31 Dec 1986	Painter	18% on oven floor; 9% on shuttle floor & 3% on quenching car floor. 40% in briquetting buildings or similar; 5% in exhauster houses and 5% in boiler houses. 10% canteens/offices; 10% workshops. One year on strike during this period.

Respiratory protective equipment

27. The evidence of Mr Hodges and Mr Turner, which I accept, was, although Racal airstream helmets were issued to process operatives working on the ovens in the early 1980s, they were not issued to painters working on the oven floors or elsewhere in the Phurnacite Plant. The 3M masks would have been available from about 1980 but the evidence is that neither Mr Davies nor his colleagues wore such a mask and their use was not enforced by management. Consequently, I have taken no account of the wearing of RPE in Mr Davies' case.

Overtime

28. Although the evidence was that Mr Davies worked a good deal of overtime and some of his overtime records have survived, I do not consider that overtime should be taken into account when assessing his exposure levels to PAHs for the reasons set out at Section 4 of my generic judgment.

Exposure levels

29. All three experts used the personal sampling results set out in *Table 6.4*[293] as the basis for calculating the extent of Mr Davies' exposure to dust, BSM and BaP. Their assessments of his exposure levels are set out in the Table below:

[293] Syred1/131

TABLE 2

Expert	Total Dust (mg y m^{-3})	Respirable Dust (mg y m^{-3}) *(x 1.84)*	BSM (mg y m^{-3})	BaP (µg y m^{-3})
Syred	1567	178	111	1080
Stear	184	n/a	18	164
Jones	292.4	44.7 *(82.2)*	23.9	198.1

30. For the purposes of Mr Davies' claim for lung cancer, the most significant figure is that for his exposure to BaP.

31. The significant disparities between the experts' assessments are to a large extent explained by their differing assumptions about Mr Davies' pattern of work during his employment as a painter and about the extent of his exposure to dust and fume during that time when compared with that of a process operative. In addition, Professor Syred assumed that, for 15% of his time as a painter, Mr Davies was performing cleaning duties with very high exposure levels comparable to those measured by static samplers in February 1979. I have included the element of cleaning duties within my assessment of the relative exposure levels of Mr Davies, as a painter, and of the process operatives employed in the areas where he worked from time to time. It is this factor that has led me to conclude that his exposure in the briquetting plants is likely to have been similar to that of a process operative employed there.

32. There were other more minor differences in the approaches adopted by the experts upon which I do not need to elaborate.

Assessment of overall exposure levels

33. I have already indicated that, in general, I accept Professor Jones' approach to the assessment of exposure levels. Therefore, once I had reached some provisional conclusions about my findings of fact in Mr Davies' case, I invited Professor Jones to re-work his calculations on the basis of those provisional conclusions. This was not an exercise that I could have performed myself and it was undertaken by Professor Jones with the consent of the parties. I asked him to provide more detail of his workings than he had given previously in the event that it was necessary for me to make any adjustments to his calculations consequent upon any further findings that I might make. Both parties have had the opportunity to comment on the additional material from Professor Jones and have done so. Save for his calculations in respect of respirable dust (which are not relevant to the causation of lung cancer and which in any event, having regard to my conclusions at Sections 4 and 11 of my generic judgment, I do not adopt), no criticism of his methodology was raised over and above that which has been discussed in my generic judgment.

34. Professor Jones' re-worked calculations are attached to this individual judgment at Appendix A. Briefly summarised, his estimates of Mr Davies' exposure during his employment at the Phurnacite Plant are for total dust 352.8 mgym^{-3}, for BSM 36 mgym^{-3} and for BaP 293.9 µgym^{-3}. Those figures make no deduction for any 'irreducible minimum' for the reasons I have discussed in Section 5 of my generic judgment. Having regard to my finding that no breach of duty has been established in respect of exposure to dust in the offices/canteen, I have excluded BaP exposure during the periods for which Mr Davies was working in those locations. That produces a figure for total BaP exposure of 290.5 µgym^{-3}.

35. Professor Jones estimated Mr Davies' lung cancer causation probability, on the basis of a multiplicative interaction between smoking and occupational exposure, at 52.1% for BaP. His estimate of excess relative risk was 1.09. I have calculated Mr Davies' revised excess relative risk, in the light of the reduction in BaP exposure I have made, at 1.07. I have re-calculated the causation probability at just below 52% on the basis of a multiplicative interaction between smoking and occupational exposure.

36. I accept Professor Jones' figures as the best available estimates of Mr Davies' exposure levels during his employment at the Phurnacite Plant. However, for the reasons set out in Section 3 of my generic judgment, I consider that, overall, the estimates will tend to under-estimate, rather than over-estimate, his exposure to BSM and BaP.

The medical issues

37. The medical evidence in Mr Davies' case came from Dr Rudd and Dr Falk.

Smoking

38. References contained in Mr Davies' medical records suggest that he smoked between 6 and 20 cigarettes a day for most of his life. In her witness statement Mrs Davies stated that he smoked an average of 10 hand-rolled cigarettes daily. The claimant's evidence was that he smoked 10-15 cigarettes a day. However, she said that he had periods – sometimes long periods – when he stopped smoking altogether.

39. Dr Rudd has assessed Mr Davies as a light smoker (i.e. less than 15 cigarettes a day) from the age of 18 years until shortly before his death, a period of about 46 years. In doing so, he has assumed that periods of heavier smoking were mitigated by periods when Mr Davies gave up smoking altogether or smoked only a small number of cigarettes a day. That seems to me a reasonable approach and I accept it.

40. Dr Rudd and Dr Falk agreed that Mr Davies' smoking history substantially increased the risk that he would develop lung cancer. Dr Rudd estimated his baseline risk of lung cancer as a result of smoking at 12%. Dr Falk reached a similar conclusion.

Lung cancer

41. The medical experts agree that Mr Davies developed lung cancer which caused his death. He first developed symptoms in early January 2000. He died about three weeks later, shortly after his lung cancer had been diagnosed. Dr Rudd's evidence, which I accept, was that his predicted life expectancy at the time of his death (taking into account the effects of his smoking) was 15.7 years.

42. I discussed the causation of lung cancer at Section 8 of my generic judgment. I am satisfied that the agreed exposure level to BaP for the 'doubling of risk' (270 μgym^{-3}) is soundly based and that the exposure levels assessed by Professor Jones are reasonably accurate albeit probably an under-estimate of Mr Davies' actual exposure. Since Professor Jones has calculated that Mr Davies' exposure to BaP amounted to 290 μgym^{-3}, I find that the claimant has established that Mr Davies' risk of developing lung cancer was more than doubled, albeit by a fairly modest margin. I have considered whether, given the size of that margin, I can be satisfied that the claimant has indeed succeeded in establishing the causation of Mr Davies' lung cancer on a balance of probabilities. I have come to the conclusion that I can. In reaching that conclusion, I take into the account all

the evidence I have heard about Mr Davies' work and the conditions in the briquetting plants and the batteries where he was employed. As I have said, I consider that the exposure levels on which I have based my findings probably represent an under-estimate of his actual exposure.

Limitation

43. I refer to Section 12 of this judgment, in which I discussed and made findings in relation to the generic issues relating to limitation. I shall now deal with the facts and issues relating specifically to Mr Davies' case, before setting out my conclusions.

Date of knowledge

44. Section 11(5) of the 1980 Act provides for the situation where (as here) the person injured (the deceased) dies within three years from the date when the cause of action accrued or from the date when he/she acquired the requisite knowledge, whichever is the later. In that situation, the primary limitation period governing a claim by the deceased's estate is three years from the date of the deceased's death or from the date when the deceased's personal representative (i.e. the executor/executrix of the deceased's will or the administrator/administratrix of his intestate estate) acquired knowledge for the purposes of the 1980 Act.

45. Mr Davies died on 30 January 2000. His cause of action arose only a short time before that date. By early 2005, Mrs Davies had contacted solicitors with a view to making a claim in respect of her late husband's death. On 18 August 2005, she signed a witness statement in support of a claim. In it she said that she had not thought that Mr Davies' illness and death could be related to his work until other people had begun to suggest to her that it might be so. She stated that, during his employment at the Phurnacite Plant, Mr Davies had been exposed to "many toxic substances". However, she was unable to provide any details of his exposure. In the early part of 2005, Mrs Davies completed a questionnaire which was then forwarded to Hugh James to enable them to consider making a claim on her behalf. It seems probable therefore that she first instructed Hugh James at or about the beginning of January 2005. I infer that she did so shortly after it had been suggested to her that Mr Davies' death might have been caused by his work.

46. Mr Davies did not leave a will. His estate was small. The house in which he and Mrs Davies lived was jointly owned and the couple's bank account was in their joint names. Other savings accounts were in Mrs Davies' sole name. Mrs Davies had no need to obtain a grant of letters of administration for her husband's estate. The claimant (who, since the death of her brother at a young age, had been the couple's only child) was able to deal with Mr Davies' affairs on her mother's behalf. A witness statement from Mr Wiljo Salen, partner of Hugh James, has confirmed the results of the investigations made by him which revealed that Mrs Davies was never the personal representative of Mr Davies.

47. The claimant was granted letters of administration for Mr Davies' estate on 17 October 2007. That being the case, the defendants accepted that, for the purposes of section 11(5) of the 1980 Act, it is the claimant's date of knowledge that is relevant, rather than that of Mrs Davies. They contended that the claimant would have had the relevant knowledge shortly after her father's death or, alternatively, in early 2005, when her mother contacted solicitors.

48. The claimant gave oral evidence about limitation and other matters. I did not find her an impressive witness. The claimant's evidence was that her mother did not tell her that she was contemplating consulting solicitors or, once she had done so, that she had taken that step. The claimant said that she had been surprised, when she was told about it, that her mother had taken such a step on her own without consulting her. She thought that her mother may not have told her because she (i.e. the claimant) was ill at the time.

49. The claimant said that it was not until Mrs Davies became ill in late 2006 that she told the claimant that she was making a claim in respect of Mr Davies' illness and death. In the claimant's witness statement, however, she said that, before that time, Mrs Davies had mentioned to her that "she was putting in" to see whether Mr Davies' lung cancer and death had been caused by his exposure to substances at work. In oral evidence, the claimant said that she could not remember when Mrs Davies had given her this information. She did not think it had been long before the conversation in 2006 after Mrs Davies had become ill.

50. The claimant was adamant that, before her mother mentioned the matter to her, she had not considered the possibility that her father's illness and death might have been caused by his work at the Phurnacite Plant. Despite the fact that she has lived in Mountain Ash all her life, she claimed to be unaware of the concerns about the risks to the health of local residents and employees caused by the activities at the Phurnacite Plant. She said that she did not remember the issue being discussed amongst members of her family or members of the local community. Nor was she aware of any items about the Phurnacite Plant that appeared in national and local newspapers or on local television and radio programmes. She said that she had never heard of any concerns about possible cancer risks for persons working at the Plant.

51. I cannot accept the claimant's evidence that she was ignorant of the concerns about the possible health risks associated with the Phurnacite Plant – in particular about the possible risks to people who had worked there – until as late as 2006. It is quite clear from the evidence I have seen and heard that these matters were widely discussed amongst the local community and were the subject of a great deal of publicity. The Phurnacite Plant had been a major employer in the area for more than four decades and the possibility that workers there might have been exposed to harmful substances must have been a source of interest and concern to the whole community. The claimant mentioned in her witness statement that a large number of Mr Davies' former work colleagues had died before her father and that attending their funerals made her father "quite depressed". I am satisfied that the claimant would have been aware of the concerns that the deaths (or some of them) had been caused by the working conditions at the Phurnacite Plant. It is just not credible that she would have been oblivious to the fears and concerns of the community in which she lived. However, I do accept that, at the time of her father's death and for some time thereafter, it probably did not occur either to the claimant or to her mother that Mr Davies' illness and death had been caused by his work. Her brother had died of cancer as a child, a fact which caused Mrs Davies to observe in her witness statement that there was a family history of cancer.

52. I do not accept that there was a significant interval between the time when Mrs Davies first began to consider whether to consult solicitors with a view to making a claim and the time she told the claimant that she had done so or was going to do so. The claimant and Mrs Davies were in regular (if not daily) contact and, after Mr Davies' death, Mrs Davies was reliant on her daughter to drive her whenever she needed to travel

any significant distance. I consider that the overwhelming probability is that the claimant had discussed with her mother the possibility of making a claim in respect of her father's death before the decision was taken to consult solicitors and that, when her mother instructed solicitors to investigate the matter, the claimant was well aware that that had been done. It is possible, if the claimant was particularly unwell at the time when her mother was considering whether or not to consult solicitors, that Mrs Davies did not bother her with the matter then. However, if that had happened, I have no doubt that Mrs Davies would have told the claimant what she had done within a short time thereafter. The commencement of a claim would have been a major step for Mrs Davies to take and I regard it as inconceivable that she would not have informed the claimant of it as soon as possible. After that, I would have expected the matter to be discussed from time to time, at least when some new development (e.g. the receipt of a draft witness statement) occurred.

53. Mr Davies' illness, diagnosis and death were very sudden and I accept that his widow and daughter may well have initially blamed his cancer on a family history of the disease. I consider it probable that neither the claimant nor Mrs Davies suspected that Mr Davies' illness and death might have been attributable to his work at the Phurnacite Plant until a short time before Mrs Davies contacted Hugh James and filled in the questionnaire, i.e. in early 2005. If Mrs Davies had been aware that Mr Davies' employment might have caused his death, I can see no reason why she would not have acted sooner. Thus, the primary limitation period would have expired at about the beginning of 2008. In the event, proceedings were not commenced until March 2010, when the claim was entered on the Phurnacite GLO Register and the claim is therefore *prima facie* statute-barred.

Section 33 discretion

54. I must therefore consider whether it would be equitable to disapply the primary limitation period in Mr Davies' case. Apart from the generic grounds of prejudice to which I have referred in Section 12, the defendants rely on specific features of Mr Davies' case in support of their contention that it would not be equitable to disapply the primary limitation period.

55. I must consider first the length of, and reasons for, the delay in Mr Davies' case. The period of delay before the commencement of proceedings was, in the context of this litigation, relatively short. The defendants contend that there was no good reason for the delay and that it has had a particularly serious effect since Mr Davies' employment at the Phurnacite Plant started over 50 years ago and it is more than 25 years since it ended.

56. Mr Davies and his family became aware of his illness only in early 2000. I have found that the claimant and her mother did not suspect that his illness might have been caused by his exposure to dust and fume at work until early 2005. The claimant's mother approached Hugh James in January 2005; the claim was one of a large number received by Hugh James in the first half of 2005. In the event, proceedings were not commenced until March 2010, when the claim was entered on the GLO Register. I set out in Section 12 of my generic judgment the steps that Hugh James took to progress the Phurnacite claims from 2005 onwards and the difficulties that they faced in investigating the claims and obtaining funding. I do not find that any of the period of delay between the date when the claimant acquired the relevant knowledge and the date of the commencement of proceedings arose as a result of fault on the part of the claimant or her solicitors.

57. I have already discussed the generic issues relating to the cogency of the evidence. In Mr Davies' case, the defendants rely on the fact that there is no witness evidence from management staff that directly bears on his employment between the start of his employment in 1959 and 1975, when Mr Turner began work as a maintenance foreman and assumed responsibility for supervising Mr Davies and the other painters. Mr Hodges' evidence covered only the period from 1980 until the end of Mr Davies' employment in 1987.

58. The precise sequence of jobs that Mr Davies carried out during the first five years of his employment at the Phurnacite Plant is not clear. I have found (in the defendants' favour) that he did not work on the batteries during that period. The defendants' records suggest that it is probable that Mr Davies worked in one of the briquetting plants for the first five years of his employment at the Phurnacite Plant. Since Professor Jones (whose approach I have accepted) has used a single exposure level for all process operatives who worked in briquetting plants 1 and 2 prior to 1974, the fact that Mr Davies' precise movements within the briquetting plant cannot be ascertained makes no difference to his calculation. Accordingly, I find that no specific prejudice arises there.

59. From 1975 onwards, there was very detailed evidence from Mr Turner and Mr Hodges about the work of a member of the painting gang. It is true that their evidence did not extend back to Mr Davies' earlier years as a painter. However, there is no reason to believe that the work of a painter underwent any material change over the years. Certainly, no significant change was reported during the 12-year period from 1975 until 1987. It seems unlikely that there would have been any significant alteration in the working conditions during the preceding 14 years – apart, possibly, from the nature of the products used, with which I am not concerned. Mr Davies' exposure to dust and fume would have been dependent on the working conditions in the various areas where he worked. There is plenty of evidence about those conditions covering the whole period of Mr Davies' employment.

60. The defendants said that they had been unable to trace any management witnesses with first hand knowledge of Mr Davies' work. Moreover, Mr Turner had died before the trial so that they were denied the opportunity of cross-examining him. They pointed to the importance of the lack of evidence in a case where causation relies on the 'doubling of risk'. They referred also to the fact that some of Mr Davies' medical records are unavailable making it difficult to determine his smoking history.

61. There is no reason to believe that, even if proceedings had been commenced within the primary limitation period – or, indeed, at any time after Mr Davies died, management witnesses would have been traced or a complete set of Mr Davies' medical records would have been available. It seems likely that the evidence would have been confined to that which was in fact before the court.

62. Even if Hugh James had commenced proceedings in Mr Davies' case immediately they were instructed, it is unlikely that the trial of the lead cases would have started earlier than in fact it did. Mr Turner died on 19 June 2011, very shortly before the trial started. Even if matters had proceeded more rapidly and he had still been alive at the time of the trial, it is highly improbable that evidence given by Mr Turner in cross-examination would have changed materially the overall effect of the evidence about Mr Davies' working conditions. The description of Mr Davies' working conditions set out in Mr Turner's witness statement was very similar to that given by Mr Hodges. The major points of disagreement between them related to the division of Mr Davies' time as

between the batteries and the briquetting plants and as to the extent of the painters' exposure when working on the batteries when compared with that of the process operatives working there. On both those matters, my findings coincide more closely with the evidence of Mr Hodges' (who gave oral evidence) than with that of Mr Turner (who did not). Thus, I do not consider that the defendants were significantly prejudiced by Mr Turner's unavailability.

63. As to the gaps in the medical records, some evidence was available from Mrs Davies and from the claimant about Mr Davies' smoking history. That evidence was broadly similar to that contained in the available medical records and allowed Dr Rudd to reach what appears to me a reasonable and fair conclusion about the likely level of Mr Davies' smoking, in addition to a diagnosis in his case.

64. It follows that I do not consider that the defendants have established any significant additional prejudice in Mr Davies' case over and above that previously identified at Section 12 of this judgment. In the circumstances, I consider that it would be equitable to disapply the limitation period.

Conclusion

65. The claimant's claim succeeds and there will be an award of damages agreed in the sum of £39,175.89, inclusive of interest.

APPENDIX A
Raymond Davies

Occupancy matrix

From	To	Job factor	Fractional occupancy: Canteen / offices	Boiler house	Workshops	Exhauster house 1	Exhauster house 2	Briquetting	Oven and shuttle floors	Quench, ramp and screens	Annual hours
01/01/1959	31/12/1959	1	0	0	0	0	0	1	0	0	1900
01/01/1960	31/12/1964	1	0	0	0	0	0	1	0	0	1900
01/01/1965	31/12/1965	1	0.1	0.05	0.1	0.025	0.025	0.4	0	0	1900
01/01/1965	31/12/1965	0.5	0	0	0	0	0	0	0.27	0.03	1900
20/03/1969	31/12/1974	1	0.1	0.05	0.1	0.025	0.025	0.4	0	0	1900
01/01/1975	29/02/1984	1	0.1	0.05	0.1	0.025	0.025	0.4	0	0	1900
01/03/1985	31/12/1986	1	0.1	0.05	0.1	0.025	0.025	0.4	0	0	1900
20/03/1969	31/12/1974	0.5	0	0	0	0	0	0	0.27	0.03	1900
01/01/1975	29/02/1984	0.5	0	0	0	0	0	0	0.27	0.03	1900
01/03/1985	31/12/1986	0.5	0	0	0	0	0	0	0.27	0.03	1900

Raymond Davies

Exposure estimates

From	To	Job	Plant	Respirable dust dust mg y m^{-3}	Tot dust mg y m^{-3}	BSM mg y m^{-3}	BaP µg y m^{-3}	Oven years	Resp excl ovens mg y m^{-3}
01/01/59	31/12/59	Spare man, briquetting	Briquetting	3.49	20.93	1.89	12.96	0.00	3.49
01/01/60	31/12/64	Back end / pug man	Briquetting	17.50	104.99	9.50	64.99	0.00	17.50
01/01/65	31/12/65	Painter	Boilerhouse	0.01	0.05	0.01	0.06	0.00	0.01
01/01/65	31/12/65	Painter	Briquetting	1.40	8.37	0.76	5.18	0.00	1.40
01/01/65	31/12/65	Painter	Canteen / offices	0.00	0.02	0.00	0.43	0.00	0.00
01/01/65	31/12/65	Painter	Exhauster house 1	0.01	0.06	0.01	0.10	0.00	0.01
01/01/65	31/12/65	Painter	Exhauster house 2	0.02	0.12	0.02	0.25	0.00	0.02
01/01/65	31/12/65	Painter	Workshops	0.05	0.25	0.05	0.54	0.00	0.05
01/01/65	31/12/65	Painter	Oven and shuttle floors	0.62	3.86	0.51	5.45	0.13	0.00
01/01/65	31/12/65	Painter	Quench, ramp and screens	0.02	0.13	0.02	0.16	0.01	0.00
20/03/69	31/12/74	Painter	Boilerhouse	0.03	0.29	0.03	0.35	0.00	0.03
01/01/75	29/02/84	Painter	Boilerhouse	0.04	0.19	0.04	3.94	0.00	0.04
01/03/85	31/12/86	Painter	Boilerhouse	0.01	0.04	0.01	0.79	0.00	0.01
20/03/69	31/12/74	Painter	Briquetting	8.10	48.57	4.39	30.07	0.00	8.10
01/01/75	29/02/84	Painter	Briquetting	12.83	76.95	6.96	47.64	0.00	12.83
01/03/85	31/12/86	Painter	Briquetting	2.57	15.41	1.39	9.54	0.00	2.57
20/03/69	31/12/74	Painter	Canteen / offices	0.02	0.13	0.02	2.49	0.00	0.02
01/01/75	29/02/84	Painter	Canteen / offices	0.04	0.14	0.04	0.37	0.00	0.04
01/03/85	31/12/86	Painter	Canteen / offices	0.01	0.03	0.01	0.07	0.00	0.01
20/03/69	31/12/74	Painter	Exhauster house 1	0.06	0.35	0.06	0.58	0.00	0.06
01/01/75	29/02/84	Painter	Exhauster house 1	0.08	0.40	0.08	0.78	0.00	0.08
01/03/85	31/12/86	Painter	Exhauster house 1	0.02	0.08	0.02	0.16	0.00	0.02

From	To	Job	Plant	Respirable dust dust mg y m^{-3}	Tot dust mg y m^{-3}	BSM mg y m^{-3}	BaP µg y m^{-3}	Oven years	Resp excl ovens mg y m^{-3}
20/03/69	31/12/74	Painter	Exhauster house 2	0.14	0.69	0.14	1.45	0.00	0.14
01/01/75	29/02/84	Painter	Exhauster house 2	0.20	0.98	0.20	2.02	0.00	0.20
01/03/85	31/12/86	Painter	Exhauster house 2	0.04	0.20	0.04	0.40	0.00	0.04
20/03/69	31/12/74	Painter	Workshops	0.31	1.45	0.31	3.12	0.00	0.31
01/01/75	29/02/84	Painter	Workshops	0.46	2.20	0.46	4.58	0.00	0.46
01/03/85	31/12/86	Painter	Workshops	0.09	0.44	0.09	0.92	0.00	0.09
20/03/69	31/12/74	Painter	Oven and shuttle floors	3.61	22.40	2.97	31.61	0.78	0.00
01/01/75	29/02/84	Painter	Oven and shuttle floors	5.69	34.13	4.70	50.09	1.24	0.00
01/03/85	31/12/86	Painter	Oven and shuttle floors	1.14	6.83	0.94	10.03	0.25	0.00
20/03/69	31/12/74	Painter	Quench, ramp and screens	0.12	0.78	0.10	0.95	0.09	0.00
01/01/75	29/02/84	Painter	Quench, ramp and screens	0.20	1.09	0.16	1.51	0.14	0.00
01/03/85	31/12/86	Painter	Quench, ramp and screens	0.04	0.22	0.03	0.30	0.03	0.00

Raymond Davies

Notes on exposure estimates

From	To	Job	Plant	Notes
01/01/59	31/12/59	Spare man, briquetting	Briquetting	Exposure levels as per exposure matrix
01/01/60	31/12/64	Back end / pug man	Briquetting	Exposure levels as per exposure matrix
01/01/65	31/12/65	Painter	Boilerhouse	Exposure levels as per exposure matrix
01/01/65	31/12/65	Painter	Briquetting	
01/01/65	31/12/65	Painter	Canteen / offices	
01/01/65	31/12/65	Painter	Exhauster house 1	
01/01/65	31/12/65	Painter	Exhauster house 2	
01/01/65	31/12/65	Painter	Workshops	
From	To	Job	Plant	Notes
01/01/65	31/12/65	Painter	Oven and shuttle floors	Factor of 0.5 applied to exposures attributable to plant
01/01/65	31/12/65	Painter	Quench, ramp and screens	
20/03/69	31/12/74	Painter	Boilerhouse	Exposure levels as per exposure matrix. Breaks in employment January 66 to March 69 (absence) and March 1984 to February 1985 (strike). No reduction for RPE in briquetting post 1980.
01/01/75	29/02/84	Painter	Boilerhouse	
01/03/85	31/12/86	Painter	Boilerhouse	
20/03/69	31/12/74	Painter	Briquetting	
01/01/75	29/02/84	Painter	Briquetting	
01/03/85	31/12/86	Painter	Briquetting	
20/03/69	31/12/74	Painter	Canteen / offices	
01/01/75	29/02/84	Painter	Canteen / offices	
01/03/85	31/12/86	Painter	Canteen / offices	
20/03/69	31/12/74	Painter	Exhauster house 1	
01/01/75	29/02/84	Painter	Exhauster house 1	

From	To	Job	Plant	Notes
01/03/85	31/12/86	Painter	Exhauster house 1	
20/03/69	31/12/74	Painter	Exhauster house 2	
01/01/75	29/02/84	Painter	Exhauster house 2	
01/03/85	31/12/86	Painter	Exhauster house 2	
20/03/69	31/12/74	Painter	Workshops	
01/01/75	29/02/84	Painter	Workshops	
01/03/85	31/12/86	Painter	Workshops	
20/03/69	31/12/74	Painter	Oven and shuttle floors	Factor of 0.5 applied to exposures attributable to plant. Breaks in employment January 66 to March 69 (absence) and March 1984 to February 1985 (strike) No reduction for RPE post 1980 or 1981.
01/01/75	29/02/84	Painter	Oven and shuttle floors	
01/03/85	31/12/86	Painter	Oven and shuttle floors	
20/03/69	31/12/74	Painter	Quench, ramp and screens	
01/01/75	29/02/84	Painter	Quench, ramp and screens	
01/03/85	31/12/86	Painter	Quench, ramp and screens	

Raymond Davies
Estimates of lung cancer causation probability

Summary exposure estimates

Period	Resp dust mg y m^{-3}	Tot dust mg y m^{-3}	BSM mg y m^{-3}	BaP µg y m^{-3}	Oven y	Resp excl ovens mg y m^{-3}
Total	59.0	352.8	36.0	293.9	2.7	47.5

Estimates of excess relative risk

	Multiplicative ERR		Submultiplicative ERR	
	BSM	BaP	BSM	BaP
All exposures	1.19	1.09	0.72	0.82

'Multiplicative ERR' is excess relative risk calculated on the assumption that the interaction between smoking and exposure is wholly multiplicative; 'submultiplicative ERR' is excess relative risk calculated on the assumption that the interaction between smoking and exposure is intermediate between multiplicative and additive (page 39 of my generic report refers).

'BSM' and 'BaP' refer respectively to the use of risk coefficients derived by using benzene soluble matter or benzo[α]pyrene as markers of risk (pages 36 and 37 of my generic report refer).

Estimates of lung cancer causation probability

	Multiplicative CP		Submultiplicative CP	
	BSM	BaP	BSM	BaP
All exposures	54.3%	52.1%	41.9%	45.1%

'Multiplicative CP' and 'submultiplicative CP' refer to estimates of causation probability based respectively on assumption of a fully multiplicative, or intermediate between multiplicative and additive, interaction between smoking and exposure; 'BSM' and 'BaP', as above, refer respectively to use of benzene soluble matter or benzo[α]pyrene as markers of risk.

'All exposures' refers to estimates of the causation probability attributable to Mr Davies' exposure during his entire period of employment at the Phurnacite plant.

JOHN GRIFFITHS

1. John Griffiths was born on 16 July 1924. He died on 9 June 2001 aged 76 years.

The claim

2. The claim is brought by Mr Griffiths' widow, Mrs Beryl Griffiths (the claimant) on behalf of his estate under the Law Reform (Miscellaneous Provisions) Act 1934 and on her own behalf, as his dependant, pursuant to the Fatal Accidents Act 1976. It is alleged that, as a result of exposure to dust and fume containing PAHs during his employment at the Phurnacite Plant, Mr Griffiths developed lung cancer which caused his death. There is also a claim for CB, allegedly exacerbated by exposure to dust at the Phurnacite Plant.

The defendants' case

3. In their closing submissions the defendants conceded that they were in breach of their duty to Mr Griffiths. They did so without limit, i.e. including the period for which he worked as a coal sampler.

4. The defendants accept that Mr Griffiths developed lung cancer which caused his death. However, they contend that the claimant cannot prove to the required standard that Mr Griffiths' lung cancer was caused by his occupational exposure to PAHs. The defendants do not admit that Mr Griffiths developed CB. They contend that, if he did, his CB was caused by his smoking, rather than by exposure to dust at the Phurnacite Plant.

5. The defendants contend that the claim is statute-barred under the provisions of the 1980 Act.

Damages

6. Damages in Mr Griffiths' case have been agreed, subject to the issues of causation, apportionment and limitation. Damages for pain, suffering and loss of amenity have been agreed in the sum of £62,500 and special damages in the sum of £21,775.20. The total damages are therefore £84,275.20, exclusive of interest.

7. Insofar as Mr Griffiths' claim for non-malignant respiratory disease is concerned, it is agreed that there should be apportionment to exclude from compensation that part of his CB, if proved, which can properly be attributed to his smoking habit. The defendants also contend that there should be apportionment to reflect any exposure to dust which would inevitably have occurred without breach of duty on the defendants' part (i.e. the 'irreducible minimum').

Employment history

Before the Phurnacite Plant

8. Between 1938/9 and 1949, Mr Griffiths was employed as a coal miner, working underground. During that period, he was exposed to large quantities of coal dust. From 1949 until 1970, he was employed as an aircraft maintenance fitter, although he had significant periods of time off work during this period as a result of illness. There is no suggestion that he was exposed to dust or fume during that period of employment.

Employment at the Phurnacite Plant

9. Mr Griffiths was employed at the Phurnacite Plant from 15 March 1970 until 24 August 1985. On 27 September 1983, he sustained injuries to his right forearm and ankle in a fall at work. He did not return to work (apart from a period of about five weeks in early 1984) after that time. He worked at the Phurnacite Plant for a total of about 13½ years.

The witnesses

10. There is no evidence from Mr Griffiths himself. The claimant made a witness statement in March 2011. However, by the time she came to give oral evidence, it was clear that her recollection of matters had faded to the point that it was virtually non-existent. I do not consider that any reliance can be placed on her oral evidence. The claimant's witness statement contained a considerable amount of detail and appeared to have been made at a time when her memory of events was much clearer. Nevertheless, it is necessary for me to consider to what extent the statement can be relied upon.

11. In March 2003, a claims questionnaire (CQ) was submitted in support of the claimant's claim in the BCRDL. The CQ was completed in manuscript. It is clear from its appearance that at least two different people had played a part in writing the answers. In answer to a question in the CQ as to whether Mr Griffiths had ever smoked, a tick had been inserted to indicate that he had never done so. That was untrue. In oral evidence, Mrs Griffiths denied that she had completed the CQ and said that she did not know who had done so. However, she signed the CQ and it is probable that the information contained in the CQ came at least partly from her. I consider that it is highly unlikely that, at the time she signed the document, she was unaware of the false information that was contained in it. This causes me to approach the evidence contained within her witness statement with a considerable degree of caution as to its reliability.

12. Mr Alan Saunders gave evidence about Mr Griffiths' work at the Phurnacite Plant. Mr Saunders began work there in February 1970, a few weeks before Mr Griffiths started. Initially, Mr Saunders was employed as a general labourer or spare man (henceforth referred to as a 'spare man') in briquetting plant 2. Within a short time, he was allocated the job of dryer's assistant. On 5 June 1972, he began work as a sampler. He was appointed senior sampler in the mid-1970s. He left the Phurnacite Plant in September 1988. In connection with Mr Griffiths' work as a shift fitter, I have also taken into account the evidence in the case of Mr David Jones.

Summary of evidence

13. Briefly summarised, the evidence of Mr Griffiths' working history at the Phurnacite Plant was as follows:

15 March 1970 – February 1975

14. On 15 March 1970, Mr Griffiths started work as a spare man in briquetting plant 2. Mr Saunders, who had carried out the same job immediately before Mr Griffiths started, described how the spare man would be assigned various tasks in the briquetting building, the press hall and on the shuttle car floor of the batteries. These tasks would

include cleaning up spillages of coal and pitch, and clearing blockages on the presses, conveyors and other machinery.

15. At some stage during this period, Mr Griffiths was transferred to work as a shift fitter. I accept Mr Saunders' evidence that the usual pattern was that, when a skilled man was taken on at the Phurnacite Plant, he would spend a few weeks working as a spare man after which he would be deployed on the work in which he was skilled. I therefore find that, given his previous experience as a fitter, Mr Griffiths is likely to have been transferred to work as a shift fitter no later than about three months after his arrival at the Phurnacite Plant. I have therefore assumed that, from 1 July 1970, Mr Griffiths worked as a fitter.

16. Mr Saunders' evidence was that he got to know Mr Griffiths whilst the latter was working as a fitter. He said that they would meet when their shifts coincided and they would discuss their work. He described how Mr Griffiths had told him that he would have to clear conveyors that were blocked and that he would become covered with fine coal and pitch dust. He would often be working in confined spaces and at speed. He would work all over the Phurnacite Plant, although Mr Saunders got the impression that most breakdowns occurred in the briquetting plants. In particular, Mr Griffiths would carry out repairs to machinery in the dryer houses, in the pitch bays and on the presses and the pugs. He would often be called upon to repair the raw ovoid conveyors on the shuttle car floor.

17. Professor Syred assumed that Mr Jones spent 75% of his time as a shift fitter working in the briquetting plants and the other 25% of his time working all over the plant. Professor Jones' estimate was that he spent 40% of his time in the briquetting plants, 25% on the batteries, 10% in the pitch bay, and the remaining 25% of his time in the workshops.

18. Having considered Mr Saunders' evidence, it seems to me probable that Mr Griffiths spent most of his time as a shift fitter working in the briquetting plants. I note the contents of a Memorandum prepared by the NCB in 1991 for the purposes of Mr Griffiths' claim for noise-induced hearing loss (NIHL). The Memorandum explained that there had been a tendency in the past for some fitters to become specialised in working on briquetting plant equipment and therefore to spend more time there than elsewhere at the Phurnacite Plant. It seems to me likely that Mr Griffiths fell into that category. I consider that the appropriate division of time would be 60% in the briquetting plants, 10% on the batteries, 5% in the pitch bay and 25% in the workshops or areas with similar exposure levels.

1975 – 1985

19. In 1975, Mr Griffiths became a member of the sampling team. The defendants' documents show that Mr Griffiths had been trained in both coal sampling and plant sampling. Mr Saunders' evidence was that Mr Griffiths was mainly employed on coal sampling, although he would undertake plant sampling when working overtime or covering for the absence of other members of the sampling team. Although Mr Griffiths might also have done some Phurnacite and effluent sampling, Mr Saunders could not confirm this and I have ignored any possible exposure from these activities. I have described the work of a coal sampler and a plant sampler at Section 2 of my generic judgment. That description is based on the evidence of Mr Saunders. He would see Mr Griffiths every day when Mr Griffiths visited the main sample room to collect his

equipment. On the occasions when Mr Griffiths was engaged in plant sampling, he would prepare his samples in the main sample room and Mr Saunders would see him then.

20. Mr Saunders' evidence was that, when working as a coal sampler, Mr Griffiths would have spent about six hours of each eight-hour shift in the coal sample room, with the rest of the time being spent at the coal blending site or the coal tippler area and walking between various locations. He said that, when working as a plant sampler, Mr Griffiths would have spent an average of four hours of an eight-hour shift in the main sample room, about three hours in the briquetting plants (where he would have been exposed to the dust in the atmosphere there) and about an hour walking between the various locations.

21. I find that, during his time as a sampler, Mr Griffiths spent 90% of his time working on coal sampling and 10% of his time employed on plant sampling. Of the 90% spent on coal sampling, I find that 65% (including breaks) was spent in the coal sample rooms (mainly the coal blending site sample room), 20% at the coal blending site or tippler area and 5% walking between his various places of work. Of the 10% of his time spent as a plant sampler, I find that he spent 5% (including breaks) in the main sample room, 4% working in the briquetting plants and 1% walking between various locations. The Table below summarises my findings in relation to Mr Griffiths' working history at the Phurnacite Plant.

TABLE 1

PERIOD	JOB TITLE	OTHER INFORMATION
Mar 1970-30 June 1970	Labourer/spare man, briquetting plant 2	
1 July 1970-1 Feb 1975	Shift fitter	60% briquetting plants; 10% batteries; 5% pitch bay; 25% in the workshops or areas with similar exposure levels.
2 Feb 1975-27 Sept 1983 and 22 Jan 1984-26 Feb 1984	Sampler	90% as a coal sampler, of which 65% in the coal sampling rooms, 20% at the coal blending site or tippler area and 5% walking between locations. 10% as a plant sampler, of which 5% in the main sample room, 4% in the briquetting plants and 1% walking between locations.

Respiratory protective equipment

22. The evidence of Mr Saunders, which I accept, was that coal samplers did not wear any form of RPE. He suggested in his witness statement that, whilst other workers at the Phurnacite Plant wore the gauze Martindale masks, such masks would not have been available for the use of men working in the coal sample rooms. In fact, it is clear that, had he wished to use a Martindale mask, Mr Griffiths could have obtained one. In oral

evidence, Mr Saunders conceded that it was possible that Mr Griffiths may have worn a Martindale mask at times when working in the coal sample rooms. However, such a mask would not have afforded him protection against anything but nuisance dust and the defendants do not contend that any deduction in the exposure levels calculated for Mr Griffiths should be made in respect of RPE.

Overtime

23. The evidence is that Mr Griffiths worked overtime on his rest days and at other times also. His work records show that, during the 12 weeks preceding his accident in 1983, his overtime hours amounted to almost 50% of his basic weekly hours. There is no reason to believe that those records do not reflect the position throughout his employment at the Phurnacite Plant. However, I do not consider that overtime should be taken into account when assessing Mr Griffiths' exposure levels to PAHs for the reasons set out at Section 4 of my generic judgment. His overtime working would be relevant to his claim for CB.

Exposure levels

24. When calculating the extent of Mr Griffiths' exposure to dust, BSM and BaP, Professor Syred and Mr Stear used the personal sampling results set out in *Table 6.4*[294]. As I have explained in Section 4 of my generic judgment, Professor Jones used a rather different method of assessment in respect of Mr Griffiths' time as a sampler. The experts' assessments of his exposure levels are set out in the Table below:

TABLE 2

Expert	**Total Dust (mg y m^{-3})**	**Respirable Dust (mg y m^{-3}) *(x 1.84)***	**BSM (mg y m^{-3})**	**BaP (µg y m^{-3})**
Syred	359	143	29	232
Stear	86	n/a	9	76
Jones	231.7	35.7 *(65.7)*	10.2	92.2

25. For the purposes of Mr Griffiths' claim for lung cancer, the most significant figure is that for his exposure to BaP.

As a spare man

26. When calculating Mr Griffiths' exposure levels during his time as a spare man, Professor Syred used the average level for all areas of the Plant, including the pitch bay. For the same period, Mr Stear assumed that he was exposed to levels equivalent to 75% of the average levels encountered by process operatives working in the briquetting plants. Professor Jones used the average exposure levels for the briquetting plants. I am satisfied that Professor Jones' approach is correct since, as a spare man, Mr Griffiths would have been required to undertake some of the dustiest jobs in the briquetting plants.

As a shift fitter

27. When calculating Mr Griffiths' exposure levels during his time as a shift fitter, Professor Syred assumed that he had the same exposure as a process operative working in the same areas. Mr Stear considered that a fitter would have had 75% of the exposure of

[294] Syred 1/131

a process operative working in the same area. Professor Jones disagreed with Mr Stear. He took the same view as Professor Syred. He accepted that the plant and machinery on which fitters worked would not be operating so would not be actually producing dust at the time the fitters' work was being carried out. In that respect, the fitters' exposure would be less than that of a process operative. However, a fitter would receive additional exposure as a result of disturbing accumulated dust when opening up machinery or cleaning dust from surfaces on which he needed to work. Professor Jones considered that it was reasonable to assume that, whilst in a working area, a fitter's exposure would on balance be the same as that of a process operative. I accept Professor Jones' evidence on this point.

As a sampler

28. I have discussed the experts' differing approaches to the assessment of the exposure levels of a coal sampler such as Mr Griffiths at Section 3 of my generic judgment. I have concluded that Professor Jones' approach of equating the work of a coal sampler with that of a man employed in a coal preparation plant provides the best basis for assessment, although I share his view that the resulting total dust exposure level of 10 mgm^{-3} for a man working in the coal blending site sample room may well be an over-estimate. I have accepted the view of both Professor Jones and Mr Stear that, during the time he was working in the coal sample rooms, Mr Griffiths would have had no significant exposure to BSM or BaP.

Assessment of overall exposure levels

29. I have already indicated that, in general, I accept Professor Jones' approach to the assessment of exposure levels. Therefore, once I had reached some provisional conclusions about my findings of fact in Mr Griffiths' case, I invited Professor Jones to re-work his calculations on the basis of those provisional conclusions. This was not an exercise that I could have performed myself and it was undertaken by Professor Jones with the consent of the parties. I asked him to provide more detail of his workings than he had given previously in the event that it was necessary for me to make any adjustments to his calculations consequent upon any further findings I might make. Both parties have had the opportunity to comment on the additional material from Professor Jones and have done so. Save for his calculations in respect of respirable dust (which are not relevant to the causation of lung cancer and which in any event, having regard to my conclusions at Sections 4 and 11 of my generic judgment, I do not adopt), no criticism of his methodology was raised over and above that which has been discussed in my generic judgment.

30. Professor Jones' re-worked calculations are attached to this individual judgment at Appendix A. Briefly summarised, his estimates of Mr Griffiths' exposure during his employment at the Phurnacite Plant are, for total dust 207.8 $mgym^{-3}$, for BSM 9.3 $mgym^{-3}$ and for BaP 77.8 μgym^{-3}. Those figures make no deduction for any 'irreducible minimum' for the reasons I have discussed in Section 5 of my generic judgment. I accept Professor Jones' figures as the best available estimates of Mr Griffiths' exposure levels during the period of his employment at the Phurnacite Plant although, as I have mentioned, I consider that they are likely, if anything, to over-estimate that exposure. The figure for total dust includes a small amount of dust exposure whilst Mr Griffiths was in the open areas of the Phurnacite Plant. Since that exposure will not affect the outcome of the case, I have not re-calculated Professor Jones' figures to exclude it.

31. Professor Jones estimated Mr Griffiths' lung cancer causation probability on the basis of a multiplicative interaction between smoking and occupational exposure, at 22.4% for BaP. His estimate of excess relative risk was 0.29 for BaP.

The medical issues

32. The medical evidence in Mr Griffiths' case came from Dr Rudd and Dr Falk.

Smoking

33. References contained in Mr Griffiths' medical records suggest that he smoked between 20 and 30 cigarettes a day until May 1986 when, after suffering a myocardial infarction, he heeded medical advice and stopped smoking. In her witness statement, Mrs Griffiths said that he had smoked since leaving school until he gave up in about 1986. In oral evidence she suggested that, before he stopped smoking in 1986, he had been smoking only about 10 cigarettes day but it was plain that she had no clear recollection about this.

34. Dr Rudd has assessed Mr Griffiths as a heavy smoker (i.e. more than 25 cigarettes a day) for 44 years. That seems to me fair and reasonable on the available evidence and I accept his assessment.

35. Dr Rudd and Dr Falk agreed that Mr Griffiths' smoking history substantially increased the risk that he would develop lung cancer. Dr Rudd estimated his baseline risk of lung cancer as a result of smoking at 15%.

Lung cancer

36. There is no dispute that Mr Griffiths had a small cell carcinoma of the lung which caused his death. He developed respiratory symptoms in August/September 2000. Lung cancer was diagnosed in December 2000, when he was admitted to hospital. He underwent radiotherapy in January 2001 which afforded him some relief. However, his condition deteriorated and he was re-admitted to hospital in May 2001. He died the following month. Dr Rudd's evidence, which I accept, was that, at the time of his death, Mr Griffiths' life expectancy was 3.9 years.

37. I have discussed the causation of lung cancer at Section 8 of my generic judgment. I am satisfied that the agreed exposure level to BaP for the 'doubling of risk' is soundly based. The claimant has failed by a significant margin to establish that Mr Griffiths' risk of developing lung cancer was more than doubled and she has therefore failed to establish that his lung cancer was caused by his occupational exposure at the Phurnacite Plant.

The history of respiratory problems

38. There is also a claim for an exacerbation of CB allegedly caused by Mr Griffiths' exposure to dust during his period of employment at the Phurnacite Plant. Before turning to the evidence relating to this claim, it is necessary to consider Mr Griffiths' history of respiratory illness, as revealed by his medical records.

39. On 6 August 1948, when Mr Griffiths was working as an underground miner, a note in his medical records stated that he had had pneumonia three months previously, as a result of which he was temporarily unfit for underground work. On 29 December 1948,

a chest x-ray was reported to show signs of coal workers pneumoconiosis (CWP), but no secondary infective changes. Mr Griffiths ceased work as a miner in 1949. From that time until 1970, he worked as an aircraft fitter.

40. Mr Griffiths' history of CWP was referred to again in a note made by his GP in November 1951. The next note relating to respiratory illness was made in June 1956 when he attended his GP with bronchial catarrh and was signed off work for a week. There were several attendances for "colds" in 1956 and 1957. In February 1957, there was another attendance with bronchial catarrh. In January 1958, a note in his GP records referred to "bronchitis". On that occasion, he was complaining of pain in the left side on his chest made worse by deep breathing and was off work for a week.

41. It is not clear whether the GP records for the 1960s are complete. So far as I have been able to ascertain, those that have survived do not contain any reference to respiratory problems. It is evident that, during the 1960s, Mr Griffiths had long absences from work due to psychiatric disorders.

42. The entries in the GP records covering the period from 1970 (when Mr Griffiths started work at the Phurnacite Plant) until 1982 are somewhat haphazard and it is impossible to know whether they are complete either. From 1982, the records are more orderly and very full and I am reasonably confident that they provide a complete picture of Mr Griffiths' attendances on his GP up to 1985 (when his employment at the Phurnacite Plant formally ceased; in effect of course he had ceased working there in September 1983) and beyond.

43. In July 1970 (a few months after Mr Griffiths started work at the Phurnacite Plant), he was complaining of a cough and stabbing pains in his chest and was referred for a chest x-ray. He told a consultant physician that he had "a little cough but no sputum". A right post-pneumonic effusion was diagnosed, with nodulation of the lung fields due to early CWP. The effusion cleared within a few weeks and, during his follow-up appointments at hospital, he made no complaints of long standing CB. There are no other surviving records relating to respiratory problems for the period up to 1982 or for the remaining period of his employment at the Phurnacite Plant.

44. The next entry in the medical records relating to respiratory problems was dated 20 July 1987, about four years after Mr Griffiths had effectively ceased working at the Phurnacite Plant. Mr Griffiths was complaining of a cold and a productive cough. In September 1989, he was complaining of shortness of breath on exertion. Five days later, he was coughing up blood and dark brown sputum. He continued to complain of severe respiratory symptoms. In January 1992, he was complaining of shortness of breath on exertion for the past six weeks and phlegm in his throat. A chest x-ray was reported to show pleural thickening and calcification, probably due to previous tuberculosis, although the possibility of asbestos-related disease was raised. In May 1992, he was complaining of a cough with thick sputum and was referred to Dr Brian Davies, a consultant respiratory physician. A letter written by Dr Davies to Mr Griffiths' GP on 4 June 1992 made no mention of any history of CB, referring only to a six-month history of significant breathlessness. Lung function tests showed evidence of a restrictive respiratory condition. Mr Griffiths was obese and he was advised to lose weight. By August 1992, pulmonary fibrosis had been diagnosed and steroid therapy was being considered.

45. In January 1993, Mr Griffiths was complaining of increased coughing and phlegm. In August 1993, he was admitted to hospital for a trial of high dose steroid

therapy. His breathlessness had worsened over the previous year and a chest x-ray showed a "ground glass" increase in density with bilateral pleural thickening. He derived little benefit from the steroid therapy which was discontinued after a few weeks. He was discharged from any further follow-up in October 1993. In November 1994, Mr Griffiths was diagnosed with a squamous cell carcinoma of the larynx which was successfully treated with radical radiotherapy.

46. In April 1996, Mr Griffiths attended before a Medical Board in connection with a claim he had made for industrial injuries benefit for asbestos-related disease. The Medical Board concluded that he had asbestosis and made an award of benefit. A GP note made in 1999 suggested that he had been assessed (possibly re-assessed) as having a 65% disability, 40% due to CWP and 25% to asbestosis.

47. In June 1997, Mr Griffiths' GP noted that he had shortness of breath at times. In December 1997, "COPD" was noted. In August 1998, he was said to remain short of breath. In December 2008, he was noted to be "always SOB [*short of breath*]". In January 1999, he had a chest infection. On a date between January 1999 and June 1999 (the entry is not clear), he complained to his GP of shortness of breath and wheezing. A bronchodilator was prescribed, together with steroid therapy. There were further attendances on his GP in 1999 and early 2000 with shortness of breath. In March and July 2000, he was again noted to have "COPD". His respiratory problems worsened from August 2000. In retrospect, it is probable that the deterioration at that time and thereafter was caused by his lung cancer. He died in June 2001.

48. The post-mortem examination showed no sign of the pulmonary fibrosis or asbestosis that had been diagnosed in life. However, histological examination of the lungs was reported to reveal the presence of slight to moderate emphysema. No asbestos fibres were detected, making it unlikely that asbestos exposure had played any part in the development of Mr Griffiths' lung cancer.

49. At the Medical Assessment Process conducted in 2005 for the purposes of the BCRDL claim, the respiratory specialist concluded, *inter alia*, that Mr Griffiths had suffered from mild COPD which, together with lung cancer, asbestosis and obesity, had caused a total respiratory disability of 90% prior to his death.

50. Dr Rudd disagreed with those findings. His evidence, which I accept, was that Mr Griffiths had not suffered from pulmonary fibrosis, asbestosis or any symptoms relating to COPD. The lung function tests which he had undergone in 1992 had showed no sign of COPD. Any emphysema that had been present at post-mortem was, he said, of insufficient extent to cause symptoms. He attributed Mr Griffiths' longstanding breathlessness to multiple causes unconnected with his work at the Phurnacite Plant. He considered that the x-ray appearances that had been attributed to fibrosis/asbestosis had resulted from a previous tubercular infection which (not unusually) had gone undetected.

Chronic bronchitis

51. The claimant's case is that Mr Griffiths initially developed CB whilst working as a miner and that his condition worsened markedly whilst he was employed at the Phurnacite Plant as a result of his exposure to dust there. Dr Rudd's view was that the evidence contained in the claimant's witness statement and/or in the CQ submitted for the purposes of the BCRDL claim, if accepted, was sufficient to establish that exposure to dust at the Phurnacite Plant caused an exacerbation of pre-existing CB in Mr Griffiths'

case. However, he acknowledged that the outcome must depend on my assessment of the reliability of the claimant's evidence and of the material contained in the CQ.

52. At trial, the defendants did not seek to undermine the claimant's evidence to any significant extent. Indeed, at times in his cross-examination of the claimant, Mr Walker appeared to be accepting that Mr Griffiths had suffered worsening symptoms whilst working at the Phurnacite Plant. This was possibly for tactical reasons related to the defendants' case on limitation. Be that as it may, however, it seems to me that I must examine the evidence for myself and reach my own conclusion as to whether the claimant's assertions can properly be relied upon. As I have said, the claimant's oral evidence was plainly unreliable. I must therefore consider the evidence contained in the claimant's witness statement and in the CQ completed for the purposes of the BCRDL claim.

53. The CQ signed by the claimant in January 2003 stated that Mr Griffiths had coughed up phlegm from his chest when he was employed underground as a miner. It stated that he did so every day and was still coughing up phlegm at the date of his death. I have already observed that the CQ contained a significant untruth, namely that Mr Griffiths had never smoked. I have found that it is highly unlikely that, when she signed the CQ, the claimant was unaware of that untruth. I take the view that I cannot rely on the contents of the CQ without some further supporting evidence.

54. In her witness statement for the purpose of these proceedings, the claimant said that, by the time Mr Griffiths ceased to be an underground miner, he had "a bit of a cough" and would produce "black spit" on occasions, although his chest was not "particularly bad" at that time. She made no mention of his episode of pneumonia in 1948 or of the diagnosis of CWP that was made later that same year. These are surprising omissions. I would have expected her to remember that her husband had been diagnosed with CWP at such a relatively young age. The claimant said that Mr Griffiths had had no chest problems during his time as an aircraft fitter, although, in the 1950s, she began to notice that he became short of breath sooner than she did. She said that, when he started work at the Phurnacite Plant in 1970, he still had "an occasional cough" and his chest "sounded a bit wheezy", but these problems did not affect his daily life.

55. The claimant said that, over the years when Mr Griffiths worked at the Phurnacite Plant, his chest problems worsened. At first this happened gradually. However, in the early 1980s, his chest appeared to get much worse. He had more regular bouts of coughing, when he would cough up black phlegm. His breathing became much more laboured and he appeared to have difficulty catching his breath. The claimant said that, because of these problems, Mr Griffiths' work as a shift fitter became too strenuous for him and he took a job as a sampler instead. She said that, by the time he left the Phurnacite Plant, Mr Griffiths' chest was "noticeably worse" than it had been before he started work there. He had a persistent tickly cough and was finding it increasingly difficult to breathe. He had an obvious wheeze and became short of breath easily. His cough and phlegm worsened and became particularly bad during the 1990s.

56. The account of events given by the claimant is not borne out by the contents of Mr Griffiths' medical records and is inconsistent with his employment history. The medical records contain only one isolated reference to "bronchitis" during Mr Griffiths' employment as an aircraft fitter. There are no references in his GP records to attendances in connection with chest problems between 1970 (when he was referred to a consultant with what appeared to be an episode of pneumonia) and July 1987, i.e. about four years

after ceasing work at the Phurnacite Plant (when he was complaining of a cough and sputum).

57. It is possible, as I have said, that some of the records are missing. However, there are a number of entries from the early 1970s, including the period from late 1974 to February 1975, when Mr Griffiths transferred to work as a sampler. These entries disclose no respiratory problems. In particular, there are no references to Mr Griffiths suffering from a productive cough. Mr Griffiths was a frequent attender at his GP surgery with a variety of minor – as well as major – ailments. I would have expected that, if he had had a chronic problem with a cough and sputum, it would have been evident from his medical records. Moreover, Mr Griffiths' move to work as a sampler occurred in 1975. It could not therefore have been caused by deterioration in his respiratory symptoms that, according to the claimant's account, occurred in the 1980s. These discrepancies, together with other features of the claimant's evidence relating to the limitation issues, and the contents of the CQ, cause me to conclude that the claimant cannot be regarded as a reliable witness.

58. There is no doubt that Mr Griffiths suffered a variety of serious respiratory symptoms over the years. Those symptoms culminated in his lung cancer and consequent death. It seems probable that, in the 1990s and thereafter, he did suffer from CB, probably related to his smoking. What is far less clear is that he suffered from CB during the course of his employment underground and/or at the Phurnacite Plant. There was a series of complaints about colds and catarrh and one complaint of "bronchitis" during the period from 1956 to 1958. However, that was at a time when Mr Griffiths was working as an aircraft fitter and therefore had no significant exposure to dust or fume.

59. That type of complaint did not appear in the medical records again until a time well after Mr Griffiths had left the Phurnacite Plant. The complaint of a cough and stabbing pains in his chest in July 1970 was clearly the result of an acute episode. It is significant in my view that, at that time, Mr Griffiths said that he was not producing sputum. It is significant also that he does not appear to have suggested to any of the doctors who treated him during the late 1980s or 1990s that he had a history of a persistent productive cough extending back over decades.

60. It would not be surprising if the claimant had difficulty in recalling the precise history of events. Nor would it be surprising if, with hindsight, she attributed all her husband's various respiratory symptoms, whenever they occurred, to his work as an underground miner and/or at the Phurnacite Plant. I accept that, during Mr Griffiths' time as a miner (and possibly also on occasion when he was working at the Phurnacite Plant), he would have coughed up black sputum as she described after a particularly dusty day at work. However, looking at the evidence as a whole, I cannot be satisfied on a balance of probabilities that, at the time when he was working at the Phurnacite Plant, Mr Griffiths suffered from CB, as defined by the Medical Research Council, or from an exacerbation of CB.

Conclusion

61. In the circumstances, the claimant's case in respect of both lung cancer and CB must fail. It is not therefore necessary for me to consider the issue of limitation.

APPENDIX A

John Griffiths

Occupancy matrix

From	To	Job factor	Fractional occupancy								Annual hours
			Avg external	Coal yard / tipplers	Coal sampling	Workshops	Pitch bay	Briquetting	Oven and shuttle floors	Quench, ramp and screens	
15/03/1970	30/06/1970	1	0	0	0	0	0	1	0	0	2725
01/07/1970	31/12/1974	1	0	0	0	0.25	0.05	0.6	0.05	0.05	2725
01/01/1975	01/02/1975	1	0	0	0	0.25	0.05	0.6	0.05	0.05	2725
02/02/1975	27/09/1983	1	0.06	0.2	0.7	0	0	0.04	0	0	2725
22/01/1984	26/02/1984	1	0.06	0.2	0.7	0	0	0.04	0	0	2725

John Griffiths

Exposure estimates

From	To	Job	Plant	Resp dust mg y m^{-3}	Tot dust mg y m^{-3}	BSM mg y m^{-3}	BaP µg y m^{-3}	Oven years	Resp excl ovens mg y m^{-3}
15/03/70	30/06/70	Labourer/spare man, briquetting	Briquetting	1.47	8.82	0.56	3.81	0.00	1.47
01/07/70	31/12/74	Shift fitter	Briquetting	13.56	81.34	5.13	35.11	0.00	13.56
01/01/75	01/02/75	Shift fitter	Briquetting	0.26	1.53	0.10	0.66	0.00	0.26
01/07/70	31/12/74	Shift fitter	Oven and shuttle floors	1.26	7.81	0.72	7.88	0.23	0.00
01/01/75	01/02/75	Shift fitter	Oven and shuttle floors	0.02	0.15	0.01	0.15	0.00	0.00
01/07/70	31/12/74	Shift fitter	Pitch bay	0.48	1.90	0.47	10.58	0.00	0.48
01/01/75	01/02/75	Shift fitter	Pitch bay	0.01	0.04	0.01	0.20	0.00	0.01
01/07/70	31/12/74	Shift fitter	Quench, ramp and screens	0.23	1.45	0.14	1.24	0.23	0.00
01/01/75	01/02/75	Shift fitter	Quench, ramp and screens	0.004	0.03	0.00	0.02	0.00	0.00
01/07/70	31/12/74	Shift fitter	Workshops	0.87	4.03	0.61	6.08	0.00	0.87
01/01/75	01/02/75	Shift fitter	Workshops	0.02	0.07	0.01	0.11	0.00	0.02
02/02/75	27/09/83	Sampler	Briquetting	1.74	10.42	0.66	4.50	0.00	1.74
22/01/84	26/02/84	Sampler	Briquetting	0.02	0.12	0.01	0.05	0.00	0.02
02/02/75	27/09/83	Sampler	Coal sampling room	13.02	86.83	0.54	3.63	0.00	13.02
22/01/84	26/02/84	Sampler	Coal sampling room	0.14	0.96	0.01	0.04	0.00	0.14
02/02/75	27/09/83	Sampler	Coal stockyard / tipplers	0.22	0.74	0.16	1.56	0.00	0.22
22/01/84	26/02/84	Sampler	Coal stockyard / tipplers	0.002	0.01	0.002	0.02	0.00	0.002
02/02/75	27/09/83	Sampler	Plant external average	0.31	1.56	0.22	2.18	0.00	0.31
22/01/84	26/02/84	Sampler	Plant external average	0.003	0.02	0.002	0.02	0.00	0.003

John Griffiths

Notes on exposure estimates

From	To	Job	Plant	Notes
15/03/70	30/06/70	Labourer/spare man, briquetting	Briquetting	Exposure levels as per exposure matrix
01/07/70	31/12/74	Shift fitter	Briquetting	Exposure levels as per exposure matrix
01/01/75	01/02/75	Shift fitter	Briquetting	
01/07/70	31/12/74	Shift fitter	Oven and shuttle floors	
01/01/75	01/02/75	Shift fitter	Oven and shuttle floors	
01/07/70	31/12/74	Shift fitter	Pitch bay	
01/01/75	01/02/75	Shift fitter	Pitch bay	
01/07/70	31/12/74	Shift fitter	Quench, ramp and screens	
01/01/75	01/02/75	Shift fitter	Quench, ramp and screens	
01/07/70	31/12/74	Shift fitter	Workshops	
01/01/75	01/02/75	Shift fitter	Workshops	
02/02/75	27/09/83	Sampler	Briquetting	Exposure levels as per exposure matrix
22/01/84	26/02/84	Sampler	Briquetting	
02/02/75	27/09/83	Sampler	Coal sampling room	
22/01/84	26/02/84	Sampler	Coal sampling room	
02/02/75	27/09/83	Sampler	Coal stockyard / tipplers	
22/01/84	26/02/84	Sampler	Coal stockyard / tipplers	
02/02/75	27/09/83	Sampler	Plant external average	
22/01/84	26/02/84	Sampler	Plant external average	

John Griffiths

Estimates of FEV_1 loss and lung cancer causation probability

Summary exposure estimates

Period	Resp dust mg y m^{-3}	Tot dust mg y m^{-3}	BSM mg y m^{-3}	BaP µg y m^{-3}	Oven y	Resp excl ovens mg y m^{-3}
Total	33.6	207.8	9.3	77.8	0.5	32.1

Estimates of FEV_1 loss (ml)

	FEV_1 loss Ml
Due to dust	45
Due to time in ovens	5
Total	50

Estimates of excess relative risk

	Multiplicative ERR		Submultiplicative ERR	
	BSM	BaP	BSM	BaP
All exposures	0.31	0.29	0.19	0.22

'Multiplicative ERR' is excess relative risk calculated on the assumption that the interaction between smoking and exposure is wholly multiplicative; 'submultiplicative ERR' is excess relative risk calculated on the assumption that the interaction between smoking and exposure is intermediate between multiplicative and additive (page 39 of my generic report refers).

'BSM' and 'BaP' refer respectively to the use of risk coefficients derived by using benzene soluble matter or benzo[α]pyrene as markers of risk (pages 36 and 37 of my generic report refer).

Estimates of lung cancer causation probability

	Multiplicative CP		Submultiplicative CP	
	BSM	BaP	BSM	BaP
All exposures	23.6%	22.4%	15.8%	17.9%

'Multiplicative CP' and 'submultiplicative CP' refer to estimates of causation probability based respectively on assumption of a fully multiplicative, or intermediate between multiplicative and additive, interaction between smoking and exposure; 'BSM' and 'BaP', as above, refer respectively to use of benzene soluble matter or benzo[α]pyrene as markers of risk.

RONALD LYNDHURST JENKINS

1. Ronald Jenkins was born on 3 January 1929 and died on 25 September 2005, aged 76 years.

The claim

2. The claim is brought by Mr Jenkins' widow, Mrs Rita Jenkins (the claimant) on behalf of his estate under the Law Reform (Miscellaneous Provisions) Act 1934 and on her own behalf, as Mr Jenkins' dependant, pursuant to the Fatal Accidents Act 1976. It is alleged that, as a result of the dust and fume containing PAHs to which he was exposed during his employment at the Phurnacite Plant, Mr Jenkins developed bladder cancer.

The defendants' case

3. In their written closing submissions, the defendants admitted that they were in breach of duty towards Mr Jenkins only for a short period of his employment with them. They did not admit breach of duty during the nine years or so for which he was employed as a pumpsman in exhauster house 1. In his oral submissions, however, Mr Walker indicated that the defendants admitted breach of duty in relation to each of the lead claimants and he did not make any submissions on breach of duty when addressing me in connection with Mr Jenkins' case. I assume that the defendants' change of stance resulted from the evidence of Professor Jones, whose 'background' exposure levels for the exhauster houses revealed levels of BSM well in excess of the ACGIH TLV of 0.2 mgm^{-3}. In any event, I have found, in Section 5 of my generic judgment that the defendants were in breach of duty to men working in exhauster house 1.

4. The defendants accept that Mr Jenkins developed bladder cancer. They also accept that, despite the fact that the immediate cause of his death was renal failure, his bladder cancer was the indirect cause of his death. However, they contend that the claimant cannot prove to the required standard either that bladder cancer is a disease caused by exposure of the kind to which Mr Jenkins would have been subject at the Phurnacite Plant or, if it is, that Mr Jenkins' bladder cancer was caused by that exposure.

5. Although the defence of limitation pursuant to the Limitation Act 1980 was pleaded in the Individual Defence in Mr Jenkins' claim, in the event the defendants did not pursue their arguments on limitation in his case.

Damages

6. Damages in Mr Jenkins' case have been agreed, subject to the issues of causation. Damages for pain, suffering and loss of amenity have been agreed in the sum of £57,500 and special damages in the sum of £56,015.83. The total damages are therefore £113,515.83, exclusive of interest.

Employment history

Period of employment

7. Mr Jenkins was employed at the Phurnacite Plant continuously from 21 May 1978 until 29 January 1989, a period of about 10½ years. It is not contended that he had any exposure to PAHs other than at the Phurnacite Plant.

The witnesses

8. Mr Jenkins signed a witness statement for the purpose of these proceedings in August 2005, the month before his death. The claimant made a witness statement in March 2011 and gave oral evidence. The other witnesses in Mr Jenkins' case were Mr Silvanus, Mr Lanyon and one of the other lead claimants, Mr Richards. A number of other witnesses described conditions on the batteries, where Mr Jenkins worked during the early part of his time at the Phurnacite Plant.

9. Mr Silvanus was employed at the Phurnacite Plant between 1972 and 1986. In 1978, when Mr Jenkins started work there, Mr Silvanus was working as a charging car operator and quenching car attendant. He often worked with Mr Jenkins on the batteries. In 1979, Mr Silvanus began to work as a pumpsman in exhauster house 1. When Mr Jenkins began his training there, Mr Silvanus helped to teach him the job of pumpsman. Mr Silvanus signed a witness statement in November 2010, but he died before the trial started.

10. Mr Lanyon worked at the Phurnacite Plant between 1968 and 1980. He had known Mr Jenkins before the two of them started to work there. He was a pumpsman in exhauster house 1 from about 1974 until January 1984. He also assisted in training Mr Jenkins in the role of a pumpsman. For a time, Mr Jenkins, Mr Silvanus and Mr Lanyon were all employed in the same job as pumpsmen in exhauster house 1, each working on a different shift. Mr Lanyon gave oral evidence. Although he was plainly somewhat infirm, he was a good witness. He had an excellent memory of the duties of a pumpsman and did his best to answer the questions asked of him fairly and accurately.

11. Mr Richards was employed as a pumpsman and exhausterman in exhauster house 1 between 1957 and 1966. He worked as a process foreman between 1966 and 1981, during which time he visited the exhauster houses on a regular basis. He knew Mr Jenkins slightly as a result of those visits.

Summary of evidence

12. Briefly summarised, the evidence about Mr Jenkins' working history at the Phurnacite Plant was as follows.

21 May 1978 – 13 October 1979

13. During this period, Mr Jenkins worked as a general labourer (or 'spare man') on the batteries. In his witness statement he described how, at various times, he carried out the duties of a charging car operator and a quenching car attendant. Whilst working in those capacities, he was responsible for charging, poking and discharging the ovens. Whilst working as a quenching car attendant, he sustained steam burns to his face when discharging an oven. He also worked on the ramps and in the screen house. Mr Jenkins also spent some shifts in the pitch bay, breaking up solid pitch using pneumatic tools.

14. Mr Silvanus, who worked with Mr Jenkins on the batteries, estimated that Mr Jenkins would have spent 45% of his time carrying out the duties of a charging car operator, 45% of his time working as a quenching car attendant and the remaining 10% of his time divided between the ramps, the screen house and the pitch bay. I accept that estimate, save that I consider it probable that Mr Jenkins spent rather less time in the pitch

bay than Mr Silvanus suggested. I have assumed that 2% of his time was spent there, 4% on the ramps and 4% in the screen house.

14 October 1979 – 29 January 1989

15. The defendants' documents state that Mr Jenkins started work as a pumpsman on 2 March 1980. However, there is clear evidence that he underwent training as a pumpsman and exhausterman between 14 October 1979 and 30 January 1980. I have therefore assumed that he ceased work as a spare man (and began to have the exposure levels of a pumpsman) on 13 October 1979, although he probably continued to be paid as a spare man (rather than as a pumpsman) until the beginning of March 1980.

16. During this period, Mr Jenkins worked mainly as a pumpsman in exhauster house 1, carrying out the work of an exhausterman as and when he was required to do so. I have described the working conditions in exhauster house 1, together with the duties of a pumpsman, at Section 2 of my generic judgment. It is possible also that, during this period, Mr Jenkins was involved in cleaning out the various tanks on the tank farm. However, the evidence about this is sparse and I am not satisfied on the balance of probabilities that he did so.

17. The Table below summarises my findings in relation to Mr Jenkins' working history at the Phurnacite Plant.

TABLE 1

PERIOD	JOB TITLE	OTHER INFORMATION
21 May 1978 -13 Oct 1979	Labourer/spare man, batteries	45% as charging car attendant; 45% as quenching car attendant; 4% in screen house; 4% on ramps; 2% in pitch bay
14 Oct 1979 -29 Jan 1989	Pumpsman, exhauster house 1	One year spent on strike during this period

Respiratory protective equipment

18. The training document for pumpsmen[295], completed at the conclusion of Mr Jenkins' training in early 1980, listed the protective clothing to be worn by pumpsmen. This clothing did not include any RPE. Mr Silvanus' evidence was that the pumpsmen were not provided with any form of RPE. Mr Lanyon said that they would wear the gauze Martindale masks on occasion when they were carrying out work which produced particularly intense fumes. He said that, on average, he would wear a Martindale mask for about one hour each day. However, the masks were of little use since they were designed to protect against nuisance dust rather than fumes. Mr Lanyon had also worn a Racal airstream helmet when working as a pumpsman. This was at a time when the helmets were on trial at the Phurnacite Plant. They were not issued to pumpsmen as a general rule. Mr Lanyon said that he had never heard of the 3M mask. I am satisfied on the evidence that Mr Jenkins was never issued with or used appropriate RPE and indeed the defendants do not contend that any deduction in the exposure levels calculated for Mr Jenkins should be made in respect of RPE.

[295] Jenkins1/111

Overtime

19. The evidence of the claimant, Mr Lanyon and Mr Silvanus was that Mr Jenkins regularly worked overtime. Some overtime records for Mr Jenkins have survived. They show that, during a 12-week period in 1986, his overtime hours amounted to about 23% of his basic weekly hours. However, I do not consider that overtime should be taken into account when assessing Mr Jenkins' exposure levels to PAHs for the reasons set out at Section 4 of my generic judgment.

The effects of exposure

20. The claimant described how her husband's skin would be yellow when he returned home from work. Although he was provided with overalls which were laundered at the Phurnacite Plant, he would bring them home to be washed again. The claimant said that they were stained and smelled of tar. She would boil and soak them but could never get them entirely clean. This evidence accords entirely with the evidence given by the witnesses who had formerly worked as pumpsmen. The evidence, which I accept, confirms that, in the course of his work, Mr Jenkins was exposed to significant quantities of tar and other substances containing pitch.

Exposure levels

21. All three experts used the personal sampling results set out in *Table 6.4*[296] as the basis for calculating the extent of Mr Jenkins' exposure to dust, BSM and BaP. The experts' assessments were as follows:

TABLE 2

Expert	Total Dust (mg y m^{-3})	Respirable Dust (mg y m^{-3}) *(x 1.84)*	BSM (mg y m^{-3})	BaP (µg y m^{-3})
Syred	76	6.5	23	490
Stear	33	n/a	6.2	84
Jones	74.5	13.7*(25.2)*	10.9	111.8

22. For the purposes of Mr Jenkins' claim for bladder cancer, the relevant figures are those for his exposure to BSM and BaP.

23. The differences in the experts' estimate of Mr Jenkins' exposure levels during his time as a spare man were mainly caused by their varying estimates of the time spent by him working in the various areas of the batteries and the pitch bay.

24. I have described at Section 3 of my generic judgment how the experts arrived at their differing assessments of Mr Jenkins' exposure levels during his time as a pumpsman. I concluded that, subject to certain matters, Professor Jones' approach to the calculation of his exposure levels was reasonable and appropriate and I accept it.

Assessment of overall exposure levels

25. Once I had reached some provisional conclusions about my findings of fact in Mr Jenkins' case, I invited Professor Jones to re-work his calculations on the basis of those provisional conclusions. This was not an exercise that I could have performed myself and

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it was undertaken by Professor Jones with the consent of the parties. I asked him to provide more detail of his workings than he had given previously in the event that it was necessary for me to make any adjustments to his calculations consequent upon any further findings I might make. Both parties have had the opportunity to comment on the additional material from Professor Jones and have done so. Save for his calculations in respect of respirable dust (which are not relevant to the causation of bladder cancer and which in any event, having regard to my conclusions at Sections 4 and 11 of my generic judgment, I do not adopt), no criticism of his methodology was raised over and above that which has been discussed in my generic judgment.

26. Professor Jones' re-worked calculations are attached to this individual judgment at Appendix A. Briefly summarised, his estimates of Mr Jenkins' exposure during his employment at the Phurnacite Plant are, for BSM 5.3 $mgym^{-3}$ and for BaP 55.6 μgym^{-3}. Those figures make no deduction for any 'irreducible minimum' for the reasons I have discussed in Section 5 of my generic judgment.

27. I accept Professor Jones' figures as the best available estimates of Mr Jenkins' exposure levels during the period of his employment at the Phurnacite Plant. However, I am satisfied that, because they take no account of the effects of the sweeping and steam cleaning activities carried out in exhauster house 1, Professor Jones' figures underestimate by an unquantifiable amount Mr Jenkins' exposure to BSM and BaP.

The medical issues

28. The medical evidence in Mr Jenkins' case came from Mr Pettersson and Mr Bishop.

Smoking

29. It is clear from the medical records that Mr Jenkins was at one time a heavy smoker but that he had given up the habit many years before his death. I find that he probably stopped in 1968. That would accord roughly with his assertion to a doctor in 1989 that he had smoked for 20 years. He was a heavy smoker, smoking as many as 60 cigarettes a day for at least part of that time. The medical experts agreed that smoking increases the risk of developing bladder cancer. However, they disagreed about whether, and if so to what extent, a man like Mr Jenkins, who had given up smoking many years previously, would still have been at an increased risk of developing bladder cancer as a result of his smoking history. I discussed their evidence and set out my conclusions at Section 9 of my generic judgment.

Bladder cancer

30. In February 2005, Mr Jenkins suffered episodes of haematoma, which were initially attributed to kidney infections. By June 2005, he was anaemic. An ultrasound scan performed in July 2008 revealed the presence of a bladder tumour. This was confirmed on cytoscopy and the tumour was re-sected. A CT scan did not show any obvious spread of the cancer. His condition deteriorated and in September 2005, he was admitted to hospital very unwell. He was in severe renal failure and had acute urinary retention. He died three days later.

31. At Section 9 of my generic judgment, I discussed the evidence relating to the causation of bladder cancer. I concluded that, although the epidemiology suggests that it

is possible that the fumes emitted during the carbonisation process at the Phurnacite Plant may have contained significant quantities of one or more substances capable of giving rise to an increased risk of bladder cancer, the epidemiological evidence, taken on its own, falls short of establishing that fact on a balance of probabilities.

32. I also found that, even if my view on the strength of the epidemiological evidence were different, I would be unable to quantify the increase in risk and would therefore be unable to reach any conclusion as to the likelihood that Mr Jenkins' exposure to PAHs at the Phurnacite Plant – rather than his smoking or some unknown and wholly unrelated cause – had caused his bladder cancer. I therefore concluded that the claimants had not succeeded in establishing causation in the bladder cancer cases.

Conclusion

33. In the circumstances, the claimant's claim must fail.

APPENDIX A
Ronald Jenkins

Occupancy matrix

From	To	Job factor	Fractional occupancy				Annual hours
			Exhauster house 1	Pitch bay	Oven and shuttle floors	Quench, ramp and screens	
21/05/1978	13/10/1979	1	0	0.02	0.45	0.53	1900
14/10/1979	29/02/1984	1	1	0	0	0	1900
01/03/1985	29/01/1989	1	1	0	0	0	1900

Exposure estimates and notes

From	To	Job	Plant	BSM mg y m^{-3}	BaP µg y m^{-3}	Notes
21/05/78	13/10/79	Labourer / spare man, batteries	Oven and shuttle floors	2.01	21.99	Exposure levels as per exposure matrix
21/05/78	13/10/79	Labourer / spare man, batteries	Pitch bay	0.06	1.31	
21/05/78	13/10/79	Labourer / spare man, batteries	Quench, ramp and screens	0.44	4.07	
14/10/79	29/02/84	Pumpsman, exhauster 1	Exhauster house 1	1.49	14.88	Exposure levels as per exposure matrix. Break in employment March 1984 to February 1985 due to strike.
01/03/85	29/01/89	Pumpsman, exhauster 1	Exhauster house 1	1.33	13.31	

Summary exposure estimates

Period	BSM mg y m^{-3}	BaP µg y m^{-3}
Total	5.3	55.6

DAVID SAMUEL JONES

1. David Jones was born on 28 June 1932. He is now aged 80 years.

The claim

2. Mr Jones alleges that the three episodes of skin cancer which he has suffered in the past were caused by exposure to dust and fume containing PAHs during his employment at the Phurnacite Plant.

The defendants' case

3. The defendants admit that they were in breach of their duty towards Mr Jones. They accepted that Mr Jones has suffered from skin cancer in the form of three basal cell carcinomas (BCCs). However, they contend that Mr Jones cannot prove to the required standard that BCC is a condition caused by exposure of the kind to which he would have been subject at the Phurnacite Plant. If it is, they contend that he cannot prove to the required standard that the BCCs from which he suffered were caused by that exposure.

4. The defendants' case is that a more likely cause of Mr Jones' BCCs was previous sun exposure. The defendants also suggested that Mr Jones may have had some exposure to carcinogens (in particular the constituents of mineral oils) when working for other employers before and after his time at the Phurnacite Plant.

5. The defendants further contend that Mr Jones' claim is statute-barred under the provisions of the 1980 Act.

Damages

6. Damages in Mr Jones' case have been agreed, subject to the issues of causation and limitation. Damages for pain, suffering and loss of amenity have been agreed in the sum of £6,500 and special damages in the sum of £114.17. The total damages are therefore £6,614.17, exclusive of interest.

Employment history

At the Phurnacite Plant

7. Mr Jones was employed at the Phurnacite Plant continuously between 1962 and 1969, a period of about 7 years.

Before and after the Phurnacite Plant

8. Before he started work at the Phurnacite Plant in 1962, Mr Jones spent about 14 years in other employment. He served for about ten years as a stoker/mechanic or stoker/fireman with the Royal Navy and subsequently in the Merchant Navy. In addition, he worked as an engine cleaner with the Great Western Railway, as a machine operator with Helliwells Tube Products and as a fitter at an opencast mine.

9. After his employment at the Phurnacite Plant ceased in 1969, Mr Jones worked for a further 30 years or so for various employers, mainly as a fitter.

The witnesses

10. Mr Jones made a lengthy witness statement and gave oral evidence. It was clear from his witness statement that, despite the time that had elapsed, he retained a reasonably good recollection of the processes carried out at the Phurnacite Plant. In other respects, however, he was not an impressive witness. His evidence about the date when he gave up smoking was wholly inconsistent with the medical records and I did not accept it. It led me to doubt the reliability of other aspects of his evidence, in particular that relating to his past sun exposure. However, his account of his working conditions was generally consistent with the evidence of other witnesses and I accept his evidence on that topic. Other witnesses gave evidence about working conditions on the batteries and (to a limited extent) as a shift fitter.

Summary of evidence

11. Briefly summarised, the evidence about Mr Jones' working history at the Phurnacite Plant was as follows.

1962-1964

12. The defendants have no employment records for Mr Jones. As a result, it is impossible to say with accuracy when he started and finished at the Phurnacite Plant and on which dates he moved from job to job. Before working at the Phurnacite Plant, he had been employed as a skilled fitter. At the time he started work at the Phurnacite Plant, there were no fitting jobs available. He therefore spent between one and two years working on the oven floor of battery 5. During his time there, he was engaged mainly as a charging car operator and was responsible for charging the ovens, opening the oven lids at the conclusion of the carbonisation process and poking the ovens when necessary.

13. During this period, I find that Mr Jones spent virtually the whole of his time engaged on work on the oven floor. The evidence was that he spent only a small amount of overtime working elsewhere.

1964-1968

14. Between about 1964 and 1968, Mr Jones was employed as a shift fitter. He was deployed wherever repairs to moving machinery were required. He estimated that he spent about half of his time in the briquetting buildings where many of the mechanical problems occurred. He carried out repair and maintenance work on the disintegrators and the pugs. He often had to work inside the pugs and would be covered in dust containing pitch. He would also carry out repairs to the presses and would come into contact with pitch there. In addition, he would carry out repairs to conveyors and elevators covered in pitch and pitch dust. The elevators in the pitch handling areas broke down very frequently and Mr Jones would have to break up and remove the build-up of pitch that had caused the breakdown.

15. Mr Jones also described working at the sub-ground floor level of the briquetting plants. The sub-ground floor housed the drive belts for the elevators and other machinery in the briquetting plants. Huge quantities of dust accumulated in this area, having fallen from the floors above. The dust would be disturbed by Mr Jones as he moved around and started up the drive belts. On occasion he also had to work inside the ESPs. Mr Jones

would also work on the oven floor, removing and cleaning the nozzles of the oil sprayers, repairing pipes and assisting in the replacing of elephants.

16. Mr Jones estimated that he spent an average of about 10% of each shift working in the workshops. Taking into account the other evidence about the activities of shift fitters, I consider that 10% is probably an under-estimate. I have assumed that he was employed in the workshops for 20% of his time. As to the remainder of his time, I consider that a split of 70% of his time at average exposure levels for the briquetting plants and 10% of his time at average exposure levels for the pitch bay would be reasonable.

1968-1969

17. For about the last year of his employment at the Phurnacite Plant, Mr Jones worked as a day fitter. He worked as a part of a gang of fitters, carrying out mainly routine maintenance work in the briquetting plants. His exposure to pitch dust was much the same as before.

18. I find that, during this period, Mr Jones would have spent less time (about 10%) in the workshops, with the remainder split as to 80% at average exposure levels for the briquetting plants and 10% at average exposure levels for the pitch bay.

19. The Table below summarises my findings in relation to Mr Jones' working history at the Phurnacite Plant:

TABLE 1

PERIOD	JOB TITLE	OTHER INFORMATION
1 Jan 1962 -31 Dec 1963	Charging car operator	100% of time on oven floor
1 Jan 1964 -31 Dec 1968	Shift fitter	70% briquetting plants; 20% workshops; 10% pitch bay or equivalent exposure
1 Jan-31 Dec 1969	Day fitter	80% briquetting plants; 10% workshops; 10% pitch bay or equivalent exposure

Protective measures

20. When working on the oven floor, Mr Jones wore overalls provided by the defendants, together with gloves to protect him from the heat. When poking the ovens, he wore asbestos pads over his gloves. However, the overalls did not cover his neck and it was possible for dust to get inside the top of them. There was a gap between the top of his gloves and the sleeves of his overalls which left his forearms exposed. Mr Jones said that he was unable to wear gloves when working as a fitter since the gloves available at the Phurnacite Plant were unsuitable for the intricate work which he had to carry out. It was not contended by the defendants that suitable gloves were provided for this work or that Mr Jones should have worn them.

21. Barrier cream was available in the changing and shower rooms and in the fitters' workshops. Mr Jones would usually apply barrier cream at the beginning of each shift. However, it would wear off in the course of the day and it was often not possible to re-apply the cream until after his shower at the end of the shift.

Overtime

22. There are no overtime records available for Mr Jones. His evidence was that, when working on the oven floor, he would usually work on one of his rest days. In general, he would carry out his normal job on the ovens on his rest day, but sometimes he would assist the riggers or work on the quenching car floor. He said that he did not do much overtime other than on his rest day. When he was working as a fitter, he did not often work overtime, although he would sometimes do so on one of his rest days. Were it appropriate to take his overtime hours into account, I consider that they should be assessed at half the average overtime hours as calculated by Professor Syred.

Exposure levels

23. Mr Stear did not carry out any assessment of Mr Jones' exposure levels to dust and fume. His view was that it was unnecessary to do so since the only form of exposure relevant to Mr Jones' case was dermal exposure which cannot be quantified. Professor Syred and Professor Jones carried out initial assessments of Mr Jones' exposure to dust, BSM and BaP. They did so because they considered that their assessments might give some guide to the extent of Mr Jones' dermal exposure. They used the personal sampling results set out in *Table 6.4*[297] as the basis for calculating the extent of Mr Jones' exposure to dust, BSM and BaP. Their assessments were as follows:

TABLE 2

Expert	**Total Dust (mg y m^{-3})**	**Respirable Dust (mg y m^{-3})*(x 1.84)***	**BSM (mg y m^{-3})**	**BaP (µg y m^{-3})**
Syred	1350	105	66	626
Jones	173.9	27.1 *(39.9)*	15.1	150.3

24. For the purposes of Mr Jones' claim for skin cancer, the relevant figures are those for his exposure to BSM and BaP.

25. It will be appreciated that there were considerable differences between the assessments made by the two experts. Professor Syred assumed that, for 30% of Mr Jones' time, whilst he was carrying out work on the disintegrators, the pugs, the presses and in the pitch handling area, his exposure levels would have been equivalent to the very high exposure levels measured in February 1979[298] by static samplers during cleaning operations in briquetting plant 2. This assumption resulted in very high estimates of total dust, BSM and BaP. Whilst I accept that it is quite possible that Mr Jones was exposed to very high levels of pitch dust at times during his employment as a fitter, I share Professor Jones' view that it is not realistic to assume that he encountered these levels for as much as 30% of his working time. Professor Syred also assumed that Mr Jones spent the whole of his time working on machinery in various parts of the Phurnacite Plant whereas it is clear from the evidence that he spent part of his working time in the fitters' workshops where exposure levels were lower than in the briquetting plants or on the batteries.

26. Mr Jones' evidence was that, throughout his time as a fitter, he would often be exposed to even more dust than process operatives working in the briquetting plant and elsewhere at the Phurnacite Plant. He said that fitters often had to work in inaccessible

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places where accumulations of dust would have gathered over a long period of time. Even though the equipment he was repairing would not have been operating whilst he was working on it, other plant and machinery in the vicinity would have been working normally and he would have been exposed to dust and/or fume from those sources.

27. As I have said, Mr Stear did not make an assessment of Mr Jones' exposure levels. However, in his Supplemental Report, he indicated (in connection with the case of Mr Robson) that he estimated that a shift fitter would have had 75% of the exposure of a process operative working in the same area. Professor Jones disagreed. He accepted that the plant and machinery on which fitters worked would not be operating. In that respect, their exposure would be less than that of a process operative carrying out his normal work. However, a fitter would receive additional exposure as a result of disturbing accumulated dust when opening up machinery or cleaning dust from the surfaces on which he needed to work. Professor Jones considered that it was reasonable to assume that, whilst in a working area, a fitter's exposure would on balance be the same as that of a process operative. I accept Professor Jones' evidence on this matter. Indeed, I consider that Professor Jones' figures are a better guide to the level of dust, BSM and BaP inhaled by Mr Jones during his employment at the Phurnacite Plant than the assessment performed by Professor Syred.

28. Once I had reached some provisional conclusions about my findings of fact in the other lead cases, I invited Professor Jones to re-work his calculations in those cases on the basis of my provisional conclusions. I did not ask Professor Jones to re-work his calculations in Mr Jones' case. That is because it was clear that the significant type of exposure in his case was dermal and such exposure cannot be quantified by reference to *Table 6.4*[299].

29. In his Individual Report on Mr Jones, Professor Jones pointed out that he would have had some degree of exposure to mineral oils during his periods of employment other than at the Phurnacite Plant. He said that dermal exposure to the older formulations of such oils, which were relatively unrefined, are recognised to give rise to an increased risk of skin cancer.

The medical issues

30. The medical evidence in Mr Jones' case came from Dr August and Dr Falk.

The effects of exposure to pitch

31. Mr Jones described how, during the working day, his face, neck, hand and forearms would be exposed to dust and fume. His overalls would become heavily contaminated with dust. At the end of each shift, his skin would be an unnaturally dark colour. The colour would be washed off when he showered. When he went outside in the sun, he experienced phototoxicity, as a result of which his skin would redden and tingle as though he had sunburn. It is clear from this description that he had a significant exposure to pitch. Mr Jones' medical records do not suggest that he ever suffered from pitch warts and he does not recall doing so.

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Type of skin

32. Mr Jones has a Type II fair skin which reddens and burns easily in the sun. He is described by Dr August as having moderate photo-ageing of the face. It is accepted that these features put him at risk of developing BCC as a result of sun exposure.

History of skin lesions

33. In December 1989, Mr Jones developed a rodent ulcer on his face which was histologically confirmed as a BCC and required removal. He had further BCCs in 2009 (on his upper back) and in 2011 (also on his upper back) which were excised. Between 2009 and 2011, he had nine actinic keratoses (also known as 'solar keratoses), most of them on his face but some on his back.

Previous sun exposure

34. In oral evidence, Mr Jones was questioned at some length about his previous exposure to the sun, in particular when he was in the Royal Navy between 1949 and 1957 and the Merchant Navy from 1959 to 1961. Mr Jones' evidence was that, whilst in the Royal Navy, he was stationed in the Mediterranean for two years. When in the Merchant Navy, he travelled to India and the Belgian Congo. During that time, he had little exposure to the sun as his working time was spent below deck. When he went ashore, he would wear his uniform. He did not feel comfortable in the sun and knew from experiences in childhood that his skin burned easily. When relaxing on deck, he would ensure that he sat in the shade and, when he knew that he was going to be exposed to sunlight, he would cover up his body as far as possible. He did not actively sunbathe and, in particular, would not have exposed his back or trunk to the sun for any significant period of time.

35. Mr Jones accepted that, over the years, he and his wife had on occasion chosen to take their holidays in hot countries. He said that this was his wife's choice. Whilst they were abroad, they did not sunbathe, but travelled around sightseeing. He said that he had always been careful to use high protection sun block whilst he was out of doors, especially when pursuing his hobby of gardening.

Discussion and conclusions

36. I find that Mr Jones sought to minimise his past exposure to the sun. I note that, in 2009, a consultant dermatologist who was at the time treating him for actinic keratoses, observed in a letter:

"He has had a lot of UV *[ultraviolet]* exposure in the past as he was posted with the Armed Forces abroad".

37. Whilst it is possible that the consultant made an unwarranted assumption about Mr Jones' previous sun exposure, I consider it far more likely that Mr Jones volunteered the information when discussing the possible cause of his keratoses. I accept that, because of his skin type, he may not at any time have been an avid sunbather. But I consider that, as a young seaman, there would have been occasions when his back, trunk and face were exposed to full and very hot sun .

38. At Section 10 of my generic judgment, I indicated that I was unable to conclude on a balance of probabilities that BCC can be caused by exposure to pitch or tar related products. I accepted that such a relationship is plausible and that it is quite possible that it exists. However, possibility – even strong possibility – is not sufficient for these purposes.

39. Even if I had decided the issue of generic causation differently, however, I would not have been able to accept Dr August's view that Mr Jones' exposure to pitch played a major and dominant part in the causation of his BCCs. His skin type made him particularly vulnerable to developing BCCs as a result of sun exposure. His time at sea took him to very hot countries where, as I have found, there would have been occasions when his back, trunk and face would have been exposed to full sun. Dr August himself expressed the view that one of Mr Jones' previous BCCs had probably been caused by exposure to sunlight and that he might develop one or more BCCs in the future, also as a result of exposure to UVR. I note also that Mr Jones has in the past developed a number of actinic keratoses which are generally attributed to UVR exposure.

40. In the circumstances, I would have been driven to the conclusion that it was far more probable that Mr Jones' BCCs were attributable to exposure to UVR than to the effects of exposure to pitch at the Phurnacite Plant.

Conclusion

41. Mr Jones' claim must therefore fail. In those circumstances, there is no need for me to go on to consider issues of limitation in his case.

DAVID MIDDLE

1. David Middle was born on 27 June 1938 and is now 74 years old.

The claim

2. Mr Middle claims damages for skin cancer which he alleges was caused by exposure to dust and fume containing PAHs during his employment at the Phurnacite Plant. There is also a claim for CB allegedly caused by exposure to dust at the Phurnacite Plant.

The defendants' case

3. The defendants admit that they were in breach of their duty towards Mr Middle throughout his period of employment at the Phurnacite Plant. They accept that Mr Middle has suffered from skin cancer in the form of multiple basal cell carcinomas (BCCs). However, they contend that Mr Middle cannot prove to the required standard that BCC is a condition caused by exposure of the kind to which he would have been subject at the Phurnacite Plant. If it is, they contend that he cannot prove to the required standard that the BCCs from which he suffered were caused by that exposure. The defendants' case is that a more likely cause of Mr Middle's BCCs was previous sun exposure. The defendants do not accept that Mr Middle developed CB as a result of exposure to dust at the Phurnacite Plant.

4. The defendants further contend that Mr Middle's claim is statute-barred under the provisions of the 1980 Act.

Damages

5. Damages in Mr Middle's case have been agreed, subject to the issues of causation, apportionment and limitation. Damages for pain, suffering and loss of amenity have been agreed in the sum of £26,500 and special damages in the sum of £3,000. The total damages are therefore £29,500, exclusive of interest.

6. Insofar as Mr Middle's claim for non-malignant respiratory disease is concerned, the defendants contend that there should be apportionment to reflect any exposure to dust which would inevitably have occurred without breach of duty on the defendants' part (i.e. the 'irreducible minimum').

Employment history

Period of employment

7. Mr Middle was employed at the Phurnacite Plant continuously between 21 June 1969 and 19 January 1991, a period of just over 21½ years. It is not contended that he had any significant exposure to PAHs and/or dust other than at the Phurnacite Plant. He had occasional dermal and inhalation exposure to creosote when employed by the Forestry Commission between 1953 and 1957.

The witnesses

8. Mr Middle made a lengthy witness statement and gave oral evidence. Both his written and oral evidence demonstrated an excellent knowledge and memory of the processes carried on at the Phurnacite Plant and the working conditions there. He was highly critical about the latter. His evidence was broadly consistent with that of the other witnesses and I accept it. Mr Middle's wife, Nancy May Middle, also provided a witness statement and gave oral evidence about Mr Middle's state of health over the years. Other witnesses gave evidence about conditions on the batteries and in the briquetting plant and about the work of rigger/platers.

Summary of evidence

9. Briefly summarised, the evidence about Mr Middle's working history at the Phurnacite Plant was as follows.

10. The dates on which Mr Middle started and finished work at the Phurnacite Plant are well-documented. However, the dates when he transferred from one job to another are not recorded. It has been necessary to make some assumptions about those dates, based on his evidence.

June-December 1959

11. For about six months from June 1959, Mr Middle worked as a spare man on the batteries. During this time he was employed mainly as a charging car operator, with the occasional shift as a quenching car attendant. He also worked on occasion in the pitch bay, breaking up solid pitch and shovelling it into the pitch bays. When he undertook such work, pitch would be deposited on his hair, moustache, face, hands and arms and it would get inside his clothes.

January 1960 – December 1965

12. At the end of 1959/beginning of 1960 (I have assumed 1 January 1960), Mr Middle took up a permanent position as a charging car operator on battery 5. I have previously given an account of the conditions on the oven floors of the batteries. Mr Middle described how the fumes from the ovens would contain particles of dust and how that dust, together with the dust on the oven tops, would be blown around and would cover his face. He would often get particles of dust in his eyes, which would have to be removed. When he first worked on the oven floor, he would wear his own clothes, usually a pair of old jeans and a shirt. At some time during this period, overalls were provided by the defendants. Even then, dust would go down the top of his overalls and would come into contact with the skin of his upper body.

January 1966 – December 1990

13. Mr Middle's evidence was that he accepted a job as a labourer with the maintenance team in 1965. I have assumed that he started this work at the beginning of January 1966. For the first three years or so, he was a rigger's labourer. Thereafter, he became a rigger, a job that later became known as a rigger/plater. When large structures (e.g. electrical motors, girders, pipes and press rolls) had to be removed or replaced, the riggers were responsible for slinging them and lifting them into the required position, before fixing them. The riggers would also lift into position and fix metal plates of all

sizes which had been manufactured at the Phurnacite Plant by specialist platers. Plates were used in structures such as conveyors, elevators, scrapers, chutes, bunkers, pugs and dryers. They frequently became corroded or damaged and required replacement. The riggers often worked with fitters on the repair and maintenance of plant and equipment. The rigger's labourers assisted the riggers and worked in essentially the same conditions as them.

14. Mr Middle described how, when working on repairs and maintenance in the briquetting plants, the environment would be very dusty. The equipment on which he was working would be covered with fine dust containing pitch. The pitch would often solidify and cause blockages and breakdowns. There would be accumulations of dust containing pitch inside the elevators and conveyors and in the pits beneath. Sometimes the equipment would have been cleaned before the riggers arrived. However, often when they were called to deal with a breakdown, no prior cleaning had been done. Often, when dust had accumulated inside or underneath an elevator or conveyor, it would not be possible to reach the dust without dismantling part of the structure. In those circumstances, the riggers would have to clean up the dust before starting work.

15. On occasion, Mr Middle would have to work inside the pugs, on top of the furnaces and inside the dryers, where there was a great deal of dust, including pitch dust. Mr Middle would also have to carry out work on the pitch crusher and pitch elevators which were situated at the sub-ground floor level of the briquetting plants. These jobs involved chipping off solid pitch which was stuck to the equipment. The whole area was contaminated with pitch dust and Mr Middle would get the dust on the exposed areas of his skin, in his hair and inside his overalls. He would carry out similar work on other elevators which were contaminated with coal dust or with a mixture of coal and pitch dust. The pits under some of the elevators were 15 feet deep. Often they would contain so much dust that, before entering a pit, Mr Middle would use a stick to ascertain the depth of the dust contained in it.

16. Mr Middle estimated, and I accept, that, for his first six years or so as a rigger, he would spend about 50% of his time working in the briquetting plants. He would also work on the batteries, replacing equipment (e.g. elephants, boxes, gas mains and pipes) on the oven floor. I find that the remaining 50% of his time was divided between the oven floor (15%), the quenching car floor (10%) and the workshops and other areas with a similar level of exposure (25%).

17. For the last six years of his employment at the Phurnacite Plant, Mr Middle was employed exclusively in briquetting plant 2.

18. The Table below summarises my findings in relation to Mr Middle's working history at the Phurnacite Plant.

TABLE 1

PERIOD	JOB TITLE	OTHER INFORMATION
Jun-Dec 1959	Spare man	90% oven floor; 5% quenching car floor; 5% pitch bay
Jan 1960-Dec 1965	Charging car operator, battery 5	100% oven floor
Jan 1966-Feb 1984	Rigger's labourer, then rigger/plater	50% briquetting plants; 15% oven floor; 10% quenching car floor; 25% workshops or areas

		of similar exposure
Mar 1984-Feb 1985		On strike
Mar 1985-Dec 1990	Rigger/plater, briquetting plant 2	75% briquetting plant; 25% workshops or areas of similar exposure

Protective measures

19. When working as a charging car operator, Mr Middle wore gloves. However, the gloves available in the Phurnacite Plant were not suitable for the intricate work which he had to carry out as a rigger's labourer or rigger and he was therefore unable to wear them when so employed. Mr Middle applied barrier cream to areas of exposed skin at the start of each shift. However, the dust would stick to the cream and, as the shift progressed and he became hot, the cream would wear off. There was usually no opportunity during the working day to wash and re-apply the barrier cream. He wore overalls from the time they first became available but they did not prevent dust from coming into contact with the skin of his upper body.

Respiratory protection

20. In the early years of his employment, Mr Middle used Martindale and paper masks when carrying out the dustiest jobs. However, the masks afforded little protection against fine dust and fume. From about 1980, 3M masks were available and Mr Middle used them whenever he could. If he was performing a heavy job, he had difficulty breathing when wearing a mask and the masks also became uncomfortable in hot and/or confined spaces, as a result of which he was sometimes unable to use them. His evidence was that, from 1981, the wearing of Racal airstream helmets became compulsory when carrying out maintenance work on the oven floor and, from that time, Mr Middle would wear one when carrying out that type of work.

21. I accept that, from 1981, Mr Middle wore a Racal airstream helmet at all times when he was working on the oven tops. I also find that, from 1980 and for about 50% of his time whilst working in the briquetting plants, he was able to wear a 3M mask.

Overtime

22. The evidence is that Mr Middle worked overtime on his rest days and did other overtime in addition. His work records show that his overtime hours amounted to about one third of his basic weekly hours. There is no reason to believe that those records do not reflect the position throughout his employment at the Phurnacite Plant. His overtime working would be relevant to the assessment of his exposure levels to dust for the purposes of his claim for CB.

The expert evidence

23. The three technical experts initially carried out assessments of Mr Middle's exposure levels to dust, BSM and BaP. The total dust levels are relevant to his claim for CB. The BSM and BaP levels relate to inhalation of those substances, whereas the type of exposure relevant for the purposes of skin cancer is dermal exposure, which cannot be quantified. However, the experts' assessments of the BSM and BaP exposure levels give some guide to the extent of his contact with PAHs. I therefore set out the assessments of the three experts in the Table below:

TABLE 2

Expert	Total Dust (mg y m^{-3})	Respirable Dust (mg y m^{-3}) *(x 1.84)*	BSM (mg y m^{-3})	BaP (µg years m^{-3})
Syred	584	279	69	699
Stear	192		27	312
Jones	396.8	61.6 *(113.34)*	35.5	329.3

24. The disparities between the experts' assessments were in part caused by their different approaches to Mr Middle's employment as a rigger's labourer and rigger. Professor Syred assumed that, throughout that employment, Mr Middle had the same exposure to dust as a process operative working in the same area. By contrast, Mr Stear estimated that Mr Middle would have had only about 25% of the exposure of a process operative. In his original Report, he had suggested that his exposure would have been between 50% and 100% of that of a process operative but, having read the transcript of Mr Middle's oral evidence, he revised his view. It was not clear why he did so.

25. In his original report in Mr Middle's case, Professor Jones assumed that, during his time as a rigger's labourer and rigger in the briquetting plants and batteries, Mr Middle would have been exposed to the same levels of dust and fume as a process operative. In the calculations set out in his Second Supplemental Report, however, Professor Jones revised that assumption. Instead, he assumed that Mr Middle would have had 50% of the exposure of a process operative working in the same areas.

26. Having considered the evidence as a whole, I have concluded that, whilst working in the briquetting plants as a rigger's labourer and rigger, Mr Middle would have had significantly more than 50% of the exposure levels to dust experienced by process operatives employed there. He would have been exposed to the general levels of dust in the briquetting plants at all times when working there and, in addition, it is clear from his evidence that he frequently had to work in areas (such as those at sub-ground level) where large quantities of dust had accumulated. In those circumstances, he would have been exposed to greater quantities of dust than the process operatives working on the floors above.

27. I find that, taken overall, when working in the briquetting plants, Mr Middle was exposed to 80% of the dust levels encountered by process operatives working there. When working in the batteries, I accept Professor Jones' estimate of 50%. Whilst in the workshops or other parts of the plant with 'background' exposure he would have had 100% of the relevant levels.

28. I have already indicated that, in general, I accept Professor Jones' approach to the assessment of exposure levels. Therefore, once I had reached some provisional conclusions about my findings of fact in Mr Middle's case, I invited Professor Jones to re-work his calculations on the basis of those provisional conclusions. I confined my request in Mr Middle's case to the levels of total dust, although Professor Jones also provided his calculations of respirable dust. The re-working was not an exercise that I could have performed myself and it was undertaken by Professor Jones with the consent of the parties. I asked Professor Jones to provide more detail of his workings than he had given previously in the event that it was necessary for me to make any adjustments to his

calculations consequent upon any further findings that I might make. Both parties have had the opportunity to comment on the additional material from Professor Jones and have done so. Save for his calculations in respect of respirable dust (which are not relevant to the causation of skin cancer or CB and which in any event, having regard to my conclusions at Sections 4 and 11 of my generic judgment, I do not adopt), no criticism of his methodology was raised over and above that which has been discussed in my generic judgment.

29. Professor Jones' re-worked calculations are attached to this individual judgment at Appendix A. His estimate of Mr Middle's exposure to total dust during his employment at the Phurnacite Plant is 489.9 mgym^{-3}. That figure makes no deduction for any 'irreducible minimum' for the reasons I have discussed in Section 5 of my generic judgment.

30. I accept Professor Jones' figure as the best available estimate of Mr Middle's exposure level to dust during his employment at the Phurnacite Plant.

The medical issues

31. The medical evidence in Mr Middle's case came from Dr August and Dr Falk in relation to his skin cancer and from Dr Rudd in relation to CB.

The effects of exposure

32. Mr Middle described how, after prolonged contact with pitch or with dust containing pitch, his skin would turn yellow. His neck would be very red and sore after working in the pitch bay. Mrs Middle gave evidence about the difficulties of washing her husband's work clothes. Even after overalls were provided, the clothes he wore underneath them would still get very dirty. The bedclothes (especially the pillow slips) would become stained yellow with pitch. When he went outside in the sun, he experienced phototoxicity and his skin would burn as though he had sunburn. As a result of contact with the pitch dust, he developed comedones (blackheads) all over his body, especially on his legs. These cleared when he left the Phurnacite Plant. It is clear from the evidence that he had significant exposure to pitch.

Type of skin

33. Mr Middle has a Type III skin, i.e. a skin that will tan readily in the sun, perhaps burning a little before a tan develops. He was described by Dr August as showing little photo-ageing of the face.

Smoking

34. Mr Middle has been a lifelong non-smoker.

History of skin lesions

35. In early 1979, Mr Middle developed a lump on his upper lip. He reported it to the medical officer at the Phurnacite Plant, who referred him to his GP. He was then referred to hospital where the lump was removed under local anaesthetic. He required three or four stitches in the wound. Mr Middle was told that the lump had been a pitch wart. He made a claim for industrial injuries benefit and, having been examined by a Medical

Board, received a 'one-off' payment of about £50. He was aware of the procedure for making a claim because other Phurnacite employees he knew had made similar claims in the past. Mr Middle said that he knew that the wart had been caused by exposure to pitch at work. He knew also that it was important for a pitch wart to be removed because it could become cancerous. He believed that, once the wart had been removed, it was the end of the matter. He had no further problems for over five years.

36. In October 1985, Mr Middle developed a lump on his left eyelid, which grew quickly. He sought medical advice and was referred to the ophthalmic department of the local hospital. He underwent surgery to remove the lump which was probably another pitch wart although no histological examination appears to have been carried out. On this occasion, Mr Middle had 17 stitches in the wound and required about a fortnight off work after the surgery. A histology report revealed that no cancer cells had been seen. Again, he claimed industrial injuries benefit and was awarded the sum of £175. Once again, he believed that, the pitch wart having been removed, all was well. It seems (although Mr Middle did not remember the incident) that he had a further wart on his eyelid in April 1987 which was removed by cauterisation.

37. Mr Middle recalled that, before he left the Phurnacite Plant, he had a red lesion on his forehead that would bleed if he scratched or knocked it. It did not resemble a pitch wart and he did not seek medical advice about it for some time. When he did so in 1994, he was advised to have it removed. Histology revealed that the lesion was a BCC. After removal of the lesion, Mr Middle continued to experience problems with the wound breaking down and bleeding.

38. In March 1995 a solar keratosis was removed from under Mr Middle's right eye by cryotherapy. In 1996 he had a recurrence of the BCC on his forehead which was excised in June 1996. In February 1997, he underwent micrographic surgery on his forehead.

39. Since 2005, Mr Middle has had a number of BCCs which have required removal. In 2006, he had BCCs removed from his forehead and his nose. In 2007, he had BCCs excised from his forehead and the left side of his nose. In 2008, BCCs on his forehead and the right side of this nose required removal. In 2010, he was noted to have BCCs on his right upper chest and upper back. In 2008, further solar keratoses were found on the right side of his forehead, the rim of his left ear and behind his right ear.

Previous sun exposure

40. Mr Middle had worked outdoors during the period of four years or so for which he was employed by the Forestry Commission in the 1950s. His chief hobbies have always been outdoor pursuits, such as fishing and gardening. The defendants contended that his BCCs were in all probability caused by exposure to UVR. There is no evidence that he has visited hot countries or been a keen sunbather.

Discussion and conclusions on skin cancer

41. At Section 10 of my generic judgment, I indicated that I was unable to conclude on a balance of probabilities that BCC can be caused or materially contributed to by exposure to pitch or tar related products. I accepted that such a relationship is plausible and that it is quite possible that it exists. However, possibility – even strong possibility - is not sufficient for these purposes.

42. Mr Middle's skin type was not such as to make him especially vulnerable to developing BCCs as a result of sun exposure. His facial skin shows little sign of photo-ageing. He had not had exposure to very hot sun as I found had been the case with Mr David Jones. Mr Middle had a history of pitch warts and comedones. The distribution of his BCCs – in the facial area and on his upper body – would be consistent with his exposure to pitch dust as described by him. I note that he has been diagnosed with a number of solar keratoses which implies that there has been some sun damage. Nevertheless, if I had decided the issue of generic causation differently, I would have accepted, on a balance of probabilities, that Mr Middle's BCCs had been caused by his exposure to pitch and dust containing pitch at the Phurnacite Plant.

History of respiratory problems

43. Mr Middle's evidence was that, whilst he was working at the Phurnacite Plant, he had frequent bouts of coughing, during which he brought up phlegm. Those bouts would be worse at night and would disturb his sleep. He told Dr Rudd that, when working at the Phurnacite Plant, he coughed up sputum numerous times daily for months at a time. He said that he continues to cough up phlegm three or four times a day and during the night. His symptoms are worse in winter. At one point in his oral evidence, he said that his symptoms of coughing and bringing up phlegm had started when he was aged about 48 years, i.e. in about 1986, four to five years before he left the Phurnacite Plant. Later, he spoke about occasions whilst working at the Phurnacite Plant when he would cough up "lots of black phlegm and dust" or, after working in "yellow gas", he would bring up "a lump of tar".

44. There is no reference in Mr Middle's medical records to symptoms of CB during the period of his employment at the Phurnacite Plant. In 1997 (several years after he had left the Phurnacite Plant), a note in his GP records referred to a cough and a "wheezy chest". "Bronchitis" was diagnosed and a course of Amoxicillin prescribed. In June 2003, an entry in his hospital records noted that he had had a cough with green phlegm for a long time but it was getting worse. Later hospital records refer to him having a "productive cough".

45. Dr Rudd concluded that, if the evidence of Mr Middle and his wife were accepted, he had developed CB during his employment at the Phurnacite Plant. Since Mr Middle is a lifelong non-smoker, Dr Rudd considered that the most likely cause of his CB was his occupational exposure to dust. His evidence was that, since Mr Middle's symptoms of cough and sputum production have continued for so long after his employment at the Phurnacite Plant ceased, it is probable that the symptoms will continue indefinitely. However, Dr Rudd said that he found it difficult to explain Mr Middle's continuing copious sputum production on the basis of CB.

46. The lung function tests carried out at the time of Dr Rudd's examination of Mr Middle showed no evidence of COPD. Indeed, Dr Rudd does not consider that Mr Middle has any disabling chronic respiratory disease. The breathlessness from which he suffers is attributable to his longstanding obesity, together with impairment of cardiac function secondary to ischemic heart disease and hypertension, with left ventricular hypertrophy. Dr Rudd did not consider that Mr Middle is at risk of developing COPD in the future. However, he considered that he was at risk of developing lung cancer.

Discussion and conclusions in relation to chronic bronchitis

47. The issue of whether Mr Middle had CB at the time he worked at the Phurnacite Plant is dependent entirely on his evidence and that of his wife. I find it very surprising that, throughout the whole of his time at the Phurnacite Plant – a period of over 30 years – he appears never to have complained to his GP of symptoms that, if his evidence is accurate, were very severe and were affecting his sleep. Mr Middle was a reasonably frequent attender at his GP's surgery and, if he had been experiencing the symptoms of which he now complains, I would have expected him to have sought medical advice. In oral evidence, Mr Middle suggested, first, that his symptoms of cough and sputum had started late in his employment at the Phurnacite Plant. He then described what appeared to be intermittent incidents when he had coughed up black phlegm or bits of tar. These incidents may have been very unpleasant but, unless they happened on a regular basis, they would not fulfil the criteria for CB. Furthermore, the fact that Dr Rudd has difficulty in reconciling Mr Middle's current complaints of copious sputum production with a diagnosis of CB suggests that there may be an element of exaggeration in Mr Middle's evidence.

48. I cannot be satisfied on a balance of probabilities that Mr Middle suffered symptoms of CB whilst he was working at the Phurnacite Plant or that he currently has CB resulting from his occupational exposure there. In reaching that conclusion, I do not overlook the note in the hospital records made in June 2003, stating that Mr Middle had suffered from a cough and sputum for a long time. By 2003, he had been away from dust and fume at the Phurnacite Plant for more than 13 years. The phrase "a long time" could mean a number of months or a number of years. It does not necessarily mean that Mr Middle had been suffering from the symptoms for more than 13 years. Mr Middle reported that the symptoms were "getting worse". If they were as bad as he claims when he was at the Phurnacite Plant, and were caused by his exposure to dust there, it is difficult to see how they could have deteriorated 12 years afterwards.

Conclusion

49. In the circumstances, Mr Middle's claims for both skin cancer and CB must fail. There is therefore no need for me to go on to consider issues of limitation in his case.

APPENDIX A

David Middle

Occupancy matrix

From	To	Job factor	Fractional occupancy					Annual hours
			Workshops	Pitch bay	Briquetting	Oven and shuttle floors	Quench, ramp and screens	
01/06/1959	31/12/1959	1	0	0.05	0	0.9	0.05	2379
01/01/1960	31/12/1965	1	0	0	0	1	0	2379
01/01/1966	31/12/1974	0.5	0.25	0	0	0.15	0.1	2379
01/01/1975	31/12/1979	0.5	0.25	0	0	0.15	0.1	2379
01/01/1980	31/12/1980	0.5	0.25	0	0	0.15	0.1	2379
01/01/1981	29/02/1984	0.5	0.25	0	0	0.15	0.1	2379
01/01/1966	31/12/1974	0.8	0	0	0.5	0	0	2379
01/01/1975	31/12/1979	0.8	0	0	0.5	0	0	2379
01/01/1980	31/12/1980	0.8	0	0	0.5	0	0	2379
01/01/1981	29/02/1984	0.8	0	0	0.5	0	0	2379
01/03/1985	31/12/1990	0.8	0.25	0	0.75	0	0	2379

David Middle
Exposure estimates

From	To	Job	Plant	Resp dust mg y m^{-3}	Tot dust mg y m^{-3}	Oven years	Resp excl ovens mg y m^{-3}
01/06/59	31/12/59	Spare man	Pitch bay	0.05	0.22	0.00	0.05
01/06/59	31/12/59	Spare man	Quench, ramp and screens	0.03	0.16	0.03	0.00
01/06/59	31/12/59	Spare man	Oven and shuttle floors	2.56	15.90	0.52	0.00
01/01/60	31/12/65	Charge car operator	Oven and shuttle floors	29.29	181.76	6.00	0.00
01/01/66	31/12/74	Rigger's labourer then rigger-plater	Briquetting	16.33	101.38	0.00	16.33
01/01/75	31/12/79	Rigger's labourer then rigger-plater	Briquetting	8.95	54.24	0.00	8.95
01/01/80	31/12/80	Rigger's labourer then rigger-plater	Briquetting	0.89	5.42	0.00	0.89
01/01/81	29/02/84	Rigger's labourer then rigger-plater	Briquetting	2.83	17.15	0.00	2.83
01/01/66	31/12/74	Rigger's labourer then rigger-plater	Oven and shuttle floors	3.90	24.25	0.67	0.00
01/01/75	31/12/79	Rigger's labourer then rigger-plater	Oven and shuttle floors	2.16	12.95	0.37	0.00
01/01/80	31/12/80	Rigger's labourer then rigger-plater	Oven and shuttle floors	0.22	1.30	0.07	0.00
01/01/81	29/02/84	Rigger's labourer then rigger-plater	Oven and shuttle floors	0.14	0.82	0.24	0.00
01/01/66	31/12/74	Rigger's labourer then rigger-plater	Quench, ramp and screens	0.81	5.07	0.45	0.00
01/01/75	31/12/79	Rigger's labourer then rigger-plater	Quench, ramp and screens	0.44	2.47	0.25	0.00
01/01/80	31/12/80	Rigger's labourer then rigger-plater	Quench, ramp and screens	0.04	0.25	0.05	0.00
01/01/81	29/02/84	Rigger's labourer then rigger-plater	Quench, ramp and screens	0.14	0.78	0.16	0.00
01/01/66	31/12/74	Rigger's labourer then rigger-plater	Workshops	1.52	7.04	0.00	1.52
01/01/75	31/12/79	Rigger's labourer then rigger-plater	Workshops	0.78	3.75	0.00	0.78
01/01/80	31/12/80	Rigger's labourer then rigger-plater	Workshops	0.16	0.75	0.00	0.16
01/01/81	29/02/84	Rigger's labourer then rigger-plater	Workshops	0.49	2.37	0.00	0.49
01/03/85	31/12/90	Rigger-plater	Briquetting	7.83	47.50	0.00	7.83
01/03/85	31/12/90	Rigger-plater	Workshops	0.91	4.38	0.00	0.91

David Middle

Notes on exposure estimates

From	To	Job	Plant	Notes
01/06/59	31/12/59	Spare man	Pitch bay	Exposure levels as per exposure matrix
01/06/59	31/12/59	Spare man	Quench, ramp and screens	
01/06/59	31/12/59	Spare man	Oven and shuttle floors	
01/01/60	31/12/65	Charge car operator	Oven and shuttle floors	Exposure levels as per exposure matrix
01/01/66	31/12/74	Rigger's labourer then rigger-plater	Briquetting	Factor of 0.8 applied to exposures attributed to the plant
01/01/75	31/12/79	Rigger's labourer then rigger-plater	Briquetting	
01/01/80	31/12/80	Rigger's labourer then rigger-plater	Briquetting	Factor of 0.8 applied to exposures attributed to the plant; factor of 0.5 applied for respiratory protection
01/01/81	29/02/84	Rigger's labourer then rigger-plater	Briquetting	
01/01/66	31/12/74	Rigger's labourer then rigger-plater	Oven and shuttle floors	Factor of 0.5 applied to exposures attributed to the plant
01/01/75	31/12/79	Rigger's labourer then rigger-plater	Oven and shuttle floors	
01/01/80	31/12/80	Rigger's labourer then rigger-plater	Oven and shuttle floors	Factor of 0.5 applied to exposures attributed to the plant; factor of 0.5 applied for respiratory protection
01/01/81	29/02/84	Rigger's labourer then rigger-plater	Oven and shuttle floors	Factor of 0.5 applied to exposures attributed to the plant; factor of 0.1 applied for respiratory protection
01/01/66	31/12/74	Rigger's labourer then rigger-plater	Quench, ramp and screens	Factor of 0.5 applied to exposures attributed to the plant
01/01/75	31/12/79	Rigger's labourer then rigger-plater	Quench, ramp and screens	
01/01/80	31/12/80	Rigger's labourer then rigger-plater	Quench, ramp and screens	Factor of 0.5 applied to exposures attributed to the plant; factor of 0.5 applied for respiratory protection
01/01/81	29/02/84	Rigger's labourer then rigger-plater	Quench, ramp and screens	
01/01/66	31/12/74	Rigger's labourer then rigger-plater	Workshops	Exposure levels as per exposure matrix.
01/01/75	31/12/79	Rigger's labourer then rigger-plater	Workshops	
01/01/80	31/12/80	Rigger's labourer then rigger-plater	Workshops	
01/01/81	29/02/84	Rigger's labourer then rigger-plater	Workshops	
01/03/85	31/12/90	Rigger-plater	Briquetting	Factor of 0.8 applied to exposures attributed to the plant; factor of 0.5 applied for respiratory protection
01/03/85	31/12/90	Rigger-plater	Workshops	Exposure levels as per exposure matrix

David Middle

Estimate of FEV_1 loss

Summary exposure estimates

Resp dust mg y m^{-3}	Tot dust mg y m^{-3}	Oven years	Resp excl ovens mg y m^{-3}
80.5	489.9	8.8	40.8

FREDERICK JOHN RICHARDS

1. Frederick Richards was born on 30 December 1932 and is now aged 79 years.

The claim

2. Mr Richards alleges that the bladder cancers from which he suffered in 2000 and 2002 were caused by exposure to dust and fume containing PAHs during his employment at the Phurnacite Plant. There are also claims for COPD and CB, allegedly caused by exposure to dust at the Phurnacite Plant.

The defendants' case

3. The defendants admit they were in breach of duty towards Mr Richards for the period from 1966 until 1981 when he was working as process foreman. They do not admit that they were in breach of duty during the period after 1981 when he was working as a yard foreman. I assume that this is because, at that time, he was working mainly in the open areas of the Phurnacite Plant.

4. The defendants accept that Mr Richards developed two small bladder cancers. However, they contend that he cannot prove to the required standard either that bladder cancer is a disease caused by exposure of the kind to which he would have been subject at the Phurnacite Plant or, if it is, that his bladder cancer was caused by that exposure. The defendants accept that Mr Richards has mild COPD and CB, caused partly by his smoking and partly by his occupational exposure at the Phurnacite Plant.

5. The defendants contend that Mr Richards' claim is statute-barred under the provisions of the 1980 Act.

Damages

6. Damages in Mr Richards' case have been agreed, subject to the issues of breach of duty, causation, apportionment and limitation. Damages for pain, suffering and loss of amenity have been agreed in the sum of £25,000 and special damages in the sum of £827.24. The total damages are therefore £25,827.24, exclusive of interest. The claim for provisional damages is no longer pursued.

7. Insofar as Mr Richards' claim for non-malignant respiratory disease is concerned, it is agreed that there should be apportionment to exclude from compensation that part of his COPD and CB which can properly be attributed to his smoking habit. The defendants also contend that there should be apportionment to reflect any exposure to dust which would inevitably have occurred without breach of duty on the defendants' part (i.e. the 'irreducible minimum').

Employment history

Period of employment

8. Mr Richards was employed at the Phurnacite Plant continuously between 11 April 1954 and 21 December 1985, a period of 31½ years. It is not contended that he had any significant exposure to PAHs, dust or fume other than at the Phurnacite Plant.

The witnesses

9. Mr Richards made a lengthy witness statement and gave oral evidence. Overall, he displayed a good knowledge of the processes and working conditions at the Phurnacite Plant. However, he had some lapses of memory, most notably about the fact that he had made a claim for vibration white finger (VWF) in 2000. That claim was later withdrawn and he appeared genuinely to have forgotten ever having made it. He was also confused about the claim he had made for noise-induced hearing loss (NIHL). I am satisfied also that, on occasion, Mr Richards somewhat exaggerated his account of the working conditions at the Phurnacite Plant. In his witness statement, for example, he claimed that men working on the oven tops were usually "up to their ankles in dust". In his oral evidence, he accepted that he had exaggerated the amount of dust that was present. I have therefore approached Mr Richards' evidence with a degree of caution.

10. There was also evidence from Mr Lanyon and Mr Silvanus about the working conditions of pumpsmen. I have referred to this evidence in my judgment in Mr Jenkins' case and at Section 2 of my generic judgment. Mr Russell Pugh (who gave a witness statement in the case of Mr Carhart) was a process foreman on the same batteries as Mr Richards between 1970 and 1985. Mr Brian Jones (a witness in the case of Mt Robson) was a shift superintendent between 1971 and 1984 and was familiar with the processes carried on at the batteries.

Summary of evidence

11. Briefly summarised, the evidence about Mr Richards' working history at the Phurnacite Plant was as follows.

April 1954 – May 1957

12. From 11 April 1954 until 19 May 1957, Mr Richards was a member of the Capital Gang, and was employed on maintenance work at a number of NCB premises, including the Phurnacite Plant.

13. Mr Richards said that, while working as part of the Capital Gang, he spent about 75% of his time at the Phurnacite Plant. At the Phurnacite Plant, he worked for about two years on the construction of roads and plant, mainly driving a dumper truck. In addition, he spent a period of about six weeks breaking up solid pitch in the pitch bay, using picks and sledgehammers. He also assisted with cleaning out the tar tanks outside exhauster house 1. This involved climbing into the tanks, cutting up the tar residue with shovels and throwing it outside the tanks. A steam lance would be used to remove any remaining tar deposits and to clean the men's shovels. It was a thoroughly dirty and unpleasant job with a lot of exposure to tar fumes.

14. I find that, during this period, Mr Richards spent the equivalent of about eight weeks (i.e. about 5% of his time) working in the pitch bay and about 109 weeks (i.e. about 70% of his time) working outside at the Phurnacite Plant where he would be subject to 'background' exposure. The remainder of his time was spent at sites other than the Phurnacite Plant.

May 1957 – January 1966

15. From 20 May 1957 until 29 January 1966, Mr Richards worked mainly as a pumpsman in exhauster house 1, carrying out the work of an exhausterman as and when he was required to do so. I have described the working conditions in exhauster house 1, together with the duties of a pumpsman, at Section 2 of my generic judgment.

January 1966 – 1981

16. From 30 January 1966 until December 1981, Mr Richards was employed as a process foreman. He was responsible for batteries 1 and 2 and also (for some time at least) for all or part of battery 3.

17. Mr Richards' evidence was that during an eight-hour shift, he would on average spend 30-45 minutes working on the screens, three to four hours on the oven floor, 10-15 minutes on the shuttle floor, 45 minutes on the quenching car floor, 15 minutes on the ramps and about one and a half hours in the foreman's office/canteen, writing reports and doing administrative work. Having considered that evidence, together with the evidence of Mr Pugh and Mr Brian Jones, I find that, on average, Mr Richards would have spent about 25% of his shift away from the working areas of the batteries, doing administrative tasks in the office/canteen, conferring with colleagues and walking between batteries or between the batteries and the office/canteen. Of the remaining 75% of his time, I find that 60% was spent on the oven floor, 10% on the quenching car floor and 5% split between the screens, the ramps and the shuttle car floor.

1982 – December 1985

18. I have assumed that Mr Richards' transfer to the job of yard foreman took place on 22 December 1981. He performed that job until he left the Phurnacite Plant on 21 December 1985.

19. As a yard foreman, Mr Richards worked day shifts only. He was in charge of supervising 60-70 labourers, known as 'yard labourers', who would work all over the Phurnacite Plant, cleaning up spillages of dust, breeze and tar deposits. They would carry out tasks such as cleaning under the conveyor belts and under the ramps, clearing around the tanks on the tank farm, clearing frozen coal from wagons, and cleaning out the tar tanks. Mr Richards would spend his shift walking around the Phurnacite Plant, ensuring that the work was being done properly and assisting when necessary. He estimated that he would spend about an hour of each shift in the area of the conveyor belts situated below the batteries. He would also spend about half an hour of each shift in the briquetting plants.

20. Mr Richards accepted that, during his time as a yard foreman, his exposure to dust and fume was much less than at the time when he was working on the batteries as a process foreman.

21. I find that, during this period, Mr Richards, spent approximately 1½ hours (i.e. about 20%) of each shift on administrative work in the foreman's office/canteen. Of the remaining 80% of his time, I have concluded that 65% was spent supervising the yard labourers in the open areas of the Phurnacite Plant, whilst 15% was spent in dusty areas such as the briquetting plants and in confined areas around conveyor belts.

22. The Table below summarises my findings in relation to Mr Richards' working history at the Phurnacite Plant.

TABLE 1

PERIOD	JOB TITLE	OTHER INFORMATION
11 Apr 1954 –19 May 1957	Member of Capital Gang	75% at Phurnacite Plant of which equivalent of 8 weeks (i.e. 5%) in pitch bay and remainder (i.e. 70%) on outside construction work
20 May 195 –29 Jan 1966	Pumpsman, exhauster house 1	100% exhauster house 1
30 Jan 1966 –21 Dec 1981	Process foreman, batteries 1, 2 & 3	60% on oven floor; 10% on quenching car floor and 5% split between screens, ramps and shuttle car floor. 25% in foreman's office/canteen or walking between locations
22 Dec 1982 –21 Dec 1985	Yard foreman	65% all over the plant outside; 15% in dusty areas such as the briquetting plants; 20% in foreman's office/canteen. One year on strike during this period.

Respiratory protective equipment

23. The evidence of Mr Richards, Mr Pugh and Mr Brian Jones was that, although Racal airstream helmets were issued to process operatives working on the ovens in the early 1980s, they were not issued to process foreman. The evidence of Mr Carhart, also a process foreman, was that he wore a Racal airstream helmet when they became available. Mr Richards never wore any kind of RPE and his employment in the batteries ceased at about the time the Racal helmets were introduced. 3M masks would have been available to him after about 1980 but their use was not enforced by management for yard foremen. The defendants did not contend that any deductions in the exposure levels calculated for Mr Richards should be made in respect of RPE.

Overtime

24. There are no figures available for overtime worked by Mr Richards. However, it is clear from the evidence that, for much of his time at the Phurnacite Plant, he worked a considerable amount of overtime. Indeed, his evidence was that he declined the opportunity of promotion to shift supervisor (at a higher salary than that of a process foreman) on the ground that, since overtime would not be available, he would lose financially if he were promoted. I do not consider that overtime should be taken into account when assessing Mr Richards' exposure levels to PAHs for the reasons set out at Section 4 of my generic judgment. I am however satisfied that it is appropriate to take overtime into account when assessing his dust exposure for the purposes of his claims for COPD and CB.

Exposure levels

25. All three experts used the personal sampling results set out in *Table 6.4*[300] as the basis for calculating the extent of Mr Richards' exposure to dust, BSM and BaP. The experts' assessments were as follows:

TABLE 2

Expert	**Total Dust (mg y m^{-3})**	**Respirable Dust (mg y m^{-3}) *(x 1.84)***	**BSM (mg y m^{-3})**	**BaP (µg years m^{-3})**
Syred	372	109	69	1147
Stear	103		18	222
Jones	203.9	32.3 *(59.4)*	21.9	242.5

26. For the purposes of Mr Richards' claim for bladder cancer, the most significant figures are those for his exposure to BSM and BaP.

As a member of the Capital Gang

27. For the period when Mr Richards was employed as a member of the Capital Gang, Professor Syred used the average exposure levels for men working on the ramps. Professor Jones assumed that, for a tenth of the time he spent at the Phurnacite Plant when working in the Capital Gang, Mr Richards had equal periods of exposure at the average levels for the briquetting plant, the oven and shuttle floors and the quenching car and ramp floors. To that he added eight weeks' exposure equivalent to that of a pitchman. He later revised his calculations to include 'background' exposure for the remaining 10% of Mr Richards' time.

28. Mr Stear's initial approach was to calculate Mr Richards' exposure levels for this period on the basis that he spent eight weeks exposed to levels of dust and PAHs equivalent to those encountered by men working in the pitch bay. For the rest of the time, Mr Stear assumed low levels of exposure which would not have contributed greatly to Mr Richards' overall exposure. Mr Stear later revised his calculations to allow six weeks' exposure at levels encountered in the pitch bay, together with four weeks' exposure in the tar tanks. For this latter period, he used figures for the levels of dust, BSM and BaP encountered by men working on the cleaning of pits in the briquetting plants, discounted by 30% to reflect the fact that Mr Richards would not have been working in a tar tank throughout the whole of a shift. For the remainder of Mr Richards' time as a member of the Capital Gang, Mr Stear adopted the 'background' exposure levels taken from Professor Jones' modelling dispersion exercise.

29. I consider that Professor Jones' approach is generally appropriate. I am satisfied that the eight weeks' exposure equivalent to a pitch man that he has included satisfactorily covers Mr Richards' exposure in the tar tanks as well as the pitch bays. For the remainder of the period, however, I conclude that Mr Richards' was working in the open air. There is no evidence that he was involved in significant amounts of work in the briquetting plants or batteries**.**

[300] Syred1/131

As a pumpsman

30. I have described at Section 3 of my generic judgment how the experts arrived at their assessments for Mr Richards' exposure levels during his time as a pumpsman.

As a process foreman

31. I have already concluded that, whilst carrying out his duties in the working areas of the batteries, a process foreman would have experienced about 75% of the exposure levels of process operatives working in the same areas. I am satisfied that the exposure levels for the various working areas calculated by Professor Jones are reasonable and appropriate.

As a yard foreman

32. For this period, Professor Syred sought to divide up Mr Richards' time between the briquetting plants, the batteries (including an estimated 22% of his time spent on the shuttle car and oven floors), the general plant areas and in the office/canteen. This division (in particular the estimate of time spent on the shuttle car and oven floors) does not accord with the evidence, which was that the yard foreman was responsible for activities at ground level.

33. In his original Report, Professor Jones observed that Mr Richards' work during this period was split between administrative duties performed in the office and work out of doors in a supervisory, rather than 'hands on', capacity. He concluded that Mr Richards' work during this period was unlikely to have added significantly to his exposure. When making his initial calculations, he did not include any exposure at all during this period. In his Second Supplemental Report, Professor Jones revised his calculations of Mr Richards' exposure levels as a yard foreman to include 'background' exposure taken from his modelling dispersion exercise. He applied a deduction of 50% to reflect Mr Richards' supervisory role. He assumed that Mr Richards spent the whole shift outside.

34. Mr Stear had originally assumed that, during his time as a yard foreman, Mr Richards had 10% of the average exposure of process operatives working in all areas of the briquetting plant and the batteries. Subsequently, he revised his figures to include the figure for 'background' exposure taken from Professor Jones' modelling dispersion exercise. A curious feature of Mr Stear's evidence was that his calculations suggested that Mr Richards' exposure levels as a yard foreman between 1981 and 1985 were virtually identical to those he would have experienced as a process foreman between 1966 and 1981. Such a result conflicted with Mr Richards' evidence and was inconsistent with all the other evidence I have read or heard. Mr Stear did not accept that it was a surprising or unlikely result. I do not agree.

35. At Section 5 of my generic judgment, I concluded that the claimants had not established breach of duty in relation to exposure in the open areas of the Phurnacite Plant or the offices/canteen. I therefore accept that, for 85% of his time as a yard foreman, Mr Richards would have had no tortious exposure. However, I have concluded that, during the 15% of his time spent supervising the yard labourers in the briquetting plants and other dusty areas, the defendants would have been in breach of duty and Mr Richards would have had, as a yard foreman, 75% of the exposure of a process operative working in the same areas.

Assessment of overall exposure levels

36. Once I had reached some provisional conclusions about my findings of fact in Mr Richards' case, I invited Professor Jones to re-work his calculations on the basis of those provisional conclusions. This was not an exercise that I could have performed myself and it was undertaken by Professor Jones with the consent of the parties. I asked him to provide more detail of his workings than he had given previously in the event that it was necessary for me to make any adjustments to his calculations consequent upon any further findings I might make. Both parties have had the opportunity to comment on the additional material from Professor Jones and have done so. Save in connection with his calculations in respect of respirable dust (which are not relevant to the causation of bladder cancer and which in any event, having regard to my conclusions at Sections 4 and 11 of my generic judgment, I do not adopt), no criticism of his methodology was raised over and above that which has been discussed in my generic judgment.

37. Professor Jones' re-worked calculations are attached to this individual judgment at Appendix A. Briefly summarised, his estimates of Mr Richards' exposure during his employment at the Phurnacite Plant are, for total dust 292.2 $mgym^{-3}$, for BSM 32.3 $mgym^{-3}$ and for BaP 355.1 μgym^{-3}. Those figures make no deduction for any 'irreducible minimum' for the reasons I have discussed in Section 5 of my generic judgment. The figures include a relatively small amount of exposure to dust, BSM and BaP whilst Mr Richards was in the open areas of the Phurnacite Plant or the offices/canteen. I have found that the defendants were not in breach of duty during those periods. Since that exposure will not affect the outcome of the case, I have not re-calculated Professor Jones' figures to exclude it. However, I have excluded that dust exposure when calculating Mr Richards' exposure units.

38. It should be noted also that, since I provided information about my provisional findings to Professor Jones, I have reconsidered my approach to Mr Richards' work during his time as a yard foreman to include 15% of his time spent at the average exposure levels for the briquetting plants. That change would result in a modest increase to his overall exposure levels. I have not re-calculated Professor Jones' figures to reflect this. I have, however, taken this additional exposure into account when calculating Mr Richards' occupational exposure units.

39. I accept Professor Jones' figures as the best available estimates of Mr Richards' exposure levels during the period of his employment at the Phurnacite Plant. However, I am satisfied that, because they take no account of the effect of the sweeping and steam cleaning activities carried out in exhauster house 1, they underestimate by an unquantifiable amount Mr Richards' exposure to dust, BSM and BaP.

The medical issues

40. The medical evidence in Mr Richards' case in respect of bladder cancer came from Mr Pettersson and Mr Bishop and, in respect of the respiratory conditions, from Dr Rudd.

41. Mr Richards' evidence was that he stopped smoking in 1960, when he was about 28 years old. Documents in his medical records, dating from 2004 and 2007, suggest that he stopped in 1962. I shall assume that the latter date is correct and that he has not smoked for 50 years. Over a period of about 18 years, he smoked between 5 and 30

cigarettes a day. The medical experts agreed that smoking increases the risk of developing bladder cancer. However, they disagreed about whether, and if so to what extent, a man like Mr Richards, who had given up smoking many years previously, would still have been at an increased risk of developing bladder cancer as a result of his smoking history. I discussed their evidence and set out my conclusions at Section 9 of my generic judgment

Bladder cancer

42. In March 2000, Mr Richards began to suffer from haematoma and pain which he attributed to ulcers from which he had previously suffered. His symptoms persisted and, in September 2000, he was referred to hospital where he underwent a sigmoidoscopy. That revealed the presence of a polyp in the sigmoid colon. At the same time, it was discovered that his right kidney was not working properly. He underwent surgery to remove the polyp, during which it was noted that he almost certainly had an obstruction of the urethra caused by cancer of the bladder wall.

43. Shortly after the sigmoidoscopy, Mr Richards underwent resection of his bladder cancer. Thereafter, he was followed up at hospital where he underwent regular checks by means of flexible cystoscopy. In April 2002, he had a further bladder carcinoma removed. The medical experts agreed about the diagnosis in Mr Richards' case, although they did not take the same view about the extent to which he remains at risk of a recurrence of bladder cancer.

44. Mr Richards said that he was not told about the diagnosis of cancer in 2000. He understood that he had a serious problem but he believed that it was concerned with his non-functioning kidney. He said that he was concerned that his problem might be connected to his work in the exhauster house. He did not raise the matter with his doctors. Mr Richards' evidence was that, even after surgery, he was still unaware that he was being treated for cancer. Mr Richards said that, after his second tumour was removed, he remained unaware that he had suffered from bladder cancer. It was not until September 2007, after he had undergone surgery for carcinoma of the colon, that he was informed by the surgeon who had performed the surgery that he had previously had bladder cancer.

45. At Section 9 of my generic judgment, I discussed the evidence relating to the causation of bladder cancer. I concluded that, although the epidemiology suggests that it is possible that the fumes emitted during the carbonisation process at the Phurnacite Plant may have contained significant quantities of one or more substances capable of giving rise to an increased risk of bladder cancer, the epidemiological evidence, taken on its own, falls short of establishing that fact on a balance of probabilities.

46. I also found that, even if my view on the strength of the epidemiological evidence were different, I would be unable to quantify the increase in risk and I would therefore be unable to reach any conclusion as to the likelihood that Mr Richards' exposure to PAHs at the Phurnacite Plant – rather than his smoking or some unknown and wholly unrelated cause – had caused his bladder cancer. I therefore concluded that the claimants had not succeeded in establishing causation in the bladder cancer cases.

Respiratory symptoms

47. Mr Richards' evidence was that, whilst he was still smoking, he became short of breath and had a cough. After he gave up smoking, his chest problems persisted. A GP note made in April 1970 recorded a chest problem and a cold, together with the fact that Mr Richards was working at the Phurnacite Plant. Benylin was prescribed. In May 1970 it was noted that he was suffering from bronchitis and he was signed off work for two weeks. More Benylin was prescribed in June 1970.

48. It is not clear whether Mr Richards' GP notes between the early 1970s and the early 1980s are complete. Those that are available are often difficult to decipher. However, no reference to respiratory problems is evident until the mid-1980s. Mr Richards said that it was then that he started to have significant symptoms. On 3 October 1986, Mr Richards was complaining of a cough and cold. Again he was said to have "bronchitis". Mr Richards said that, at about that time, he realised that he had real problems with his chest as he was coughing up phlegm every morning. There were further entries in his GP records relating to respiratory symptoms in September 1989 and October 1990.

49. On 21 November 1990, Mr Richards' GP noted that he had a history of shortness of breath. He had a cough and had been "chesty" for over a month. He was referred for a chest x-ray. No results of that x-ray are available.

50. Further entries in the GP's records relating to respiratory symptoms were recorded in June 1991, February 1995, December 1995 and June 2003. Between 2006 and 2010, Mr Richards underwent a series of x-rays and CT scans which showed some mild pleural thickening. An x-ray report dated 25 April 2008 referred to the presence of "COAD" (another term for COPD). Mr Richards' evidence was that his symptoms have gradually worsened and he has shortness of breath on exertion and a productive cough.

Chronic obstructive pulmonary disease

51. The defendants accept that Mr Richards has mild COPD and that, in 2011, his respiratory disability was 10%. The parties agreed that his loss of respiratory function has been caused by a combination of his smoking and his exposure to dust at the Phurnacite Plant.

52. I have concluded at Section 11 of my generic judgment that Dr Rudd's 'broad brush' approach to quantifying the contribution made to a claimant's COPD by exposure to dust at the Phurnacite Plant is the appropriate method to adopt in the circumstances of this litigation. I have accepted Dr Rudd's evidence that a year's work on the oven floor was equivalent to a year's average smoking and, using that correlation as a basis, I have calculated Mr Richards' total occupational exposure units. My calculation is at Appendix B to this individual judgment.

53. The apportionment as between smoking and occupational exposure is as follows:

Smoking for 18 years (mixture of light, heavy and average smoking as apportioned by Dr Rudd)	*17 units*
Exposure to dust at the Phurnacite Plant Total exposure units	*10.62 units*
Occupational exposure responsible for	

10.62 ÷ (10.62 + 17) = 38% of causation

54. I therefore find that 38% of Mr Richards' respiratory disability of 10% (or a disability of 3.8%) is attributable to his occupational exposure to dust and fume at the Phurnacite Plant. It is to be noted that Mr Richards' exercise tolerance has been limited by pain and angina in the past so his disability is unlikely to have had a great deal of effect on his activities.

Chronic bronchitis

55. The defendants agree that Mr Richards currently has CB. They also agree that the issue of whether or not Mr Richards was suffering from CB during the period of his employment at the Phurnacite Plant depends on whether I accept his evidence. That evidence derives support from Mr Richards' medical records. I am satisfied that he had symptoms of CB during his employment with the defendants. I find that his CB was attributable in part to his smoking and in part to occupational exposure to dust in the same proportions as his COPD.

Limitation

56. I refer to Section 12 of my generic judgment, in which I discussed the generic issues relating to limitation. I shall now deal with the facts and issues relating specifically to Mr Richards' case.

Date of knowledge

57. It is accepted on Mr Richards' behalf that his date of knowledge for the purposes of the 1980 Act arose more than three years before the commencement of proceedings in his case. The issue of precisely when it arose (and therefore the exact length of delay that occurred before the commencement of proceedings) is, however, relevant to his application under section 33 of the 1980 Act. The defendants contend that Mr Richards acquired the necessary knowledge for the purposes of the 1980 Act during the 1970s when his respiratory symptoms started. Alternatively, they contend that he acquired knowledge in October 1986, when bronchitis was diagnosed.

58. I have already set out Mr Richards' relevant medical history, as disclosed by his medical records.

59. Mr Richards acknowledged that, in the 1970s, whilst working at the Phurnacite Plant, he suffered from respiratory symptoms which he believed were caused by a combination of his previous smoking and the dust and fume to which he was exposed at the Phurnacite Plant. He said that he did not think of making a claim at that time. It would not have occurred to him that he could do so. Nor did he seek any advice from his Union. Even in the 1980s, when his symptoms became worse, he did not consider making a claim.

60. Mr Richards made a claim against the defendants for NIHL in 1996. He said that he had consulted his Union solicitors in response to an advertisement in a newspaper. Other people he knew were making similar claims. Conditions in the exhauster house had been very noisy and he was suffering from constant buzzing in his ears. Mr Richards remembered making the claim but believed that he had claimed for tinnitus alone, not

hearing loss. However, the documents show that he received damages of £4,000 for both hearing loss and tinnitus.

61. In 2000, Mr Richards instructed a firm of solicitors, Browell Smith, to make a claim for VWF on his behalf. The claim was registered in the BCC VWF Scheme. No claims questionnaire or other evidence was lodged at that stage. Mr Richards did not undergo a medical examination. In 2001, the claim was rejected. Browell Smith indicated their intention to contest the rejection. In the event, however, no evidence was obtained and Mr Richards instructed his solicitors to withdraw the claim. In oral evidence, when the documents relating to this claim were shown to him for the first time, he denied having instructed solicitors to make the claim. Indeed he suggested that someone else must have done so. It is now clear from the additional documents that have been obtained that he had initiated the claim. He confirmed that he had in fact never suffered any symptoms of VWF.

62. Mr Richards accepted that, although he had not been aware in 2000 that he had been treated for bladder cancer, he had known that he had a serious problem and he had believed that it might have been caused by his working conditions at the Phurnacite Plant. He said that he had been aware that an Action Group had been formed with a view to obtaining compensation for former employees of the Phurnacite Plant. He did not think that it was open to him to become involved with the Action Group because he had been a foreman and belonged to a different Union from the men who were organising the Action Group. In about November 2009, he met a colleague who told him that former employees were making claims for cancer and respiratory disease. He referred Mr Richards to an article in the local newspaper, which identified Hugh James as the firm of solicitors involved in bringing the claims. Mr Richards contacted Hugh James and his name was entered onto the Phurnacite GLO Register on 15 March 2010. He said that, at that time, he was told that he could make claim in respect of his respiratory disease as well as his bladder cancer and he did so. By that time, his chest had got worse and he was having difficulty walking any distance.

63. I find that Mr Richards had the necessary knowledge about his symptoms of chronic bronchitis for the purposes of the 1980 Act no later than October 1986 when a diagnosis of bronchitis was made. It must have been clear to him by that time that his symptoms were likely to be lasting. However, it must be borne in mind that the symptoms referable to his respiratory disease have never been severe; even now, more than 25 years later, he is assessed as having only a 10% disability due to his COPD. In 2000, he became aware he had a more serious problem that might also be linked to his work at the Phurnacite Plant.

64. The primary limitation period in Mr Richards' case would have expired in October 1989. Proceedings in Mr Richards' case were commenced (by registration on the Phurnacite GLO Register) on 15 March 2010, over 20 years after the expiration of the primary limitation period.

Section 33

65. Apart from their generic grounds of prejudice, the defendants rely on specific features of Mr Richards' case in support of their contention that it would not be equitable to disapply the primary limitation period.

66. I must consider first the length of, and reasons for, the delay in Mr Richards' case. The defendants contend that the delay in commencing proceedings was very lengthy and that there was no good reason for it. Mr Richards' full-time employment at the Phurnacite Plant began 55 years ago and it is more than 26 years since it ended.

67. The defendants pointed out that Mr Richards had made claims for NIHL in 1996 and for VWF in 2000. Not only did that demonstrate that he was able and willing, if he chose, to institute a claim against his former employers, but it had also afforded him an opportunity to seek the advice of the solicitors dealing with his claims about the possibility of claiming for his respiratory disease. However, the process of making claims within the NIHL and VWF schemes was very straightforward. The schemes were well advertised and Mr Richards would no doubt have heard that some of his former colleagues were making claims under them. He may well have been encouraged to make a claim by former colleagues. He must have received that sort of encouragement with regard to his VWF claim since he was not suffering from the condition. I consider it unlikely, in the course of either of his claims, that he would have had a face to face meeting with a solicitor. Even if he did, it would not necessarily have occurred to him that he should seek advice about his respiratory disease.

68. If, in the mid-late 1990s, Mr Richards became aware of the claims being made for respiratory disease by miners and former miners in the BCRDL, he may well have concluded that, since the BCRDL claims related to underground work only, they had no relevance to his position.

69. There is no doubt that the delay here was lengthy. Mr Richards' evidence is that it had not occurred to him that he could make a claim for his respiratory symptoms. When he developed further symptoms, he still did not think that he could make a claim. He did not become aware until 2009 that a claim was possible. It was only when a friend told him about the GLO being co-ordinated by Hugh James that he took action. He then sought advice promptly and his claim was registered in the GLO shortly afterwards.

70. I accept the claimant's evidence that, until 2009, he was unaware that he could make a claim for his respiratory symptoms. The claims he made for NIHL and VWF do not affect my view since those claims were made in the context of existing organised schemes in which claimants were required to participate to a minimal extent. The fact that Mr Richards participated in those schemes does not mean that he was aware that it might be open to him to bring a claim at common law. His respiratory symptoms were mild and, even if he had known that a claim might be possible, he might have decided that it was not worth exploring the possibility. However when, in 2000, he developed a more serious problem that he believed might be attributable to his work, one would have expected him, if he knew that a claim was possible, at least to seek the advice of his Union. The fact that he did not do so strongly suggests that he was unaware that it would or might be open to him to make a claim. Thus, the delay, although lengthy, cannot in my view be considered to be in any way culpable.

71. I have already discussed the generic issues relating to the cogency of the evidence. In Mr Richards' case, I had the benefit of Mr Richards' own evidence, together with two witnesses (Mr Lanyon and Mr Silvanus) with detailed and personal knowledge of the work of a pumpsman and two witnesses (Mr Pugh and Mr Brian Jones), both of whom were very familiar with the duties of a process foreman. As a result, I am satisfied that I have a reasonably accurate picture of Mr Richards' working conditions throughout his time at the Phurnacite Plant.

72. I have not overlooked the fact that, if Mr Richards had acted promptly and had consulted solicitors soon after he had acquired knowledge in October 1986, the Phurnacite Plant would still have been open and it would have been possible for the Plant to have been inspected by experts and for exposure levels (in particular levels of respirable dust and exposure levels in the exhauster house) to have been measured. If he had delayed taking action until near the end of the primary limitation period it might have been too late for that to be done before production ceased. I have considered carefully whether that factor, in conjunction with the fact that other witnesses and additional documentation might also have been available then, has adversely affected the cogency of the evidence available to the defendants or their ability to defend themselves in the action.

73. Given all the evidence I have heard about the conditions at the Phurnacite Plant – and, in particular, about conditions on the batteries where Mr Richards mainly worked – I do not consider that the additional evidence is likely materially to have assisted the defendants in their defence of the action for respiratory disease for the reasons set out in Section 12 of my generic judgment. In the event, I have not based my findings in relation to the apportionment of Mr Richards' non-malignant respiratory disease on measurements of respirable dust. When assessing the extent of Mr Richards' respiratory disability that is attributable to occupational exposure, I have chosen to adopt the 'broad brush' approach advocated by Dr Rudd, an approach with which Professor Jones agreed in principle, at least with regard to exposure on the oven floor. Moreover, even if further measurements of respirable dust had been taken in the late 1980s, there would still have been the problem of estimating Mr Richards' exposure levels to respirable dust over the previous 30 years of his employment. It is highly likely that the 'broad brush' approach would still have been the best way of assessing his exposure for the purposes of COPD.

74. In all the circumstances, I have concluded, on balance, that the defendants' ability to defend the claim has not been compromised as a result of the delay and that it is fair and just to permit the action to proceed.

Conclusions

75. Mr Richards' claim therefore succeeds in respect of COPD and CB, but fails in relation to his bladder cancer. The agreed award of damages in his case is £4,500, inclusive of interest.

APPENDIX A

Frederick Richards

Occupancy Matrix

From	To	Job factor	Canteen / offices	Average external	Exhauster house 1	Pitch bay	Oven and shuttle floors	Quench, ramp and screens	Annual hours
11/04/1954	19/05/1957	1	0	0.7	0	0.05	0	0	2407
20/05/1957	29/01/1966	1	0	0	1	0	0	0	2407
30/01/1966	31/12/1974	0.75	0.25	0	0	0	0.617	0.133	2407
01/01/1975	31/12/1979	0.75	0.25	0	0	0	0.617	0.133	2407
01/01/1980	21/12/1981	0.75	0.25	0	0	0	0.617	0.133	2407
22/12/1981	28/02/1984	1	0.2	0.8	0	0	0	0	2407
01/03/1985	21/12/1985	1	0.2	0.8	0	0	0	0	2407

Frederick Richards

Exposure estimates

From	To	Job	Plant	Resp dust mg y m^{-3}	Tot dust mg y m^{-3}	BSM mg y m^{-3}	BaP µg y m^{-3}	Oven years	Resp excl ovens mg y m^{-3}
11/04/54	19/05/57	Capital gang	Pitch bay	0.29	1.16	0.33	7.30	0.00	0.29
11/04/54	19/05/57	Capital gang	Plant external average	1.29	7.71	1.02	10.21	0.00	1.29
20/05/57	29/01/66	Pumpsman, exhauster house 1	Exhauster house 1	4.41	26.44	3.48	34.78	0.00	4.41
30/01/66	31/12/74	Oven foreman, batteries 1, 2 and 3	Canteen / offices	0.12	0.62	0.10	9.59	0.00	0.12
01/01/75	31/12/79	Oven foreman, batteries 1, 2 and 3	Canteen / offices	0.06	0.24	0.05	0.50	0.00	0.06
01/01/80	21/12/81	Oven foreman, batteries 1, 2 and 3	Canteen / offices	0.02	0.09	0.02	0.20	0.00	0.02
30/01/66	31/12/74	Oven foreman, batteries 1, 2 and 3	Oven and shuttle floors	21.63	134.28	14.02	151.92	4.12	0.00
01/01/75	31/12/79	Oven foreman, batteries 1, 2 and 3	Oven and shuttle floors	12.10	74.17	7.86	85.12	2.31	0.00
01/01/80	21/12/81	Oven foreman, batteries 1, 2 and 3	Oven and shuttle floors	4.77	29.26	3.10	33.58	0.91	0.00
30/01/66	31/12/74	Oven foreman, batteries 1, 2 and 3	Quench, ramp and screens	1.08	6.76	0.71	6.52	0.89	0.00
01/01/75	31/12/79	Oven foreman, batteries 1, 2 and 3	Quench, ramp and screens	0.60	3.56	0.40	3.65	0.50	0.00
01/01/80	21/12/81	Oven foreman, batteries 1, 2 and 3	Quench, ramp and screens	0.24	1.40	0.16	1.44	0.20	0.00
22/12/81	28/02/84	Yard foreman	Canteen / offices	0.02	0.08	0.02	0.17	0.00	0.02
01/03/85	21/12/85	Yard foreman	Canteen / offices	0.01	0.03	0.01	0.06	0.00	0.01
22/12/81	28/02/84	Yard foreman	Plant external average	0.93	4.65	0.73	7.34	0.00	0.93
01/03/85	21/12/85	Yard foreman	Plant external average	0.34	1.72	0.27	2.71	0.00	0.34

Frederick Richards

Notes on exposure estimates

From	To	Job	Plant	Notes
11/04/54	19/05/57	Capital gang	Pitch bay	Exposure levels as per exposure matrix
11/04/54	19/05/57	Capital gang	Plant external average	
20/05/57	29/01/66	Pumpsman, exhauster house 1	Exhauster house 1	Exposure levels as per exposure matrix
30/01/66	31/12/74	Oven foreman, batteries 1, 2 and 3	Canteen / offices	Exposure levels as per exposure matrix
01/01/75	31/12/79	Oven foreman, batteries 1, 2 and 3	Canteen / offices	
01/01/80	21/12/81	Oven foreman, batteries 1, 2 and 3	Canteen / offices	
30/01/66	31/12/74	Oven foreman, batteries 1, 2 and 3	Oven and shuttle floors	Factor of 0.75 applied to exposure levels, but no further reduction for respiratory protection.
01/01/75	31/12/79	Oven foreman, batteries 1, 2 and 3	Oven and shuttle floors	
01/01/80	21/12/81	Oven foreman, batteries 1, 2 and 3	Oven and shuttle floors	
30/01/66	31/12/74	Oven foreman, batteries 1, 2 and 3	Quench, ramp and screens	
01/01/75	31/12/79	Oven foreman, batteries 1, 2 and 3	Quench, ramp and screens	
01/01/80	21/12/81	Oven foreman, batteries 1, 2 and 3	Quench, ramp and screens	
22/12/81	28/02/84	Yard foreman	Canteen / offices	Exposure levels as per exposure matrix. 12 month break in employment from March 1984 due to strike.
01/03/85	21/12/85	Yard foreman	Canteen / offices	
22/12/81	28/02/84	Yard foreman	Plant external average	
01/03/85	21/12/85	Yard foreman	Plant external average	

Frederick Richards
Estimates of FEV_1 loss

Summary exposure estimates

Resp dust mg y m^{-3}	Tot dust mg y m^{-3}	BSM mg y m^{-3}	BaP µg y m^{-3}	Oven years	Resp excl ovens mg y m^{-3}
47.9	292.2	32.3	355.1	8.9	7.5

Estimates of FEV_1 loss (ml)

	FEV_1 loss ml
Due to dust	11
Due to time in ovens	89
Total	100

APPENDIX B
RICHARDS

PERIOD	AREA	% TIME SPENT	EXPOSURE UNIT	DEDUCTION FOR NON-PROCESS JOB	NO. OF EXPOSURE UNITS
11/4/54-19/5/57 (3.1 years)	Pitch bay	5%	0.75	N/A	0.12
20/5/57-29/1/66 (8.7 years)	Exhauster house	100%	0.25	N/A	2.18
30/1/66-21/12/81 (14.9 years)	Oven floor	62%	1.00	75%	6.93
	Quenching car floor, screens and ramps	13%	0.75	75%	1.09
22/12/81-21/12/85 (3 years taking into account strike)	Briquetting plant	15%	0.90	75%	0.30
				Total exposure units	**10.62**

MICHAEL DOUGLAS ROBSON

1. Michael Douglas Robson was born on 30 December 1916. He died on 9 January 2000 aged 83 years.

The claim

2. The claim is brought by Mr Robson's son and executor, Mr Colin Robson (the claimant) on behalf of Mr Robson's estate under the provisions of the Law Reform (Miscellaneous Provisions) Act 1934. It is alleged that, as a result of his exposure to dust in the course of his employment at the Phurnacite Plant, coupled with his smoking habit, Mr Robson developed COPD which caused his death, together with CB.

The defendants' case

3. The defendants admit that they were in breach of duty towards Mr Robson throughout the period of his employment. They admit also that he developed COPD and CB and that his COPD probably caused his death. Dr Rudd and Professor Jones agreed that in broad terms a cumulative exposure respirable coal dust level of 200 mg y m^{-3} would be sufficient to double the risk of a disabling loss of lung function. The defendants contend that Mr Robson's exposure to dust fell well below that threshold and was therefore unlikely to have been caused by his occupational exposure at the Phurnacite Plant. They argued that the likely cause of his COPD and CB was his smoking habit.

4. The defendants contend that Mr Robson's claim is statute-barred under the provisions of the 1980 Act.

Damages

5. Damages in Mr Robson's case have been agreed, subject to the issues of causation, apportionment and limitation. Damages for pain, suffering and loss of amenity have been agreed in the sum of £62,381 and special damages in the sum of £5,996.70. The total damages are therefore £68,377.70, exclusive of interest.

6. It is agreed that there should be apportionment to exclude from compensation that part of Mr Robson's COPD and CB which can properly be attributed to his smoking habit. The defendants also contend that there should be apportionment to reflect any exposure to dust and fume which would inevitably have occurred without breach of duty on the defendants' part (i.e. the 'irreducible minimum').

Employment history

7. Mr Robson worked for various employers between 1931 and 1952. He then moved to the Phurnacite Plant. The defendants have been unable to trace any employment records for him. However, a detailed work history (presumably compiled by him) was included in a solicitors' letter claiming damages on his behalf for noise-induced hearing loss (NIHL) against the British Coal Corporation in March 1992. That work history stated that he worked at the Phurnacite Plant continuously between 1952 and 1980, a period of about 28 years. It is not suggested that he had any significant exposure to dust or fume other than at the Phurnacite Plant.

The witnesses

8. There is no evidence from Mr Robson himself. The claimant made a witness statement in March 2011 and gave oral evidence about his father's respiratory problems, the nature and extent of his disability, his smoking history and matters relating to limitation. The evidence about Mr Robson's working conditions came primarily from Mr Glanville Harris and Mr Brian Jones although they were only able to talk about conditions after 1971. Mr Harris was employed at the Phurnacite Plant between 1971 and 1982, first as deputy works chemist, then as a shift superintendent and finally as ovens assistant manager. He went on to hold the positions of deputy manager, then manager, of the Cwm Coke Works and subsequently held a senior post at CPL's Head Office. When Mr Harris joined the Phurnacite Plant, Mr Robson was a shift superintendent. Mr Harris got to know him slightly then. Between 1974 and 1975, the two men carried out the job of shift superintendent on different shifts. Mr Brian Jones worked as a shift superintendent with Mr Robson from 1974 until 1980. Having performed the job of shift superintendent themselves, both Mr Harris and Mr Brian Jones were in an excellent position to describe Mr Robson's working conditions.

9. There is no direct evidence about Mr Robson's employment between 1952 and 1971. It appears from the work history to which I have already referred that he worked in one of the briquetting plants as a labourer/spare man, a shift fitter and a foreman. I have heard a good deal of evidence about conditions in the briquetting plants and about the roles of a shift fitter and of a foreman. Mr Robson was described by another witness, Mr Lanyon, as a very "hands on" foreman.

Summary of evidence

10. Briefly summarised, the evidence about Mr Robson's working history at the Phurnacite Plant, as detailed in his solicitors' letter of March 1992, was as follows.

January 1952 – December 1953

11. In the letter of March 1992, written in support of his claim for NIHL, the potential sources of noise during his time as a spare man were identified as the boilers and the "drives". I infer from that that he spent this period working in one of the briquetting plants, where the boilers were situated. The "drives" could refer to the drive belts for the conveyors and other machinery in the briquetting plants. Alternatively, it could be a reference to "dryers". In either event, I find that Mr Robson was working in one of the briquetting plants during this period. A reasonable division of time would be 50% in the boiler house and 50% in the briquetting building.

January 1954 – December 1955

12. The work history states that, from 1954 to 1956, Mr Robson was a shift fitter and was exposed to noise from "dry core" (presumably dry coal) elevators and scrapers. The dry coal elevators were situated in the briquetting plants and there were also scrapers there. I consider it reasonable to assume that, during this period, Mr Robson spent 25% of his time in the fitter's workshop and other areas with a similar amount of 'background' exposure and the remainder of his time in the briquetting plants. For the reasons I have already referred to in my judgment in the case of Mr David Jones, I consider that, whilst in the briquetting plants, a fitter would on average be exposed to similar levels of dust as a process operative working in the same area.

January 1956 – December 1960

13. During this period, Mr Robson worked as a shift foreman. It is clear from the work history that he was employed in one of the briquetting plants at this time. I did not hear any direct evidence about the duties of a shift foreman working in a briquetting plant but assume that he would have fulfilled a similar role to that of a process foreman on the batteries. I have found that, when in the working areas, a process foreman would have had 75% of the exposure levels of a process operative working in the same areas. I adopt the same percentage for a shift foreman.

14. As to the division of time, I consider it appropriate to assume that, like Mr Richards, Mr Robson would have spent about 25% of his shift away from the working areas of the briquetting plant, carrying out administrative work in the foreman's office/canteen or in his own office in the briquetting plant, conferring with colleagues and walking between the various parts of the briquetting plant and between the briquetting plant and the foreman's office/canteen. I find that he would have spent the remainder of his time in the working areas of the briquetting plant.

January 1961 – December 1980

15. The work history states that Mr Robson was appointed to the position of shift superintendent in 1961. For the first ten years of his time in this role, he would have been in charge of both the briquetting plants and the batteries. The evidence of both Mr Brian Jones and Mr Harris was that, despite Mr Robson's responsibility for the batteries, most of his time would have been spent in the briquetting plants. It was there that most of the mechanical problems occurred. As from 1971, Mr Robson was responsible only for the briquetting plants, including the shuttle floors of the batteries. He would continue to visit the oven floors of the batteries on occasion in order to liaise with the shift superintendent there and would visit more often when the shift superintendent was absent for any reason. However, his time there would have been limited.

16. I have described the job of a shift superintendent at Section 4 of my generic judgment. It involved significant amounts of administrative work and regular discussions with colleagues. I am satisfied that these activities would have occupied an average of about 20% of each shift. In addition, some part of every shift would have been spent walking between the various locations. Given the distances involved, I am satisfied that this cannot have been less than 10% of each shift. During the remainder of the time, he would have been in the working areas of the briquetting plants or the batteries.

17. During the ten years for which he was covering the batteries as well as the briquetting plants, I consider it reasonable to assume that, of the 70% of his time remaining, Mr Robson would have spent 50% in the working areas of the briquetting plants and 10% on the oven floors of the batteries, 5% on the shuttle car floors of the batteries and 5% on the quenching car floor/ramps.

18. For the final nine years of his employment at the Phurnacite Plant, Mr Robson would have spent less time on the batteries. I consider it probable that, of the 70% of his time remaining after administrative work and travelling between locations, he would have spent 65% in the briquetting plants and 5% on the shuttle car floor and oven floors of the batteries.

19. I have found that, whilst in the working areas, a shift superintendent would have had 60% of the exposure levels of a process operative employed in the same areas.

20. The Table below summarises my findings in relation to Mr Robson's working history at the Phurnacite Plant.

TABLE 1

PERIOD	JOB TITLE	OTHER INFORMATION
Jan 1952-Dec 1953	Labourer/spare man, briquetting plant	50% boiler house; 50% briquetting building
Jan 1954-Dec 1955	Shift fitter	75% briquetting plant; 25% workshops or similar areas
Jan 1956-Dec 1960	Shift foreman, briquetting plant	75% briquetting plant; 25% in foreman's office/canteen or similar areas
Jan 1961-Dec 1970	Shift superintendent , briquetting plant and batteries	50% briquetting plant; 10% oven floors of batteries; 5% shuttle floors; 5% quenching car floors/ramps; 20% foreman's office/canteen; 10% walking between locations
Jan 1971-Dec 1979	Shift superintendent, briquetting plant	65% briquetting plant; 5% divided between oven floors and shuttle floors of batteries; 20% foreman's office/canteen; 10% walking between locations

Respiratory protective equipment

21. No suitable RPE was provided for use of employees at the Phurnacite Plant during Mr Robson's time there.

Overtime

22. There is no evidence about the extent to which Mr Robson worked overtime during the first nine years of his employment at the Phurnacite Plant. However, it is reasonable to assume that he worked an average amount, as calculated by Professor Syred. The evidence was that paid overtime was not available to shift superintendents. Thus, from January 1961 onwards, it should be assumed that Mr Robson did not work any overtime.

Exposure levels

23. The experts' assessments of Mr Robson's exposure levels are set out in the Table below:

TABLE 2

Expert	Total Dust (mg y m^{-3})	Respirable Dust (mg y m^{-3}) *(x 1.84)*	BSM (mg y m^{-3})	BaP (µg years m^{-3})
Syred	724	312	69	565
Stear	178		19	159
Jones	379.9	55.5*(102.12)*	27.8	251.2

24. The significant disparities between the experts' assessments are attributable to a number of factors. The first and most important of these is the difference of view about

the dust levels to which Mr Robson would have been exposed when working as a shift fitter, shift foreman and shift superintendent, when compared with the dust levels to which a process operative working in the same areas would have been exposed.

25. The experts also made different assumptions about the division of Mr Robson's time during his various periods of employment, especially when working as a shift superintendent.

Assessment of overall exposure levels

26. I have already indicated that, in general, I accept Professor Jones' approach to the assessment of exposure levels. Therefore, once I had reached some provisional conclusions about my findings of fact in Mr Robson's case, I invited Professor Jones to re-work his calculations on the basis of those provisional conclusions. This was not an exercise that I could have performed myself and it was undertaken by Professor Jones with the consent of the parties. I asked him to provide more detail of his workings than he had given previously in the event that it was necessary for me to make any adjustments to his calculations consequent upon any further findings that I might make. Both parties have had the opportunity to comment on the additional material from Professor Jones and have done so. Save for his calculations in respect of respirable dust (which, having regard to my conclusions at Sections 4 and 11 of my generic judgment, I do not adopt), no criticism of his methodology was raised over and above that which has been discussed in my generic judgment.

27. Professor Jones' re-worked calculations are attached to this individual judgment at Appendix A. Briefly summarised, his estimate of Mr Robson's total dust exposure during his employment at the Phurnacite Plant is 365.3mgym^{-3}. This figure includes a small amount of dust exposure during periods when Mr Robson was in the open areas of the Phurnacite Plant or the offices/canteen. I have found that the defendants were not in breach of duty during those periods. However, since that exposure will not affect the outcome of the case, I have not re-calculated Professor Jones' figures to exclude it. I have excluded that dust exposure when calculating Mr Robson's occupational exposure units. The figure makes no deduction for any 'irreducible minimum' for the reasons I have discussed in Section 5 of my generic judgment.

The medical issues

28. The medical evidence in Mr Robson's case comes from Dr Rudd. Whilst not a medical expert, Professor Jones has provided evidence about the epidemiological work on the causation of damage to lung function.

Smoking

29. There are entries in Mr Robson's medical records which indicate that he was smoking in 1976 but had stopped by July 1983. He had undergone surgery for a hernia in late 1982 and was reported to be concerned about his chest symptoms when he saw a consultant in March 1983. In the claims questionnaire (CQ) completed for the purposes of his BCRDL claim, the claimant stated that his father had stopped smoking in approximately 1980. Until that time, he had been smoking 20 cigarettes a day. In evidence, he said that so far as he was aware his father had given up smoking "quite a few years before he died". In 1996, when Mr Robson changed GPs, he was noted on the new GP's records to be a non-smoker. A note in April 1997 recorded that he had given up

smoking about 12 years previously, at the time of his hernia repair. All this evidence would point to the conclusion that Mr Robson had ceased smoking in 1983 at about the age of 67 years.

30. However, Dr Rudd referred to a measurement of Mr Robson's carboxyhaemaglobin level taken in June 1997 which he said made it "highly likely" that Mr Robson was a smoker at that time. The measurement constituted objective evidence and was therefore likely to be reliable. Moreover, Dr Rudd did not consider that the undoubted deterioration of Mr Robson's respiratory disability in the 1980s and 1990s was consistent with the cessation of his occupational exposure to dust in 1980 and of his smoking habit in 1983. He considered that the deterioration could only be explained by the fact that Mr Robson had continued smoking well beyond 1983. He therefore concluded that Mr Robson had smoked until 1997, i.e. for a total period of 63 years. Dr Rudd's evidence on that point was accepted by both parties and I too accept it.

31. Dr Rudd had seen no evidence relating to the number of cigarettes smoked by Mr Robson. He therefore assumed that his consumption was average, i.e. 15-25 cigarettes a day. That would accord with the information given by the claimant on the CQ.

History of respiratory illness

32. There are comparatively few medical records in Mr Robson's case and this has caused Dr Rudd some difficulty in formulating his conclusions.

33. Mr Robson's GP records are incomplete. There are no notes for the period between 1960 and 1973 or between 1976 and 1982. There are other, shorter, gaps of time also. The claimant's evidence was that his father's respiratory symptoms began in the late 1960s. He developed a productive cough and wheeze. The claimant moved away from his parents' home in 1969 and remembered that his father's symptoms had started before then. He described his father having fits of coughing during which he would bring up phlegm. These episodes became more frequent and lengthy as time went on. They disturbed his sleep. He also developed a wheeze in his chest.

34. In May 1975, Mr Robson's GP notes recorded a complaint of progressively worsening exertional breathlessness for several months. In April 1976, he was admitted to hospital with chest pain. A chest infection was diagnosed and treated. He reported having a productive cough in the mornings and breathlessness when climbing hills or stairs. At the time the GP's note was made, Mr Robson was still working at the Phurnacite Plant.

35. The claimant's evidence was that, during the 1970s, his father's symptoms worsened. They were more severe in cold weather. By the time he left the Phurnacite Plant in 1980, he was finding it hard to carry out his duties. After his retirement, his condition deteriorated and he required assistance with some everyday tasks. For about ten years from 1982, he and his wife used to spend three months in Cyprus each winter, which improved his condition. That arrangement ceased when Mr Robson suffered a bad attack of breathlessness at the airport. He did not go abroad again.

36. In October 1982, a consultant who was treating Mr Robson for a hernia described him as having "bad emphysema". In March 1983, Mr Robson told the consultant that he was experiencing increased problems relating to CB. In April 1989, he attended his GP reporting exertional breathlessness for the previous three to four weeks. Throughout the

early and mid-1990s, he was complaining of breathlessness which his GP attributed to COPD. In 1997, his GP noted that he was cyanosed and referred him to the chest clinic at the local hospital. Emphysema was diagnosed, together with COPD. He was to be assessed for oxygen therapy and to have nebulised bronchodilator therapy.

37. In June 1997, Mr Robson underwent lung function tests which showed evidence of COPD with emphysema. His FEV_1 was 1.3 litres. He was considered suitable for long term oxygen therapy. There were further attendances at the chest clinic when his symptoms of productive cough, breathlessness and cyanosis were again noted. In January 1999, he was unable to lie flat for examination and was using oxygen continuously at night. In April 1999, he was cyanosed and had obvious signs of airways obstruction. There are no further records relating to his respiratory symptoms up to the time of his death in January 2000.

38. The claimant said that, during the last five years before his father's death, his difficulties in breathing dominated his life. He had difficulty moving from room to room and eventually it came to the point when he required oxygen therapy at all times.

The medical evidence

39. The primary cause of death was certified as an acute exacerbation of chronic obstructive airways disease (COAD), another term for COPD. Emphysema was named as a secondary cause, with ischemic heart disease as a co-existing condition. The medical records that are available do not contain any reference to ischemic heart disease. There is no dispute that COPD caused Mr Robson's death. Dr Rudd considered that, the pathological basis of Mr Richards' COPD was predominately emphysema. He noted that the medical records confirmed the presence of CB during the time when Mr Robson was employed at the Phurnacite Plant.

40. Dr Rudd concluded that, as early as April 1976, Mr Robson had a respiratory disability due to COPD which Dr Rudd estimated at 20%. He considered that the disability would have been 30%-40% by the mid 1980s and that it would have increased to 60% by 1997. It would probably have increased to about 70%-80% by 1999. He estimated that, at the time of his death, Mr Robson would (but for his respiratory condition) have had a life expectancy of 2.4 years. I accept that evidence.

Causation

41. There is no doubt that Mr Robson was exposed to large quantities of dust. Since he was employed for much of his time in the briquetting plants, it is probable that a good deal of the dust to which he was exposed was respirable. However as I explained in Sections 4 and 11 of my generic judgment, I do not consider that it is possible on the available data to reach a reliable conclusion about the percentage of respirable dust present in the various areas of the Phurnacite Plant. It is not possible to say whether, if his exposure levels to respirable dust were known, he would have satisfied the 'doubling of risk' test.

42. However, I do not consider that, in the circumstances of Mr Robson's case, it is necessary for him to do so. COPD is a dose related condition and it is well known that both occupational exposure to dust and exposure to cigarette smoke can have the effect of causing the condition and/or of acting cumulatively to make it more severe. Mr Robson had a significant level of occupational exposure to dust whilst he was working at the

Phurnacite Plant and he developed symptoms of COPD and CB during his period of employment there. The evidence of the only medical witness to give evidence in Mr Robson's case was that his occupational exposure made a material contribution to the development of both conditions. I have no hesitation in accepting that evidence.

43. Mr Robson's injury will fall to be apportioned as between the effects of his occupational exposure and of his smoking. I have accepted Dr Rudd's evidence that a year's work on the oven floor was equivalent to a year's average smoking and, using that correlation as a basis, I have calculated Mr Robson's total occupational exposure units. My calculation is at Appendix B to this individual judgment.

44. The apportionment as between smoking and occupational exposure is as follows:

Average smoking for 62 years *62 units*
Exposure to dust at the
Phurnacite Plant *12.43 units*
Occupational exposure responsible for
12.43 ÷ (62 + 12.43) =17% of causation

45. I therefore find that 17% of Mr Robson's final respiratory disability of 70% (or a disability of 12%) was attributable to his occupational exposure to dust at the Phurnacite Plant. I find that his CB was attributable in part to his smoking and in part to occupational exposure to dust in the same proportions as his COPD.

Limitation

46. I refer to Section 12 of my generic judgment, in which I discussed the generic issues relating to limitation. I shall now deal with the facts and issues relating specifically to Mr Robson's case.

Date of knowledge

47. It is accepted on Mr Robson's behalf that his date of knowledge for the purposes of the 1980 Act arose more than three years before the commencement of proceedings. The issue of precisely when it arose (and therefore the exact length of delay that occurred before the commencement of proceedings) is, however, relevant to the claimant's application under section 33 of the 1980 Act.

48. I have already set out Mr Robson's relevant medical history, as disclosed by his medical records.

49. The claimant's evidence is that, from the late 1960s, when he first developed respiratory symptoms, Mr Robson recognised that they might be caused by exposure to dust at the Phurnacite Plant. The claimant said that his father was a proud, stoical individual who was good at his job and was not a person who would complain about his working conditions. He accepted his respiratory symptoms as "part and parcel" of his job. He did not believe that his father had considered making a claim at that stage. He assumed from the fact that his father had not made a claim that he did not know it was possible to do so. Even when Mr Robson's respiratory condition deteriorated, he never mentioned the possibility of making a claim.

50. Mr Robson made a claim for NIHL in 1992, through solicitors acting for his Union. His claim was settled for £1,500 in 1993. The claimant said that he was unaware of the fact that his father had made such a claim. His father had not mentioned it to him. He could not say whether his father had sought or received any legal advice about the possibility of bringing a claim in respect of his respiratory condition. He said that his father might have been aware of the publicity surrounding the claims by underground workers in what became known as the BCRDL. If so, he had not mentioned it to the claimant. The claimant accepted that, in the 1980s and 1990s, there was local and national publicity about possible health risks to employees and former employees at the Phurnacite Plant. However, the matter had not been discussed between him and his father.

51. The claimant said that, after his father's death, he saw some publicity about the BCRDL which identified COPD as one of the conditions for which a claim could be made. He responded to an advertisement placed by Hugh James who registered his claim in the BCRDL in January 2003. Proceedings are deemed to have been commenced on that date. The claimant completed a CQ in September in 2003. In the event, his claim was rejected on the ground that Mr Robson had not worked underground. At a later stage, the claimant was advised that he may be able to make a claim within the Phurnacite litigation.

52. The defendants contended that Mr Robson acquired the necessary knowledge for the purposes of the 1980 Act in about 1969 when his respiratory symptoms started. On behalf of the claimant, it was conceded that he had acquired the relevant knowledge by early October 1982, when emphysema was diagnosed.

53. It seems to me that it may not have been clear to Mr Robson, at the time his symptoms first appeared, that his condition would be lasting and that it was therefore 'significant'. I am satisfied, however, that, by mid-1975, when his symptoms of cough and sputum were persisting and, in addition, he had been suffering from progressive exertional breathlessness for several months, he had the relevant knowledge. By that time, he was finding his work more difficult and, according to his son, he believed that his condition was, in part at least, caused by exposure to dust at work. The primary limitation period in his case would have expired in mid-1978. Proceedings in respect of his exposure were commenced about 25 years after that time.

Section 33 of the 1980 Act

54. Apart from their generic grounds of prejudice, the defendants rely on specific features of Mr Robson's case in support of their contention that it would not be equitable to disapply the primary limitation period.

55. I must consider first the length of, and reasons for, the delay in Mr Robson's case. The defendants contend that the delay in commencing proceedings was very lengthy and that there was no good reason for it. Mr Robson's employment at the Phurnacite Plant began almost 60 years ago and it is more than 30 years since it ended.

56. The defendants pointed out that Mr Robson had made a claim for NIHL in 1992. Not only did that demonstrate that he was able and willing, if he chose, to institute a claim against his former employers, but it had also afforded him an opportunity to seek the advice of the solicitors dealing with his NIHL claim about the possibility of claiming for his respiratory disease. However, the process of making a claim within the NIHL

scheme was very straightforward. The scheme was well advertised and Mr Robson would no doubt have heard that some of his former colleagues were making claims under it. He may well have been encouraged to make a claim by his Union or former colleagues. I consider it unlikely that, in the course of his NIHL, he would have had a face to face meeting with a solicitor. Even if he did, it would not necessarily have occurred to him that he should seek advice about a condition other than deafness.

57. It seems probable that, in the mid-late 1990s, Mr Robson would have become aware of the claims being made for respiratory disease by miners and former miners in the BCRDL. However, the BCRDL claims related to underground work only and, thus, Mr Robson may well have concluded (correctly) that they had no relevance to his position.

58. There is no doubt that the delay here was very lengthy. Since Mr Robson is dead, we cannot be sure why he did not make a claim. His respiratory disease was causing him significant disability by the early 1980s and it may have been one of the factors which caused him to retire in 1980. If he had been aware that a claim was or might be possible, one would have expected him at least to seek the advice of his Union about the matter at that stage. The fact that Mr Robson made a claim for his relatively minor noise-induced deafness and did not make a claim for his respiratory disease strongly suggests that he was unaware that it would or might be open to him do so. Certainly, it does not seem that he discussed the possibility with his family. The claimant did not become aware until 2003 that a claim was possible. By that time of course his father was dead. The claimant himself took prompt action to seek advice and his claim was registered within the BCRDL shortly afterwards.

59. I consider it probable that the claimant's assumption is right and that Mr Robson was unaware that he could make a claim. The claim he made for NIHL does not affect my view since that claim was made in the context of an existing organised scheme in which claimants were required to participate to a minimal extent. The fact that Mr Robson participated in that scheme does not mean that he was aware that it might be open to him to bring a claim at common law. The delay, although lengthy, cannot in my view be considered to be culpable.

60. I have already discussed the generic issues relating to the cogency of the evidence. In Mr Robson's case, no training records are available. That might have presented very real difficulties in ascertaining his work history at the Phurnacite Plant. However, there is the work history set out in March 1992 letter, which makes it reasonably clear where Mr Robson would have been working in his early years at the Plant. Although there were no witnesses with direct knowledge about Mr Robson's work between 1952 and 1971, I have receieved a considerable amount of evidence about conditions in the briquetting plants during that period.

61. I also had the benefit of two witnesses of management level (Mr Harris and Mr Brian Jones), both of whom had personal and detailed knowledge of Mr Robson and of the work of a shift superintendent, the role he occupied from 1961 until his retirement in 1980. Both Mr Harris and Mr Brian Jones gave oral evidence and the defendants' counsel was able to cross-examine them. As a result, I am satisfied that I have a reasonably accurate picture of Mr Robson's working conditions throughout his time at the Phurnacite Plant.

62. As I have already mentioned, the medical records in Mr Robson's case are somewhat sparse. Nevertheless, it has been possible for Dr Rudd to reach a clear diagnosis, with which Dr Moore-Gillon agreed. As to Mr Robson's smoking history, I have accepted Dr Rudd's view, which is favourable to the defendants.

63. I have not overlooked the fact that, if Mr Robson had acted promptly and had consulted solicitors in the 1970s or 1980s, the Phurnacite Plant would still have been open and it would have been possible for the Plant to have been inspected by experts and for exposure levels (in particular levels of respirable dust) to have been measured. I have considered carefully whether that factor, in conjunction with the fact that other witnesses and additional documentation might also have been available then, has adversely affected the cogency of the evidence available to the defendants or their ability to defend themselves in the action.

64. Given all the evidence I have heard about the conditions at the Phurnacite Plant – and, in particular, about conditions in the briquetting plants where Mr Robson mainly worked – I do not consider that the additional evidence is likely materially to have assisted the defendants in their defence of the action for the reasons set out in Section 12 of my generic judgment. In the event, I have not based my findings in relation to causation upon measurements of respirable dust. Instead, I have chosen to adopt the 'broad brush' approach advocated by Dr Rudd, an approach with which Professor Jones agreed in principle, at least with regard to exposure on the oven floor. Even if further measurements of respirable dust had been taken in the 1970s or 1980s, there would still have been the problem of estimating Mr Robson's exposure levels to respirable dust over the previous 20 or 30 years of his employment. It is highly likely that the 'broad brush' approach would still have been the best way of assessing his exposure for the purposes of COPD.

65. In all the circumstances, I have concluded, on balance, that the defendants' ability to defend the claim has not been compromised as a result of the delay and that it is fair and just to permit the action to proceed.

Conclusions

66. Mr Robson's claims for COPD and CB therefore succeed. The agreed award of damages in his case is £13,233.43, inclusive of interest.

APPENDIX A

Michael Douglas Robson

Occupancy matrix

From	To	Job factor	Fractional occupancy							Annual hours
			Canteen / offices	Average external	Boiler house	Workshops	Briquetting	Oven and shuttle floors	Quench, ramp and screens	
01/01/1952	31/12/1953	1	0	0	0.5	0	0.5	0	0	2407
01/01/1954	31/12/1955	1	0	0	0	0.25	0.75	0	0	2407
01/01/1956	31/12/1960	0.75	0.25	0	0	0	0.75	0	0	2407
01/01/1961	31/12/1970	0.75	0.2	0.1	0	0	0.5	0.15	0.05	1900
01/01/1971	31/12/1974	0.6	0.2	0.1	0	0	0.65	0.05	0	1900
01/01/1975	31/12/1979	0.6	0.2	0.1	0	0	0.65	0.05	0	1900

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Exposure estimates

From	To	Job	Plant	Resp dust mg y m^{-3}	Tot dust mg y m^{-3}	Oven years	Resp excl ovens mg y m^{-3}
01/01/52	31/12/53	Labourer/spare man, briquetting	Boilerhouse	0.15	1.27	0.12	1.20
01/01/52	31/12/53	Labourer/spare man, briquetting	Briquetting	4.43	26.59	1.90	12.99
01/01/54	31/12/55	Shift fitter	Briquetting	6.64	39.82	2.84	19.46
01/01/54	31/12/55	Shift fitter	Workshops	0.34	1.58	0.27	2.69
01/01/56	31/12/60	Shift foreman, briquetting	Briquetting	13.06	81.94	5.81	41.24
01/01/56	31/12/60	Shift foreman, briquetting	Canteen / offices	0.07	0.35	0.05	5.37
01/01/61	31/12/70	Shift superintendent, Briquetting and batteries	Briquetting	13.74	86.21	7.75	54.98
01/01/61	31/12/70	Shift superintendent, Briquetting and batteries	Canteen / offices	0.09	0.44	0.09	8.60
01/01/61	31/12/70	Shift superintendent, Briquetting and batteries	Oven and shuttle floors	4.66	28.90	3.82	41.42
01/01/61	31/12/70	Shift superintendent, Briquetting and batteries	Plant external average	0.47	2.80	0.47	4.70
01/01/61	31/12/70	Shift superintendent, Briquetting and batteries	Quench, ramp and screens	0.36	2.25	0.30	2.75
01/01/71	31/12/74	Shift superintendent, Briquetting	Briquetting	5.98	38.97	3.48	25.46
01/01/75	31/12/79	Shift superintendent, Briquetting	Briquetting	7.21	44.43	4.09	29.23
01/01/71	31/12/74	Shift superintendent, Briquetting	Canteen / offices	0.03	0.18	0.03	3.44
01/01/75	31/12/79	Shift superintendent, Briquetting	Canteen / offices	0.04	0.15	0.04	0.40
01/01/71	31/12/74	Shift superintendent, Briquetting	Oven and shuttle floors	0.53	3.26	0.43	4.64
01/01/75	31/12/79	Shift superintendent, Briquetting	Oven and shuttle floors	0.65	3.97	0.54	5.80
01/01/71	31/12/74	Shift superintendent, Briquetting	Plant external average	0.19	1.12	0.19	1.88
01/01/75	31/12/79	Shift superintendent, Briquetting	Plant external average	0.21	1.05	0.21	2.10

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Notes on exposure estimates

From	To	Job	Plant	Notes
01/01/52 01/01/52	31/12/53 31/12/53	Labourer/spare man, briquetting Labourer/spare man, briquetting	Boilerhouse Briquetting	Exposure levels as per exposure matrix
01/01/54 01/01/54	31/12/55 31/12/55	Shift fitter Shift fitter	Briquetting Workshops	Exposure levels as per exposure matrix
01/01/56	31/12/60	Shift foreman, briquetting	Briquetting	Factor of 0.75 applied to exposure levels attributed to plant
01/01/56	31/12/60	Shift foreman, briquetting	Canteen / offices	Exposure levels as per exposure matrix
01/01/61	31/12/70	Shift superintendent, Briquetting and batteries	Briquetting	Factor of 0.75 applied to exposure levels attributed to plant
01/01/61	31/12/70	Shift superintendent, Briquetting and batteries	Canteen / offices	Exposure levels as per exposure matrix
01/01/61	31/12/70	Shift superintendent, Briquetting and batteries	Oven and shuttle floors	Factor of 0.75 applied to exposure levels attributed to plant
01/01/61	31/12/70	Shift superintendent, Briquetting and batteries	Plant external average	Exposure levels as per exposure matrix
01/01/61	31/12/70	Shift superintendent, Briquetting and batteries	Quench, ramp and screens	Factor of 0.75 applied to exposure levels attributed to plant
01/01/71 01/01/75	31/12/74 31/12/79	Shift superintendent, Briquetting Shift superintendent, Briquetting	Briquetting Briquetting	Factor of 0.6 applied to exposure levels attributed to plant
01/01/71 01/01/75	31/12/74 31/12/79	Shift superintendent, Briquetting Shift superintendent, Briquetting	Canteen / offices Canteen / offices	Exposure levels as per exposure matrix
01/01/71 01/01/75	31/12/74 31/12/79	Shift superintendent, Briquetting Shift superintendent, Briquetting	Oven and shuttle floors Oven and shuttle floors	Factor of 0.6 applied to exposure levels attributed to plant
01/01/71 01/01/75	31/12/74 31/12/79	Shift superintendent, Briquetting Shift superintendent, Briquetting	Plant external average Plant external average	Exposure levels as per exposure matrix

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Estimate of FEV_1 loss

Summary exposure estimates

Resp dust mg y m^{-3}	Tot dust mg y m^{-3}	Oven years	Resp excl ovens mg y m^{-3}
58.9	365.3	1.8	52.7

Estimates of FEV_1 loss (ml)

	FEV_1 loss ml
Due to dust	74
Due to time in ovens	18
Total	92

APPENDIX B
ROBSON

PERIOD	AREA	% TIME SPENT	EXPOSURE UNIT	DEDUCTION FOR NON-PROCESS JOB	NO. OF EXPOSURE UNITS
1952-53 (2 years)	Briquetting plant	50%	0.90	N/A	0.90
	Boiler House	50%	0.25	N/A	0.25
1954-55 (2 years)	Briquetting plant	75%	0.90	N/A	1.35
	Workshops	25%	0.25	N/A	0.14
1955-60 (5 years)	Briquetting plant	75%	0.90	75%	2.53
1961-70 (10 years)	Briquetting plant	50%	0.90	60%	2.70
	Oven and shuttle floors	15%	1.00	60%	0.90
	Quench, ramp and screens	50%	0.75	60%	0.23
1971-79 (9 years)	Briquetting plant	65%	0.90	60%	3.16
	Ovens and shuttle floors	5%	1.00	60%	0.27
				Total exposure units	**12.43**