

MAXIMUM EXPOSURE LIMIT FOR HYDROQUINONE

REGULATORY IMPACT ASSESSMENT

PURPOSE AND INTENDED EFFECT

Issue and objective

1. Hydroquinone has been considered for review alongside phenol, as the two substances are inter-convertible in the body, and have similarities in metabolic pathways and toxicological profiles.
2. Phenol has been dealt with earlier, because of its inclusion in a Commission Directive on Indicative Occupational Exposure Limit Values (IOELVs). The IOELV for phenol is 2 ppm (7.7 mg.m⁻³) 8-hour time-weighted average (TWA) exposure, based on a recommendation by the EU Scientific Experts Group in 1992. The Health and Safety Commission's (HSC's) Advisory Committee on Toxic Substances (ACTS) agreed in July 2000 to recommend a maximum exposure limit (MEL) at 2 ppm (8-hour TWA). This recommendation was consulted externally. In July 2001, ACTS endorsed the proposal for a MEL at this value, subsequently agreed by HSC in September 2001 to come into effect on 31 December 2001.
3. The Occupational Exposure Standards (OESs) for hydroquinone at 2 mg.m⁻³ (8-hour TWA) and 4 mg.m⁻³ (15-minute short-term exposure limit) were withdrawn in 2001 following external consultation. A Chemical Hazard Alert Notice (CHAN 18) was issued in 2000.
4. The objective of this proposal is to assure protection of health by the setting of a maximum exposure limit (MEL) for hydroquinone as an 8-hour time-weighted average value. The costs quoted in the document are (unless otherwise stated) those that were current at the time this RIA was written (2000).

Risk assessment

5. Hydroquinone and phenol share practically identical major metabolic pathways. This is indicated by phenol being eliminated as phenol and hydroquinone urinary conjugates. Phenol had been scheduled in the ACTS Working Group on the Assessment of Toxic Chemicals (WATCH) programme through concerns about mutagenic effects. WATCH reviewed hydroquinone in January 2000.
6. In October 1999, the UK Committee on Mutagenicity (CoM) had concluded that there was insufficient evidence to support a threshold approach to risk assessment for inhalation or dermal exposure to hydroquinone. The available data showed that occupational exposure to hydroquinone was associated with a risk of mutagenicity but it was not possible to quantify that risk.
7. Considering the opinion of CoM, WATCH recommended for hydroquinone:
 - that the criteria were not met for recommending that an OES be set, and as genotoxicity was the critical adverse health effect, a MEL was appropriate;
 - that no short-term exposure limit (STEL) was necessary;
 - that the criteria for "Skin" and "Sen" notations were not fulfilled, and no notations were needed.

8. WATCH agreed that hydroquinone did not meet the criteria for development of a Biological Monitoring Guidance Value (BMGV).

9. The genotoxic properties raise concerns that hydroquinone could cause changes in the body that may lead to cancer. However, in relation to the potency of any carcinogenic properties, WATCH advised that hydroquinone was not a potent carcinogen, and there appeared to be no positive evidence of serious implications for health arising from current occupational conditions of exposure to hydroquinone.

OPTIONS

10. HSE has undertaken a Regulatory Impact Assessment for a MEL at two levels of exposure (8-hour TWA):

- a MEL of 0.5 mg.m^{-3} ; and
- a MEL of 1.0 mg.m^{-3} .

11. The occupational exposure data collected for the WATCH risk assessment review suggested that it was reasonably practicable for industry to control exposure to 1 mg.m^{-3} or below.

INFORMATION SOURCES AND BACKGROUND ASSUMPTIONS

12. The WATCH review indicated that fewer than 5,000 people are potentially exposed to hydroquinone at work, although only a minor proportion of these incur exposure by inhalation. HSE sought evidence from industry for the implications of compliance with MEL proposals at 0.5 mg.m^{-3} and 1 mg.m^{-3} (8-hour TWA).

13. Hydroquinone is not synthesised in Britain – it is all imported. A questionnaire was issued to 15 companies who used hydroquinone. The questionnaire sought information on:

- the industry sector and its plans to continue use of hydroquinone, the numbers exposed and the tasks performed;
- the existing control measures and the associated concentration ranges;
- the estimated costs of reducing exposure below 0.5 mg.m^{-3} and 1 mg.m^{-3} ; and
- data on ill health, work days lost or necessary job changes.

14. Individual responses to the questionnaire are detailed in the Appendix.

15. The information in this RIA is based on the responses of 13 user companies to the questionnaire. One user's reply concerned the formulation of surface coatings and asserted no use of hydroquinone as a raw material.

Technical Assumptions

16. All costs are calculated in 2000/2001 prices over a ten-year period¹. The base year for appraisal is year 2000/2001. Details of the actual costings are described below.

¹ In arriving at ten year cost figures, two adjustments are made. Firstly, earnings are assumed to rise by 1.8% per year in real terms - the observed increase for the whole economy over the past twenty-five years or so. Secondly, costs are discounted to present value using the Treasury recommended 6% discount rate.

BENEFITS

Health and Safety benefits

17. An estimated 1,060 people are occupationally exposed to hydroquinone (in powder form) by inhalation. In the opinion of the Committee on Mutagenicity, occupational exposure to hydroquinone is associated with a risk of mutagenicity, but it is not possible to quantify the risk. Granted that such a risk exists, any reduction in exposure would be expected to reduce the risk, but it is not possible to quantify this. There is no information that shows ill health currently attributable to inhalation of hydroquinone (See Balance of Costs and Benefits section below).

Cost savings

18. There are some cost savings in the industry sector c) (see paragraph 20), *using hydroquinone as a raw material in manufacture of fine chemical, rubber, thermoplastic polymers, etc.* These arise through the installation of local exhaust ventilation (LEV) making the need for respiratory protective equipment unnecessary. The cost savings are based on the following:

- an estimate of £500-£600 per person per year for RPE²;
- 90 companies install LEV; and
- an average of 2 employees exposed per company.

This results in annual cost savings of approximately between £90,000 and £108,000.

19. Total cost savings over ten years would be between approximately £662,000 and £795,000 in net present value terms.

COSTS

Business sectors affected

20. The risk assessment identified numerous sectors where people are exposed to hydroquinone. The business sectors potentially affected by implementing a MEL for hydroquinone are listed below:

- a) photographic and imaging product manufacture
- b) polymerisation inhibitors for bulk chemical supply
- c) fine chemical, rubber, thermoplastic polymer etc. manufacture
- d) resin manufacture and resin use for surface coatings and inks
- e) plate making in printing
- f) photographic and imaging product use
- g) use of printing ink
- h) spraying paint and surface coatings

² McAlinden JJ, Costing a Respiratory protective Equipment (RPE) Programme, (1996) Specialist Inspector Report Number 50).

Compliance costs for each sector of industry

21. Tables 1 and 2 below summarise the costs of the two MEL options. The costs per sector are detailed in the paragraphs below. Details for the individual user sectors appear in Tables 3 to 9.

Table 1 Handling hydroquinone as a raw material

Companies in this sector	339 companies or sites.	
Total number of workers exposed	1060 using powder	
Control required	LEV for powder addition and bag crushing	
MEL value proposal	0.5 mg/m ³	1.0 mg/m ³
Companies / sites requiring improvement	264	144
Capital cost	£1,640k to £1670k	£1,400k to £1430k
Control maintenance, continuing cost	£138k to £143k	£138k to 143k
Continuing substitute cost	£54k	£54k
Continuing RPE savings (see para 18 above)	minus £90k to £108k	minus £90k to £108k
Monitoring cost	£144 to £217k	£144 to £217k

Table 2 Exposure to hydroquinone in products

Control required	Existing RPE for antifoulant spraying	
MEL value proposal	0.5 mg/m ³	1.0 mg/m ³
Capital cost	None	None
Control maintenance - continuing cost	None	None
Continuing substitute cost	None	None
Monitoring cost	None	None

22. HSE believes that loading is the task with the potential for significant exposure. To demonstrate compliance with the MEL, each company will have to monitor its employees' exposure during loading crystalline hydroquinone. HSE estimates the cost of hiring a consultant to measure exposure to hydroquinone at £400 to £600, and that monitoring would be required once to demonstrate compliance.

23. Although industry did not identify compliance costs, HSE believes that compliance with a MEL at 1 mg.m⁻³ will require all companies to have local exhaust ventilation at charging and bag crushing, and that installation of new LEV will incur a cost of £10,000 per site. Such installations incur ongoing maintenance costs of £1,000 per annum.

Exposure to hydroquinone as a raw material

(a) Photographic and imaging product manufacture

24. Hydroquinone is supplied as crystalline powder in 25 kg sacks for dissolution in water to make photographic preparations with potential exposure by inhalation at the mixer charging stage.

25. The cost estimates below are based on the following assumptions:

- 16 companies operate in this sector, two-thirds of which have local exhaust ventilation in place for loading operations³;
- 5 companies will need to install this control at £10,000, with ongoing maintenance costs of 10%;
- existing LEV systems at charging and bag crushing are capable of controlling exposure below 1.0 mg.m⁻³ TWA;
- for compliance with a MEL of 0.5 mg.m⁻³, in addition to the cost identified above, some companies will need to improve the design or use of this control. HSE estimates that 5 companies – half of those with existing LEV systems – will need to invest £2,000 but without additional ongoing maintenance costs.

26. The cost estimate for photographic and imaging product manufacture is set out in Table 3.

Table 3 Photographic and imaging product manufacture

Powder dissolution – making bulk developer	One of three responses quoted exposure at 0.1 to 0.9 mg/m ³ (8-hour TWA) using LEV and two of the three responses identified using LEV.	
Companies in this sector	16	
Total number of workers	(average - 15 exposed per company) = 240 workers	
Control required	LEV for loading point and bag collector	
MEL value proposal	0.5 mg.m ⁻³	1.0 mg.m ⁻³
Capital cost	£2k for 5 companies + £10k for 5 companies = £60k total	£10k for 5 companies = £50k total
Control maintenance - continuing cost	£5k total	£5k total
Other continuing cost	-	-
Monitoring cost (one-off)	£6.4k - £9.6k	£6.4k - £9.6k

27. For a MEL of 0.5 mg.m⁻³ over ten years, costs would be approximately £103,000 to £106,000 in net present value terms. For a MEL of 1.0 mg.m⁻³ over ten years, costs would be approximately £94,000 to £97,000 in net present value terms.

(b) Use as a polymerisation inhibitor in bulk chemical supply

³ 16 companies based on HSE search of trade directories. Other assumptions based on sample responses to the questionnaire.

28. Hydroquinone is supplied as crystalline powder in 25 kg sacks for dissolution in the bulk chemical with potential exposure during mixer charging. As for photographic and imaging products, the potential exposure routes are by inhalation and dermal contact at the mixer charging stage. Mixer charging is an intermittent activity

29. The number of employees potentially exposed in the two companies is 97, of which up to 30% handle hydroquinone directly. Neither company reported ill health, days lost or the necessity for change of job through exposure to hydroquinone.

30. The cost estimates below are based on the following assumptions:

- 50 companies operate in this sector;
- 50% of these companies have local exhaust ventilation in place for loading operations;
- 25 companies will each need to install LEV control at £10,000, with ongoing maintenance of 10%;
- if a limit were set at 0.5 mg.m^{-3} , an additional 25 companies would need to improve the standard of control at a unit cost of £2,000.

31. The cost estimates for addition of polymerisation inhibitors are set out in Table 4.

Table 4 Polymerisation inhibitors for bulk chemical supply

Powder addition to bulk mixer	Two responses. One estimated exposure at $>1 \text{ mg.m}^{-3}$ and used air-fed RPE (additional risk from monomer). The other used LEV, estimating $0.5 \text{ to } 1.0 \text{ mg.m}^{-3}$ (8-hour TWA)	
Companies in this sector	50	
Total number of workers	Average 2 users of 15 exposed per company = 750 workers	
Control required	LEV for loading point and bag collector	
MEL value proposal	0.5 mg.m^{-3}	1.0 mg.m^{-3}
Capital cost	£10k for 25 companies + £2 k for 25 companies = £300k total (or research on substitutes)	£10k for 25 companies = £250k total
Control maintenance - continuing cost	£25k total	£25k total
Other continuing cost	Substitute	-
Monitoring cost	£20 to 30k	£20 to 30k

32. For a MEL of 0.5 mg.m^{-3} over ten years, costs would be approximately £504,000 to £513,000 in net present value terms. For a MEL of 1.0 mg.m^{-3} over ten years, costs would be approximately £457,000 to £466,000 in net present value terms.

(c) Fine chemical, rubber and thermoplastic polymer etc. manufacture

33. The number of employees potentially exposed is 110, of which about 25% were reported to handle hydroquinone directly. 30.

34. The cost estimates below are based on the following assumptions:

- 250 companies operate in this sector;
- 1/3 of these companies have adequate LEV in place for loading operations;
- 90 companies will need to install adequate LEV at £10,000, with ongoing maintenance costs of 10%;
- if a limit were set at 0.5 mg.m⁻³, an additional 90 companies would need to upgrade their LEV at a cost of £2000.

35. Table 5 sets out the cost estimate in the fine chemical, etc. sector.

Table 5 Fine chemical, rubber, thermoplastic polymer etc. manufacture

Powder addition to reactor or mixer	Three responses. 1 - loading point enclosure, control to 0.15 mg.m ⁻³ 2 - replacement of charging point LEV system 3 - no data, believed exposure below 0.5 mg.m ⁻³	
Companies in this sector	Many companies do not use hydroquinone – estimated number of users - 250	
Total number of workers	Average 2 users of 12 exposed per company = 750 workers	
Control required	LEV for loading point and bag collector	
MEL value proposal	0.5 mg.m ⁻³	1.0 mg.m ⁻³
Capital cost	£10 k for 90 companies + £2k for 90 companies = £1080k	£10k for 90 companies = £900k
Control maintenance - continuing cost	£90k	£90k
Continuing RPE savings (see paras 19-21 above)	- £90k to -£108k per annum	- £90k to -£108k per annum
Monitoring cost	£100k to £150k	£100k to £150k

36. For a MEL of 0.5 mg.m⁻³ over ten years, costs would be approximately £1.8 million to £1.9 million in net present value terms. Net of the cost savings, ten-year costs would be approximately £1.2 million to £1.1 million in net present value terms.

37. For a MEL of 1.0 mg.m⁻³ over ten years, costs would be approximately £1.7 million to £1.8 million in net present value terms. Net of the cost savings, ten-year costs would be approximately £1 million to £0.9 million in net present value terms.

(d) Manufacture of resins for surface coatings and inks

38. The cost estimates for resin manufacturers are based on the following assumptions :

- 12 companies make resins with powder in this sector;
- none has adequate LEV in place for charging operations;
- all 12 will need to install this control, with ongoing maintenance costs.

39. The number of employees potentially exposed is 35 across 5 sites. The majority of these handle hydroquinone directly.

40. The cost of research into potential substitutes was estimated at £3,300 and one company (19 employees, 3 sites) put the recurring cost of the more expensive substitute at £27,000 per annum. A potential substitute is approximately 2.7 times more costly than hydroquinone. Its toxicological profile has not been determined.

41. One company dosing hydroquinone solution into packages estimated that, were substitution to fail and a limit below 0.5 mg.m^{-3} be set, new LEV would be needed at an estimated capital cost of £10,000, and continuing analytical costs of £200 per annum. That company had about 10 employees exposed and 130 employees in all.

42. The cost estimates for ink manufacturers are based on the following assumptions :

- 33 companies operate in this sector, of which 11 use powder addition of hydroquinone;
- none has adequate LEV in place for charging operations;
- all will need to install this control, with ongoing maintenance costs;
- more than half of the 11 (6) may invest in substitutes.

43. The cost estimate for resin manufacture and use is set out in Table 6.

Table 6 Resin manufacture and resin use for surface coatings and inks

Powder addition to bulk mixer	Four responses. None conducted monitoring. No effective LEV used in mixing. Of ink makers, $\frac{2}{3}$ use liquid addition.	
Companies in this sector	12 companies making resins with powder addition 33 sites making ink, 11 with powder addition - some companies are multi-site.	
Total number of workers exposed	144 for resin-making plus 77 for ink making = 221 using powder	
Control required	LEV for powder addition and bag crushing or substitution of liquid for powder (research cost)	
MEL value proposal	0.5 mg.m^{-3}	1.0 mg.m^{-3}
Capital cost	£10k for 23 companies = £230k or £10k for 18 companies + research by 6 companies at £3.3k = £200k	£10k for 23 companies = £230k or £10k for 18 companies + research by 6 companies at £3.3k = £200k
Control maintenance - continuing cost	£23k or £18k	£23k or £18k
Continuing substitute cost	£9k per site = £54k	£9k per site = 54k
Monitoring cost	£18 to £27k	£18k to £27k

44. For a MEL of 0.5 mg.m^{-3} over ten years, costs would be approximately £842,000 in net present value terms. For a MEL of 1.0 mg.m^{-3} over ten years, costs would be approximately £842,000 in net present value terms.

Exposure to hydroquinone in products

45. The analysis per sector is detailed in the paragraphs below. Table 2 above summarises that there are no foreseeable additional costs. Monitoring is considered to be unnecessary.

Use of imaging solutions containing hydroquinone

(e) Plate-making in printing

46. The trade association made no comment on the extent of exposure to hydroquinone in plate making. Plate making is an intermittent process that is substantially enclosed. Feed solutions are normally supplied in solution, though they may be as powders for dilution.

47. The highest liquid concentration of hydroquinone used in image development is 2%. To have airborne concentrations of in-use developer at 0.5 and 1 mg.m⁻³ implies aerosol at 25 and 50 mg.m⁻³. There is no EASE prediction for this type of process, but HSE believes that level of aerosol emission is not reasonably foreseeable.

48. A reasonable worst case predicted exposure (EASE) for scooping and pouring hydroquinone powder without controls was in the range 5 to 20 mg.m⁻³. However this task is unlikely to take more than 5 minutes per day. This would equate to a full shift TWA exposure at 0.05 to 0.2 mg.m⁻³ hydroquinone powder.

(f) Film development

49. HSE records for personal exposure to hydroquinone in film development (health services radiography, 1987) produced 15 data. All the results were below the limit of quantitation or detection, that is, lower than 0.02 mg.m⁻³ hydroquinone, 8-hour TWA.

50. Information from one company suggests bulk film development of black and white and colour-reversal film involves tank dipping, with no generation of aerosols. Mini-lab developers are entirely enclosed. Developers containing hydroquinone are normally placed on the market as solutions, but exposure to hydroquinone can occur if solutions are prepared from powders.

Table 7 Photographic and imaging product users

Powder dissolution and use of developer	Mixing – one event per day 5 minute exposure = 0.05 to 0.2 mg.m ⁻³ TWA. Use – radiographic negative development, all results below 0.02 mg.m ⁻³ . Film /plate development – negligible aerosol generation	
Control required	Exposures are below 0.5 mg.m ⁻³ . Substitution of liquid concentrate would reduce exposure on mixing.	
MEL value proposal	0.5 mg.m ⁻³	1.0 mg.m ⁻³
Capital cost	None	None
Control maintenance – continuing cost	None	None
Monitoring cost	None	None

51. For MELs of 0.5 mg.m⁻³ and 1.0 mg.m⁻³ there are no costs.

(g) Use of printing ink containing hydroquinone

52. Printing inks contain up to 0.3% hydroquinone by weight (information from the British Coatings Federation). Antioxidant helps to prevent the ink “skinning” and stabiliser reduces in-can polymerisation. Exposure occurs by skin contact (cleaning processes) and by inhalation of ink-fly.

53. HSE records for ink-fly (mostly newspaper printing, 1985 and 1989) produced 38 data for total inhalable particulate. The data ranged 0.1 to 2.3 mg.m⁻³ (TWA), with the 95th percentile at 1.6 mg.m⁻³. If all the particulate were ink fly, the anticipated aerosol concentration of hydroquinone in air would be 0.005 mg.m⁻³.

Table 8 Use of printing inks

Powder dissolution – making bulk developer	Ink fly data shows 95 th percentile at 1.6 mg.m ⁻³ With 0.3% hydroquinone, = 0.005 mg.m ⁻³ TWA	
Control required	Exposures well below 0.5 mg.m ⁻³ .	
MEL value proposal	0.5 mg.m ⁻³	1.0 mg.m ⁻³
Capital cost	None	None
Control maintenance - continuing cost	None	None
Monitoring cost	None	None

54. For MELs of 0.5 mg.m⁻³ and 1.0 mg.m⁻³ there are no costs.

(h) Use of paint and surface coating products containing hydroquinone

55. Surface coating products such as epoxy resins and unsaturated polyester resins for use in glass-reinforced plastics contain hydroquinone as a stabiliser. Such products are applied by hand-held tools and by spraying and contain hydroquinone at concentrations up to 0.05%. The British Coatings Federation stated that hydroquinone is not commonly used in spray paints.

56. Industrial spraying exposure is modelled by EASE and the predicted range is 5 to 20 mg.m⁻³ particulate. Exposure at 20 mg.m⁻³ for 4 hours per day is a reasonable worst case. This equates to a full-shift TWA concentration of hydroquinone at 0.005 mg/m³.

57. HSE records for high pressure spraying antifoulant preparations on ships outdoors (1995-6) produced 19 data, ranging 0.04 to 79.4 mg.m⁻³ as in-use product, with the 95th percentile at 64.6 mg.m⁻³. The spraying duration ranged from less than 1 to 5.5 hours/day and 5 hours’ spraying is assumed as a reasonable worst case.

58. This equates to a full shift TWA exposure of 44 mg.m⁻³ in-use product. Hydroquinone was a component of one product at 1.3% by weight. All antifoulant product labels stipulate the requirement to use airline-fed RPE (Control of Pesticides Regulations). The potential exposure to hydroquinone by inhalation is estimated at 0.6 mg.m⁻³ TWA, and the actual exposure (RPE protection factor of 40) is estimated at 0.02 mg.m⁻³.

59. The data profile for surface coating is set out in Table 9.

Table 9 Paint and surface coating spraying

Spraying antifoulant or epoxy / polyester resins	Spraying resins - 0.01 mg.m ⁻³ hydroquinone Spraying antifoulant – 0.6 mg.m ⁻³ hydroquinone with RPE at x40 protection	
Companies in this sector	30 companies using antifoulant.	
Total number of workers	100 exposed to antifoulant	
Control required	Antifoulant sprayers use air-fed RPE as a stipulation of product use. None required for resin users.	
MEL value proposal	0.5 mg.m ⁻³	1.0 mg.m ⁻³
Capital cost	None	None
Control maintenance - continuing cost	None	None
Monitoring cost	None	None

60. For MELs of 0.5 mg.m⁻³ and 1.0 mg.m⁻³ there are no costs.

Total Compliance Costs

For a MEL set at 0.5 mg.m⁻³

61. Total initial costs are equivalent to between £1.8 million and £1.9 million. Total costs over ten years are approximately £2.6 million in net present value terms (net of the cost savings at paragraphs 19-21). Undiscounted annual costs are shown in Table 10 below.

Table 10 Annual undiscounted costs, 0.5 mg.m⁻³

	Yr1	Yr2	Yr3	Yr4	Yr5	Yr6	Yr7	Yr8	Yr9	Yr10
Annual costs £m	1.8-1.9	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4

For a MEL set at 1 mg.m⁻³

62. Total initial costs are equivalent to about £1.6 million. Total costs over ten years are approximately £2.4 million in net present value terms (net of the cost savings at paragraphs 19-21). Undiscounted annual costs are shown in Table 11 below.

Table 11 Annual undiscounted costs, 1 mg.m⁻³

	Yr1	Yr2	Yr3	Yr4	Yr5	Yr6	Yr7	Yr8	Yr9	Yr10
Annual costs £m	1.5-1.6	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4

Costs to HSE

63. The MEL will be enforced at workplaces by HSE. Assigning a MEL will require an increase in the emphasis inspectors attach to hydroquinone exposure. This will

result in a slightly increased workload for inspectors during inspection and any resulting enforcement action.

Total costs to society

64. The vast majority of the societal cost is borne by industry. This is detailed above.

Policy costs

65. These are the costs that can be directly attributable to the policy goal. All of the costs are policy costs.

Implementation costs

66. These are commonly referred to as 'red tape' costs. There are no implementation costs associated with this proposal.

IMPACT ON SMALL BUSINESSES, CHARITIES AND VOLUNTARY ORGANISATIONS

67. The highest risk of exposure to hydroquinone is where it is handled as a raw material (photographic and imaging product manufacture; polymerisation inhibitors for bulk chemical supply; fine chemical, rubber, thermoplastic polymer etc manufacture; and resin manufacture and resin use for surface coatings and inks) rather than in product form (plate making in printing; photographic & imaging product use; use of printing ink; and paint surface coating spraying). HSE believes that small firms are concentrated in these latter sectors. There are no compliance costs associated with either MEL value for these sectors.

Environmental impacts

68. It is believed that there will be no environmental impact of setting a MEL at either 1 mg.m^{-3} or 0.5 mg.m^{-3} .

BALANCE OF COSTS AND BENEFITS

69. There will be a cost to industry associated with compliance to a MEL for hydroquinone set at either 1 mg.m^{-3} or 0.5 mg.m^{-3} . The total cost of a MEL set at 0.5 mg.m^{-3} is expected to be about £2.6 million in present values over a ten-year appraisal period. The total cost of a MEL set at 1 mg.m^{-3} is expected to be approximately £2.4 million over the same appraisal period.

70. The benefits are subject to substantial uncertainties. It has not been possible to quantify benefits, as there is no conclusive evidence regarding dose and effects.

71. However, it is useful to consider what the costs per worker exposed are from setting this MEL, and how these costs compare with some MELs agreed in the recent past for genotoxic substances. The table below shows the cost to employers per worker exposed (rounded figures) of approved MELs for genotoxic substances. For a MEL of 0.5 mg.m^{-3} the cost per exposed worker is about £2,500. For a MEL of 1.0 mg.m^{-3} the cost per exposed worker is about £2,200.

Table 12: Estimated cost of exposure per worker in MELs set recently for genotoxic substances

Substance	Cost per worker exposed (£, 1999/2000 prices)
Dimethyl sulfate and diethyl sulphate	410-550
Hydrazine	390-1,330
Vanadium pentoxide	
Engineering control strategy	550-1,830
RPE control strategy	1130-2,670
Phenol	13 - 15

72. For either suggested MEL option for hydroquinone, the cost per employee exposed is likely to be in the upper part of the range of estimated costs per employee exposed for MELs set for other genotoxic substances.

Uncertainties

73. Uncertainties in the assumptions made on costs are reflected in the use of range rather than point estimates.

74. The benefits are subject to substantial uncertainties. Because there is no information on dose-effect it is not possible to make a direct estimate of benefits and an alternative approach has been adopted.

SUMMARY AND RECOMMENDATIONS

75. It is not possible to quantify the benefits anticipated from setting a MEL, but as there is no identifiable threshold for possible genotoxic effects, any reduction in exposure will reduce the risks of adverse health effects.

76. At any projected MEL value, the main costs will arise from introduction of local exhaust ventilation (LEV), which is a reasonably practicable control measure, at powder addition and bag-crushing operations, and monitoring of personal exposures at these sites. These costs are anticipated only for manufacturers of products containing hydroquinone; no significant additional costs are expected at those sites putting the products to use.

77. In the manufacturing sectors, there would be a need for monitoring, and a varying need to install or modify LEV, as present practice varies from no LEV to fully effective LEV. The LEV and monitoring costs are not especially sensitive to a projected MEL value; the main differences arise at those sites with existing LEV that would have to be upgraded to conform to a lower MEL value.

78. If costs in the manufacturing sectors are averaged over the number of employees exposed in those sectors, they are £2,500 at 0.5 mg.m⁻³ and £2,200 at 1 mg.m⁻³. These lie in the upper part of the range of costs per exposed employee for MELs agreed for genotoxic substances, but, as noted above, are relatively insensitive to the MEL value considered.

79. In the light of these considerations, an 8-hour TWA MEL of 0.5 mg.m⁻³ is proposed.

RESULTS OF CONSULTATION

80. Further to the questionnaire referred to in paragraph 13, a wide public consultation as held between March and June 2002 recommending a MEL set at 0.5 mg.m⁻³. All but one of those who commented supported this proposal; the one respondent who disagreed with it disputed the classification of hydroquinone as a Category 3 carcinogen and Category 3 mutagen. The HSE is, nevertheless, satisfied that this classification is a fair reflection of the available information on this substance.

ARRANGEMENTS FOR MONITORING AND EVALUATION

81. The MEL will be enforced at workplaces by HSE. Assigning a MEL will require an increase in the emphasis inspectors attach to hydroquinone exposure. This will result in a slightly increased workload for inspectors during inspection and any resulting enforcement action. The MEL will be revised if significant new scientific information becomes available, which places doubt on the current assessment of the health risks.

CONTACT POINT AND DATE

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APPENDIX

Questionnaire responses by sector.

a) *Photographic and imaging product manufacture*

Two of three companies reported the use of local exhaust ventilation (LEV) at the charging point as the control measure, and one these, the use of personal protective equipment with disposable respiratory protective equipment (RPE). That company also reported LEV at bag crushing. Charging was an intermittent activity.

b) *Polymerisation inhibitors for bulk chemical supply*

One company reported the use of LEV at the charging point as the control measure, with disposable RPE. The second company used air-fed RPE for the charging task and also reported the manual addition of quantities less than 1 kg to road tankers (average one per day).

Mixer charging: One company estimated that for charging, up to two employees are exposed for one hour per 12-hour shift. The company estimated the exposure to be above 1 mg.m^{-3} and the charging workers used air-fed RPE. The other company estimated exposure between 0.5 and 1 mg.m^{-3} (8-hour TWA) using LEV, and stated the intention to monitor.

One company reported that if a limit were set at 0.5 mg.m^{-3} then automatic bag handling and disposal would be considered, along with substitution. That company made no estimate of the engineering cost or the research and development cost associated with substitution. The second company reported that it was seeking alternative forms of supply and was examining its level of engineering control.

c) *Fine chemical, rubber, thermoplastic polymer etc manufacture*

Two manufacturers of agrochemicals identified exposure to hydroquinone through charging reactors from sacks of hydroquinone. One used LEV at a charging enclosure, where bags were crushed and collected: protective gloves were also used. The other manufacturer reported using LEV with RPE, and was now installing a charging booth and lifting table (for reasons of safety and exposure control). A thermoplastic polymer manufacturer did not report the use of controls or RPE.

The manufacturer having a charging enclosure reported all exposures below 0.15 mg.m^{-3} (8-hour TWA) with 5 reactor charges per shift, each charging task lasting 20 minutes, with 10 minutes' cleaning ($2\frac{1}{2}$ hours exposure per 12-hour shift). The other manufacturer estimated current exposures between 0.5 and 1 mg.m^{-3} . The thermoplastic polymer manufacturer estimated that exposures fell below 0.5 mg.m^{-3} .

One manufacturer reported a health surveillance scheme (corneal pigmentation screening). No company reported ill health, days lost or the necessity for change of job through exposure to hydroquinone.

One manufacturer estimated that a MEL would impose a monitoring programme cost of £1000 per annum (up to 12 workers) and the other reported that the safety and health related improvements at the charging position cost £70,000. However this cost is not attributable to hydroquinone, the improvement is related to minimising manual handling risks.

d) *Resin manufacture and resin use for surface coatings and inks*

One resin manufacturer reported exposure through charging hydroquinone into a reactor with unspecified engineering controls. The manufacturer believed that exposures fell within the OES (2 mg.m^{-3}) with twelve employees handling hydroquinone directly. The company reported no ill health, nor any days lost, or the necessity for change of job through exposure to hydroquinone.

This company reported that it would need to investigate exposure and to enclose and ventilate bag handling were a MEL to be set.

Hydroquinone addition to ink formulations involves charging. Of three companies, two are supplied with low-dust products (25% hydroquinone paste in an oil-based preparation; hydroquinone in solution). The third company used a mobile dust control unit to capture dust at the charging port, and made no estimate of exposure, and using RPE.

For fluid handling, one company dispensed fluids from a drum to a bucket and thence to a mixer, and estimated exposure between 0.5 and 1 mg.m^{-3} . The other company dispensing solution to packages reported using LEV and protective gloves, with RPE available if necessary.

No company reported ill health though one reported minor skin irritation. None reported any days lost, or the necessity for change of job through exposure to hydroquinone.

One company (4 employees) has plans to conduct air monitoring. Two companies plan to cease use of hydroquinone, one citing "health and safety" reasons: both are researching substitutes. The cost of research was estimated at £3,300 and one company (19 employees, 3 sites) put the recurring cost of the more expensive substitute at £26,000 per annum.

Information from the Internet suggests that tertiary butyl hydroquinone may be a substitute for hydroquinone. This potential substitute is approximately 2.7 times more costly than hydroquinone. Its toxicological profile has not been determined.

One company dosing hydroquinone solution into packages estimated that were substitution to fail, and a limit below 0.5 mg.m^{-3} be set, new LEV would be needed at an estimated capital cost of £10,000, and continuing analytical costs of £200 per annum. That company had about 10 employees exposed and 130 employees in all.