Department of the Environment
Industry Profile

Road vehicle fuelling, service and repair

garages and filling stations

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Liabilities Division

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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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DOE Industry Profile

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

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.

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

1. Background

Fuel retail outlets can be subdivided into three main categories as shown below:

Filling stations	Establishments where the sale of motor fuel is the main part of the business. Few repair services are provided.
Garages	Establishments where the primary aim is the repair and rebuilding of motor vehicles. They may hold an agency for a motor manufacturer. Sales of petrol may represent only a small proportion of the total turnover.
Service stations	Establishments that sell motor fuel and provide facilities for servicing vehicles and minor running repairs. Other 'value-added' services such as forecourt convenience stores may also be provided.

Filling stations traditionally sell petrol, diesel fuel and paraffin. All of these fuel types are normally stored in underground tanks of varying capacity. The majority of filling stations sell petrol and diesel, but there are a limited number of stations that sell diesel only.

1.1 History

The invention of the high speed internal combustion engine (patented in Germany in 1885-6) led to the development of the motor car and motor cycle. Until the late 19th Century, the development of motoring in the United Kingdom was inhibited by legislation which limited power driven vehicles to four mile per hour and required them to be preceded by a man carrying a red flag; the law was repealed in 1896.

The first retailers of motor vehicles and petrol were cycle repairers and kerosene merchants. From 1899, petrol was transported in bulk by rail, road or water to inland storage depots, from where it was distributed to petrol retail outlets in two-gallon cans.

The government took over the import of petroleum products during the First World War, but distribution remained in the hands of petrol companies. Private motoring and the commercial use of motor vehicles developed rapidly during the inter-war period. The first hand-operated petrol pump with underground storage tanks was introduced in 1920. By 1929, there were 28 000 retail petrol outlets in the United Kingdom, which had increased to 35 000 outlets by 1939. Few petrol stations at this time had forecourt accommodation for refuelling.

During the Second World War petrol was rationed and its price controlled. After the war a free market was reintroduced and the trend was for outlets to enter into exclusive supply agreements with one or other of the major oil companies. The number of vehicles, together with petrol consumption, continued to rise during the

1950s and 1960s. In 1953 there were 34 000 petrol retail outlets and by 1964 an estimated 39 000 outlets, of which about 4000 were one-pump sites.

Between 1974 and 1990, the number of petrol retail outlets fell by 40% to about 19 500. A number of factors contributed to the closures, including the growing popularity of smaller cars with lower fuel consumption and the cost of bringing old outlets up to modern specifications.

When 'cut price' supermarket petrol was introduced in 1989, further closures of retail outlets became inevitable. The number of retail petrol outlets in the United Kingdom in 1995 was about 17 000, of which some 3% were located at supermarket sites.

In 1995 there were about 2000 sites operating convenience stores and about 5000 with vehicle wash facilities.

1.2 Location

Garages and filling stations are widely distributed throughout the country. Sites range from the small urban and rural petrol stations, with just one or two petrol pumps, to large garages with a comprehensive workshop offering a complete repair and maintenance service. The larger premises tend to be concentrated along the trunk road network and on the edges of built-up areas, along by-passes and at major road junctions. Specialist repair shops tend to be sited in urban areas.

Many private bus companies, road haulage contractors and other large businesses maintain their own repair facilities and fuel storage depots. For further information regarding these activities, see the relevant Industry Profile (Section 4)

2. Activities

2.1 Filling stations

2.1.1 Petrol and diesel

Petrol consists of a mixture of volatile hydrocarbons (distilled from crude petroleum in the boiling range 70-180°C) and chemical additives. Additives include oxygenates (for example alcohols and ethers, used as stabilising and blending agents) and anti-knock components (normally organo-lead compounds, for example tetraethyllead). Oxygenates are added in the range of 3-10% by volume. The levels of anti-knock compounds are controlled by legislation and have been progressively reduced. In unleaded petrol, the anti-knock compounds are replaced with other chemicals, for example methyl tertiary butyl ether (MTBE) which is an octane booster.

In recent years, detergent additives have been added to petrol which help to keep carburettors, fuel injectors and inlet valves free of carbon deposits.

Other materials may also be present in petrol as impurities from crude petroleum, for example sulphur.

Diesel is a mixture of hydrocarbons distilled from crude petroleum, consisting of a mixture of cetane (n-hexadecane, $C_{16}H_{34}$) and a methyl naphthalene ($C_{11}H_{10}$). The

higher the cetane (C) number, the greater the percentage of cetane and therefore the better the performance of the fuel. Fuel in the distillation range 400-700°C and with a C number of 40-60 gives a lightweight fuel which is generally used in most automotive engines. Heavier fuels of a lower distillation range, with a lower C number are used for fixed, low-speed or marine engines.

Commonly used diesel fuel additives include:

Anti-oxidants	To improve oxidation stability in storage.
Metal deactivators	To provide a passive film on active metals to inhibit fuel oxidation.
Detergents	To maintain a clean fuel system.
Corrosion inhibitors	To protect fuel pumps and injectors.
Cetane improvers	To improve ignition quality.
Low temperature flow improvers	To prevent 'waxing' in cold weather.
Combustion modifiers	Mainly inorganic salts used to reduce smoke production and deposits in combustion chambers.

2.1.2 Delivery and storage

Petrol is delivered by road tanker to filling stations and pumped into underground storage tanks and pipework. Diesel fuel and paraffin are also delivered by tankers and are stored in tanks above or below ground.

The Health and Safety Executive in HSE Guidance Note HS(G)41 (first published 1990) gives advice on the planning, design, construction and operation of petrol filling stations. It describes standards and methods of work at filling stations necessary for the grant of a license, by a licensing authority, under the Petroleum (Consolidation Act) Act 1928, to keep petrol and to minimise the risk.

The protection of soil is not a primary consideration of HS(G) 41, but the standards and methods of work set out in it reduce the possibility of contamination. For example, it advises that underground single skin petrol storage tanks should be surrounded by sulphate-resistant concrete not less than 150mm thick. Double skin underground petrol storage tanks may stand on reinforced concrete slabs not less than 150mm thick, and the excavation may be backfilled with suitable granular material.

HS(G)41 also includes guidelines on the construction of petrol filling station forecourts. There should be petrol interceptors to collect any petrol spilled from tankers or from metering pumps, dispensers and hoses and they should be sited to prevent any petrol, or water contaminated with petrol, from entering any watercourses, public drains or sewers. Water from car wash facilities should not be allowed to drain into petrol interceptors.

HS(G)41 does not deal with diesel.

HS(G)41 was rreplaced by a new framework of guidance in 1996. This comprised of a new guidance document, HS(G)146: 'Dispensing petrol', which gives guidance on using risk assessment methods to decide on appropriate safety and control measures, and technical guidance by the petroleum industry.

2.2 Car washes

In addition to activities associated with storage and retail of petrol and diesel, 'added-value' services including car washes are found at most service stations.

Car wash detergents essentially comprise a surfactant and other chemicals to increase the effectiveness of the surfactants. Alkylbenzene sulphonates have been replaced as surfactants by more readily biodegradable linear alkyl sulphonates.

Chemicals to enhance the performance of the surfactant were traditionally phosphate-silicate formulations but they have been superseded by sodium carbonate, sodium silicate and chelating compounds, for example ethylenediaminetetracetic acid (EDTA), nitrilotriacetic acid (NTA) salts and calcium/sodium aluminosilicates (zeolites).

Minor components include corrosion inhibitors, dyes and foaming agents. Information on detergents is given in a separate profile (see Section 4).

2.3 Repair garages

2.3.1 Lubricating oils

Engine and transmission lubricating oils, both new and used, are stored on site in metal containers and storage tanks. The quantities vary from site to site, but only a few garages are likely to have stored over 1000 gallons of waste oils. Lighter oils are used in metal machining operations. The composition of automotive lubricating oils has changed through time and they are now likely to contain many more additives than previously.

Contaminants in used oils are mainly heavy metals and products of combustion, for example:

lead from fuel
copper from engine bearings
a range of metals from other parts of the engine
unburnt fuel
products of combustion, for example polycyclic aromatic hydrocarbons (PAHs).

2.3.2 Anti-freeze

Ethylene glycol, along with methanol, is used as an anti-freeze in coolant systems.

2.3.3 Brake fluids

Polymerised glycols and ethers are the main constituents of brake fluid. Brake fluids are changed at regular intervals during vehicle servicing, and waste fluid is generated during repair work on brake systems.

2.3.4 Solvents

A variety of solvents are used by garages in cleaners, degreasers, thinners, fillers, adhesives, paints and strippers. The range and use of available solvents has increased over the years and many of the widely used ones are chlorinated hydrocarbons; in the past, carbon tetrachloride was commonly used. Also widely used are paraffin and proprietary degreasing compounds.

2.3.5 Paints

Historically lead-based paints were used extensively, in the automotive industry, with primers often containing chromates. Most of the decorative finishes were nitrocellulose-based and various esters, for example, ethyl acetate and butyl acetate along with glycol ethers, were used as thinners until about twenty years ago. Styrenated alkyds (a modified polyester resin) were also used, with white spirit as the solvent. Since then, zinc-rich epoxy primers have been used. Until recently, these contained small amounts of chromates.

Polyurethanes became popular for decorative finishes in the 1960s. Thinners used with polyurethanes were usually ketones (eg methyl isobutyl ketone, methyl ethyl ketone and cyclohexanone) and esters (eg ethyl acetate). Isocyanate curing agents are being phased out due to concern about their use with polyurethanes. They are being replaced by acrylic coatings using ketone thinners.

In the past, paints used in refinishing operations for vehicle repairs contained 85% organic solvents. Volatile organic compounds (VOCs) play a central role in the formation of ozone and other photochemical pollutants. Due to the tightening of emission regulations relating to these compounds, water-based metallic vehicle basecoat paints containing 10-15% organic solvents are becoming more popular.

2.4 Wastes

Petrol filling stations are unlikely to generate significant quantities of waste since their major commodity, petrol, is sold on for direct use. However, there may be spent oil containers and sludges from petrol storage tanks left on site.

Waste from repair garages may include any, or all, of the materials mentioned above. There may be small quantities of used batteries, asbestos from brake linings and spent oil or solvent containers.

3. Contamination

The contaminants on a site will largely depend on the history of the site and on the range of materials present 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

3.1.1 Filling stations

Contamination associated with petrol filling stations and garage repair sites is possible due to the storage, spillage, leakage or disposal of raw materials or waste products. In the past, contamination of the ground from spillage was common due to overfilling or faulty pipes or caps etc. Today, strict precautions are taken when fuel is delivered and the number of spills has been reduced. However, all filling stations are susceptible to spillages occurring due to operator error or equipment failure. Spills may also occur when motorists overfill vehicle tanks. Contamination of the ground may also be caused by petrol leaking from underground tanks and pipework.

Residual petrol storage tanks may pose a risk of explosion, fire and ground and surface water contamination, unless they have decommissioned in accordance with the licence by filling with concrete, water or foam.

3.1.2 Car washes

Ground adjacent to car washes, where these are present on filling stations, may be contaminated by the run-off of water which contain chemicals used for cleaning.

3.1.3 Repair garages

In the past, waste oils and other fluids are likely to have been disposed of down nearby drains or thrown on to open ground. Combustible materials may have been burned on-site along with some of the waste oils. Used tyres and parts often presented a disposal problem and may have been left lying on site.

3.2 Migration and persistence of contaminants

3.2.1 Organic compounds

Petrol and diesel are highly mobile and may migrate to contaminate a wide area. Free product released at the surface or leaking from an underground structure may migrate through the ground; vapour may diffuse into the soil and migrate as a vapour front ahead of the free product. Vapour may accumulate in poorly ventilated spaces and present a fire and explosion hazard.

MTBE (an anti-knock additive to petrol) is at least ten times more soluble in water than other constituents of petrol, and when in contact with groundwater will dissolve and spread rapidly. Its taste threshold is extremely low (10 µg/l) and it may taint potable water supplies at low concentrations.

Chlorinated hydrocarbons, used as degreasing solvents, have low viscosities and are highly mobile. The risk to groundwater from petroleum hydrocarbons and solvents depends on the depth of the water table and the properties of the soil. Normally, the higher the organic matter and clay content within the soil, the greater the adsorption of organic compounds and the lower their mobility. Conversely, the greatest migration of contaminants will occur in coarse-grained sands and gravels with little organic content. The less soluble compounds which become adsorbed on to clay or organic matter may cause water pollution long after the original source has been removed, as a result of the chemical continuing to desorb into soil-water. Organic compounds may pose a threat to current and potential potable water supplies.

Less soluble solvents and spillages of oil hydrocarbons will tend to migrate to the water table. These compounds are usually less dense than water and float on the water table surface. Chlorinated solvents (also of low aqueous solubility) are denser than water and tend to migrate to the bottom of aquifers. They are persistent chemicals and can render groundwater unsuitable for public supply at low concentrations.

The soluble hydrocarbons may contaminate surface water via run-off or surface discharge of contaminated groundwater.

3.2.2 Heavy metals

The movement of metals through soil is significantly retarded by the presence of clay minerals and organic matter. The solubility of some metals (for example 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.

3.2.3 Other substances

Vehicle washing areas should not pose a threat of potential contamination if a catchment pit with an interceptor is used. Inadequate drainage systems and spillage of detergents may release potential contaminative chemicals on to land, surface and groundwater. However, most detergents are 80% biodegradable and residual detergent chemicals and their degradation products are likely to be readily leached from the soil. Although there may be short term accumulation of phosphates, sulphur-containing compounds and alkalinity, long-term contamination is unlikely. Contact of detergents with soil contaminated with oils may increase the mobility of the oil, accelerating its release from the soil.

Asbestos is neither soluble nor biodegradable but may be moved around a site by wind dispersal.

4. Sources of further information

4.1 Organisations

For information concerning garages and filling stations in the United Kingdom, the following organisations should be consulted:

The Associated Octel Company Limited
23 Berkeley Square
London
W1X 6DT

Ford Motor Company
Room 14/215
Research and Engineering Centre
Laindon
Basildon
Essex
SS16 6EE

The Institute of Petroleum
61 New Cavendish Street
London
W1M 8AR

The Petrol Retailers Association
201 Great Portland Street
London
W1N 6AB

The United Kingdom Petroleum Industry Association
9 Kingsway
London
WC2B 6XH

4.2 Sources of information concerning the activities described in this profile

British Standards Institution. *Specification for leaded petrol (gasoline) for motor vehicles,* British Standard BS 4040: 1988. BSI, 1988.

British Standards Institution. *Specification for unleaded petrol (gasoline) for motor vehicles,* British Standard BS 7070: 1988. BSI, 1988.

British Standards Institution. *Specification for fuel oils for non-marine use, Part 1: Specification for automotive diesel fuel (class 1A),* British Standard BS 2869: Part: 1988. BSI, 1988.

Health and Safety Executive. *Dispensing petrol.* Guidance Note 146, London, HMSO, 1996.

Health and Safety Executive. *Petrol filling stations: Construction and operation.* Guidance Note 41, London, HMSO, 1990.

Health and Safety Executive. *The carcinogenicity of mineral oils.* Guidance Note EH 58, London, HMSO, 1990.

Health and Safety Executive. *The cleaning and gas freeing of tanks containing flammable residues.* Booklet CS15, London, HMSO, 1985.

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

Chemical works: soap and detergent manufacturing works
Engineering works: vehicle manufacturing works
Oil refineries and bulk storage of crude oil and petroleum products
Road vehicle fuelling, service and repair: transport and haulage centres

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.

Fuelling areas

Petroleum spirit	alcohols ethers organo-lead compounds benzene branched olefins long chain aliphatic compounds naphthalenes polycyclic aromatic hydrocarbons (PAHs)
Petrol additives	eg tetramethyllead (TML) tetraethlyllead (TEL) methyl tertiary butyl ether (MTBE)
Diesel (derv or gas oil)	additives

Workshops

Metals and metal compounds	copper zinc lead chromium vanadium
Waste oil	polycyclic aromatic hydrocarbons (PAHs) heavy metals
Anti-freeze	eg ethylene glycol
Brake fluids	eg polymerised glycols and ethers
Solvents (non-chlorinated)	eg white spirit methanol xylene glycols esters ketones
Solvents (chlorinated)	eg dichloromethane 1,1,1 trichloroethane trichloroethylene tetrachloroethylene

Paints containing	lead zinc esters eg ethyl acetate butyl acetate isocyanates ketones eg methyl isobutyl ketone methyl ethyl ketone cyclohexanone
Thinners	glycol ethers
Inorganic compounds	asbestos sulphur isocyanates battery acids

Vehicle wash areas

Detergent constituents	linear alkyl sulphonates sodium carbonate sodium silicate sodium hydroxide ethylene diamine tetraacetic acid (EDTA) nitrilotriacetic acid (NTA)

Table 1 Main groups of contaminants and their probable locations

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

Contaminant		Location			
		Fuelling areas	Workshops	Vehicle washing areas	Paint shops
Main group	**Sub-group**				
Metals and their compounds	Lead	■	■		■
	Chromium		■		■
	Zinc		■		■
	Copper		■		
	Vanadium		■		
Acids/alkalis			■	■	
Asbestos			■		
Organic compounds	Non-halogenated solvents		■		■
	Halogenated solvents		■		■
	Polycyclic aromatic hydrocarbons (PAHs)		■		
	Fuels/hydrocarbons	■	■	■	
	Ethylene glycol		■		
	Polymerised glycols and ethers		■		
	Detergents			■	

Shaded boxes indicated areas where contamination is most likely to occur

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

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