

Engineering works

*shipbuilding, repair and shipbreaking
(including naval shipyards)*

Industry Profiles, together with the Contaminated Land Research Report series, are financed under the Department of the Environment's contaminated land research programme.

The purpose of these publications is to provide regulators, developers and other interested parties with authoritative and researched advice on how best to identify, assess and tackle the problems associated with land contamination. The publications cannot address the specific circumstances of each site, since every site is unique. Anyone using the information in a publication must, therefore, make appropriate and specific assessments of any particular site or group of sites. Neither the Department or the contractor it employs can accept liabilities resulting from the use or interpretation of the contents of the publications.

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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DOE Industry Profile

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

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This profile is based on work by Dames and Moore International and was prepared for publication by the Building Research Establishment.

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.

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

1. Background

For many centuries, wooden ships were constructed and repaired at coastal locations, usually estuaries, particularly along the Thames and the South coast.

The most extensive shipbuilding and repair facilities were developed at the Royal Dockyards to build and maintain Royal Navy warships. The first Royal Dockyard was established at Portsmouth in 1496 and others were subsequently developed at Devonport, Chatham, Harwich, Woolwich, Deptford, Sheerness and in the 20th Century, at Rosyth and Faslane in Scotland. At large dockyards like these, there would be a number of excavated dry docks, each lined with timber or stone.

Steam power was developed in the early decades of the 19th Century and there was a change from wood to iron and steel for ship construction. New technology was required and the range of equipment, instrumentation and fittings built into ships increased dramatically. The fuel supply for steam engines changed from coal to oil. Today diesel is the primary fuel, although gas turbines and nuclear reactors are used in some modern naval vessels.

With the change in technology, the distribution of shipbuilding activities shifted to a number of very large centres in the North, adjacent to coal mining, iron founding and engineering industries. The most notable of these were Tyneside, Wearside, Teesside, Clydeside, Merseyside, Humberside, Barrow-in-Furness and Belfast.

Britain dominated world markets in shipbuilding until the 1950s when competition from other European and Far Eastern countries led to a decline; the United Kingdom's share of world mercantile production was less than 3% by the early 1980s. In the late 1970s, nationalisation of the largest shipbuilders into British Shipbuilding resulted in the closure of a number of yards and redevelopment of the sites. Re-privatisation in the 1980s coincided with further yard closures.

The remaining yards are still concentrated on the rivers Tyne, Clyde, Mersey, Humber and at Barrow-in-Furness and Belfast. A number of yards also operate on the Thames estuary and along the South coast at Southampton, Plymouth, Falmouth and Appledore in Devon. The only inland yard of any significant size is based on the River Ouse at Selby in Yorkshire.

Following reviews of the Royal Dockyards between 1971 and 1984, the dockyards at Devonport and Rosyth were transferred from Ministry of Defence to commercial management. The dockyard at Chatham was closed in the early 1980s and the Portsmouth and Faslane dockyards are now the only facilities under the direct management of the Ministry of Defence.

The Shipbuilders and Shiprepairers Association (SSA), formed in 1989, represents approximately 40 companies, accounting for 80-90% of current United Kingdom shipbuilding and repair activity. Seventeen companies are listed as merchant shipbuilders and fleet auxiliary builders, four as warship builders and nineteen as ship repairers, of whom fifteen have dry dock facilities. The SSA estimates the

current building capacity to be 200 000 gross registered tonnes (GRT) per annum but this does not include the production from a small number of specialist warship construction yards.

The number of works associated with marine engineering has increased gradually from about 1000 in the 1920s-1940s to over 1600 establishments recorded by the Census of Production in the late 1980s, the vast majority being small facilities. However, the overall decline of the marine engineering industry is demonstrated by the fact that over 250 000 people were employed in the industry in 1948, compared with only 60 000 in 1993.

Activities associated with shipbuilding and repairing include the manufacture of marine engines and a wide range of fixtures, fittings, instrumentation and surface coatings. The fixtures, fittings and instrumentation include propellers, winches, deck cranes, chain, steering gear, gauges, valves, pumps, fire equipment, electronic controls, radar and radio. The surface anti-corrosive and toxic antifouling coatings prevent the growth of barnacles, marine grasses, algae and other marine organisms on ships. Historically, some of these materials, for example marine coatings, might have been manufactured on site, although this is generally not the modern practice.

2. Activities

2.1 Wooden shipbuilding

Wooden shipbuilding involved a number of traditional craft activities. Foremost amongst these was that of the shipwright, which involved the cutting, shaping and fixing of large timbers. Ancillary crafts included sailmaking, ropemaking, rigging and blacksmithing. Iron fixtures, brackets, chains, etc, may have been made on site using traditional blacksmithing techniques. Significant quantities of tar were used for caulking seams and simple paints may have been produced on site by grinding coloured pigments into natural resins and linseed oil. From the 1760s, the underwater areas of outer hulls were 'copper-bottomed', ie covered in sheets of copper fastened with copper/zinc bolts, to protect against marine borer damage.

2.2 Steel shipbuilding

Modern steel shipbuilding involves the fabrication of a complex steel structure, into which a wide range of ready-made equipment is fixed. Some 60% of the value of a ship is derived from materials and services purchased from outside suppliers.

Historically, iron and steel components may have been manufactured on site (see Section 4 for a list of related profiles).

Today, the principal raw material is steel plate and the layout of a modern shipyard is arranged to facilitate the flow of steel from delivery from the steel mill through the various processes of marking out, cutting, bending, fabricating sub-assemblies and final erection of the prefabricated units into the hull and superstructure. Final assembly may take place on a building slip or in a dry dock. After the bare hull is launched, the vessel is usually moved to a fitting-out berth where engines and other equipment are fixed.

2.2.1 Preparing templates

The yard drawing office produces detailed plans to make templates which are used to mark out the correct shapes on to the steel plates prior to cutting. Templates used to be made of wood or paper and the shapes transcribed on to the plates. In all modern yards, scale drawings are generated by computer and the information fed directly into computer-controlled automatic cutting machines.

2.2.2 Cleaning and priming

New steel invariably has a surface layer of mixed iron oxides which must be removed prior to fabrication. This was done by chemical cleaning or 'pickling', typically by immersing the plates in hot sulphuric acid containing corrosion inhibiting agents. This was followed by thoroughly rinsing with hot water, a further immersion in hot phosphoric acid and a final water rinse. Immediately after the steel surface had dried, it was coated with a thin coat of special 'shop-primer' paint, to protect the steel from further corrosion. Steel may also be treated with cyanides in hardening operations. Chemical cleaning treatments, such as pickling, have now been entirely superseded by abrasive cleaning using automatic plant. The steel plates are fed on roller conveyors through an enclosed unit where the surface is blasted with steel shot or mineral grit. The surfaces are then cleaned by compressed air blowers and brushes before passing through an automatic spray booth where the shop-primer is applied.

2.2.3 Production

After shop-priming, the steel plate moves to the production bays. It is cut, generally using automatic flame cutting machines, and shaped using a variety of plate bending and pressing equipment. Shaped pieces are welded into two dimensional sub-assemblies, three dimensional assemblies and then into final prefabricated units. These prefabricated units may be very large, comprising, for example, entire sections of the hull or superstructure and may weigh several hundred tonnes each. In the final stage of construction, the units are moved outside to the building slip or dock to be erected and welded into position.

2.2.4 Fitting-out

After the hull is launched, the fitting-out process generally involves installation of the engines and other machinery (for example, steering gear, winches, deck cranes and pumps), completion of the internal pipework, electrical wiring, instrumentation, radio and radar, cabin furniture and decoration. Insulation of pipework and fire protection measures may have involved asbestos-based materials.

Many different handling processes are used throughout the overall construction process, for example, overhead travelling cranes, vacuum lift cranes, roller conveyors, and fork-lift trucks.

2.2.5 Painting

Painting may take place at various stages during the construction process. It is common practice to do as much painting as possible on the various prefabricated units prior to final erection. Internal spaces may be painted during fitting out, then the vessel generally undergoes a final dry docking when the final outer hull coatings are applied.

Airless paint spray equipment is normally used, although rollers and brushes are used for fine work and in difficult areas. A wide range of anti-corrosive and

antifouling paints are typically used in shipyards as well as specialist tank coatings. The main types of coating used and the associated thinners/solvents are summarised in the Annex.

2.2.6 Antifouling treatments

Historically, treatments used to prevent the growth of barnacles, marine grasses, algae and other marine organisms on ships contained metals such as lead, copper, tin, arsenic and mercury. The only active ingredients permitted in modern treatments are approved for use under the Control of Pesticides Regulations 1986 (see Section 4). This control has led to the withdrawal of many antifouling treatments on health, safety and environmental grounds and the introduction of new, safer products. However, many compounds withdrawn from use may have caused past contamination at existing or former shipbuilding, repair or shipbreaking sites.

2.3 Ship repair and shipbreaking

The basic processes involved in ship repair are the same as those used in shipbuilding and the two activities are often carried out at the same yard. Vessels are generally brought into dry dock for repair, although engine room machinery refits and other work on internal spaces may be undertaken at a fitting-out berth. As well as modifications to internal machinery and equipment, repairs may involve substantial structural work to the outer hull and/or superstructure; this work involves all the metal working techniques used in shipbuilding. A substantial amount of painting generally takes place during ship repair. Vessels must be dry docked at intervals of between 18 and 60 weeks to have their antifouling protection renewed.

Shipbreaking involves the complete dismantling of a vessel for scrap. The process begins with the vessel alongside, possibly at a fitting-out dock where the engines and other large items of useful equipment such as winches and deck cranes are removed. The vessel is then systematically cut into manageable pieces using flame cutting equipment. As the break-up progresses, the vessel may be moved into a dry dock or beached at some suitable location.

2.4 Waste materials

In the past, many wastes were stored temporarily on site prior to off-site disposal and some may have been buried on site. Liquid effluents, such as spent pickling liquors, may have been discharged directly into adjacent surface waters and a variety of materials sluiced out of the dry dock.

Chemical wastes may include a number of used products and/or their residues, for example fuel and engineering oils, transformer fluids, tank and bilge sludges, paints, blasting grit contaminated with paint residues, thinners and cleaning solvents. These wastes may have been drummed for off-site disposal or even poured on to the ground.

Metallic wastes may include quantities of copper and its alloys such as copper/nickel, copper/zinc (brass) and copper/tin (bronze), used in condensers and heat exchangers, pumps, valves and other fittings where good resistance to seawater corrosion was required.

Other wastes are likely to include discarded equipment, for example welding and paint spraying equipment, transformers, dials and gauges (containing alcohols or mercury), cables, batteries, scrap metals, pockets of finely divided metals, and metal fastenings.

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

Contamination of land associated with shipbuilding, ship repair and shipbreaking yards may result from the use, storage, spillage or disposal of any materials used. It could also arise from any of the wastes generated during these processes and from any associated on-site industries.

Fuel oils, lubricating oils and hydraulic fluids may contaminate the ground through leakage or spillage, particularly around former fuel storage tanks and drum storage areas. Also, leakage along the lines of drains, sewers, pipes, or from on-site disposal locations for oil tank sludges, may have caused contamination.

Solvents used in paints or for degreasing, thinning or cleaning, may have caused contamination through spillage or leakage around bulk storage tanks and drum storage areas. On-site disposal locations such as soakaways, waste storage tanks and in former production areas could also have been affected.

Asbestos was used extensively as an insulation material and may have been released during application or the stripping of lagging on pipes and tanks. It is most likely to be found in the waste storage and on-site disposal areas in shipbreaking yards but it may be distributed generally across the site. Residual quantities may also be found in shipbuilding and ship repair yards.

Heavy metals and their oxides, from welding, cutting, grinding, discing and shot blasting operations, and metal compounds, used as pigments or corrosion inhibitors in paints or as the active ingredient in antifouling treatments, can also be present. Contamination is most likely around waste storage areas which may contain floor sweepings from metal working areas, dust and residues containing paint particles, metal oxides from shot blasting cabinets and paint sludges. On-site disposal and/or waste burning areas may be a source of contamination.

Contaminating waste materials from other industrial sites may have been imported as infill during the development of docks and quays (see the profile describing dockyards, Section 4).

Methane and carbon dioxide gas emissions may also arise from infilled dock basins as a result of the anaerobic degradation of any putrescible fill material or from highly organic silts left in the docks prior to infilling.

Decommissioning and demolition works may have contributed to ground contamination owing to spillages from tanks and pipework and the general movement of materials and wastes.

Remnants of coal stores and waste ash may still be found on very old sites. Some low-level radioactive wastes from luminous paints and/or scrapped military instruments may be found on some sites, especially warship yards and Royal Dockyards.

In the past, electrical transformers may have used polychlorinated biphenyls (PCBs) as dielectric fluid. PCBs may be associated with scrapped instrumentation on some sites.

3.2 Migration and persistence of contaminants

By the nature of their mainly coastal location, few shipbuilding, repair and shipbreaking sites will pose a possible risk to useable groundwater resources. However, the threat to surface waters may be considerable, through leaching of water-soluble substances from soil and from liquid chemicals.

3.2.1 Heavy metals

Except in waste burial areas, metal contamination is likely to decrease with depth from the surface.

The movement of metals through the soil is significantly retarded by the presence of clay minerals and organic matter. The solubility of some metals (eg copper, zinc and lead) may increase under acidic conditions. In other cases the relationship is more complex. For example, trivalent chromium is more soluble under acidic conditions, whereas the solubility of hexavalent chromium is increased under both acidic and alkaline conditions and arsenic may become more soluble at higher pHs.

3.2.2 Fuel oils and solvents

Fuel oils and solvents are typically highly mobile, volatile liquids, and pose a considerable threat to water resources. Close to the soil surface, some may be lost directly to the atmosphere by evaporation. Groundwater may be contaminated by the downward seepage of liquids, the movement of vapours in unsaturated soils and their subsequent solution in groundwater, and the infiltration of groundwater through oil and solvent-contaminated soils. Surface water may be affected by run-off from tips and dumps, contaminated soil or the discharge of oils and solvents into nearby waterbodies or watercourses. Although the solubility of some of these oils and solvents is relatively low, their dissolved concentrations may be several orders of magnitude greater than water quality standards permit. In most cases, these compounds are less dense than water and will, therefore, float on the surface of the water-table. However, chlorinated solvents are denser than water and tend to migrate to the bottom of water bodies. Their migration may not be consistent with the general groundwater flow.

Widespread contamination by solvents may improve the mobility and potential for groundwater contamination by other compounds eg metals and other organic compounds which have low aqueous solubility but may dissolve in organic solvents.

The transport and fate of both inorganic and organic compounds within the soil will be dependent on a combination of 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 and the greater the reduction in contaminant migration. Thus, the greatest degree of mobility will occur in coarse-grained sands and gravels with little organic matter. The less soluble compounds, which become adsorbed on to clay or organic matter may be sources of water pollution long after the source has been removed, by continuing to desorb into the soil water. The risk from buried organic compounds to current and potential water supplies may therefore be considerable. Lateral movement through the soil, either in the dissolved or free phase, may also affect surface 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, eg 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. Because of these factors, at high concentrations in soil, even relatively non-persistent compounds may not biodegrade readily.

3.2.3 Other factors

Asbestos is neither soluble nor biodegradable and persists in the soil. Wind dispersion of contaminated soil may occur where there is gross surface contamination by less mobile contaminants, particularly asbestos and metals.

Polychlorinated biphenyls and some of the halogenated organics are fat-soluble and have a propensity to accumulate in food chains.

Some organo-metallic compounds may be absorbed by plants and enter the food chain.

4. Sources of further information

4.1 Organisations

For information concerning shipbuilding, repair and shipbreaking in the United Kingdom, the following organisations should be consulted:

British Maritime Technology
BMT Cortec Limited
Wallsend Research Station
Wallsend
Tyne and Wear
NE28 6UY

The National Maritime Museum
Greenwich
London
SE10 9NF

The Shipbuilders and Shiprepairers Association
33 Catherine Place
London
SW1E 6DY

The Tyne and Wear Development Corporation
Scotswood House
Newcastle Business Park
Newcastle upon Tyne
NA4 7YL

4.2 Sources of information concerning the activities described in this profile

Allen G C. *British industries and their organisation*. London, Longman, 1970.

Brown D K. *A century of naval construction*. London, Conway Maritime Press, 1983.

Eyres D J. *Ship construction*. London, Heinemann, 1988.

Ireland B. *Warship construction*. London, Ian Allen, 1987.

MacDougal P. *Royal dockyards*. London, Charles, 1982.

Ministry of Agriculture, Fisheries and Food/Health and Safety Executive. *Pesticides Handbook (Pesticides approved under The Control of Pesticides Regulations)*. London, HMSO, (published annually).

Newton R N. *Practical construction of warships*. London, Longmans, 1970.

Taylor D A. *Merchant ship construction*. London, Butterworths, 1985.

Walker F M. *Song of the Clyde. A history of Clyde shipbuilding*. Cambridge, Patrick Stephens, 1984.

Walker F M and Slaven A (Editors). *European shipbuilding - 100 years of change*. Proceedings of the 3rd Shipbuilding History Conference, National Maritime Museum, 1983.

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 shipbuilding 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.

4.3 Related DOE Industry Profiles

Asbestos manufacturing works
Chemical works: coatings (paints and printing inks) manufacturing works
Chemical works: pesticides manufacturing works
Dockyards and dockland
Engineering works: mechanical engineering and ordnance works
Metal manufacturing, refining and finishing works: iron and steel works
Waste recycling, treatment and disposal sites: metal recycling sites

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. *The application or removal of tributyltin or triphenyl coatings at shipyards or boatyards.* Chief Inspector's Guidance to Inspectors, Process Guidance Note IPR 6/1. London, HMSO, 1995.

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.

Verschuieren 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/groups 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.

General contaminants

Metals and metal compounds	finely divided metal wastes - steel, copper alloys and solders pigments - aluminium, chlorinated zinc, zinc, titanium dioxide, lead oxide, copper oxide, ferrous oxides, zinc lead oxide, zinc chromate scrapped instruments - mercury
Fuels/oils/oily sludges	diesel and lubricating oils hydraulic fluids
Organic compounds	paints and solvents (see list on next page) non-chlorinated degreasing solvents eg ketones, glycol ethers chlorinated hydrocarbons white spirit aromatic hydrocarbons alcohols
Pickling acids	sulphuric phosphoric
Cyanides	
Coal, ash	
Polychlorinated biphenyls (PCBs)	
Asbestos	
Radioactive materials (Ra-226)	
Methane (from site infill)	

Typical marine coatings and associated thinners/solvents

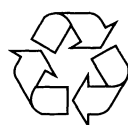
Shop primers	aluminium zinc epoxy iron oxide epoxy zinc silicate
Anti-corrosives	coal tar vinyl and coal tar epoxy zinc silicate - these paints may contain lead, zinc and chromium (as chromate)
Antifouling treatments	carriers active ingredients - historically lead, copper, tin, mercury and arsenic compounds; modern treatments contain copper, zinc and organotin compounds
Thinners/ solvents	ketones eg methyl ethyl ketone (MEK), methyl iso-butyl ketone (MBK) glycol ethers eg glycol ether acetates, glycol ether alcohols aromatic hydrocarbons eg benzene, toluene, xylenes white spirit alkanes halogenated hydrocarbons alcohols eg butanol

Table 1 Main groups of contaminants and their probable locations

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

Main groups of contaminants	Location									
	Raw materials delivery/storage transfer	Process areas			Waste storage	Waste disposal	Process pipework/pumps	Drainage system including soakaways	Fuel storage/pipework	Electricity transformer areas
		Coatings/steel treatment	Fitting out/repair	Breaking						
Metals										
Cyanides										
Mineral acids										
Asbestos										
Organic solvents/thinners										
Biocides										
Epoxies/vinyls										
Polychlorinated biphenyls (PCBs)										
Oily sludges										
Fuel/lubricating oils										
Coal/ash										

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.