

Chemical works

fertiliser manufacturing works

Industry Profile sponsored by
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The Department's Contaminated Land Research Report series deals with information needed to assess risks; procedures for categorising and assessing risks; and evaluation and selection of remedial measures.

General guidance on assessing contaminated land and developing remedial solutions which is complementary to the Department's publications is provided by the Construction Industry Research and Information Association (CIRIA).

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Preface

DOE Industry Profiles provide developers, local authorities and anyone else interested in contaminated land, with information on the processes, materials and wastes associated with individual industries. They are not definitive studies but they introduce some of the technical considerations that need to be borne in mind at the start of an investigation for possible contamination.

Every site is unique. Investigation of a site should begin with documentary research to establish past uses. Information on the site's history helps to focus a more detailed investigation. This knowledge needs to be supplemented by information on the type of contamination that may be present and where on site it may be found. Profiles give information on the contamination which might be associated with specific industries, factors that affect the likely presence of contamination, the effect of mobility of contaminants and guidance on potential contaminants.

The date when industrial practices first commenced on a site and its location are important clues in establishing the types of operations that may have taken place, so each profile provides a summary of the history of the industry and its likely geographical spread within the United Kingdom.

Profiles should be read with the following reservations in mind:

- individual sites will not necessarily have all of the characteristics described in the profile of that industry;

- practices can vary between sites and change over time;

- as practices change, problems of possible contamination may also change;

- the profile may refer to practices which are no longer followed, and may omit current practices which avoid contamination.

The risks presented by contaminated sites depend on the nature of the contaminants, the targets to which they are a potential threat (such as humans or groundwater) and the routes or pathways by which they reach these targets. The current or proposed use of a site and its environmental setting are crucial in deciding whether treatment is necessary and if so, the methods to be used. Some sites may not need treatment.

The information in profiles may help in carrying out Control of Substances Hazardous to Health (COSHH) assessments for work on contaminated land - see Health and Safety Guidance Note HS(G) 66 *Protection of workers and the general public during the development of contaminated land*, Health and Safety Executive, 1991, and *A guide to safe working practices for contaminated sites*, Construction Industry Research and Information Association, 1995.

Note: the chemical names given to substances in this profile are often not the modern chemical nomenclature, but the names used historically for those substances.

Chemical works: fertiliser manufacturing works

1. Background

Fertilisers are inorganic or organic-based nutrients that promote plant growth. A range of materials has been used as fertilisers, including manure, marl, ground bone, slurry, limestone, chalk, green manure and straw. This profile considers only the commercial production of fertilisers for use in farming, horticulture, forestry and market gardening, as well as for use in domestic gardens.

Inorganic fertilisers include the primary nutrients nitrogen, phosphorus and potassium (NPK), as well as micro-nutrients such as essential trace elements. Organic fertilisers include natural products such as composts and animal and vegetable by-products.

The two main inorganic fertilisers produced by basic chemical manufacture in the 19th Century were:

Nitrogen fertiliser	Made from ammonia, a by-product of the manufacture of town gas by coal carbonisation processes, and Chile saltpetre (sodium nitrate).
Phosphate fertiliser	Produced by the addition of acid to imported phosphate rock and bones to produce soluble phosphates.

In the early decades of this century, the Haber-Bosch process for the synthesis of ammonia (developed between 1910 and 1915) led to the production of synthetic nitrogenous fertilisers.

The demand for fertiliser increased considerably after the Second World War as farmers were encouraged to grow more food. The number of fertiliser manufacturing works increased, particularly the number of small granulation plants.

Since the late 1950s, there has been a steady decline in basic chemical manufacture and mixing/granulation, but an increase in the number of small operations that produce organic fertilisers. The Census of Production data indicate that the number of fertiliser works employing more than 10 people was 114 in 1948, 176 in 1968 and declined to 126 in 1993. The production of phosphoric acid for fertiliser ceased in the 1980s as it became cheaper to import phosphoric acid or intermediate ammonium phosphates. There are now only four major sites in the United Kingdom producing nitrogen fertiliser and two companies making superphosphates.

Historically, the fertiliser manufacturing industry was located in coastal areas, as the industry relied upon imported raw materials. In later years the dependency on foreign materials diminished and plants were established in the main agricultural areas of the United Kingdom.

2. Processes

2.1 Delivery and transport of raw materials on site

The majority of process and process-related raw materials received at a fertiliser manufacturing works arrive by either sea, rail or road in bulk quantities.

Natural gas, used for the manufacture of ammonia, is received by pipeline directly from the national supply network. Nitrogen gas, also used as a raw material for ammonia production, is delivered in liquefied form to bulk storage vessels by road tanker or by pipeline from a local supplier; alternatively it may be produced on site.

Acids and alkalis, which may be used in either production or wastewater treatment processes, are usually delivered by bulk road tanker. Other chemicals are typically delivered in drums or kegs. Raw materials for organic fertilisers, including degradable material, are usually transported by road.

Bulk liquid raw materials are typically transferred by pump from delivery tanker to bulk storage vessels on site. Bulk materials or inorganic solids are mechanically off-loaded into storage. Ammonia may be stored under liquefied conditions in storage vessels and transferred to points of use by pipeline. Bulk fluids are typically pumped to reactors or mixing vessels.

Organic fertilisers are typically transferred to areas within the plant using mechanical equipment such as tractors. Handling of drums, kegs and bags within storage areas and plant is usually carried out using fork-lift trucks. Materials in bags and small kegs may also be handled by process operators. At smaller works, manual handling of fertiliser may be commonplace, depending upon the quantities involved.

2.2 Fertiliser production

Both batch and continuous production methods have been used in the manufacture of fertilisers.

2.2.1 Inorganic fertiliser manufacture

Nitrogen fertilisers

The bulk manufacture of nitrogen fertilisers in the United Kingdom involves the synthesis of ammonium nitrate from ammonia and nitric acid.

Ammonia is manufactured by combining nitrogen with hydrogen; the latter formed by the catalytic reforming of natural gas and steam. Historically, coal tar naphtha was used to produce the hydrogen. The ammonia product is liquefied and stored. Organic and inorganic absorbents, usually solvents, are used to purify the reactant gases and remove carbon dioxide (see relevant profiles in Section 4).

Nitric acid is manufactured by the catalytic oxidation of ammonia; the ammonium nitrate solution is then formed from the reaction of nitric acid with ammonia. The ammonium nitrate is solidified as beads, usually in a prilling tower, in which liquid sprays fall through an upward current of air causing the evaporation of water and solidification of the ammonium nitrate into 'prills'. The prills are cooled, screened and conveyed to a bagging and distribution centre.

Urea (carbonyl-diamide) is an important nitrogen fertiliser, as it contains the largest amount of available nitrogen of any of the nitrogen fertilisers (46% in the solid form). It was first manufactured by Wohler in 1828 by reacting ammonia with cyanic acid. Today, the main manufacturing method is by the combination of liquid ammonia and carbon dioxide to produce ammonium carboamide, which is hydrated to produce a aqueous solution of urea. Other manufacturing processes include the hydrolysis of cyanide gas to produce urea, and by heating ammonium nitrate at high pressure.

Solid urea is available as crystals, flakes, prills and granules. It can also be applied in liquid form, usually in combination with ammonia and ammonium nitrate solution, and with superphosphate as *Phosphazote*.

Phosphate fertilisers

Modern phosphate fertilisers are manufactured from phosphate rock (essentially tricalcium phosphate). This is processed into superphosphate, a mixture of mono- and di-calcium phosphate with calcium sulphate (gypsum), by acidification with concentrated sulphuric acid. Phosphate fertilisers are also produced by ammoniation of phosphoric acid to produce ammonium phosphate. Phosphoric acid production for fertiliser manufacture ceased in the United Kingdom during the 1980s, as it became economically viable to import intermediate ammonium phosphates and phosphoric acid.

Potassium fertilisers

The source of potassium for modern potassium fertilisers is 'potash', a term generally applied to potassium-containing compounds or salts. Potash is usually extracted from evaporite beds, either by mining or by dissolving it in a solution of salts and pumping it to the surface for recovery and separation by crystallisation. The major constituents of potash are potassium chloride, potassium sulphate and potassium magnesium sulphate; potassium chloride is the most abundant compound in potash. It is usually separated from naturally occurring impurities such as sodium chloride and clays using flotation methods.

Compound fertilisers

Compound (NPK) fertilisers are produced by the combination of nitrogen, phosphorus and potassium fertiliser. Until the introduction of granulated fertilisers, the mixing process generally consisted of the following elements:

- 'maturing' or 'curing' of the fertiliser
- the addition of a small amount of organic conditioners to prevent caking of the mixture
- screening the constituents so that they were of uniform size and crushing any oversize material until it passed through the screens
- mechanical mixing.

In the past, despite the use of anti-caking additives, some powdered compound fertilisers still caked. Granulation processes were developed to combat this problem. Approximately spherical granules or agglomerates were formed so that contact areas were minimised, thus reducing caking tendencies. The flow characteristics of the fertilisers were also improved. Techniques used for the production of fertiliser granules include:

- rotation in drums, discs or other containers

compression into moulds (pelletising)
flaking and tumbling where the fertiliser mixture was formed into a sheet,
broken up into fragments and rounded off into granules in rotating drums
extrusion methods using dies
crystallisation
spray-drying a solution or slurry of the material
prilling (see above)
addition of an oil or clay coating to prevent caking.

In the United Kingdom, granulation is usually carried out using simple drum or paddle mixers (known as 'blungers').

Granulation plants typically use phosphoric acid, potash and ammonium nitrate as the basic feeds. The manufacture of granulated compound NPK fertilisers by combining ammonium nitrate, ammonium phosphate and potash in various proportions is still undertaken.

Blending plants

After manufacture, chemical fertilisers are distributed directly to the consumer or to bulk blending plants. These blending plants consist of areas for bulk raw materials storage, facilities for weighing and transferring materials to mixing units (typically rotary drums) and a discharge and bagging system. Bagging systems can be automatic, semi-automatic or manual and use a combination of intermediate bulk containers and bags.

2.2.2 Organic fertiliser manufacture

Organic fertilisers include ground bonemeal, fishmeal, compost and manure. The animal and animal products processing industry is described in a separate Industry Profile (see Section 4).

Bonemeal is produced by sterilising and grinding animal bones. Some bonemeal is imported and may not have been sterilised to the standards of bonemeal prepared in the United Kingdom. Fishmeal fertiliser is produced by steaming, drying and grinding fish waste.

Compost is produced from degradable organic materials, such as plant and animal remains and abattoir wastes. Composting facilities may have several batches of compost biologically degrading in mounds or in vessels; each may contain up to 50 tonnes of material. Sewage sludge from wastewater treatment works can also be used but may contain a range of non-degradable materials, such as heavy metals from industrial facilities. These may give rise to long-term concerns of bio-accumulation or phytotoxicity. The compost material produced from sewage treatment sludges is often directly applied onto the land without intermediate storage.

Manure or animal excrement is typically stored on farms and mixed with straw to add bulk.

2.3 Nature of the finished products

The quantity and size of finished fertiliser products depends upon the market served by the company. Fertilisers may be produced in either granular form or as liquids. They may be supplied in bulk, intermediate bulk containers, packages (typically 50 kg bags), drums or kegs.

Final transfer of the packaged product from the storage area is usually by fork-lift truck. The packages are loaded on to road or rail vehicles. Solid and liquid fertilisers may be distributed in bulk by road or rail tankers to other fertiliser companies for blending, to packaging companies or to the consumer. Organic fertilisers used in smaller quantities may also involve small-scale manual transfer to areas of delivery.

2.4 Ancillary activities

Ancillary activities are only likely in the larger fertiliser works in the United Kingdom and include on-site power generation, raw water purification and wastewater treatment plants

2.5 Waste management

Waste management has undergone considerable change during the lifetime of the fertiliser industry. Historically, management of wastes may have been varied and, at times, inadequate.

Wastes are usually stored in a variety of drums and vessels, in properly designed storage compounds with appropriate bunding and in-floor drains to wastewater treatment facilities. Wastes are typically collected and stored until sufficient quantities are available for cost-effective disposal by an outside contractor. Wastes that contain organic solvents are usually disposed of by incineration. Waste materials may also have been disposed of in on-site landfills.

Wastewaters may contain nitrates, ammonia, phosphoric acid and solvents.

3. Contamination

The contaminants on a site will largely depend on the history of the site and on the range of materials produced there. Potential contaminants are listed in the Annex and the probable locations on site of the main groups of contaminants are shown in Table 1. It is most unlikely that any one site will contain all of the contaminants listed. It is recommended that an appropriate site investigation be carried out to determine the exact nature of the contamination associated with individual sites.

3.1 Factors affecting contamination

A site may have been occupied by the fertiliser manufacturing industry over a considerable period of time, during which the nature of the activities and the physical location of plant, buildings and storage areas may have changed. Older sites may have tanks or storage vessels containing residues of process chemicals, effluents and fuel oils. Underground pipework may also be present and may contain residues. The main areas where soil may be contaminated due to spillage

or leakage of materials are around bulk storage vessels, off-loading areas, effluent vessels, manufacturing plant, underground storage containers and associated pipework. Some sites may be contaminated by oil from equipment such as gas compression units.

Amines and other organic absorbents, used for the removal of carbon dioxide during ammonia production, may contain traces of heavy metals. Residues of phosphate rock may contain traces of heavy metals such as cadmium and uranium oxide, a naturally radioactive substance.

Various other chemicals are also indirectly associated with fertiliser manufacture, such as acids, alkalis and coagulants (iron or aluminium sulphate) used for water treatment. Transformer oils containing polychlorinated biphenyls (PCBs) may have been used in on-site electricity substations.

It is possible that plant buildings and infrastructure were insulated with asbestos lagging, or cement sheeting used in roofing or cladding. This waste asbestos material may be found in discrete dumps on the site where plant has been dismantled or may still be associated with existing buildings and plant.

Organic fertiliser production sites may have residues of animal and plant waste. Heavy metals, such as cadmium and zinc, may be found on sites where sewage sludge has been handled and if solid waste has been composted. There is a small but significant possibility that spores of the bacterium *Bacillus anthracis*, the causative agent of anthrax, could be present on sites that have handled imported bonemeal, as it may not have undergone the appropriate degree of sterilisation.

Composting also produces an acidic leachate which may leak into soil, thus reducing its pH and affecting the migration in the soil of some substances, for example some metals.

3.2 Migration and persistence of contaminants

Most chemical fertilisers are readily soluble in water and have the potential for both vertical and lateral migration through the soil profile. Biological mechanisms such as uptake by micro-organisms and plants would affect the fate of such compounds. Soil chemistry and structure would affect their mobility.

Migration of ammonia solution, potassium salts and sulphates would be retarded in soils with high clay or organic matter content. The movement of phosphorus compounds is dependent on soil pH and tends to be slow as fixation by clays may occur. However, extensive and recurrent spillages of phosphoric acid may have a significant impact on both groundwater and surface water beneath fertiliser manufacturing plants. Amine absorbents used in ammonia production are also likely to be significantly mobile and could migrate to the water table.

Acids can migrate within the soil-water in the dissociated form, ie as the hydrogen ion and the corresponding anion for example nitrate or sulphate. The buffering capacity of most soils tends to neutralise slight acidity. Dissolved nitrate and sulphate can migrate freely through the soil.

The transport and fate of organic compounds such as fuel oil within the sub-surface environment is dependent upon physical, chemical and biological factors.

The higher the organic matter and clay content of the soil, the greater the degree of adsorption of the organic compounds. Thus, the greatest degree of migration occurs in coarse-grained sands and gravels with little natural organic matter. Organic contaminants which become adsorbed on to clay or organic matter provide on-going sources of water pollution long after the original source has been removed, by continuing to dissolve into the soil-water.

Biodegradation processes in soils can be influenced by a number of factors, namely moisture content, oxygen concentration and pH, acting separately or in combination. For example low moisture content reduces microbiological activity, while high moisture content can reduce oxygen penetration and possibly lead to anaerobic soil conditions. Such conditions enhance the biodegradation of some materials, for example chlorinated compounds, while aerobic conditions are needed to biodegrade many oils. Also, low pHs tend to reduce the bacterial population and encourage fungal activity; at pHs lower than 5, microbiological activity is much reduced. The presence of heavy metals also inhibits micro-organisms. As a result of these factors, at high concentrations in soil, even relatively non-persistent compounds may not biodegrade readily.

The movement of metals through the soil is significantly retarded by the presence of clay minerals and organic matter. The solubility of some metals may increase under acidic conditions, however, the relationship can be complex.

PCBs, present in some types of electrical equipment, have a low solubility in water and do not degrade. They are fat-soluble and tend to accumulate in food chains.

Asbestos is neither soluble or biodegradable but where there is gross surface contamination by asbestos, wind dispersal may occur.

In addition, wind dispersion of raw materials and bulk product is likely to be a significant transport mechanism.

4. Sources of further information

4.1 Organisations

For information concerning the fertiliser manufacturing industry in the United Kingdom, the following organisations should be consulted:

Society of Chemical Industry
14/15 Belgrave Square
London
SW1X 8PS

The Fertiliser Manufacturers Association Limited
Greenhill House
Thorpe Road
Peterborough
PE3 6GF

The United Kingdom Chemical Industries Association Limited
Kings Buildings
Smith Square
London
SW1P 3JJ

4.2 Sources of information concerning the activities described in this profile

Austin G T. *Shreve's chemical process industries*. 5th Edition. London, McGrawHill, 1984.

British Standards Institution. *Code of Practice for the identification of potentially contaminated land and its investigation*. Draft for Development DD175. London, BSI, 1988.

Dragun J. *The soil chemistry of hazardous materials*. Silver Spring MD (USA), Hazardous Materials Control Research Institute, 1988.

Eckroth D, Graber E, Kingsberg A and Siegel P M. *Kirk-Othmer concise encyclopaedia of chemical technology*. Chichester, John Wiley and Sons, 1985.

European Fertilisers Manufacturers Association. *Best available techniques for pollution prevention and control in the European fertiliser industry*. (series of eight booklets). EFMA, Belgium, 1995.

Fertiliser Manufacturers Association. *Briefing note – organic farming*. London, Mackit, 1990.

Fertiliser Manufacturers Association. *Code of practice for the prevention of water pollution from the storage and handling of fluid fertilisers*. FMA, Peterborough, 1995.

Fertiliser Manufacturers Association. *Fertilisers, food production and the environment.* London, Mackit, 1990.

Fertiliser Manufacturers Association. *Fertiliser review.* London, Mackit, (published annually).

Lowrison G C. *Fertiliser technology.* Chichester, Ellis Horwood Limited, 1989.

Case study including information relevant to this Industry Profile:

Paul V. *Bibliography of case studies on contaminated land: investigation, remediation and redevelopment.* Garston, Building Research Establishment, 1995.

Estimates of the size and geographical distribution of the fertiliser manufacturing industry can be obtained from the following Central Government statistics, held principally by the Guildhall Library, Aldermanbury, London and the City Business Library, 1 Brewers Hall Garden, London:

Census of Production Reports, Board of Trade. HMSO (from 1924 to 1969).

Business Monitor Series: Annual Census of Production Reports. Central Statistical Office, HMSO (from 1970 to date).

Information on researching the history of sites may be found in:

Department of the Environment. *Documentary research on industrial sites.* DOE, 1994.

Information can also be obtained from membership records of the Fertiliser Manufacturers Association.

4.3 Related DOE Industry Profiles

Animal and animal products processing works
Chemical works: inorganic chemicals manufacturing works
Gas works, coke works and other coal carbonisation plants

4.4 Health, safety and environmental risks

The Notes issued by the Chief Inspector of Her Majesty's Inspectorate of Pollution (HMIP) provide guidance for the processes prescribed for integrated pollution control in Regulations made under the Environmental Protection Act 1990. Of particular relevance is:

Her Majesty's Inspectorate of Pollution. *Processes for the manufacture of chemical fertilisers or their conversion into granules.* Chief Inspector's Guidance to Inspectors, Process Guidance Note IPR 4/16. London, HMSO, 1993.

The Control of Substances Hazardous to Health (COSHH) Regulations 1994 and the Management of Health and Safety at Work Regulations 1992 are available from HMSO. Information on relevant health and safety legislation and approved codes of practice published by HSE publications are available from Health and Safety

Executive Books, PO Box 1999, Sudbury, Suffolk, CO10 6FS (telephone 01787 881165), as well as HMSO and other retailers.

Information on the health, safety and environmental hazards associated with individual contaminants mentioned in this profile may be obtained from the following sources:

Howard P H. *Handbook of environmental fate and exposure data for organic chemicals*. Vols I and II. USA, Lewis Publishers, 1990.

Sax N and Lewis R. *Hazardous chemicals desk reference*. New York, Van Nostrand Reinhold Company, 1987.

Verschuere K. *Handbook of environmental data on organic chemicals*. 2nd Edition. New York, Van Nostrand Reinhold Company, 1983.

4.5 Waste disposal and remediation options

Useful information may be obtained from the Department of the Environment series of Waste Management Papers, which contain details of the nature of industrial waste arisings, their treatment and disposal. A current list of titles in this series is available from HMSO Publications Centre, PO Box 276, London, SW8 5DT.

Publications containing information on the treatment options available for the remediation of contaminated land sites, prepared with the support of the Department of the Environment's Research Programme, can be obtained from National Environmental Technology Centre Library, F6, Culham, Abingdon, Oxfordshire, OX14 3DB.

A full list of current titles of Government publications on all aspects of contaminated land can be obtained from CLL Division, Room A323, Department of the Environment, Romney House, 43 Marsham Street, London, SW1P 3PY.

Advice on the assessment and remediation of contaminated land is contained in guidance published by the Construction Industry Research and Information Association (CIRIA), 6 Storey's Gate, Westminster, London, SW1P 3AU.

Annex Potential contaminants

The chemical compounds and other materials listed below generally reflect those associated with the industry and which have the potential to contaminate the ground. The list is not exhaustive; neither does it imply that all these chemicals might be present nor that they have caused contamination.

Inorganic fertilisers

Acids	nitric phosphoric
Alkalis	ammonium hydroxide
Metals and their compounds	potassium chloride potassium magnesium sulphate potassium sulphate uranium oxide (and radioactive decay products)
Ammonium salts	ammonium nitrate ammonium phosphate (including both mono- and di- derivatives) ammonium sulphate
Phosphates and superphosphates	calcium hydrogen orthophosphate calcium phosphate dihydrogen calcium phosphate
Organic chemicals	amine absorbents with trace heavy metal contamination polycyclic aromatic hydrocarbons (PAHs) from coal tar residues

Organic fertilisers

Bacteria	<i>Bacillus anthracis</i>
Metals and their compounds (from sewage sludge)	eg cadmium chromium copper lead nickel zinc

General contaminants

Wastewater treatment chemicals	eg aluminium or iron sulphate (coagulants) hydrochloric acid sulphuric acid ammonium hydroxide
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Fuels

eg oil
coal
gas

Lubricating oils

Polychlorinated biphenyls (PCBs)

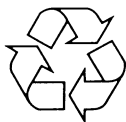
Asbestos

Table 1 Main groups of contaminants and their probable locations

Chemical works: fertiliser manufacturing works

Contaminant		Location								
Main groups	Sub-group	Building fabric	Raw material delivery and storage	Process areas	Tanks, pipework and pumps	Product storage and blending	Waste storage/ on-site disposal	Waste water treatment facilities	Fuel storage	Electricity substations and transformers
Metal and metallic compounds	cadmium and other heavy metals									
	aluminium, iron									
Inorganic compounds	sulphates, phosphates, nitrate, chloride									
Acids/alkalis										
Organic compounds	fuel, lubricating oils									
	amines									
	polychlorinated biphenyls (PCBs)									
	polycyclic aromatic hydrocarbons (PAHs)									
Asbestos										

Shaded boxes indicate areas where contamination is most likely to occur.



Recycled paper

DOE Industry Profiles

Airports

Animal and animal products processing works

Asbestos manufacturing works

Ceramics, cement and asphalt manufacturing works

Chemical works: coatings (paints and printing inks) manufacturing works

Chemical works: cosmetics and toiletries manufacturing works

Chemical works: disinfectants manufacturing works

Chemical works: explosives, propellants and pyrotechnics manufacturing works

Chemical works: fertiliser manufacturing works

Chemical works: fine chemicals manufacturing works

Chemical works: inorganic chemicals manufacturing works

Chemical works: linoleum, vinyl and bitumen-based floor covering manufacturing works

Chemical works: mastics, sealants, adhesives and roofing felt manufacturing works

Chemical works: organic chemicals manufacturing works

Chemical works: pesticides manufacturing works

Chemical works: pharmaceuticals manufacturing works

Chemical works: rubber processing works (including works manufacturing tyres or other rubber products)

Chemical works: soap and detergent manufacturing works

Dockyards and dockland

Engineering works: aircraft manufacturing works

Engineering works: electrical and electronic equipment manufacturing works (including works manufacturing equipment containing PCBs)

Engineering works: mechanical engineering and ordnance works

Engineering works: railway engineering works

Engineering works: shipbuilding, repair and shipbreaking (including naval shipyards)

Engineering works: vehicle manufacturing works

Gas works, coke works and other coal carbonisation plants

Metal manufacturing, refining and finishing works: electroplating and other metal finishing works

Metal manufacturing, refining and finishing works: iron and steelworks

Metal manufacturing, refining and finishing works: lead works

Metal manufacturing, refining and finishing works: non-ferrous metal works (excluding lead works)

Metal manufacturing, refining and finishing works: precious metal recovery works

Oil refineries and bulk storage of crude oil and petroleum products

Power stations (excluding nuclear power stations)

Pulp and paper manufacturing works

Railway land

Road vehicle fuelling, service and repair: garages and filling stations

Road vehicle fuelling, service and repair: transport and haulage centres

Sewage works and sewage farms

Textile works and dye works

Timber products manufacturing works

Timber treatment works

Waste recycling, treatment and disposal sites: drum and tank cleaning and recycling plants

Waste recycling, treatment and disposal sites: hazardous waste treatment plants

Waste recycling, treatment and disposal sites: landfills and other waste treatment or waste disposal sites

Waste recycling, treatment and disposal sites: metal recycling sites

Waste recycling, treatment and disposal sites: solvent recovery works

Profile of miscellaneous industries incorporating:

Charcoal works

Dry-cleaners

Fibreglass and fibreglass resins manufacturing works

Glass manufacturing works

Photographic processing industry

Printing and bookbinding works

Copies may be purchased from:

Publications Sales Unit

Block 3, Spur 7,

Government Buildings,

Lime Grove,

Ruislip, HA4 8SF

Price £10

Cheques payable to DOE.