

INSTITUTE OF PETROLEUM

Tank Cleaning Safety Code

*Being Part 16 of the Institute of
Petroleum Model Code of Safe
Practice in the Petroleum Industry*

2nd Edition

July 1996

Published on behalf of
THE INSTITUTE OF PETROLEUM, LONDON
by
John Wiley & Sons
Chichester • New York • Brisbane • Toronto • Singapore

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FOREWORD

An IP Code of Safe Practice is not intended necessarily to represent the most stringent work methods that might be devised for performing a potentially hazardous operation, nor does it represent a minimum standard. Instead, it advocates procedures, which, in the opinion of a cross-section of experts and based on their practical experience, should ensure a safe standard of work under conditions typically encountered.

As a consequence, some organisations may choose to follow the Code as written. Others may support it in principle, but in considering local circumstances, may elect to vary conditions, sometimes adopting more stringent requirements and sometimes more relaxed. Whichever interpretation is adopted, it is a matter for local management to select conditions appropriate to its specific circumstances, preferably based on a *risk assessment*.

The cleaning of oil storage tanks is, by its nature, a dirty and unpleasant operation. This adds to the inherent hazards of the *flammable* materials that may be involved.

In the production of this Code, the objective has been to present in one volume sound advice on the specific hazards encountered in cleaning tanks of the types commonly used for the storage of crude oil and liquid petroleum products. Ways are presented of dealing with such hazards. Although the Code does not set out to give detailed instruction on cleaning techniques, general guidance on cleaning procedures is given.

Those responsible for tank cleaning should realise that every job is different and they should be prepared to study the circumstances and plan the work. It should be appreciated that the Code is a guide and that it cannot remove the need for experienced and well trained supervision, a trained, disciplined and trustworthy workforce and a carefully prepared, thorough work plan. The plan should be based on safety and environmental *risk assessments* that take full account of current regulatory requirements and related guidance.

The Code assumes that the refinery, installation, depot or terminal where the tank to be cleaned is located, has a fully staffed operations and maintenance organisation. For smaller sites and those where major manpower reductions have taken place, the organisation will be much smaller and responsibilities more diverse. However, provision of the appropriate level of technical expertise remains essential for tank cleaning and, in these cases, it may be necessary to make use of experts from outside the organisation.

Attention is drawn to the fact that many countries have statutory requirements, both local and national, relating to the petroleum industry. Such requirements have precedence over the corresponding clauses in this Code except that, where the requirements of the Code are more rigorous, its use is recommended. Where specific regulations are referred to in the text, these apply only to the United Kingdom, unless otherwise indicated.

The Code also makes reference to a number of British Standards. In countries outside the United Kingdom the appropriate local or national standards should be applied.

For the purpose of this Code certain interpretations, which are given in the glossary (Annex A), apply irrespective of any meaning the words may have in other connections. Where used in this Code, such terms are printed in italics.

Although it is believed that adoption of the recommendations of this Code will help to reduce the risk of accident, the Institute of Petroleum cannot accept any responsibility, of whatsoever kind, for damage or alleged damage arising or otherwise occurring in or about premises where this Code has been applied.

The first edition of this code was prepared by a Working Group reporting to the IP Safety Sub-Committee. It has now been revised by the IP Microbiology Committee, the Advisory Committee for Health, the Occupational Hygiene Committee and by members of the Safety Committee. The Institute is also grateful for the valuable assistance provided by other experts who are not members of IP Committees. The Code will be further reviewed from time to time and it would be of assistance for any future revision if users could send comments or suggestions to:

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SCOPE

1.1 TANKS

This Code covers the precautions to be observed during the cleaning of fixed bulk storage tanks operating at near-atmospheric pressure, of the types commonly encountered in petroleum refineries, installations, depots and terminals. These are principally vertical, cylindrical steel tanks above ground with floating roofs, or fixed roofs (with or without internal floating covers). The cleaning of horizontal cylindrical tanks, such as the common 30' x 9' type, is also included.

Buried, semi-buried or mounded storage tanks are usually of the vertical cylindrical type, to which the guidance given in this Code will apply. However, certain aspects of their construction, such as roof columns and entrance tunnel, require special consideration and additional precautions. Advice should be sought from organisations with experience in operating such tankage.

The Code does not cover road and rail tankers, container tanks, barge or ship tanks, pressure storage vessels such as spheres and bullets, refrigerated storage or underground cavern storage. Service station and consumer tankage is not expressly addressed. Whilst the cleaning of similar types of tanks is described, their siting and access may require additional precautions to be observed.

1.2 PRODUCTS

The Code covers tanks which have been used for storage of crude oil, and refined or intermediate petroleum products. It also covers tanks which have been used for the storage of process water and ballast water. These will contain varying amounts of oil and will therefore demand the same precautions as those applied for oil storage tanks.

Additionally covered are situations where the product(s) have been contaminated by microorganisms. In some of these cases biocides may have been used either for treatment of the product and/or disinfecting the tank.

No attempt is made to cover the cleaning of tanks which have been used for storing chemicals or additives. Although the procedures recommended in the Code are equally relevant in many cases, it is recommended that advice on hazards and precautions should be sought from the suppliers of the materials.

1.3 CLEANING

This Code focuses on the safety and health hazards associated with the preparation for and performance of tank cleaning operations. It provides guidance on how a safe method of work can be devised. General guidance on tank cleaning procedures is provided. However, the Code does not constitute a detailed manual on the subject nor attempt to advise on the relative efficiency of the various methods or the choice of method for any particular case.

The purpose of the tank cleaning covered by this Code may be to:

- prepare the tank for a change of product;
- remove accumulations which are interfering with operation or quality control;
- decontaminate tanks that have contained products subjected to microbial spoilage;
- enable inspection, maintenance or modifications to be carried out;
- enable the tank to be safely demolished and removed.

The cleaning may give rise to hazardous liquid, semi-solid or solid waste material, and brief guidance is given on its disposal.

1.4 SAFETY AND HEALTH

The Code provides recommendations on the limits of hazardous substances in tank atmospheres during entry for normal tank cleaning operations. Different entry conditions may be appropriate for other operations in the petroleum industry, or for tank cleaning carried out by trained operators using specialised techniques and/or equipment.

Although this Code details the precautions needed for cleaning tanks it does not deal with the additional precautions necessary before and during subsequent repairs, modifications or demolition which may involve flame cutting, welding and other forms of *hot work*.

Brief guidance is given however on the precautions to be observed before taking tanks back into service after cleaning.

PREPARATORY WORK

2.1 ORGANISATION AND PERSONNEL

Any company involved in tank cleaning of any nature should organise and maintain a system whereby tank entry and cleaning operations are carried out in a responsible, safe and controlled manner. In this context, it is important that Annexes D and E are carefully studied and a thorough work plan prepared, based on a project safety review.

The work plan should be consistent with all regulatory requirements relevant to the work that is to be undertaken. Where the requirements of this Code of Practice are more rigorous than regulatory requirements, it is recommended that the Code should be observed. A list of regulations appertaining to the UK is provided in Annex H.

2.1.1 Supervisor

A supervisor should be appointed to control any tank cleaning. The supervisor should be thoroughly competent and fully conversant with all the applicable safety regulations and procedures, including the characteristics of the product being handled prior to and during the period of tank cleaning operations.

If a contractor company is engaged to undertake the work, the supervisor should be trained to the standard of a *Performing Authority* of the client company and may be accepted as such if local rules allow.

The person should possess high standards of responsibility and safety consciousness and a personal commitment to health and safety interests.

He/she should also have the ability to deal immediately and firmly with any laxity on the part of personnel engaged on the cleaning operation, both inside and outside the tank and also in the associated working area.

The person should be able to communicate effectively with the cleaning workforce taking into account any differences in working languages.

Whilst safety is a responsibility of all personnel involved, it is the tank cleaning supervisor's specific responsibility to ensure an adequate *risk assessment* has been conducted and documented. In addition, he/she should minimise all recognized risks before the tank cleaning operation begins and maintain a safe operation until the tank has been completely cleaned and handed over to the subsequent function. He/she will also monitor changes in conditions and adapt the cleaning activity accordingly. Throughout the cleaning process the supervisor's responsibility will cover the control of all cleaning personnel.

Before work starts clear lines of reporting from the supervisor upwards should be established. Where appropriate, this should also cover the client and the contracting company.

2.1.2 Workforce

2.1.2.1 Qualifications

The tank cleaning workforce should be comprised of personnel who are medically fit and sufficiently competent and intelligent to complete the training programme outlined in 2.1.2.2 and to appreciate the significance of the hazards that may be present during cleaning operations.

They should be thoroughly familiar with safety precautions, equipment and procedures associated with tank cleaning. They should have a proven ability to read and understand notes, instructions, signs, etc., in the local working language. In cases where language problems exist, alternative means of communication of critical information should be adopted.

2.1.2.2 Instruction and training

It is essential that tank cleaning personnel are adequately instructed and trained in the following subjects and that this can be verified:

- hazards involved with hydrocarbon vapours, liquids and solids;
- relevant product properties;
- the potential operational hazards, including hot working, electrical equipment (fixed and portable) and toxicity;
- safety precautions and procedures involved in the preparation of the tank for cleaning, in the subsequent cleaning operation and its handover for recommissioning;
- emergency procedures, including basic fire fighting and location of muster points;
- first aid;
- *work permit* systems;
- decontamination of equipment and clothing;
- occupational hygiene;
- use of *breathing apparatus* and protective equipment where necessary;
- a complete understanding of the work involved;
- local site safety rules and regulations.

2.1.2.3 Radioactive Materials in Tank Sludges

Some sludges in crude oil tanks may be contaminated by *low specific activity (LSA) radioactive material or naturally occurring radioactive material (NORM)*. Where work is to be carried out in conditions where the radiation level is sufficiently high (see C.6), workers should be registered for such operations and subject to control and medical examination in accordance with relevant legislation (Ionising Radiations Regulations, Regulation 9 - Classified Persons).

2.1.3 Medical Aspects

2.1.3.1 Health and Fitness

Work in and near tanks can result not only in exposure to potential chemical and microbiological hazards (e.g. organic lead compounds, hydrogen sulphide, polycyclic aromatics, benzene, tank cleaning agents and other chemicals) and physical hazards (e.g. dust, heat and noise), but can also involve strenuous physical activity due to hard physical labour whilst wearing protective clothing and *breathing apparatus*. A certain standard of fitness and health surveillance is necessary for personnel engaged in this type of work, as discussed below.

2.1.3.2 Pre-Placement Health Assessment

All personnel considered for involvement in tank cleaning activities should have been subjected to medical assessment, which may include examination, to assess their suitability for the work, including assessment of fitness to use *breathing apparatus* and any pre-exposure to lead. Subsequent routine health reviews should also be carried out. Workplace *risk assessment(s)* carried out in accordance with the Control of Substances Hazardous to Health (COSHH) Regulations should be made available to the examining physician at the time of assessment. Records of such examinations should be retained.

The physician carrying out the assessment should be conversant with the basic requirements of tank cleaning and of the attendant health implications. In addition, the examining doctor should have specific knowledge of the physical demands of *breathing apparatus* and should be conversant with potential health hazards of lead, both organic and inorganic, and any other chemical and microbial hazards which may be encountered. A knowledge of the potential health hazards of *low specific activity (LSA) radioactive contamination* may also be necessary. The physician should agree with site management on the extent of the medical examinations and health reviews.

Where work is to be carried out in tanks which have contained toxic products, or have been subject to contamination by hazardous micro-organisms, or the cleaning process/operation necessitates the use of a substance hazardous to health, the examining physician should be informed about the specific hazards involved. In such cases a regular programme of appropriate medical surveillance should be carried out.

2.1.3.3 Periodic Health Assessment

Employers of personnel engaged in tank cleaning operations should carry out periodic health surveillance on the employees according to the potential hazards of their exposure.

Any person who is involved or has recently been involved in tank cleaning, and who falls ill or shows unusual symptoms or behaviour should report to his/ her supervisor and consult a physician. The identification of any possible relationship between the symptoms and the work may require consultation with an Occupational Health physician.

More information on health standards and surveillance is provided in the Institute's Model Code of Safe Practice, Part 18, *Occupational Health* and in other publications listed in Annex H.

2.2 PERMITS

It is the practice within the petroleum industry to require work which is not of a routine operational nature to be carried out under the control of a *work permit* system. This includes tank cleaning.

A permit system helps ensure that the strict control can be maintained throughout the work when processing and/or storing potentially hazardous or toxic materials.

A permit should specify: where the work is to be carried out the work permitted, the control measures and conditions to be observed, the period for which the permit is valid, the results of any tests to confirm the absence/presence of harmful material (e.g. gas tests), and the signatures of the Issuing and Performing Authorities.

The *issuing authority* will normally be the manager responsible for the site or his formally authorised representative. Annex D contains a check list for use by the applicant and the *issuing authority*.

In the case of tank cleaning, a series of *work permits* may be required to cover the work, from preparation for entry to final cleaning. Each stage of the work should be controlled through the appropriate combination of permits, each of which should be revalidated at the start of each work period. The type and number of permits required should be included in the overall work programme in order to identify when resources for preparation and monitoring are required.

Further guidance on *work permit* systems is included in the IP's '*Guidance Notes on Refinery and Distribution Terminals Work Permit Systems*' and the HSC-Oil Industry Advisory Committee (OIAC) publication '*Guidance on permit-to-work systems in the petroleum industry*'.

23 PRE-CLEANING INSPECTION

231 General

Before a tank is taken out of service for cleaning, a number of preparatory activities should be undertaken, in close liaison with operations, engineering and safety groups as appropriate. A concise record should be maintained of all pre-cleaning activities and findings.

2.3.2 Tank Contents

The operational history of the tank as regards the liquids that have been stored in it should be checked. The physical, chemical, radioactive and microbiological properties of these tank contents and any associated deposits should be assessed for expected behaviour under tank cleaning circumstances at, for example, low or high ambient temperatures. Particular attention should be paid to physical properties such as *flash point*, electrical conductivity, lead content and benzene content, and to the potential presence of biocides and other toxic additives, micro-organisms, hydrogen sulphide and pyrophoric deposits (see 5.9 and Annex C).

Before taking the tank out of service any sludge, water and sediment accumulations should be minimised as far as it is possible by operational measures, e.g., by dilution, heat, use of tank mixers or additives (see 6.1). Subsequently an estimate should be made of volumes and profiles of any remaining sludge and sediment with particular reference to levels at entry manholes and to the possibility of landing a floating roof safely on its supports. Deposits may be present at the bottom of the tank, on the walls and on the underside of the roof. The sludge and sediment should be sampled from the various surfaces as appropriate and analysed. A safe and environmentally acceptable means of treatment and disposal should be established.

Biocides in tank effluent can present a health hazard and may incapacitate biological effluent treatment plants. If biocide use is known or suspected, the type and concentration in sludge, sediment or residual water should be assessed and if necessary the biocide deactivated prior to handling and disposal of waste.

2.3.3 Tank Inspection

Engineering drawings and inspection records should be checked for relevant construction details that may influence the tank cleaning process, e.g., the existence of heating coils, floating suction, drainage systems, potential oil pockets, unsafe roofs and railings, internal sumps and piping. Confirmation should be obtained that the records and drawings are up-to-date and fully reflect all modifications carried out since original construction. These studies should be completed by external inspection of the tank. Special attention should be paid to the system of tank connections, valves and piping which should be assessed for possible use for drainage and recirculation during the cleaning process.

The means of providing positive isolation of the tank from the process and utilities systems (including vapour recovery) should be studied and recorded (see 4.2).

2.3.4 Roof Inspection

A general inspection should be made of the condition of the roof and of any equipment and connections thereon. Before permission is given to walk on a roof, enough information should be obtained about the condition of the roof plates to ensure that this can be done safely. Measurements of metal thickness should be taken to confirm the load-bearing capabilities of the roof plates. Access for this should be made using load-spreading devices. It is recommended that tank roof inspections should be subject to control under the installation's permit-to-work system. Roof inspections of tanks should not be undertaken during inclement weather, especially during periods of electrical storms (see C.2.2.2) or high winds.

Roof inspection should be executed by a team of at least two persons, at least one of whom should supervise from the top of the tank by the access stairway. He/she should have available adequate means of communication, preferably a portable two-way radio, appropriately certified, in order to be able to summon help from a pre-arranged contact.

2.3.4.1 Inspection of Fixed Roofs

In addition to the points listed in 2.3.4 certain extra precautions should apply in the case of fixed roofs.

If the contents of the tank give any reason to suspect that the atmosphere above the roof might be unsafe owing to toxic contaminants expelled by tank breathing, special precautions should apply. This may require the use of *breathing apparatus*. If *breathing apparatus* is used by the roof inspector, the person supervising from the tank top should also have such equipment adjacent and ready for immediate use. Airline *breathing apparatus*, rather than self-contained BA, is recommended. The air sources for the person on the roof and the supervising person should be supplied directly from a suitably sized common manifold and not via 'Y' pieces in the air supply piping.

Unless the tank handrail is constructed and maintained in such a way that it will prevent a person slipping down the roof from falling off, any person walking on the roof in areas away from the handrail should be attached via full body harness to an *inertia reel lifeline*. This lifeline should be securely attached to a suitable structural member of the tank which has been checked for strength and reliability beforehand.

Walking on roofs in wet or freezing conditions should be avoided.

2.3.4.2 Inspection of Floating Roofs

Floating roof inspection should especially include:

- all *earthing* shunts and cables,
- roof drains (also to be inspected at ground level),
- any water or product collected within pontoons or double decks,
- proper functioning of roof ladder,
- condition, operability and setting of roof supports and automatic vents,
- condition of roof seals.

Inspection of floating roofs should preferably be done with the roof floating at high level and when the level of the tank contents is static. In situations where there is no access ladder between tank rim and roof, it is necessary to provide a temporary means of safe access. If possible, in such cases the roof should float at or near its highest position during the inspection. Unless the roof is within 2 m of the tank rim, the person or persons on a floating roof should use *breathing apparatus* and a lifeline.

If the tank contains material which is liable to produce toxic vapours or gases at concentrations above *OEL* levels, *breathing apparatus* and a lifeline should be used by the inspection team irrespective of the elevation of the roof. In such cases, it is also recommended that appropriate portable monitors should be worn. Consideration should be given to providing the person(s) supervising from the tank top with a breathing set adjacent and ready for immediate use, even if the person on the tank roof uses *breathing apparatus*. A *risk assessment* should take into account factors such as the working height of the roof from the rim, the diameter of the roof and the nature of the product stored in the tank.

Entry into pontoons while the roof is floating should be strictly prohibited.

2.3.5 Inspection of Internal Floating Covers

Inspection of fixed roof tanks with internal floating covers should be subject to similar precautions to those for both fixed roofs and floating roofs.

Because of the limited possibility of visually inspecting the floating cover and the occurrence of various different types of construction, it is essential that drawings should be studied and where appropriate the manufacturer should be consulted.

The external condition of the floating cover and its circumferential seals should be observed through manholes on the fixed roof of the tank with special attention to any liquid present on the top of the floating cover.

Before this visual inspection can proceed, gas tests for oxygen content, explosivity and toxicity, as appropriate, should be made through the opened manholes.

Entry into the space between the floating cover and the fixed tank roof should not be permitted when the tank still contains hydrocarbons.

2.3.6 Site Inspection

A survey of the tank surroundings should be made, both inside and directly outside the relevant bund wall area (if applicable) to plan normal access possibilities for tank cleaning personnel and equipment and to establish possible emergency escape routes.

If required, additional ramps, stairs, ladders, etc., to cross piping or bund wall should be considered. The wall of a bunded area should not be breached when any tank within that area is still operational, unless restricted tank operating levels or the existence of intermediate bund walls make this requirement unnecessary.

The surroundings of the tank should be surveyed for any sources of ignition, vents, combustible materials and contamination with hydrocarbons.

The tank-farm drainage systems should be checked for proper functioning.

The local fire-fighting resources should be checked and an assessment should be made of any additional requirements for the tank cleaning period.

The locations of any electrical and instrument cables and ducts should be established.

Consideration should be given to any construction or maintenance activities in the surroundings of the tank that may influence the cleaning operations.

The proximity of any other operational tankage, facility or equipment should be taken into consideration, particularly as regards the possible discharge of *flammable* or toxic vapours.

2.4 WORK PROGRAMME

A safety and environmental review of the work should be carried out, taking account of the job requirements for cleaning each tank and the findings of the precleaning inspections. A comprehensive work programme, including the cleaning contractor's detailed *method statement*, should then be established (see Annex E). This work programme should be made available in written form. It should be agreed by all concerned, particularly by the person responsible for overall safety in the area and by the cleaning operations supervisor, before decommissioning and cleaning of the tank is permitted to commence.

2.5 ENVIRONMENTAL CONTROLS

Plans should be made for the disposal of sludge, waste and waste water before tank cleaning work commences. Where necessary, permits should be obtained. Consideration should be given to vapour emissions, especially during the gas-freeing stage preparatory to tank entry. Local regulations governing VOC emissions should be observed.

2.5.1 Responsibility

It is the responsibility of the company operating the tankage to ensure that the sludge and waste water resulting from tank cleaning operations is disposed of in accordance with responsible environmental practices and relevant statutory regulations. Particular attention should be paid to the longterm consequences of the selected disposal method. It should be ensured in all cases that waste waters do not contain concentrations of biocides which could deactivate biological effluent treatment plants. It may be necessary to seek professional advice.

2.5.2 Documentation

All permits required by current waste disposal regulations should be obtained. Records should be kept of the character and final location of any sludge.

2.5.3 Sludge Disposal

Sludge should be disposed of by an environmentally acceptable method. Possible disposal methods include, but are not limited to - reprocessing, land fill, land farming or incineration.

2.5.3.1 Disposal to Land Sites

Both land fill and land farming should be only at authorised waste disposal sites, even when the site is inside the confines of the refinery, terminal or depot. Special consideration may apply to the safe disposal of sludges containing heavy metals such as lead. Biocides in sludges may need deactivation before disposal.

Sludges or sludge products contaminated by *low specific activity radiation* may require special handling, packaging and disposal arrangements according to the level of contamination. Specialist advice should be obtained from a qualified Radiation Protection Advisor and/or HM Pollution Inspectorate.

Access to all sludge disposal sites should be strictly controlled.

2.5.3.2 Incineration

Incineration may be necessary for those sludges which cannot be safely disposed of within the provisions of a licensed land fill site.

2.5.4 Waste Water Disposal

Waste water may frequently be discharged into normal site effluent via interceptors or oily water separators, providing this is in accordance with local regulations and any relevant restrictions e.g. toxic substances, BOD and COD.

2.5.4.1 Disposal to Effluent

Where biocides are present in waste water or cleaning water they may be discharged in normal effluent after appropriate chemical deactivation. It should be ensured that sufficient mixing and holding time is allowed for effective deactivation. Some biocides are not easily deactivated and it may be necessary to seek professional advice prior to the adoption of a method.

2.5.4.2 Other Disposal Methods

Where disposal in normal site effluent is not an option the methods described for sludge disposal (see 2.5.3) should be considered.

2.6 CUSTOMS APPROVAL

In bonded installations, approval may be required from Customs and Excise for the removal of sludge. Certification of disposal may also be required.

3

EQUIPMENT AND SERVICES

3.1 POWERED EQUIPMENT

Owing to the potential hazards which exist when cleaning petroleum storage tanks, it is recommended that, where possible, any mechanical equipment used (i.e. pumps, blowers, eductors, etc.) is powered by compressed air or hydraulics.

Guidance on the use of electrically powered equipment is provided in 3.4.3.

If compression ignition engines are to be used, their design should be in accordance with EEMUA Publication No 107, *Recommendations for the Protection of Diesel Engines For Use in Zone 2 Hazardous Areas*.

All engine-driven plant should be kept as far away as practicable and preferably upwind of any possible vapour source. It is recommended that protected engines should not be located closer than 4.25 m from any potential source of *flammable* gas or vapour, such as tank manholes, vents etc. It is recommended that engines should not be positioned inside tank bunds; otherwise they should be subject to control through a *hot work* permit..

Spark ignition engines should not be used. Entry to the work area and the operation of transient vehicles/ plant (e.g. cranes, forklift trucks etc.) should be kept to a minimum and controlled under the installation's permit-to-work system.

3.2 LIGHTING

Lighting equipment used in tanks where *flammable* vapours may be present should be suitably certified for the area of operation (see *IP Area Classification Code for Petroleum Installations*). Compressed air-driven lights are recommended for use during stages of the work before the tank is certified *gas-free*. The air-hoses should be of antistatic material and bonded to the tank's earth bond connection point; hoses should be electrically continuous throughout their length.

If rechargeable battery type units are used, the charging units should be permanently located in a safe area.

Subsequent to cleaning and removal of sludge, and where regular testing is carried out to ensure that the tank is gas-free, lighting may be installed in accordance with the general requirements of BS 5345 (see Annex H) to permit more detailed inspection or more substantial repair work to be undertaken.

It is recommended that hand lamps should not exceed 25 volts to earth.

3.3 PROTECTIVE RESPIRATORY EQUIPMENT

Protective respiratory equipment for entry into tanks falls into two categories:

- a) *breathing apparatus*, in which breathing air is supplied from external sources, either by air line or from cylinders;
- b) *respirators*, in which air is taken from the surroundings and filtered through canisters or cartridges containing materials which adsorb specific contaminants.

In general, equipment of type (a) offers a higher degree of safety, especially if the level and type of contaminants are uncertain and may be subject to variation. If uncertainty exists about the type of equipment to use for tank entry and work, *breathing apparatus* should be selected.

3.3.1 Breathing apparatus

Breathing apparatus for entry into tanks should provide a positive air pressure throughout the breathing cycle and normally be supplied by airline. Air supplies for individual face masks should be taken directly from a common manifold sized to feed all connected hoses with sufficient air for all wearers. The use of 'Y' pieces to divide common air supplies taken through hoses should not be permitted as this arrangement may restrict air supplies to individuals and hinder mobility and the ability to escape from a confined space.

Where there is a significantly raised risk of accidental disconnection of the airline, such as where moving machinery is being operated or where objects may fall onto supply hoses, consideration should be given to providing additional reserves of air carried by operators. The amount of time required for an orderly exit from the work site should be assessed and the reserve capacity should comfortably exceed this for all operators. All breathing air supply systems should provide a minimum of ten minutes of reserve supply for use following any malfunction in the compressor.

There are three main types of *breathing apparatus* employed:

- a) Demand-type with positive pressure -
where air flows only as the operator inhales. This equipment offers the greatest level of protection and the lowest air consumption.
- b) Constant flow type -
where air flows into the face mask at all times. The surplus air passes through the mask and out through a valve with the exhaled air. This type provides an excellent level of protection and, at high work rates as well as in hot conditions, acts to cool the wearer.
- c) Demand-type with negative pressure -
where air flows only as the operator inhales. As every breath requires the face mask to be at negative pressure to operate the demand valve, this type often has high inward leakage and offers a low level of protection. Although some negative pressure demand-type equipment is still in use for emergencies, it should be avoided for continuous service, such as for tank cleaning.

Note: Fresh hose type equipment, in which a large diameter hose carries clean air to the work area, is not *breathing apparatus*. It is not recommended as an alternative to wearing *breathing apparatus* under conditions specified in table 6.1 and the accompanying notes.

As guidance, the relative protection factors afforded by the three methods (a), (b) and (c), are in a ratio of approximately 25:13:1 respectively.

The effects of wearer discomfort on the effective protection provided by *breathing apparatus* should be considered when selecting appropriate equipment, including the increased face seal leakage resulting from unshaven operators and improperly fitted equipment.

Under the COSHH code of practice COP 29, it is required that each piece of *breathing apparatus* be inspected by a *competent person* at least once per month. The volume flow and quality of breathing-air should also be checked to ensure that they meet the standard set down in BS 4275 and EN 132. (Note: These will be superseded by an EN Standard specifically on breathing-air quality.)

Where air is taken from a mobile compressor the tests should be carried out prior to the first use at each new location. The definition of this is debatable, but for these purposes a 'new location' means a significantly different place; this is open to interpretation according to the site.

Records of inspections should be kept to show the identity of the equipment, what was checked, what was found, any repairs, the name of the person who carried out the inspection and the date on which it was inspected. Every operator should have a level of training enabling him/her to inspect the personal protective equipment which is provided before using it, to establish that it is complete and working properly. The *competent person* who carries out more detailed checks should have a greater level of training and be provided with any necessary equipment required to carry out the inspection and tests.

Self-contained compressed air *breathing apparatus* should only be used for emergency response and rescue, or for short-time working in an area where adequate access and egress are available. It should have a pressure gauge and an audible low pressure alarm. Airlines and connectors should be capable of withstanding the tensile loads that could be encountered in service and should be made of a material resistant to the effects of the tank contents and any cleaning agents used.

Oxygen-supplied *breathing apparatus* should not be allowed inside a tank, except perhaps for emergency resuscitation purposes, because of the danger of producing an oxygen-enriched atmosphere.

3.3.2 Respirators

Canister or cartridge respirators should not be used inside tanks where toxic levels are above acceptable exposure limits (see Annex C.3 and table 6.1) or where the oxygen level is less than 20%. Their use will generally be restricted to protection when carrying out simple operations such as those involving low concentrations of non-toxic dust.

Negative pressure respiratory protective equipment, including *canister or cartridge respirators* and demand type *breathing apparatus*, may be used inside tanks provided that a comprehensive *risk assessment* has been carried out by a *competent person* and the assessment indicates an acceptably low level of risk. Factors that should be considered in the *risk assessment* include:

- an adequate oxygen level;
- the potential concentrations of airborne hydrocarbons and other, toxic gases;
- the ability of the respirator to provide sufficient protection, ensuring that its nominal protection factor is suitable for the operational task;
- the capacity of the cartridge or canister to cover for the duration of the work when it is required to provide protection.

Note: Cartridges and canisters should be periodically inspected and maintained by a *competent person* in accordance with the manufacture's instructions. Records should be kept of inspection and maintenance. In the UK, the COSHH Regulations ACOP provides guidance of these requirements.

3.4 SERVICES

3.4.1 Breathing Air

It is recommended that a dedicated, diesel-driven air compressor, incorporating reserves of air for emergency use, is provided for the *breathing apparatus*. Alternatively, high-pressure breathing-air supplied from banks of cylinders via an approved pressure reducer may be used.

It is essential that the air reserves are adequately sized to allow time for all the personnel using the *breathing apparatus* to reach a place of safety in the event of a compressor failure. In such an event it is important that the reserves do not automatically vent to atmosphere and that prior arrangements have been made to warn the persons using *breathing apparatus*. Fault alarm/warning devices should operate automatically and not be reliant on the vigilance of the machine minder. Reserve air supplies may be stored in large low-pressure (7 bar-10 bar) air receivers or in small high-pressure cylinders (200 bar-300 bar).

Low-pressure supply systems are simple to operate, but have the disadvantage that receivers have to be very large to hold adequate air for a number of operators. Normally when considering constant flow equipment, each wearer will require a receiver of 500 litres (0.5 m³) capacity at 7 bar for 10 minutes of air supply. Using demand-type equipment the same receiver might give 25 minutes of supply. The duration in this case is lower than might be expected because the specified minimum operating pressure for demandtype equipment is higher. Under similar circumstances a single 9 litre cylinder at 200 bar would last the operator 10 minutes on constant flow and 35 minutes on demand.

Air in reserve is that air stored between the pressure at which a warning of failure is given and the minimum operating pressure of the *breathing apparatus* being used. Below this pressure the apparatus may not maintain the necessary flow.

High-pressure supply and air reserve systems are very compact and almost all of the reserve can be used. The reserve supply air quality is not affected by local conditions, but the duration of supply is limited and arrangements should be made for obtaining refilled cylinders.

Air held in reserve in case of compressor failure should be made available automatically and should not rely on the vigilance of the operator to move controls.

Consideration should be given to providing back-up cylinders for escape purposes to each operator. Where appropriate, local regulations on this point should be observed.

The compressor should be fitted with air intake and discharge filters to provide an air supply meeting the purity requirements for airline apparatus in BS 4275 (see Annex F) and be sited upwind of the tank on which work is being carried out, in an area free from *flammable* and toxic vapours.

The air intake should be upwind and well clear of the compressor's engine emissions, the exhausts of any other engine-driven equipment and any other source of *flammable* or toxic vapours. Operators should be instructed to be aware at all times of changes in wind direction. Where there is a raised risk of the ingestion of rogue gases into the compressor intake, consideration should be given to continuous monitoring by electronic instruments of the intake air quality, particularly when a rising contamination level may pollute the reserve supply.

Compressors should be inspected and the alarms and safety devices checked regularly. Operators should be thoroughly trained in the use of the equipment and have no doubts about the order of priorities in the event of a compressor failure.

The compressor used to supply air for breathing purposes should not be used at the same time to supply air for air-driven equipment. Hand-operated blowers are not recommended for supplying breathing air.

Air hoses for use with *breathing apparatus* should comply with BS 4667 Part 3 (see Annex H) or its equivalent. The hoses should be maintained, cleaned and tested in accordance with the manufacturers' instructions. Any sections of hose which are found to be defective should be replaced immediately.

3.4.2 Water

All temporary pipelines, test equipment, hoses, etc., which may be required between the water supply point and the point of use, should be maintained in good condition and free from leaks.

The fire main should not be used without authorisation. If it is used for water supply, provision should be made to shut it off if water is required in an emergency. In particular, personnel using the fire main for cleaning purposes should be instructed to stop using hoses immediately on hearing the fire alarm and to close the hydrant valve in order to prevent injury arising from a pressure surge. Fire mains water is likely to be at a higher pressure than is required for tank cleaning and a suitable pressure reducer or flow restrictor should be placed between the offtake hydrant and the point of delivery. Consideration should be given to the installation of a non-return valve to prevent hydrocarbon-contaminated water from entering the supply main.

Care should be taken with water supplied from effluent or other process water systems, which are likely to contain contaminants.

In the event of using potable water from the mains as a water source, precautions should be taken to prevent contamination of the mains, such as by installing a non-return valve or, preferably, by use of a separate header tank.

3.4.3 Electrical Supply and Equipment

Electrical equipment used where petroleum vapours may be present should comply with the area's classification and be appropriately certified for use in *hazardous (flammable) atmospheres*.

Start and stop facilities should be provided in the vicinity of the equipment. Associated equipment should have a type of protection suitable for the area classification. Equipment and supply cabling should be protected against short circuits, overloads and earth faults.

Earth leakage contact breakers should be installed in temporary electrical supplies to protect workers against electrical shock, particularly where trailing cables are in use. Voltages should be kept as low as reasonably practical. Power supplies to hand-held lamps should not exceed 25 v. IEE Wiring Regulations, Section 606 (see also BS 7671), give information on the use of electrical equipment within electrically conductive confined spaces.

Temporary cabling should be protected and installed in such a way that the risk of damage will be minimised. Cables should be of the heavy duty type, resistant against oil products, and provided with an earthed metal armouring or braiding, with a rubber, PVC or other insulating and protective sheath overall. The cables should be adequately sized and should enter any terminal box by means of appropriately certified cable glands.

Electrical equipment should be securely and effectively earthed and bonded to the shells of the tanks, as detailed in Annex G.

The complete installation should be checked by a *competent person* for conformity with the appropriate safety rules (electrical safety as well as area classification). Regular checks should be carried out to ensure that conformity is maintained.

Mobile telephones, personal radios and other equipment not certified for use in *hazardous areas* should only be permitted in safe, i.e. non-hazardous, areas.

3.5 TEST EQUIPMENT

Instruments used should be certified for use in *flammable* atmospheres by the recognized testing authority. They should be carefully selected in accordance with the usage aspects discussed in 5.3.

3.5.1 Measurement of Oxygen Level

Portable instruments are available to measure the percentage oxygen level in the atmosphere. These may include audible and visual alarms which indicate when the level of oxygen falls below or rises above a safe level (see table 6.1). It is important to check the operation of the instrument prior to starting the tank cleaning and, at intervals, throughout the cleaning operation. For the reason noted in 3.5.2, an oxygen test should be conducted prior to carrying out any test for the presence of *flammable* gases since combustible gas indicators do not function properly in atmospheres where the oxygen level differs from normal (see also F.4). The instrument should be calibrated by the manufacturer and have valid certification.

3.5.2 Measurement of Flammable Vapour Concentration

The proportion of *flammable* vapour in an air/vapour mixture can be measured by means of an *intrinsically safe combustible gas indicator*.

Combustible gas indicator scales are graduated from 0-100 per cent of the *lower flammable limit* of the gas for which the instrument has been calibrated. It should be noted that these instruments may not function satisfactorily in oxygen-deficient atmospheres. Hence the atmosphere should be tested for oxygen content immediately prior to carrying out a test for flammability.

The instrument used for measuring the concentration of this vapour should be of an approved design, should be regularly tested for accuracy before each use and should be used only by a *competent person*. Where lead alkyl vapours are likely to be present, a *combustible gas indicator* should be used which is not sensitive to their interference.

Further details of the calibration and use of *combustible gas indicators* are contained in Annex F.

3.5.3 Measurement of Toxic Substances

Historical data concerning the products previously stored in the tank will indicate whether there is a need for monitoring of toxic vapour or toxic substances in residual fluid, sludge or sediment.

Historical data on biocide use in the stored product may not be available. If biocides are used in tank cleaning operations, there may be a requirement for monitoring of the tank atmosphere, or cleaning fluids, for biocides or toxic by-products. Biocides should not be mixed together without obtaining specialist advice, because toxic products could be generated.

Toxic substances potentially present are referred to in Chapter 6. Monitoring instruments are commercially available which may be specific to the toxic hazard. They include gas chromatographs, concentration meters and calibrated self-indicating detector tubes for specific vapours. Various test kits and indicators are available for measuring some biocides and other toxic substances in fluid, sludge or sediment.

Depending upon the choice of indicator, the accuracy and response times will differ and therefore manufacturers' operating instructions should be strictly adhered to.

Accurate measurements of toxic vapours and toxic substances in residual fluid, sludge and sediment can only be obtained by personnel entering the tank, where sludge levels permit, wearing suitable *breathing apparatus* and full protective clothing.

3.5.4 Measurement of Microbiological Populations

Microbial numbers can be monitored using commercially available on-site test kits. Tests usually take 2 to 5 days before results are available. On-site test kits are unlikely to determine whether hazardous species are present and professional advice should be sought. On-site test kits are available which will indicate whether bacteria responsible for the generation of H₂S are present.

Test results will be dependent on the sample taken e.g. water bottoms for overall microbial numbers, sludge for H₂S generating bacteria. Water bottom samples may be taken from tank drains or using a sterilised bottom sample device. Sludge samples are best taken by personnel entering the tank wearing *breathing apparatus* and protective clothing.

3.5.5 Measurement of Radioactive Contamination

Tanks that have contained certain crude oils may contain LSA *radioactive contamination*. Three types of measurement are used to monitor radioactivity and control any work associated with *low specific activity*:

- dose rate, measured in microsieverts per hour, $\mu\text{Sv/h}$;
- surface contamination, measured in Bq/cm² (deduced from counts per second, cps, registered by meter);
- bulk material contamination, measured in becquerels per gram, Bq/g.

3.5.5.1 Dose rate checks

Limits should be set for the dose rate for external gamma radiation. Workers should be monitored to ensure limits are not exceeded; for guidance, see Annex C.6. The installation's procedures should ensure that all plant is decontaminated from radioactive material distributed over the tank's surfaces before the tank is worked on.

Suitable dose rate meters for use with LSA are portable gamma dose rate meters that utilise an internal Geiger; typical dose rate range: 0.5 $\mu\text{Sv/h}$ -500 $\mu\text{Sv/h}$.

For naturally occurring radioactive material (NORM), as opposed to LSA, beta-particle radiation may be a significant problem; beta-particle dose rates are generally measured using an ion-chamber type of instrument. Where LSA and/or NORM is present, the installation should obtain advice from a Radiation Protection Adviser

Monitoring equipment should be tested in accordance with regulatory requirements. The Ionising Substances Regulations 1985 stipulate checks every 14 months; the frequency of such checks may be subject to change in legislation. In addition, a response check against a known radiation source should be carried out each day before the equipment is used.

Note: Under the Ionising Radiations Regulations 1985, classified persons have a personal legal duty to wear a dosimeter.

3.5.5.2 Surface contamination

Surface contamination levels may be measured with a portable meter that measures alpha and beta particle emissions in counts per second (cps). Typical instrument ranges are 0 cps-500 cps and 0 cps-5000 cps.

Meters should be tested weekly against a known radiation source. If the cps reading differs by more than $\pm 20\%$ from the equivalent figure in becquerels/ cm^2 for that instrument, the instrument should be recalibrated by an authorised laboratory.

3.5.5.3 Bulk material contamination

Site instruments are not usually available for measuring radioactivity levels in bulk material, such as tank sludge. Samples should be submitted for analysis at an appropriate industrial laboratory.

3.6 MISCELLANEOUS EQUIPMENT

3.6.1 Washing and Changing Rooms

Welfare facilities should be located in a safe area remote from the work site and outside the tank bund.

A wash room with washing and showering facilities, including hot and cold water, should be provided. The wash room should be equipped with a sufficient supply of clean towels, soap, nail brushes, etc. The wash room should not be used for storing or cleaning contaminated outer protective clothing, but should have a container for used underclothing.

A changing room should also be provided adjacent to the wash room, or it may be combined with, but partitioned off from, the washroom in a single unit.

Where necessary, a portable canteen or rest room should also be provided. This should be sited remote from the work site and, for hygiene reasons, restricted to work people who have washed and changed. The electrical installation should be protected by earth leakage trips.

Where *leaded gasoline* tank cleaning activities are carried out, special washing and changing room arrangements should be provided (see Associated OCTEL Guidelines).

3.6.2 Personal Protective Equipment

Personal protective equipment should normally include:

- A suit manufactured from a material impervious to liquids likely to be encountered in the tank. The suit should be light in colour to highlight contamination and to render the wearer visible in poor light.
- Safety helmet with chin-strap to an approved standard.
- Safety boots manufactured from materials impervious to liquids likely to be encountered in the tank. Where there are substantial sludge deposits, boots of the chest-high wader type should be worn. The sole pattern should provide a good grip against slippery surfaces. Hobnailed boots and boots with external steel toecaps should be prohibited.
- Gloves of material impervious to liquids likely to be encountered in the tank and of sufficient length to cover and fit over protective clothing at the wrists.
- Goggles to a recognized chemical splash standard with anti-misting feature.

If specialist cleaning techniques are employed, the protective clothing should be appropriate to the method e.g. face visors and/or air-fed hoods for chemical cleaning, grit blasting or pressurised water washing.

Protective equipment should be cleaned and inspected regularly. If there is any doubt about the integrity of any piece of protective clothing, it should be discarded. It should be noted that protective clothing should never be removed in an atmosphere that is potentially *flammable* or toxic.

The use of protective clothing to prevent exposure to toxic substances also presents an additional barrier to sweat evaporation, thereby increasing significantly the potential for heat stress in a hot environment. In such circumstances supervision should ensure that the work is planned to allow for adequate rest periods in order to prevent heat stress arising.

3.6.3 Wind indicator

A wind sock or flag should be provided to assist in the safe location of equipment and a watch kept thereafter for changes in the wind direction. It is recommended that data should be recorded at regular intervals (see also 4.3 and Figure 1).

3.6.4 Windsail

Windsails may be mounted alongside a roof or shell manhole to assist in natural ventilation of the tank (see also 4.3 and Figure 1).

3.6.5 Vapour/air eductors

Eductors may be used for removing vapours from tanks. They should be of the compressed air or steam type and may be used with flexible trunking to draw vapours from low level in the tank and discharge at high level downwind. They should be electrically continuous and bonded to the tank (see also 4.3 and Figure 1).

3.6.6 Air blowers

Air blowers should be of a non-sparking, non-static accumulating design. They should be driven by flameproof electric motors or air motors. They should be electrically bonded to the tank.

A blower should not run in reverse and operate as an extractor unless the tank has been tested and found to be gas-free. Electrical connections and rotation should therefore be checked before the blower is started (see also 4.3 and Figure 1).

3.6.7 Ejectors

Ejectors may be used to remove liquids from tank bottoms. Water-operated ejectors are preferred. Ejectors should be bonded to earth (see also 4.3 and Figure 1).

3.6.8 Hoses

Hoses used for the transfer of sludge should be resistant to the material being pumped. Their pressure or vacuum rating should be appropriate to the service and they should be electrically continuous, bonded and earthed. Canvas or other porous hoses should not be used for hydrocarbon sludge. Hoses should be regularly checked for wear, damage and electrical continuity.

3.6.9 Sludge Pumps

Sludge pumps may be located inside or outside the tank and powered remotely by hydraulics or compressed air. The sludge is pushed manually or mechanically, using equipment made of wood, rubber or other non-sparking material, to the open-ended hose located in a sump or low point in the tank.

Pump selection should take into account the possibility of extraneous items, such as rags, bolts etc, being drawn into the pump if a strainer is not used. Consideration should be given to the required delivery point of the sludge in terms of its distance and elevation, the need for non-return valves etc, in order to avoid spillage risks. If long distances are involved, including road crossings, the sludge should preferably be pumped through temporary steel pipelines. Constant surveillance should be maintained during the operation.

3.6.10 Vacuum Equipment

Vacuum equipment may be used to remove heavy sludges and in certain cases dry solids. The method employs either special, temporarily erected on-site vacuum facilities (with or without facilities for sludge separation) or vacuum trucks. High efficiency vacuum trucks are available for uplifting heavier materials than the conventional type. Where the tank is open and the sludge level is below the man-way, hoses varying in diameter from 75 mm to 200 mm are introduced and the sludge pushed manually or mechanically to the open end. Since the equipment operates at a high vacuum, care should be taken with the open end of the suction line to avoid operator injury.

The unit and its suction hose should be adequately earthed. When extracting hydrocarbon products, vacuum pump exhaust emissions to atmosphere should be monitored if personnel may be exposed. The vehicle should be positioned at a safe distance from the open man-way (see 5.4.2.2). Vehicle equipment should be constructed and have protection in accordance with the classification of the area in which it is operated and the emissions from its vacuum exhaust. Spark-ignition engine driven vacuum equipment or trucks should not be used. The internal parts of vacuum blowers handling *flammable* gas/air mixtures should be constructed of non-sparking materials.

Unloading at the sludge disposal site may require entry of personnel into the tank of the vacuum truck. This is a hazardous activity which should only be undertaken by well-trained and experienced personnel, where necessary using breathing equipment.

3.6.11 Mechanical Squeegees

The mechanical squeegee (a small bulldozer) is made in several sizes and is designed to go in sections through a 450 mm man-way and be rebuilt inside the tank. It is hydraulically driven from an outside power pack. Although it is used mainly in large diameter tanks to reduce man entry time and numbers, it is also particularly useful in difficult or hazardous conditions, e.g. deep sludge or confined spaces. The equipment can be operated by a driver on the machine or at a distance by remote control. It is essential that the operator has sufficient training before operating the equipment. The tank should also be checked for internal obstructions and hazards, e.g. pipes, coils, sump, etc.

3.6.12 Scaffolding and Ladders

Scaffolding may be required where work is to take place at height. The Construction (Working Places) Regulations 1966 (SI No. 94) and BS 5973 (see Annex H) provide a useful code for the safe erection and use of scaffolds generally. Scaffolding should be inspected and approved by a *competent person* before use.

Ladders or scaffolding used in *hazardous areas* should be of wooden or steel construction and not of aluminium or other light alloy that may cause an *incendive spark* when struck against rusty steel.

3.6.13 Equipment Made of Light Alloys

Light alloys pose a risk of producing an exothermic reaction and spark on impact with iron oxide (rust). Thus equipment made of such alloys should not be used in hazardous areas. In this context, light metals and alloys are those containing more than 15% total by weight of aluminium, titanium and magnesium, and more than 6% total of magnesium and titanium. Where the term 'aluminium' is used in this document, it should be understood to apply to any metals and their alloys of the compositions described here.

4

TAKING TANKS OUT OF SERVICE

4.1 EMPTYING AND LINE CLEARING

4.1.1 General

Tanks should be emptied to the maximum extent by using the normal operational piping system.

Where tanks cannot be emptied completely via the normal piping system, special measures should be considered such as temporary connections to low drains, or introduction of a water bottom to raise oil level to the normal product suction level.

After the tank has been emptied all relevant tank connections, connecting pipelines and any internal piping elements (swing arms, air mixing spiders, floating roof drains) should be emptied, drained and flushed with water as appropriate. Caution should be exercised when removing low-level man-ways because sludge may have accumulated behind them and *flammable* vapours may be released.

Any instrument and permanent foam connections should be checked for possible presence of hydrocarbons (via burst seals) and flushed and drained when necessary.

Water used for line clearance and flushing of tanks which have contained toxic materials should be collected for separate treatment or disposal unless its quality is acceptable for the normal oily water disposal system.

4.1.2 Floating Roof Tanks

In the case of floating roof tanks the roof legs should be lowered and set in their high support position before emptying the tank. The automatic vent should be set correspondingly. The bulk of any liquid that may have been found collected in pontoons of floating roofs should be removed before landing the roof. Floating roofs should be landed slowly and special care should be exercised to ensure an even landing if at all possible in tanks that contain large accumulations of bottom sludge or sediment.

It should be stressed that floating roofs standing on their legs are very vulnerable. Accumulation of rain or snow may cause collapse. For this reason arrangements should be made to ensure that any rain water is adequately drained. If the roof drain is left open, its closure should be included in the recommissioning procedure.

4.1.2.1 Roof Legs

Prior to the tank roof being supported on its legs during cleaning operations, the legs and associated roof plates should be inspected to ensure there is no excessive corrosion. Inspection of the legs may require their removal. Consideration may be given to the temporary installation of replacement, longer, roof legs in order to improve access during cleaning operations. Replacement legs should be designed and manufactured to ensure adequate roof support.

4.2 ISOLATION

4.2.1 General

After the tank and its connections have been drained and flushed to the maximum extent, preparations can be made for gas-freeing and/or opening of the tank. These preparations comprise the complete physical isolation of the tank from any other tankage and pipelines, and from electrical systems.

4.2.2 Isolation from Piping Systems

Closed valves, even when sealed and made inoperative, are not acceptable as safe means of tank isolation. If possible, sections of piping should be removed from every line to the tank, including product connections, drains, steam, condensate, air, foam, and vapour collecting pipework. The pipework that remains connected to the system should be blanked off.

Alternatively, spades (slip blinds) should be inserted in pipelines as close to the tank shell as possible. Blinds and blank flanges should be sufficiently strong to withstand the maximum internal pressure which might be exerted against them, both from within the tank during testing and from connected piping systems.

Checks should be made that no liquid-filled lines are left in a blocked condition. This includes heating coils inside the tank which should be isolated, cooled and drained.

Before any flanges can be loosened in the pipework it should be ensured that all valves directly upstream and downstream are tightly closed. These valves should then be made inoperative, e.g. by locking or removing hand-wheels and (in the case of motor operated, remotely controlled valves) by isolating the power supply to the valve operator.

To minimise spillage the pipe section to be opened should be drained if at all possible through fixed drain points. Where fixed drainage systems cannot be used, spillages should be collected by using funnels, buckets and other appropriate means. These should be emptied into movable slops containers and all such material should be safely removed from the site before further work is done. The method used should include precautions to circumvent the generation and discharge of *static electricity*. Any spillage reaching the ground may percolate into the tank foundations and make it difficult to obtain *gas-free* conditions at later stages during the cleaning and/or overhaul. Such spillage is also a pollution hazard; an appropriate clean-up operation should be undertaken promptly.

As the disconnection of joints and flanges (e.g. in the fitting of line blinds) may release small amounts of hazardous liquids and vapours, any *source of ignition* should be eliminated from the area and work methods and tools should be selected accordingly.

Fire extinguishers and/or fire water hoses should be at site and ready for immediate use. Personal protective equipment such as *breathing apparatus* may have to be used depending on conditions and toxicity of the product concerned.

4.2.3 Thermal Pressure Relief System

Any pipeline *thermal relief valve* discharge connected to the tank should be disconnected and blinded off. It should be checked however that the proper functioning of the relief system is not obstructed thereby. In that case the pressure relief line should be re-routed and connected temporarily to another point of discharge in compatible duty. This is often an opportune time to test *thermal relief valves*.

4.2.4 Drainage Systems

Any open or closed drainage systems affected by the tank cleaning operations should be disconnected and/or closed off from the system. If the tank cleaning procedures will require the use of drainage systems appropriate measures should be taken to avoid the risk of backflow from other sources. Tank bund service drains should be kept operable but normally closed.

4.2.5 Electrical Isolation

All electrical supply connections to tank-mounted equipment should be isolated by a *competent person* prior to any *gas-freeing* operations taking place. Disconnection should be both at the equipment itself and at the upstream distribution system by racking out isolators in order to avoid the presence of live power cables in the immediate vicinity of the tank. All cable ends should be properly insulated, secured, protected and tagged; remote isolation should also be locked and tagged. A system is required to ensure continued isolation until recommissioning of the tank

The system of *bonding* and *earthing* of the tank should not be disconnected (see Annex G). It should be inspected to confirm proper *bonding* and *earthing*.

In the case of cathodic protection of the tank, the relevant power supply should be disconnected at least 24 hours before any other work can commence. The *earthing* system should then be re-established as appropriate and checked for proper functioning before any further work is undertaken.

Refer to 3.4.3 for guidance on the selection of electrical equipment for use in confined spaces.

GAS-FREEING

5.1 INTRODUCTION

5.1.1 Overview of Precautions

Before any personnel are allowed to enter a tank, the safety of the tank atmosphere should be verified by a competent and responsible person using appropriate gas testing equipment and procedures as described in 5.10 and Annex F. If the tank atmosphere is found to be unsafe, the tank should be gas-freed to the appropriate level as defined in 5.2.

Whilst certain products are likely to leave a safe atmosphere after the tank is emptied, it is nevertheless essential that the atmosphere inside any tank be considered unsafe until tested. Apart from the testing for reasons of oxygen level and flammability, tank atmospheres which are under suspicion of containing toxic contaminants, e.g. H_2S , or inert gas, should be tested additionally for safety from these materials before personnel may enter.

Whilst a tank atmosphere may have been safe for entry at a particular moment, this situation may change with time, e.g. owing to disturbance or removal of scale and sediments during cleaning, which may release fresh vapours. Other sources of fresh vapour release may be the clearing of liquid or vapour filled tank internals. It is therefore essential that good air ventilation of the tank is maintained, using air blowers or extractors, whilst personnel are working inside and that the tank atmosphere is monitored.

Tanks which have been standing empty for long periods whilst closed may be unsafe for entry even when clean, owing to oxygen depletion. Also in these cases, the atmosphere should be tested to ensure adequate oxygen levels before entry.

In tanks which have been used for the storage of material containing sulphur compounds, particularly H_2S , it is possible that potentially dangerous pyrophoric deposits and scale have been formed. In such cases special measures may be needed during *gas-freeing* (see 5.9).

5.1.2 Environmental Effects

The gas-freeing and cleaning procedure may release significant quantities of hydrocarbon vapour to atmosphere, especially if the tank contains volatile material combined with sludge deposits, as occurs frequently in crude oil tanks. When selecting a cleaning procedure, consideration should be given to techniques that minimise VOC emissions. Local regulations on emissions should be observed. Reducing the quantity of sludge deposits in the tank at the first stage in the cleaning process will reduce both the time for subsequent gas-freeing and the quantity of hydrocarbon vapour emitted to atmosphere.

5.2 SITE PRECAUTIONS DURING GAS-FREEING

During the gas-freeing operation the hazardous tank atmosphere is gradually discharged to the environment outside the tank where it disperses. As a consequence the area around the tank should be regarded as potentially hazardous during the gas-freeing operation and a number of precautions should be taken. Roads should be closed, areas roped off and warning signs posted as appropriate. Special consideration should be given to low-lying areas where hydrocarbon vapours may collect. The use of *combustible gas indicators* for checking concentrations in tank bunds and the surrounding area during critical stages of opening up the tank (removing manways etc.), and of continuous monitoring during entry for inspection/sludge removal, are recommended.

Admission of personnel and equipment to the affected area should be minimised and strictly controlled. It is however necessary that regular control and inspection be carried out by a *competent person*, who should have the resources and authority for quick intervention.

Potential sources of ignition should be prohibited in the affected area. Close liaison should be maintained with neighbouring operational departments and other on-site contractors. In cases where tanks being gas-freed are located close to a site boundary the required liaison and recommended precautions may have to extend to third parties.

It is recommended to install a wind sock or other means to check on wind direction and strength. Recordings should be logged at regular intervals during cleaning operations.

During electrical storms, at very low wind-speeds, or during periods of substantial fog in the area, the gas-freeing operation should be stopped. Where practicable, all large tank openings should be temporarily covered or closed, except those for pressure/vacuum relief.

Consideration should be given to providing lightweight non-metallic covers of the proper size to allow fast and easy covering of tank openings. Plastic wrapping film should not be used as a cover because of its propensity to generate *static electricity*.

Many gas-freeing methods expose the tank to potential over/under pressure. The provision and correct functioning of devices to protect the tank against this hazard should be confirmed prior to commencement of gas-freeing operations.

5.3 GAS-FREEING METHODS

Gas-freeing of storage tanks entails the removal of the hazardous tank atmosphere through replacement by clean air. Oxygen should never be used for gasfreeing.

A variety of methods can be applied for gas-freeing depending on local circumstances and the particulars of the tank concerned. In 5.4 to 5.8 brief descriptions are given of commonly applied methods, together with specific safety precautions. See also Figure 1.

During gas-freeing the tank atmosphere may be in the *flammable* range during a certain period of time. To shorten this period rapid gas-freeing rates are generally recommended. However, depending on the tank environment and weather conditions, it may be preferable to decide otherwise and to reduce the rate of vapour expulsion from the tank by limiting the number of tank openings used or by partially closing them off. A balanced decision should be taken on each occasion and this may be modified as circumstances change (see e.g. 5.9)

Nearly all hydrocarbon vapours are heavier than air and tend to concentrate near the ground both inside and around the tank. It is therefore preferable for the vapours to be discharged at high level such as the tank roof which will promote dispersion to the lowest possible concentration in the area around the tank. Low level apertures of the tank such as shell manholes should remain closed during the gas-freeing process if at all possible.

However, if it is necessary that shell manholes or comparable apertures are opened for gas-freeing purposes, it is recommended that roof manholes are opened first and that some inward draught is created by opening smaller shell apertures such as drain connections, etc., before the larger shell manholes are opened. If the gas-freeing operation should be interrupted for any reason, any open low level apertures should be closed.

In order to facilitate rapid opening of man-ways and other openings, bolts may be removed singly beforehand whilst the tank is still in service, and then replaced after greasing. Opening of either roof or shell manholes should be done carefully and only after any possible internal over- or under-pressure has been equalised by the opening of smaller apertures, such as dip hatches, drain nozzles, etc. As far as possible the team in charge of opening should remain upwind of the aperture.

Depending on the product stored the opening of large low level apertures of non-gas-free tanks may require the use of *breathing apparatus* and surveillance from a safe distance by other staff who have additional breathing equipment, life lines, etc., ready for immediate deployment.

Before any shell manhole is opened the possible presence of high sludge levels should be checked.

Working on tank roofs should be minimised and should be subject to the precautions described in 2.3.4.

5.4 GAS-FREEING - FIXED ROOF TANKS

5.4.1 Displacement by Natural Air Ventilation

With this displacement method, air is allowed to enter the tank directly by natural draught whereby the tank atmosphere is gradually diluted and displaced until it is safe for entry. Examples of the method are shown in Figure 1.

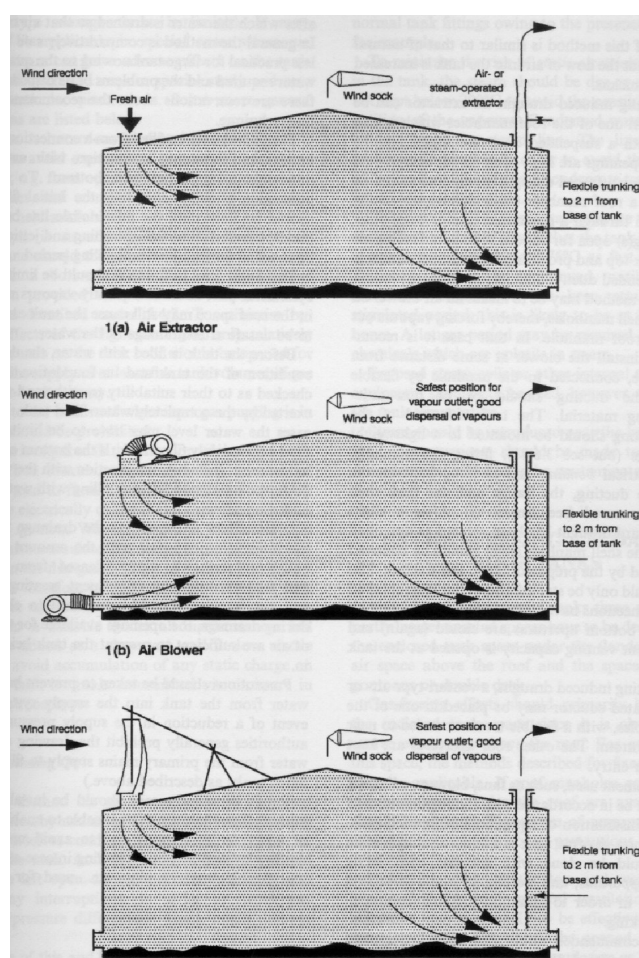


Figure 1 Examples of Ventilation Arrangements

Multiple roof manholes should preferably be used for natural ventilation. If only one manhole is available additional top connections (gauging tubes, sampling hatches, etc.) should be opened. To minimise short circuiting, the apertures used should, however, be as far apart as possible.

For better effect an upwind manhole may be fitted with a windsail and a downwind manhole with a suspended flexible duct reaching down to near the tank bottom or sludge level.

It should be ensured that the flexible duct is made from non-static generating material and is prevented from flattening (e.g. by means of hoops).

If gas-freeing using only tank roof openings is considered insufficiently effective in the prevailing circumstances, shell manholes or comparable low elevation apertures can be used in addition. In that case the precautions outlined under 5.3 apply.

5.4.2 Displacement by Artificial Air Ventilation

The effect of this method is similar to that of natural ventilation but the flow of air into the tank is increased by artificial means.

For creating induced draught an extractor can be positioned on one of the roof manholes which is also provided with a suspended duct (see Figure 1). The other roof openings are kept open for air entry.

For creating a forced draught an air blower can be installed in a roof manhole either forcing air to the tank bottom through a suspended duct leaving other roof opening(s) open for vapour release or forcing air into the tank top and providing another roof manhole with a suspended duct.

A further method may be to install an air blower on one of the shell manholes, thereby forcing vapours out through a roof manhole. In that case it is recommended to install the blower at some distance from the manhole, connected to the manhole by flexible ducting. The ducting should be of non-static-accumulating material. The tank side end of the flexible ducting should be mounted to a lightweight metal flange (but see 3.6.13), fitting the manhole. Proper electrical *bonding* and *earthing* between the blower, the ducting, the flange and the tank shell should be ensured (see Annex G). After a slight natural inward draught has been created as described under 5.3 the shell manhole cover should be removed and replaced by the prepared flange and ducting. The blower should only be started after it has been checked that all connections have been made properly, that all other tank bottom apertures are closed (again) and that sufficient venting capacity is opened at the tank roof.

For creating induced draught, a venturi-type air- or steam-operated eductor may be placed in one of the roof manholes, with a flexible trunk extended to near the tank bottom. The other roof apertures are kept open for air entry.

All equipment used, such as fans, blowers, eductors, etc., should be in accordance with the requirements of 3.4.3. The installation of equipment on opened manholes of a non-gas-free tank is a hazardous operation which should be done with extreme care, using *breathing apparatus*, and wetting by water hose, wet sacks, etc., in order to minimise the risk from accidental sparking.

It is recommended that aluminium equipment should not be fitted directly against (possibly rusty) steel surfaces of tank flanges. Impact between these surfaces may create *incendive sparks*.

5.4.3 Water Displacement

In the water displacement method the tank vapours are displaced via open manholes or other vent openings on the roof by filling the tank with water, after which the water is drained so that air can enter. In general the method is comparatively safe but often less practical for large tanks owing to the quantities of water required and the problems of its disposal. Hence there are reservations about the recommendation of this technique. The tank should be filled from a connection near the bottom or via a top connection with an internal downpipe to near the tank bottom. To minimise generation of *static electricity* the initial filling rate should be slow until the inlet nozzle has been completely covered. Free fall, splashing and jetting should be avoided during the whole filling period.

The water level in the tank should be limited to the cylindrical part and consequently vapours remaining in the roof space may still cause the tank atmosphere to be unsafe after drainage of the water.

Before the tank is filled with water, the design and condition of the tank and its foundation should be checked as to their suitability to withstand the forces exerted by the completely water-filled tank. In certain cases the

water level may have to be limited to less than a completely filled tank. If the bottom of the tank has become distorted, the junction with the walls may become over-stressed during filling with water, or the tank may move.

It should be ensured that the drainage system of the installation can deal with the amount of potentially contaminated water released from the tank and that the capacity of effluent treating facilities will not be exceeded. It is essential to check that, during drainage, the openings available for the ingress of air are sufficient to prevent the tank being sucked in.

Precautions should be taken to prevent backflow of water from the tank into the supply system in the event of a reduction in the supply pressure. (Water authorities generally prohibit the drawing of potable water from the primary mains supply to fill contaminated tanks as described above.)

Valves or other means should be installed at the tank shell or tank top as applicable to enable the flow of water to be stopped and to avoid uncontrolled outflow by draining or syphoning in case of failure of any flexible hose or pipe, etc., used for the water supply.

5.4.4 Inert Gas Displacement

In the inert gas displacement method, the tank atmosphere is dispersed and displaced via vent openings on the tank roof by introducing inert gas. After the inert gas has displaced the original vapours, the operation can be terminated. The inert gas atmosphere is then displaced by air. In general, this method of gas-freeing is not recommended.

The scope for applying inert gas to atmospheric pressure type storage tanks is limited. It may, however, be applicable in special cases where air, water or steam can have adverse effects on the tank. Each application will require special study and may require particular precautions. Some more general precautions are listed below.

Inert gas is hazardous to man and special care is required to avoid exposure of personnel to inert gas emissions, e.g. from openings in the tank or inert gas supply lines and connections. *Breathing apparatus* should be held available.

Inert gas is usually lighter than hydrocarbon vapours and should therefore be admitted to the tank either via a bottom connection or via a roof connection provided with a duct to near the tank bottom as described under 5.4.2. To minimise bypassing effects of the light inert gas, only relatively small apertures on the tank roof should be opened for venting. The supply of at least five tank volumes of gas is likely to be necessary.

Access to the tank roof when inert gas purging is in progress should be prohibited.

Caution is required in the selection of inert gas to be used. Carbon dioxide, when expanding from cylinders, will tend to form a mist of particles (ice) which are highly electrically charged and therefore can be a *source of ignition*. When flue gas is used, electrical charges can accumulate as a consequence of small soot particles in the flue gas. Neither of these types of inert gas should therefore be used in cases where the tank atmosphere may be in the *flammable* range.

Nitrogen is suitable under all circumstances but should be added at a slow rate and at low nozzle speeds to avoid accumulation of any static charge on insulated tank internals transmitted via moisture in the tank atmosphere.

5.4.5 Steaming Out

With this method the tank atmosphere is dispersed and displaced by steam. After termination of steaming the steam is left to condense, thereby allowing fresh air to enter the tank. At least one roof manhole should always be left open during and after steaming and during any interruptions, in order to avoid any excessive pressure differentials which might damage the tank.

Because of this and the possibility of a build-up of *static electrical* charge, gas-freeing by steam is not recommended for tanks larger than 100 m³ capacity. It is also often impracticable in such cases owing to the

large volumes of steam required. Checks should be made prior to using the technique that tank coatings or linings will not be damaged by the operation.

Where steam purging is used, all fittings and nozzles should be properly earthed and bonded to the tank. It cannot be assumed that this situation already exists for normal tank fittings owing to the presence of gaskets, for example.

To minimise the risk of *static electricity* generation in the tank, the steam should be dry or superheated, but kept below 200°C to avoid the possibility of autoignition of the vapours. Condensed water should be cleared from the steam line. The line should be preheated if possible in order to avoid the formation of further condensate and a condensate trap should be fitted close to the nozzle.

To compensate for condensation in the tank the rate of application should ensure that the tank temperature is raised to approximately 75°C as fast as possible. Steaming should be continued until a steady maximum temperature has been attained for a stipulated period; this is likely to be at least several hours. A longer period may be required with certain chemicals which are volatile in steam.

Exposed steam coils or other internal tank heating equipment should not be used, however, to help raise the tank temperature.

Steam should be introduced near the bottom of the tank. Arrangements should be made to drain condensed steam, which may be contaminated.

5.5 GAS-FREEING - FLOATING ROOF TANKS

In the case of floating roof tanks three separate but partly interconnected spaces have to be dealt with, viz. the enclosed tank space under the (landed) roof, the air space above the roof and the spaces inside the pontoons or double deck.

Gas-freeing efforts should primarily be aimed at the enclosed tank space since it is also the main source of vapours above the roof. For gas-freeing of this space, the methods described for fixed roof tanks may be applicable. If roof manholes connecting to the tank space under the roof are available these should be opened. The access of personnel onto the roof should be subject to the precautions of 2.3.5 and 2.3.6.

However, owing to the low and wind-protected position of the roof, natural ventilation via roof manholes only is unlikely to be effective and one or more shell manholes should be opened additionally for either natural or forced ventilation as described in 5.4. Where no roof manholes can be used two or more shell manholes should be opened, where necessary with blowers or eductors on one of these. When eductors or blowers are used it should be checked that the space under the roof cannot be subjected to too high pressure or to vacuum by, for example, ensuring that other manholes, roof vents and all other apertures are open. With the introduction of efficient roof seals, it should no longer be assumed that the seals leave adequate free gaps.

When vapours are released in large volumes and at low level it should be ensured that this can be done safely. Alternatively a duct to lead such vapours to a higher point of discharge may be needed.

To allow gradual dispersion of any vapours left in roof pontoons or double deck spaces the manholes of such spaces should be opened after the space under the roof has been gas-freed. Roof drains should be checked for the presence of vapour.

When the enclosed tank area under the floating roof has been gas-freed it is to be expected that the space above the roof will become gas-free by natural draughts and air circulation. However, in certain circumstances, for example with tall tanks, with particularly low wind speeds or where time pressure exists, additional ventilation of the space above the roof may be required. In such cases an eductor or blower mounted at the tank rim with a duct lowered to the roof can be used to discharge vapours over the top of the tank. Alternatively, where roof manholes are available, ventilation from the space under the roof can be continued for some time by keeping open one shell manhole, preferably provided with a blower.

Persistent vapour accumulations can be expected under wind-protected areas of the floating roof seal, especially when secondary seals are applied. The spaces between the primary and secondary seals should be checked for trapped hydrocarbon as part of the gas-freeing process. This space should be carefully monitored and if

necessary a number of secondary seal plates or weather shields should be removed to allow wind to circulate through the annular spaces.

Certain types of roof seal may become saturated with oil. No general rules can be given for such cases and therefore specialist advice should be obtained.

Note: In some tank designs, hydrocarbons may become trapped inside voids between the roof plates and compensating pads. This could present a hazard, especially if hot work is carried out in such areas.

5.6 GAS-FREEING - FIXED ROOF TANKS WITH INTERNAL FLOATING COVERS

In general the tank space above the floating cover and the space under the cover should be considered separately for gas-freeing, gas testing, etc., since it may not be possible to enter the tank from above for opening any available manholes in the cover unless the space above the cover is found to be safe for entry. If the space above the cover of a non-gas-freed tank is found to be safe for entry the use of self-contained *breathing apparatus* may still be required since the vapour concentration at lower levels can be expected to be higher than that measured from above through rooftop openings. Furthermore, some designs of internal floating covers may trap product or vapours in their materials of construction. In such cases, apparently gas-free tanks may still be hazardous.

Gas-freeing of the space under the floating cover, which is the source of any vapours, should always be done first. The procedures and precautions described for open top floating roofs in 5.5 are also applicable in this case, but are limited to those methods where no use is made of roof manholes.

The space above the cover should be gas-freed (if necessary) after gas-freeing the space under the cover or simultaneously with it.

If not already installed as part of the design when the floating cover was installed, a windsail at the manhole may expedite gas-freeing. Otherwise a forced or induced draught may be applied via the roof manhole, generally as described in 5.4.

5.7 GAS-FREEING - HORIZONTAL TANKS

Horizontal cylindrical tanks are usually of relatively small capacity. Water displacement, steaming, inert gas or air ventilation are therefore applicable methods for preliminary cleaning and gas-freeing a tank prior to entry. Procedures and precautions are similar to those described in 5.4.

When no permanent facilities exist for safe access to the tank top and/or for safely carrying out work at the tank top (e.g. removal of man-lids and mounting equipment), temporary facilities should be provided before any other work is commenced.

The way in which work within the tank is carried out will depend on the configuration of the tank and its manholes. Factors to be considered in planning the work are:

- the location and number of tank manholes e.g. whether on top or at the end; if on top, whether at the centre point or biased to one end;
- the size of the access manhole(s);
- the presence of compartments within the tank.

Many horizontal tanks have only a single entry point. Gas-freeing therefore poses special problems concerning safe access and ensuring a safe atmosphere at all points within the tank. The use of a long airsampling lance is recommended where practical. After satisfactory gas tests have been conducted that indicate a safe atmosphere, it is recommended that initial entry be made with *breathing apparatus* and further tests be carried out, especially in areas where pockets of vapour or other contaminants may be present. Entry should be made without *breathing apparatus* only when a satisfactory atmosphere is confirmed throughout the vessel.

When tanks are partitioned, no access should be allowed unless the entire tank has been emptied and *gas-freed*.

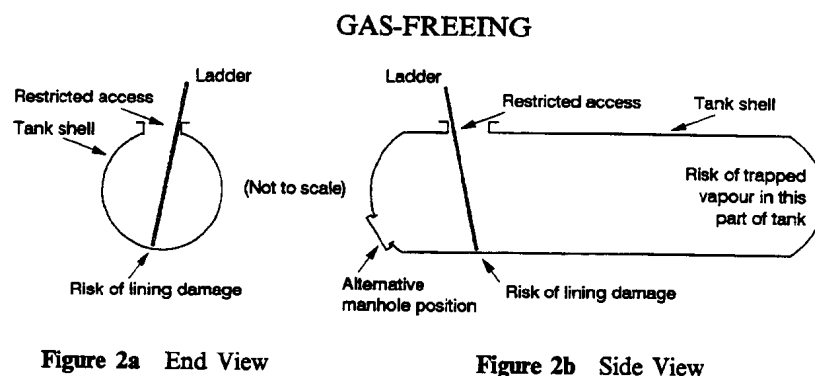


Figure 2 above illustrates a typical horizontal tank with a top manhole.

5.8 GAS-FREEING - SPECIAL CASES

For any tanks not clearly falling into the above-mentioned categories, general recommendations cannot be given. It will be necessary to study each case on its merits and advice from specialists should be obtained.

Particular care is required in the case of tanks built in enclosures such as rock caverns, since direct vapour dispersal to the environment may then not always be possible. In such cases additional ducting for both fresh air supply and discharge of vapours to a safe location may be necessary.

Other tanks requiring special consideration are those which have a protective wall made of concrete, brick or earth, thereby creating an annular space around the tank in which hazardous vapours may accumulate.

5.9 CONTROL OF PYROPHORIC DEPOSITS (see also C.2.2.5)

If a tank has stored any material containing hydrogen sulphide or other sulphur compounds there is the possibility that *pyrophoric scale* is present on the roof and walls. Also the accumulated tank bottom sediment may contain such pyrophoric constituents. This applies in particular to tanks which have been held under oxygen-depleted atmospheres with a very low (less than 3-4%) oxygen content.

To avoid the possibility that the suspected pyrophoric deposits will heat sufficiently (by rapid *exothermic oxidation*) to become a *source of ignition* in the presence of a *flammable* atmosphere, or ignite other deposits in the tank, gas-freeing should proceed with particular care.

It is difficult to predict the presence of pyrophoric deposits. However, reference can be made to any cleaning and corrosion records of tanks in similar service and to those showing the history of the materials stored in the tank to be cleaned.

Wherever the presence of pyrophoric deposits is suspected, the lower part of the tank, which normally remained liquid-covered whilst in operation, should be emptied very slowly during the decommissioning. During the entire gas-freeing period, water-flooding or water-spraying of the tank bottom sediments is recommended.

When air ventilation is used for gas-freeing tanks which were inerted in service, natural draught is preferred. It should proceed at a restricted rate to let the oxygen level in the tank rise slowly, thus allowing any pyrophoric material in contact with air to reoxidise at a harmless rate.

Where tanks have been blanketed with a *flammable* product, such as methane, gas-freeing with air is not normally recommended when there is also a risk of pyrophoric material being present. In such cases other methods, such as water displacement (see 5.4.3) are preferable or, alternatively, temporary use of an inert gas should be considered in order to reduce the possibility of an ignition.

After the tank has been entered, the wetting of deposits should continue until they have been removed from the vicinity of the tank for safe disposal.

5.10 GAS TESTING

Guidance on *combustible gas indicators* is given in Annex F. Gas testing for both *flammable* and toxic vapours and for oxygen levels should be carried out by an authorised *competent person*, at several points, before anyone is allowed to enter a tank which is being prepared for cleaning. This should be repeated periodically or continuously (depending on circumstances) while cleaning is in progress. Results of such tests should be recorded.

It should be noted that monitoring equipment may be adversely affected by low or high temperatures (e.g. below 0°C or above 40°C) and special equipment may be needed in such circumstances.

5.10.1 Flammable Gas Detection

The *combustible gas indicator* used should be suitable for use in the type of vapour to be tested. Where the tank has contained leaded product the instrument should be designed to function accurately in *leaded gasoline* vapour. In addition the instrument should have been recently calibrated according to the manufacturer's instructions. Guidance on *combustible gas indicators* is provided in Annex F.

5.10.1.1 Testing During Gas-Freeing

The manner in which vapour tests are carried out during gas-freeing both in and around tanks will vary depending on the type of tank, method of ventilation, type of product previously stored in the tank and many other variable factors. For these reasons it is not possible to define a rigid procedure but the following guidelines should be considered:

a) Fixed roof tanks

Where mechanical or natural ventilation techniques are employed, tests for *flammable* vapour concentration should be made at the point(s) where the vapours are being discharged to the atmosphere. In

addition frequent checks should be made at grade level around the tank and the surrounding area to ascertain if any hydrocarbons are collecting.

Note: The tank cannot be considered completely free of *flammable* vapours until all sludge and other deposits such as scale have been removed.

b) Fixed roof tanks with internal floating covers

Entry into the space between the fixed roof and the floating cover should be in accordance with the guidance in Table 6.1 and its accompanying Notes. Personnel should wear air-fed *breathing apparatus* and be fitted with a lifeline. Further tests may then be conducted to ascertain concentration of *flammable* vapours, toxic substances and oxygen.

c) Open top floating roof tanks

When eductors are fitted to the roof man-ways on the tank and the vapours are ducted to the rim of the tank shell, tests should be carried out at this point. Where vapours are discharged onto the roof of the tank (large floating roof tanks), it will be necessary to enter onto the tank roof to carry out the tests. This should only be done by personnel wearing air fed *breathing apparatus* and secured by a lifeline.

5.10.2 Toxic Vapour Detection

To conduct meaningful tests for the presence of toxic vapours in a tank, it is necessary to have information concerning the products previously stored in the tank.

Tests for toxic substances conducted at tank manways or hatches are not always satisfactory. An accurate assessment should therefore be made by personnel entering the tank when sludge levels permit. Such entry should only be made by personnel wearing suitable *breathing apparatus* and protective clothing. The results of these tests should be interpreted by a *competent person*.

Tanks that have contained *leaded gasoline* may contain TEL and/or TML in sufficient quantities to present a serious health hazard even though the tank may be hydrocarbon vapour free and safe from fire, explosion and asphyxiation hazards (see 7.5).

Sludge in tanks prone to microbiological contamination may contain sulphide generating microorganisms which can generate H₂S gas in sufficient quantities to present a serious health hazard. They may continue to do this until they are killed. Disturbance or chemical treatment of sludge may cause further release of H₂S and thus gas concentrations should be monitored throughout the cleaning operation.

5.103 Testing for Oxygen

See 3.5.1 and C.4.

5.104 Testing for LSA Radioactive Contamination

See 3.5.5 and C.6.

6

CLEANING PROCEDURES

6.1 INITIAL CLEANING FROM OUTSIDE THE TANK

6.1.1 General

The general practice that should be adopted in all tank cleaning is:

- keep the time spent inside the tank to a minimum;
- maximise the amount of cleaning from the outside.

After pumping down to minimum level, the tank may be flushed with cold water and the bottoms pumped out. Alternatively, depending on type, the product may be floated to allow skimming by suction from an available point or suitably adapted man-way. Water should be introduced slowly, without splashing, to avoid generation of *static electricity*.

Tanks containing substantial quantities of sludge deposits are best handled by first reducing the quantity of sludge as far as possible by techniques such as circulating with light product, agitation with mixers or jetting.

6.1.2 Crude Oil and High Viscosity Oils

Crude oils and high viscosity oils are particularly susceptible to the deposition of large amounts of semisolid material on the tank bottom, the extent of which can be minimised by installing and operating side-entry mixers (or similar equipment) during normal operation with the tank.

After pumping down to minimum level for cleaning, the tank may be flushed with hot water, or cold light product, or product of the same type in the case of crude oils tanks. Any method of removing residual material from the tank that reduces the time personnel spend in the tank contributes to the safety of the tank cleaning operation.

Removing the residual material also reduces the time for the subsequent gas-freeing of the tank and reduces the quantity of hydrocarbons (VOCs) released to atmosphere as vapour during that operation.

After flushing or circulating, the tank may be pumped out to achieve the lowest level. If the tank is fitted with heating coils, they may be used (provided that they remain fully covered and are serviceable) to improve pumpability. Overheating should be avoided.

Care should be taken when circulating, using temporary lines and nozzles, that the discharge point is kept submerged in the liquid at all times. A jet breaking the surface may produce static generation problems (see C.2.2.3).

The large size of many tanks holding the above products often results in substantial volumes of residue remaining on completion of the sludge-reducing activities described previously.

Re-suspension techniques are commercially available which utilise submerged jet technology to re-suspend the hydrocarbon sludge in its parent product or in a lighter product.

Chemicals may or may not be an integral part of the re-suspension process.

Certain techniques re-suspend sludge by jetting from above the hydrocarbon level. In this instance it is imperative that an inert atmosphere is maintained in the vapour space above the sludge for the duration of the operation (see C.2.2.3 *Static Electricity*).

6.1.3 Cleaning Through Open Man-way

When conditions allow, it may be possible to work through an open man-way to carry out certain cleaning before entry is necessary. This method should normally be limited to tanks in which it has been proved that a hazardous atmosphere is no longer

Table 6.1 Working conditions in petroleum tanks

Combustible gas indicator scale reading (scale graduated 0-100)	Actual percentage by volume of hydrocarbon vapour (where lower <i>flammable limit</i> is 1% volume)	Conditions of entry and work
Less than or equal to 1	Less than or equal to 0.01	Safe for persons to enter and carry out hot or cold work without respiratory protection, provided oxygen content not less than 20% or more than 21%.
Above 1 but not greater than 10	0.01-0.10	Safe for persons to enter and carry out inspection and cold work with appropriate respiratory protection, provided oxygen content not less than 20% or more than 21%. Unsafe for <i>hot work</i> .
Above 10 but not greater than 20	0.10-0.20	Entry for work permitted only with special authorisation with appropriate <i>breathing apparatus</i> and provided oxygen content not less than 20% or more than 21%. Unsafe for <i>hot work</i> .
Above 20	Greater than 0.20	Unsuitable as a work environment. Entry permitted only under exceptional circumstances with special authorisation and with appropriate <i>breathing apparatus</i> , and for rescue.

Notes

- 1) A formal written entry permit or *work permit* is always required for tank entry. In the case of entry with special authorisation or under exceptional circumstances, assessment should be made of the risks associated with the levels of *flammable* and toxic substances potentially present. Precautions and work procedures should be designated in accordance with the assessment.
- 2) A general Occupational Exposure Limit (OEL) for petroleum vapours cannot be given because the constituent hydrocarbons have different toxicities. However, a figure of 1% of the *lower flammable limit*, i.e. a scale reading of 1 or less on a combustible gas monitor, may be taken as a general guide, providing toxics such as H₂S, benzene or organic lead compounds are absent.
- 3) Where specific toxic materials such as H₂S and benzene are known to be or likely to be present, each should be considered individually and appropriate systems of control applied. In general terms, when a single toxic gas concentration reading, taken with a gas detection tube or a direct reading monitor, is in excess of 10% of the *OEL* for that material, a detailed risk *assessment* should be carried out by a *competent person* before proceeding. (For *OEL* values, reference should be made to the latest Guidance Note EH 40, *Occupational Exposure Limits*, from the Health & Safety Executive; see Annex H.)
- 4) Where a tank has been in leaded gasoline service, *breathing apparatus* should always be worn during work inside the tank unless it has been declassified (see *IP Guidance on the Declassification of Tanks Previously in Leaded Gasoline Service*), or a comprehensive risk *assessment* has been carried out by a *competent person*, indicating a safe working environment
- 5) When sludge is removed from a tank or vessel in preparation for work, there may be local release of hydrocarbon vapour near the surface. It is therefore recommended that regular checks are made of the overall atmosphere at head height and preferably in the breathing zone, to monitor that the concentration does not exceed the *OEL* for toxic gases and 10% of the lower *flammable limit*.
- 6) Where H₂S is present, it is recommended that a continuously registering, warning monitor be used as this will provide a rapid warning in the event of a release of gas from the sludge. The availability of such equipment should be taken into account in conducting the risk *assessment* referred to in (3) above.
- 7) It is recommended that, for normal tank cleaning work, entry should only be made when combustible gas indicator readings are not greater than 10 and the levels of toxics and oxygen are within the safe ranges indicated above. If, during the course of work, the level of any hazardous substance rises above that deemed acceptable in a *risk assessment*, tank cleaning work should be suspended until the level has been reduced to and remains within safe working limits.

present. Otherwise, appropriate precautions should be taken. Caution should be exercised when removing low-level man-ways because sludge may have accumulated behind them.

Liquid and sludge levels may be reduced by placing a pump or vacuum truck suction hose through the open man-way and remotely controlled hydraulically driven machines may be introduced to assist the gathering of non-flowing, pumpable sludge. Such remotely controlled equipment will reduce the time that personnel should spend in the tank (see 3.6.11).

Small tanks may be cleaned through top man-ways using a 360° rotating nozzle lowered inside. Hot water under pressure and, in certain cases, with chemical addition is passed through the machine which produces a cleaning jet and activates the rotating mechanism (see C.2.2.3 *Static Electricity*).

6.2 PREPARATION FOR ENTRY

6.2.1 Entry Permit

Table 6.1 gives guidance on the *flammable* vapour conditions governing entry to petroleum storage tanks. **A formal written entry permit or work permit is always required.** The table should be read in conjunction with the notes at its foot.

6.2.2 Pre-Inspection

Before work starts, the interior of the tank should be inspected for any materials which might fall, such as loose rafters, angle irons or columns. It should be ensured that swing lines have been lowered to the tank bottom or that they are properly supported by angle frames. It should also be ensured as far as possible that any hazardous obstacles projecting into the tank (such as propeller mixers, instruments, etc.) have been removed.

6.2.3 Check-List

The following check list will assist in confirming that the necessary safety measures in preparation for tank entry have been carried out.

- 1) Ensure that all process and utility lines to and from the tank have been positively blanked and that all manholes have been opened to provide the maximum number of escape routes.
- 2) Check that the power supply to any cathodic protection system to the tank is disconnected at least 24 hours before any work is permitted.
- 3) Ensure that all electrical bonds and earths have been tested and the tests recorded.
- 4) Confirm that all atmosphere tests (flammables, toxics, oxygen and *LSA*) have been carried out and that these have been recorded on the permit. The time period for which the test is valid should be stated on the permit. If the results of these tests indicate that respiratory protective equipment is required, ensure that this is readily available.
- 5) Before any person enters a tank to carry out cleaning, the appropriate, duly authorised permit should be issued (see Annex D).
- 6) If an electrical storm or high winds prevail or are expected while a tank entry permit is in operation and the tank has not been completely gas-freed, the permit should be withdrawn. No person should be permitted entry into or onto the tank (see also 5.2).
- 7) Where personnel entry into non-gas-free tanks has to be undertaken, ensure that there are always two people on duty outside the tank. One of these should be stationed at the entrance man-way keeping observation on the people in the tank. The person should be equipped with the means to raise an alarm and obtain assistance. The person should also be equipped with a self-contained air-supplied respirator for emergency use and should hold a second unit in readiness. Use of a lifeline should be considered.

The second person is responsible for ensuring a continual and satisfactory air supply from the compressor unit to the people in the tank.

- 8) Even where a vessel is gas-free and well-ventilated, ensure that a safety observer is posted at the entrance man-way when anyone is working **inside** the tank.
- 9) If either steam or water jets are used during the early stages of tank cleaning when the tank is not gas-free, ensure that all precautions are taken to avoid any *static electricity* build up (see C.2.2.3).
- 10) Ensure that the breathing air compressor unit is located upwind of the tank and that the air inlet to the compressor is upwind and remote from the engine exhaust (see 3.4.1).

- 11) Take measures to monitor the air temperature in the tank. Additional ventilation will be necessary if the temperature could rise to 40°C.
- 12) Ensure that only approved lighting is used in the tank (see 3.2).
- 13) Lighting in the tank bund should also be of the approved type (see 3.4.3).
- 14) Ensure that only tools and equipment as specified on the permit are used in tanks that are not *gas-free*.
- 15) Check that tank cleaning personnel are equipped with the appropriate protective clothing.
- 16) Ensure that fire fighting equipment as specified on the permit is available at the tank site before cleaning commences and that all involved personnel are familiar with its operation.
- 17) Before any cleaning work commences, check that all mobile pumping equipment is located upwind of the tank, and that spark arrestors and overspeed shut-off devices are fitted. Also check that the area around the equipment is free from *flammable* vapours before the equipment is started up. To assist in the maintenance of a *gas-free* area in the immediate vicinity of the tank ensure that all hydrocarbon vapours from the tank are released at the roof.
- 18) Do not allow smoking inside the tank or in the surrounding area at any stage of the operation, and ensure that personnel are not carrying matches or lighters.
- 19) Ensure that all potentially *pyrophoric scale* and deposits are promptly removed from the immediate area of tank cleaning and are kept wet until safely disposed of.
- 20) When a tank is left unattended either during meal breaks or overnight, ensure that NO ENTRY signs are erected at any open manways. When a tank is left unattended for longer periods, barriers should be installed to prevent entry by personnel or animals.
- 21) Manual tank cleaning operations during the hours of darkness should be minimised. If such operations are to be carried out check that exits are clearly marked and that emergency lighting is available in case of a power failure.
- 22) Showering and washing facilities should be provided. Where practicable these should be located close to the work area (see 3.6.1).
- 23) First aid facilities should be provided.

6.3 WORKING IN THE TANK - GENERAL

6.3.1 Hazards

Details of hazards related to specific products are described in Chapter 7. All personnel should be protected against the known risks which include, but are not limited to, the following:

Ingestion (swallowing)

- Protective clothing should be worn and personal hygiene measures observed.

Inhalation

- *Breathing apparatus* appropriate to the task should be worn.

Absorption

- Protective clothing (including goggles) should be worn and personal hygiene measures observed.

Explosion risk

- Equipment and lighting used should be selected according to the area's classification.

Noise

- Ear defenders should be worn, particularly when grit blasting.

Slipping

- Special attention to avoid slipping should be taken particularly in lined tanks. Boards etc. may be laid on the tank floor in certain cases to minimise this hazard.

Falling

- When work is necessary at height, scaffolding should be used and personnel should be provided with safety harnesses and *inertia reel lifelines*.

Heat stress

- Heat stress develops quickly when working inside tanks exposed to solar radiation. The duration of work periods should be adapted to the conditions.

Work inside the tank may include sludge removal, liquid removal, descaling by high pressure water or water/slag mixture, or grit blasting. In view of the inherent hazards of these methods, they should be carried out only by appropriately trained specialist personnel. Personnel not directly involved should be kept as far away as practicable.

All personnel working inside the tank should be detailed their specific tasks by the supervisor and should operate within sight of one another and of the safety observer.

Where entry to pontoons is necessary a harness and lifeline should be worn in addition to the protective clothing and equipment specified.

It should be noted that the use of lifelines in large diameter tanks is not normal practice. Although technically feasible, in practice lifelines, trailing air lines and hydraulic or pump hoses can become tangled, thus reducing the ease of rapid escape in an emergency, particularly where roof support legs or columns are numerous.

6.3.2 Escape Procedures

It is recommended that escape procedures are demonstrated before the start of the cleaning operations.

As a minimum, the safety observer should have an air horn plus a spare charged cylinder to raise the alarm should compressor failure occur or a nearby alarm be raised. He or she should be familiar with the procedure to be followed should an emergency arise.

Methods of signalling such as tugging air lines or lifelines can easily be mistaken due to the frequency of false alarms triggered by normal movement. The preferred method of working gangs in view of each other is a practical solution to this problem.

Intrinsically safe air-driven signalling devices powered by the wearer's own breathing air apparatus may be preferred. The site operator should satisfy himself or herself that a practicable system is in operation.

6.3.3 Safety Helmets

Safety helmets should normally be used at all times. However, in exceptional circumstances, e.g. where *breathing apparatus* and full protective clothing including hoods are worn, it may not be possible to wear helmets.

Full air-supplied suits have a built-in head protector but these suits should be limited only to the most extreme of conditions owing to their inflexibility, which restricts the wearer's movement and necessitates full body-turns for vision to the sides or rear.

6.3.4 Tank Internal Hazards

The physical characteristics of tanks vary, but generally all tanks present the cleaner or inspector with slip, trip or fall hazards (see also Annex C).

Even when forewarned, workers inside the tank may lose their orientation and be put at risk.

The hazards fall into the following groups:

Sumps

- After studying information on the tank interior, the first persons to enter should be issued with a rod or squeegee and be sent to locate the sumps. These may be at the side or in the centre of a tank. Centre sumps are not of major concern but all operatives should be informed of their existence. When covered in sludge or liquid, sumps can cause serious injury.

Once located, the sump may be marked out either by bunting around the nearest legs to the sump or by cones, if practicable.

Pipework and heating coils

- These are usually more apparent and all operatives should be informed of their existence. In any event, it is not practicable to mark out the coil lay-out.

Roating roof landing height

- The landing height of the roof plays a major role in the cleaning operation, both in terms of time and in operative safety and welfare. Landing of the roof below maintenance height is not generally acceptable for tank cleaning activities.

Internal covers

- When access to the top of an internal floating cover is required it should be protected by planks. It is essential to check the design of the cover to ensure that it is capable of carrying personnel.

6.3.5 Roof Support Leg Cleaning (Floating Roofs)

In all cases roof legs should be cleaned, e.g. by water jetting through the drainage hole at the foot of the leg. If the drainage hole or rodding points are not available, it may be necessary to jack up the legs to facilitate internal cleaning.

This operation should be carried out in a methodical manner where each leg is jacked individually after proprietary adjustable props have been placed, if necessary, next to the leg to be jacked. Baulks of timber should be placed at the top and bottom of each prop. This will not only avoid damage to the tank floor and roof but, if done correctly, obviate any collapse which may result in the prop puncturing the relatively thin gauge roof plates.

Care should be taken, when props are established, that the roof remains level and is not itself jacked out of position as this could conceivably cause progressive collapse of other legs and bring the roof down.

In all cases a thorough inspection of all other internals should be made and they should be cleaned where required, e.g. roof drains, coils, suction and discharge lines.

6.3.6 Horizontal Tanks

Access to and working within horizontal cylindrical tanks will often pose special safety problems, depending on the tank's design. The planning of work to be undertaken inside the tank should take into account the tank's design features (see 5.7 and Figure 2).

Descent into a tank with a top manhole is usually made using a ladder, mounted either vertically or at an angle. Ladders should be of wood or steel (see 3.6.12). If the tank is lined, a wooden ladder is recommended in order to reduce the risk of damage to the lining. With the ladder in place through a top manhole, access will be further restricted and may influence the selection of protective respiratory equipment that may be required. *Breathing apparatus* should be supplied by airline (see 3.3.1). Self-contained, compressed air, *breathing apparatus* supplied from air cylinders is not recommended since the wearing of cylinders will further impede restricted access.

If the tank has a single access point, only one person should be allowed inside the tank at any time. In planning the work, consideration should be given to the practicalities of rescue in case the person within the tank is overcome by atmospheric conditions or by physical disablement.

In the case of tanks with top access only, deposits cleaned from the tank surface will normally have to be removed from the tank in buckets. The ladder should be left in position throughout the cleaning operation in order to assist escape should it become necessary.

6.4 INTERNAL CLEANING

From a safety viewpoint it is desirable to maximise the cleaning of tanks without entry of personnel. However, it is not usually possible to achieve the required degree of cleanliness in this way. Final internal cleaning requiring people to work inside the tank will usually be necessary.

The applicable techniques vary, subject to local conditions and the desired final standard of cleanliness. The latter may be graded under the following headings:

- 1) Liquid removal, i.e. pumpable residues.
- 2) Sludge and solid residue removal, involving heavy and/or non-pumpable material.
- 3) Change of product duty of the tank.
- 4) Scale removal.
- 5) *Hot work* standard.
- 6) Inspection standard, i.e. to allow non-destructive testing or other tests.
- 7) Internal painting standard.
- 8) Decontamination, i.e. for demolition.

(9) Microbial decontamination.

6.4.1 Liquid Removal

Liquid can usually be removed by vacuum and pumping techniques as described in 6.4.2.2 and 6.4.2.3.

6.4.2 Sludge and Solid Residue Removal

Sludge and solids can generally be removed

- manually,
- by using vacuum equipment,
- by pumping,
- by mechanical squeegees,

or by combinations of these.

Each of these methods requires that personnel enter the tank to carry out activities ranging from supervision of personnel and equipment to manual digging and sludge removal.

Special hazards include:

- Physical contact with sludge, requiring protective clothing as appropriate.
- The sometimes unstable nature and unpredictable behaviour of sludge accumulations, requiring careful working, close supervision and the ability to render immediate mutual assistance.
- The *flammable* or toxic tank atmosphere which may arise, even in gas-freed tanks, when sludge is disturbed. This may call for continuous monitoring of the tank atmosphere as appropriate.
- The invisibility of submerged sumps and low level obstacles in the tank, which are both a hindrance to working and a physical hazard.
- Micro-organisms which may present a health hazard if personnel are exposed via any of the following transmission routes; inhalation of aerosol produced during sludge or liquid removal; ingress into open cuts; accidental ingestion. Disinfection of the tank prior to entry and/or the wearing of protective clothing, including *breathing apparatus* may be required.
- Exposure to irritant concentrations of biocides which have accumulated by migration from stored product into sludge and residual water, requiring protective clothing as appropriate.

6.4.2.1 Manual sludge removal

This method employs personnel to dig out sludge, which is removed from the tank via manholes and put in wheelbarrows, containers, etc., for further disposal. Wooden or other non-sparking tools and equipment should be used. Tools made of or containing light metals and their alloys should comply with 3.6.13.

Some tanks are provided with removable clean-out doors which will ease the cleaning operations and may even allow small earth moving equipment to be brought inside.

It is not recommended to create temporary clean-out ports by removing plates from the tank unless this can be done by methods which do not create sparks, flames or hot surfaces.

Before plates are removed it should be verified that this is allowed by local regulations and that the structural integrity of the tank and/or the properties of the tank plate material are not adversely affected. It is essential to obtain appropriate professional advice and authorisation on this matter.

6.4.2.2 Vacuum equipment

This method employs either special, temporarily erected, on-site vacuum facilities (with or without facilities for sludge separation) or vacuum trucks (see 3.6.10). Where the tanks are open and sludge is below the man-way, hoses, which may typically vary in diameter from 75 mm to 200 mm, are introduced and the sludge is pushed by hand or mechanically to the open end.

In general the vacuum extraction technique is less labour intensive than the purely manual methods.

Vacuum working on hydrocarbon material may produce additional vapours and consequent hazards when these vapours are being exhausted to the atmosphere from the vacuum equipment. The precautions noted in 3.6.10 should therefore be taken.

High efficiency vacuum trucks can be used, where available, which are able to uplift heavier materials than the conventional type. Unloading at the sludge disposal site may require entry of personnel into the tank of the vacuum truck. This is a hazardous activity which should only be undertaken by well trained and experienced personnel, operating under a formal *work permit* system.

It is necessary that vacuum equipment is earthed and/or bonded to the tank to be cleaned. In the case of vacuum trucks a *bonding* wire should be connected between the vacuum tank and the storage tank being cleaned and should not be disconnected until after the suction hose has been uncoupled before the tanker leaves for the sludge discharge site. This *bonding* wire and its proper attachment to tank and vacuum tank on bare metal should be regularly inspected.

6.4.2.3 *Pumping of sludge*

This operation is similar to the vacuum technique but special pumps (usually positive displacement type) are used.

These are located inside or outside the tank and normally powered remotely by hydraulics or compressed air. Sludge may be pushed by hand or mechanically to the open ended hose located in a sump or low point in the tank.

Pump selection should take into account the possibility of extraneous items, for example rags, bolts, etc., which may be drawn into the pump if a strainer is not used. Consideration should be given to the required delivery point of the sludge, i.e. distance to be pumped, fitting of non-return valves, selection of pipework, hoses and couplings and protection from damage, e.g. at road crossing, to avoid spillage risks. **Constant** surveillance is essential during this operation.

6.4.2.4 *Scale removal*

Scale is often bound up in product on tank floors, and this material may need to be dug out by hand.

Where there is accumulated scale in the bottom of a storage tank it may become dry after surface liquids have been pumped away. However, if the risk of pyrophoric materials is present the scale should be kept wet to avoid generation of heat.

6.4.2.5 *Hard solid material removal*

This type of deposit can be met in tanks which have contained certain grades of hard bitumen.

Removal can be difficult but it is normally dug out by hand using air driven tools, high pressure water jetting or a specialised hydraulically driven mechanical digger.

Special attention should be given to the heavy layers of solid or seemingly solid bitumen that may sometimes be present on the inner walls of **(uninsulated)** bitumen tanks. These layers are liable to sudden shifts or collapse endangering personnel and equipment in the tanks.

6.4.3 Microbiological Decontamination

Tanks may need decontamination where microbial proliferation or contamination presents problems of spoilage of stored product or accelerated internal tank corrosion. Various strategies can be employed depending on the severity and type of contamination, product type and degree of microbiological cleanliness required. Usually a biocide addition will be involved, either direct to stored product, to the water in the tank bottom, or to cleaning water used after liquid and sludge removal. Most biocides are hazardous chemicals. In their undiluted form they usually present a serious irritant, corrosive, sensitising or toxic hazard and the recommendations of manufacturers should be strictly adhered to when handling concentrate. Material Safety Data Sheets should be provided to all those handling such materials.

6.4.3.1 *Biocide addition to stored product*

Biocide additions to product can be used to impart resistance to microbial spoilage to that product and/or to decontaminate product and associated tanks and systems. For tank decontamination the level of product will usually be lowered to reduce the volume requiring dosing. Microbial proliferation occurs in water phase and hence most biocides for petroleum products possess hydrocarbon and water solubility. Frequently solubility in water is far greater than hydrocarbon solubility and as a result biocide will migrate from dosed product, concentrating in associated water phase at concentrations which can be extremely hazardous. Lack of information on the volume of water in the tank, and on relevant biocide solubility's and stability's can make prediction of water phase concentrations exceedingly difficult.

Appropriate precautions and protective clothing should be considered for operatives draining water from dosed tanks. Biocide may continue to migrate to water phase even after several successive tank draining and/or movements of the dosed product. All product movements should be monitored and recorded and operatives draining relevant tanks should be provided with adequate instruction and protective clothing to prevent exposure to drained water. Drained water should be tested for biocide concentration. Consideration should be given to environmental aspects of disposal of water drained from dosed tanks and from tanks or systems receiving dosed product (see 2.5.4). Biocide in drained water will require inactivation prior to passage to biological effluent treatment systems.

6.4.3.2 *Addition of water phase biocide to tanks*

To avoid undesired product additions, decontamination can sometimes be accomplished by addition under the stored hydrocarbon of a biocide which only has water solubility. Dilution of many biocides to their in-use concentration greatly reduces their irritant, corrosive or toxic hazard although some may still retain sensitising properties. Inability to assess volumes of water in tanks makes accurate dosing difficult. Overdosing can result in hazardous water phase biocide concentrations and precautions should be taken to provide adequate instruction and protection to tank draining operatives. Ineffective tank draining systems may result in failure to remove all biocide dosed water in a single draining operation and precautions should be continued for successive draining operations. Water phase biocide concentrations should be monitored for successive drainings and due consideration given to protection of draining operatives and disposal (see 2.5.4).

6.4.3.3 Desludging combined with biocide treatment

For heavily contaminated tanks, removal of sludge may be necessary to ensure efficient biocide activity and prevent future product spoilage by dead microbial material. Typically procedures described in 6.4.2 can be followed with due consideration to the special hazards listed. Only if there is deemed to be a serious hazard from exposure to harmful micro-organisms during sludge and water removal should biocide treatment prior to sludge removal be considered (see 6.4.3 and 6.4.3.2). In such a case care should be taken to prevent subsequent exposure to high concentrations of biocide in sludge and water. Biocide treatment may stimulate release of microbially produced H_2S from sludge.

Biocide wash solutions may froth or foam; the bubbles may be contaminated with *flammable* vapours which can be carried to drainage systems, where release may generate hazards.

Usually treatment of empty deslugged tanks with a biocide dosed wash is preferable. This strategy enables selection of a relatively safe biocide which can be easily and rapidly monitored and easily deactivated prior to disposal. Biocides based on free halogen release are appropriate, usually used in conjunction with wetting agents or detergents. Dosed wash waters may be irritant and spraying operations may result in production of irritant mists. Where possible automatic spraying devices should be used. If it is necessary for personnel to work inside tanks, during or after spraying they should use full protective clothing and *breathing apparatus*. At excessive doses of halogen biocides, free halogen gas may be produced at concentrations in excess of statutory exposure limits. Halogen biocides are easily inactivated with thiosulphate. Sulphur dioxide (SO_2) gas may be produced as a product of the inactivation reaction. Both chlorine (Cl_2) and SO_2 should be monitored when gas testing after halogen biocide use prior to entry of personnel (see Chapter 5).

Use of incompatible wetting agents or detergents with halogen biocides can result in toxic gas release. Ensure that any detergents or wetting agents used, are compatible with halogens.

Wash water containing detergents may impair the efficiency of interceptors and separators and therefore be unsuitable to go to site drainage systems. It may have to be treated on site or removed for safe disposal in accordance with legislation.

6.5 CLEANING STANDARDS

The standard of cleaning that is applied to a tank will depend on the future duty of the tank and/or the type of work that is planned to be carried out on it.

6.5.1 Change of Product Standard

The standard of cleanliness required for a change of product will depend on the compatibility of the old and new products. The new product can be used as a cleaning solvent in some cases, thus ensuring that the 'old' product is searched out. Spray application, however, should not be used.

6.5.2 Hot Work Standard

The hot work standard of cleaning is that required to allow subsequent *hot work*, such as welding, cutting, grinding etc., to be carried out safely in the tank. After removal of all product, sludge and other residues, the tank should be tested to demonstrate a gas-free condition, using a *combustible gas indicator*.

Special attention should be given to void spaces in tank internals, floating roofs and possible vapour accumulations under the bottom plates of tanks (as a result of leakage) and within the seal areas of floating roof tanks. These spaces should all be gas-freed unless special precautions are to be taken.

It should be noted that a gas-free indication can be obtained even before all residue has been removed and whilst a greasy film may still be present. It is important to ensure that all residues and sludges are removed prior to *hot work*, irrespective of whether they generate a *flammable* gas in their cold state, since they will be

subjected to the heat of the *hot work*. When the tank has been cleaned to a waxy, greasy film, the plates are washed to a metal or coating finish. This may be achieved in several ways:

- hot water washing,
- cold water spray or jetting under high pressure,
- steam jetting,
- gas oil washing,
- chemical wash or wipe, using detergents,
- Manual wiping with, e.g., rags, etc.

The method of cleaning used will depend on the product previously stored in the tank, the degree of cleanliness already achieved and local facilities available.

The hazards and the precautions to be taken can be derived from other chapters of this code. However, a few additional remarks include:

- When water is used as a cleaning medium it should not be recirculated and used again in the case of application by spraying or jetting.
- Steam jetting is not normally recommended when there is any risk of a *flammable atmosphere* still being present. Steam should be dry or superheated but below auto-ignition temperature of the hydrocarbons to be removed. Before steam jetting is started all steam lines, hoses, etc., should be carefully drained free of condensed water. Steam nozzles should be properly earthed.
- Gas oil washing should only be applied mildly, under carefully controlled conditions, including continuous monitoring of the atmosphere in the tank for flammability. Any gas oil remaining on the tank surfaces should be washed away with water.
- Spraying or jetting of gas oil under pressure might produce a *flammable* mist and should therefore be avoided (see C.2.2.3). Gas oil used for cleaning should not be heated, or recirculated.
- **Washing, spraying or jetting with a hydrocarbon liquid that has a higher volatility than gas oil, or with mixtures of higher volatility hydrocarbon liquids and gas oil, should not be performed in any circumstances.**
- When chemical detergents are used either in pure form or diluted in other liquids a continuous monitoring of the tank atmosphere may have to be maintained depending on the *flammable* and/or toxic properties of vapours generated. A thorough familiarisation with and understanding of the chemicals and their properties is therefore required.
- Wash water containing chemicals, detergents or emulsified oils may impair the efficiency of interceptors and separators, and therefore be unsuitable to go to site drainage systems. It may have to be treated on site or removed for safe disposal in accordance with legislation.

6.5.3 Inspection Standard

The inspection standard is similar to the *hot work* standard but may require a higher finish depending on circumstances and type of inspection. It may be necessary to scrub welds and plate laps to remove all traces of oil and debris. For health reasons, abrasives should not contain silica (in some countries, its use is prohibited). The use of volatile solvents should be minimised for environmental reasons. When their use is necessary, it should be ensured that ventilation is adequate to reduce the concentration below the *OEL*. Respiratory protection should be provided to inspectors when solvents are involved during testing, e.g. dye penetrant crack detection.

6.5.4 Internal Painting Standard

The internal painting standard is similar to the inspection standard. In almost all cases abrasive blasting will be required, as well as manual cleaning by scrubbing or brushing of welds and plate laps which have not been adequately cleaned by the abrasive blasting process. This standard also applies to preparation for glass fibre repairs to tank bottoms.

6.5.5 Decontamination Standard for Demolition

This standard is less frequently required. The methods to be employed should be discussed in detail and a *method statement* prepared before work starts. There are no general rules.

PRECAUTIONS SPECIFIC TO PRODUCT GROUPS

7.1 GENERAL

This chapter provides a summary of cleaning problems and specific hazards that may be encountered during the cleaning of tanks used for different classes of products within the scope of this Code. It is to be seen as complementary to the preceding chapters, to which references are made as appropriate.

The products that are stored in tanks and the sediments and residues that may be left behind can vary widely as regards composition, toxicity, etc., especially when taking into account the increasing use of additives. It is also clear that not all products can be specifically mentioned in this Code.

Beyond the general information given in this Code, it is therefore essential for the custodian of a tank that is to be cleaned to inform the tank cleaning supervisor about any significant physical or chemical property of products and additives in the tank. It is the responsibility of the tank cleaning supervisor that such information is obtained and assessed before tank cleaning can start and, in case of any doubts, to err on the safe side in taking precautionary measures.

Special attention should be given to tanks which, whilst in non-leaded product service, may have contained leaded material in the past (see 7.5).

7.2 CRUDE OILS

7.2.1 Introduction

Depending on their origin, crude oils can have widely differing properties which will determine the way in which they are stored and handled. Certain heavy and/or waxy types of crude oils are heated during storage.

Usually crude oils are stored in floating roof tanks.

However, fixed roof storage is sometimes in use for heavy crude oils.

7.2.2 Potential Hazards

A considerable number of crude oils can contain hydrogen sulphide (H_2S) in various amounts. Therefore the presence of pyrophoric iron sulphide deposits is possible in tanks containing crude oil, particularly with crude high in H_2S , and precautions should be taken accordingly. In addition, crude oils may contain significant amounts of benzene or other toxic compounds, including radioactive substances (see Annex C). This aspect should always be checked before the cleaning of a crude oil tank.

7.2.3 Sludge Deposits

Many crude oils have a tendency to precipitate sludge on the tank bottom. The composition of the sludge varies, but it often contains a high percentage of hydrocarbons (e.g. waxy deposits), together with smaller amounts of inorganic matter such as sand. Iron scale may also be present, which, if formed in the presence of hydrogen sulphide or mercaptans, may be pyrophoric. For guidance, see 5.9.

Good operating practices aim at minimising the sludge deposition, e.g. by means of heating and/or various tank mixing and circulation methods. Nevertheless, sludge deposits can be considerable and form the major significant aspect of crude oil tank cleaning. The sludge can sometimes be very unstable and inhomogeneous and unequally built up on the tank bottom. This requires special precautions in cleaning and handling. It is essential before a cleaning operation to assess as accurately as possible the sludge profile and to take a number of samples at different places.

If there are concerns about layering of sludge deposits, samples should be taken for analysis at stages during the cleaning operation. The results of analyses may be used to define any changes in the treatment required. Records of sample analyses should be retained to support decisions made on waste disposal methods.

Sludge removed from crude oil tanks should be kept wet to avoid rapid oxidation of pyrophoric deposits, which could lead to ignition of any hydrocarbons present. Solids removed from sludge by filtration or centrifuging should also be kept wet until disposal since they may also be liable to ignition or release of toxic vapour.

7.2.4 Flammable Vapours

Crude oils may have a high flammability requiring special attention to gas-freeing. The disturbance of sludge by the cleaning action may release *flammable* vapours which makes it essential to monitor the tank atmosphere continuously during cleaning as gas concentrations may well rise again to dangerous levels. This monitoring should continue until all sludge has been removed.

73 SWEET LIGHT AND MIDDLE DISTILLATES

7.3.1 Introduction

This group includes unleaded gasoline, naphtha, kerosine, jet fuels, gas oil and diesel oil (or their component fractions) which have been treated to remove reactive sulphur compounds (mercaptans and H_2S). The finished fuels may contain special additives. Both fixed roof and floating roof tanks are used for these products but the more volatile products (e.g. gasoline or naphtha) are usually stored in floating roof tanks or in fixed roof tanks with internal floating covers

7.3.2 Potential Hazards

Particular hazards related to some or all products in this group include:

- Flammability, requiring particular attention to gas-freeing and to the monitoring of the atmosphere during cleaning.
- Corrosivity, leading to large amounts of (possibly contaminated) rust in the tank bottom and a risk of large pieces of rust falling from roof trusses.
- Biological activity in any water/product bottom layers can sometimes leave a slimy and slippery layer in the tank bottom. Micro-organisms present may be infectious or allergenic if inhaled or accidentally ingested, or if they enter open cuts. Even in sweet products activity of sulphide generating micro-organisms in tank bottom sludge may result in release of H_2S , particularly if sludge is disturbed, biocide treated or acidified. There is some evidence that unleaded gasoline's may be subject to microbial contamination similar to light and middle distillates. Therefore the same potential hazards should be considered to apply.
- Certain additives and/or product components (caustic entrainments, benzene, methanol, etc.) may be harmless in normal dilution but become concentrated in the bottom water phase or bottom residue and present a hazard in such concentration.
- Carry-over of processing catalyst from refinery processes can lead to substantial sediment layers in certain dedicated tanks.
- Products with a low electrical conductivity (< 50 pS/m) require special precautions with, for example, recirculation during cleaning, water jetting, etc. Normally such activity should not be undertaken unless the vapour concentration is below 10% of LFL. It should be noted that misleading results of conductivity measurements may be obtained unless sampling and testing are carefully controlled.

7.4 SOUR LIGHT AND MIDDLE DISTILLATES

7.4.1 Introduction

This group is similar to the previous one but the presence of H₂S, mercaptans or other reactive constituents is a factor of significance. The risk of H₂S production due to microbial activity is considerably greater for sour distillates.

7.4.2 Potential Hazards

The hazards are generally similar to those listed in 7.3.2, but the presence of H₂S can give rise to the formation and accumulation of pyrophoric iron sulphide deposits, particularly when the product has been stored under oxygen deficient atmospheres. This leads to special precautions during gas-freeing (see 5.9) and to the necessity of keeping bottom deposits wet by spraying or covering with a water layer until removed to a safe location.

7.5 LEADED GASOLINE

7.5.1 Leaded Gasoline

The hydrocarbon components of *leaded gasoline* are similar to those of *unleaded gasoline*, which belongs to the product group mentioned in 7.3. Consequently the hazards and precautions mentioned for that group also apply to *leaded gasoline* tank cleaning. However, additionally, *leaded gasoline* contains small amounts of very toxic organic lead compounds in the form of tetraethyl lead (TEL), tetramethyl lead (TML) or a mixture thereof. Special precautions are required to be taken when dealing with tanks or other equipment that have contained or handled *leaded gasoline* unless a rigorous decontamination procedure has been carried out. Advice is contained in the Associated OCTEL Company Ltd publication OIP No 5: *Leaded gasoline tank cleaning and disposal of sludge* (see Annex H).

7.5.1.1 Potential Hazards

In normal dilution in the products these lead additives are not unduly dangerous, although this takes into account that gasoline is a toxic substance and exposure to it should be minimised. However, the lead additives tend to concentrate in tank scale and bottom deposits, making the cleaning of *leaded gasoline* tanks particularly hazardous.

Apart from the hazard of contact with these lead compounds during sludge or scale removal and handling, toxic vapours are also generated from the sludge or scale.

7.5.1.2 Protective Measures

A high degree of attention should therefore be given to health protection and control of personnel engaged in cleaning *leaded gasoline* tanks, to the working conditions in and around the tank, and to decontamination of any materials, equipment and clothing used.

7.5.1.3 Warning Notices

Leaded gasoline tanks should be clearly marked with permanently fitted or painted warning notices adjacent to all manholes.

7.5.1.4 Scale and Sludge

The meticulous control and careful handling of lead contaminated scale and sludge from the tank is essential. Attention should be paid to the avoidance of spillage and the disposal of the scale and sludge removed should be specially organised.

7.5.1.5 Cleaning Procedures

Detailed tank cleaning and sludge handling instructions for *leaded gasoline* tanks have been published by the major manufacturers of lead alkyls (see Annex H). It is essential, when a leaded tank cleaning operation is contemplated, that the relevant publications of these manufacturers are studied and that the recommended equipment, materials, etc., are obtained well before cleaning starts. During cleaning the recommended procedures should be meticulously followed.

7.5.1.6 Declassification

Tanks which have contained *leaded gasoline*, but have been transferred to other, non-leaded product service or have been taken out of service, can still pose a hazard even after thorough cleaning and many years of non-leaded service. This is caused by a possible residual lead alkyl presence, e.g. in scale on roof plates or roof trusses and in any paint layers. Lead compounds may also be absorbed into tank shell and floor surfaces, which may result in the release of lead fumes during *hot work* such as welding or cutting. Simple lead-in-air testing prior to the work is unsuitable as an indicator of whether fumes will or will not be released.

It is therefore essential that warning notices (see 7.5.1.3) are retained and that all personal protective measures continue to be applied as if the tank were still in leaded product service.

Precautions should continue until the tank has been proved free from lead contamination. This should be determined by a specialist of the lead alkyl manufacturers, or a competent and authorised staff member, on the basis of the results of lead-in-air tests conducted according to special procedures.

Guidance on procedures for the declassification of tanks is provided in the IP publication *Guidance on the Declassification of Tanks Previously in Leaded Gasoline Service*.

76 AROMATIC PRODUCTS

7.6.1 Introduction

This group comprises gas oils, cycle oils, aromatic lubricating oil distillates, as well as solvents, white spirits and certain special boiling point products, which contain relatively high amounts (up to 80% in certain cases) of aromatic hydrocarbons. They are stored in either fixed roof or floating roof tanks.

7.6.2 Potential Hazards

General hazards and precautions are similar to those described in 7.3.

An additional hazard is the toxic nature of aromatic constituents, particularly benzene (see Annex C).

7.7 RESIDUAL FUEL OILS

7.7.1 Introduction

This group comprises all straight run or converted petroleum residues and the products in which such residues form the major component. Residual fuel oils are usually stored in fixed roof tanks.

7.7.2 Potential Hazards

Depending on origin and/or processing routes residual fuel oils can contain relatively high levels of toxic contaminants, such as H₂S, polycyclic aromatics (see Annex C), traces of metals (e.g. vanadium, nickel) and additives. The legally permitted addition of slops/ waste oil in certain parts of the world can further add traces of heavy metal compounds, polychlorinated biphenyls, etc. In normal dilution these additives and contaminants are not hazardous but they may tend to accumulate in tank deposits and sludge. Some may also be released as vapours during sludge handling. The headspaces of fuel oil tanks may also accumulate hazardous levels of flammable and toxic substances that desorb during storage even when the product flash point may be well above storage temperature.

It is therefore particularly important that, before cleaning, the product history of the tank and the possible presence of harmful substances are discussed with operational staff concerned and that samples of bottom sludge and headspace gases are taken and analysed. Precautions during cleaning should then be taken accordingly.

7.7.3 Sludge Deposits

Residual fuel oils have a tendency to form heavy and/ or sticky sludge deposits on the tank bottom, tank internals, etc., whereas the tank wall may be coated with a thin layer of highly viscous residue after the tank has been emptied.

7.7.4 Lagging

A specific aspect of residual fuel oils is the usual high storage temperature which may be well above 100°C.

Because of this high temperature operation residual fuel oil tanks are often externally insulated. During tank operation the insulation material may become contaminated or soaked with fuel oil (e.g. from spillage's) or condensates (e.g. from leaking vent pipes). This situation constitutes a hazard also during tank cleaning since hydrocarbons absorbed in insulation material may ignite at temperatures substantially below the normal oil auto-ignition temperature.

It is therefore recommended that the tank insulation around roof and shell manholes and any other areas likely to be affected by tank cleaning activities should be inspected before the tank is opened. If necessary certain sections of the insulation around tank cleaning work areas may have to be removed.

7.7.5 Gas Testing

Because of the nature of the product, residual fuel oil tanks often leave, after emptying, an atmosphere inside the tank which is sufficiently below LFL to permit entry of personnel without special gas-freeing being required.

However, such a condition should never be assumed to exist and appropriate gas tests should always be taken.

7.7.6 Use of Diluents for Cleaning

If, during the internal pre-cleaning (see 6.1.2) of residual fuel oil tanks, lighter hydrocarbons have been used for flushing or dilution, the tank should be classified and handled accordingly, employing gas-freeing, gas testing, etc.

7.7.7 Internal Fittings

Residual fuel oil tanks may have various internal constructions. Heating coils (steam, oil or hot water) or other internal heating elements are often installed. These internal heating facilities hinder manual and mechanical internal tank cleaning.

7.8 BITUMEN, CUTBACKS AND BITUMEN EMULSIONS

7.8.1 Introduction

Bitumen's are heavy viscous liquids which are substantially non-volatile. They are found in natural deposits but more usually are produced in refineries. They are made in a large variety of grades which differ widely in viscosity and other properties, the lighter of these being essentially similar to heavy fuel oils (see 7.7). Cutbacks are bitumen's of which the viscosity has been reduced by blending with a diluent such as kerosine. Bitumen emulsions are dispersions of bitumen in water. Bitumen's, cutbacks and emulsions are normally stored in fixed roof tanks.

7.8.2 Tank Deposits

Depending on the grade, bitumen tanks are heated to high temperatures (often above 200°C) and are insulated. Upon cooling down of the tank for cleaning, a bottom layer of solidified unpumpable product is often formed. In the case of hard grades this solidified layer may be removed mechanically. In the case of softer grades it may be necessary to apply extended circulation with lighter fuel oil. In each case it is essential to carefully assess the nature of the remaining bitumen layer before any person is allowed to enter the tank.

If bitumen removal is to be eased by recirculation with lighter fuel oil, careful control and monitoring should be exercised over heating operations.

7.8.3 Potential Hazards

Other hazards related to bitumen tank cleaning are similar to those mentioned for residual fuel oils in 7.7. As H₂S is often present the formation of pyrophoric iron sulphides is likely to occur, particularly when the tank has operated under an oxygen deficient atmosphere such as inert gas or steam blanketing.

Additionally bitumen's form heavy, sticky carbonaceous deposits on the walls of the tank and on the underside of roof plates and trusses. As for pyrophoric iron sulphide deposits, these carbonaceous deposits react exothermally with oxygen and can attain pyrophoric properties under certain circumstances. During this process small amounts of volatile hydrocarbons can be released which render the atmosphere locally *flammable* and which can be ignited by glowing pyrophoric deposits.

Usually pyrophoric iron sulphides and carbonaceous deposits are found together.

The above-mentioned deposits tend to dry out when tanks are taken out of service and present a hazard to personnel in the tank when large size lumps may fall from the roof area.

7.8.4 Cut-Back Grades

Tanks which have held cutback bitumen may contain volatile residues and condensate, which require precautions as outlined in 7.3.

7.9 LUBRICATING OILS

7.9.1 Introduction

Lubricating oils exist in a great variety of grades having very different properties, especially as regards viscosity. They can be products from refinery processes or complex blends. Usually lubricating oils are stored in fixed roof tanks.

7.9.2 Potential Hazards

Blended lubricating oils usually contain a number of special additives. These may have toxic properties. Although in dilution in the oil they are normally not hazardous, this should be verified with the custodian of the tank (see 7.1).

7.9.3 Sludge Deposits

The amount of sludge left behind on the walls and bottom of lubricating oil tanks is usually small. However, it can be very slippery and may contain toxic material .

7.10 WAX AND WAXY OILS

7.10.1 Introduction

Waxy oils contain large amounts of paraffinic compounds having high pour points. In its extreme form the product consists entirely of wax, which is solid at ambient temperatures. Waxy products are usually stored in fixed roof tanks equipped with tank heating.

7.10.2 Potential Hazards

The refined oils and their deposits do not normally have toxic or other hazardous properties. However, large amounts of waxy deposits may be left behind on the walls and the bottom of the tank. During tank cleaning lumps or slabs of this material may fall from the tank walls. Furthermore the deposits are slippery. Unrefined oils, such as vacuum distillates (sometimes termed waxy distillates or vacuum gas oil) normally contain aromatic compounds, including polycyclic aromatic hydrocarbons, which may have *carcinogenic* properties. Skin contact with these oils should be avoided (see also the note in C.3.4).

7.10.3 Deposits

The removal of waxy deposits often requires the application of heat, for example by steaming. In order to avoid auto-ignition of the deposits, their auto-ignition temperature should be determined beforehand and the steam temperature controlled accordingly with a wide margin of safety.

7.10.4 Lagging

Tankage in this category is usually heated, causing potential hazards referred to in 7.7.4 and 7.7.7.

7.11 BALLAST WATER

7.11.1 Introduction

Ballast water carried in ships' tanks is often contaminated with oily residues and should be pumped ashore for treatment and cleaning before release to sea or river. The water can range between fully fresh and sea water.

Ballast water tanks include floating roof and fixed roof designs. In some cases the tanks may have open tops.

7.11.2 Potential Hazards

The greatest hazard during the cleaning of ballast water tanks is the complete unpredictability of the residues and sediments left in the tank.

These may contain various types of *flammable* oil residues, unknown additives and chemical cleaning agents having toxic properties. They may also present a radiation hazard from *Low Specific Activity (LSA)* scale. The silt may release gases such as H₂S, methane, etc., as a result of anaerobic bacterial activity in the tank.

It is therefore essential to obtain a representative sample of the tank sediment which should be carefully analysed to determine tank cleaning precautions.

7.11.3 Tank Internals

Ballast water tanks often contain heating coils as well as unusual internal constructions to improve water/oil separation. These constructions hinder tank cleaning and may contain numerous locations where hazardous material may remain trapped after the tank has been emptied.

Ballast water mixtures are often highly corrosive and an inspection of roof support structures (legs, in the case of floating roof tanks) should be carried out as early as possible in the cleaning programme.

7.11.4 Deposits

The tank internals may contain sand or other filtering material, which should be removed during tank cleaning. Such materials may be as hazardous as the bottom sediments mentioned above, requiring similar precautions.

7.12 SLOPS

7.12.1 Introduction

Slops is the common designation of any liquid product that is collected from drainage, spillage's or ballast water tanks.

7.12.2 Potential Hazards

The greatest hazard in cleaning slops tanks is the variable nature and composition of the slops and any deposits formed in the tank. It is therefore essential that, before cleaning starts, samples of the slops and of any bottom deposits be analysed to assess their composition, including the presence of toxic such as hydrogen sulphide. Depending on the outcome precautions should be taken in accordance with the various chapters of this Code.

RECOMMISSIONING

The tank cleaning exercise often continues over a relatively long period and involves a wide range of individuals during the different phases of the work. It is therefore particularly important that appropriate checks are carried out under the supervision of the custodian to ensure that the tank may be recommissioned safely. At this time the records of any abnormal situations encountered during the cleaning should be handed over to the custodian's representative to facilitate updating of the tank history.

Immediately prior to replacing the shell manhole covers in preparation for hydraulic testing and/or recommissioning of the tank, confirmation of the following points should be made.

8.1 INSPECTION

- 1) The tank foundations have been inspected and confirmed in satisfactory condition.
- 2) The bund walls have been reinstated.
- 3) The bund drainage system is serviceable and clean.
- 4) All necessary repairs to the tank have been completed.

8.2 ELECTRICAL

- 1) The tank shell is earthed.
- 2) Any *earthing* cables associated with the floating roof or internal floating cover are securely connected and intact and have been satisfactorily tested for continuity (see also 8.2(6)).
- 3) Any seal *earthing* shunts on a floating roof tank are correctly installed and intact.
- 4) Any tank or associated pipework cathodic protection system has been reinstated.
- 5) The electrical fittings associated with any side entry mixers have been correctly installed.
- 6) All electrical tests have been carried out and readings have been recorded.

8.3 INSTRUMENTS

- 1) All tank level gauging equipment has been correctly reinstalled and reconnected and is functioning correctly.
- 2) Any separate high and/or low level alarms have been correctly reinstalled and are functioning correctly.
- 3) Any tank temperature measurement instrumentation has been correctly reinstalled.
- 4) Any instrumentation associated with the side entry mixers has been correctly replaced.

8.4 FIRE PROTECTION

- 1) Any foam lines and their associated fittings have been inspected and confirmed as correctly reinstalled. If necessary, repairs should be carried out.
Note: Foam systems deteriorate in service and may be overlooked during inspection.
- 2) Any drencher or sprinkler system is correctly reinstalled.
- 3) Any halon fire fighting facilities for the seal area of a floating roof tank have been correctly reinstalled. *Note:* Halon systems are being discontinued for environmental reasons and suitable alternative extinguishing agents should be used.
- 4) Fire detection systems have been correctly reinstalled and tested through to their alarm stations.

8.5 MECHANICAL

- 1) All materials, tools and debris arising from the tank cleaning operation and subsequent inspection and any repair work have been removed from inside the tank, from the roof of the tank, from any internal floating cover and from the vicinity of the tank, for appropriate disposal outside the bunded area.
- 2) Any internal floating cover is intact and has been installed in accordance with the manufacturer's requirements. Floating suction pipes and support floats are correctly reinstalled and are properly articulated to ensure floatation.
- 3) Any side entry mixers have been correctly reinstalled.
- 4) Hand-railings on stairways and around the tank roof or wind girder are intact and secure.
- 5) The roof ladder is correctly positioned and intact.
- 6) The roof legs are all in position and correctly set.
- 7) The automatic vent legs are all in position and correctly set.
- 8) The roof drains are correctly installed and have been tested.
- 9) The roof drain sumps are all clear of debris and all non-return valves operational.
- 10) Foam risers and distributors/pourers are free of obstruction.
- 11) All pontoons are clean internally and all pontoon man-way covers have been replaced.
- 12) Any free vents, at the top of the shell or on the tank roof, have the correct 'free area' mesh installed, where a mesh is fitted, and are clear and free from blockage.
- 13) The pressure and vacuum relief valves have been tested, are in position, have the correct 'free area' mesh fitted and are clear and free from blockage.
- 14) All roof man-way covers and other roof fitting covers are closed.
- 15) Tank level gauging systems have been correctly installed and a verification check on gauging accuracy carried out.
- 16) Internal mechanisms that ensure correct operation of roof seals are correctly installed and free to move.

8.6 OPERATIONAL

- 1) The tank has been inspected internally and is acceptable for service.
- 2) The tank has been inspected externally, including the roof and any internal floating cover, and is acceptable for service.
- 3) All roof drain, water draw-off, suction and discharge valves are serviceable and properly identified.
- 4) All emergency roof drains, on single deck roofs, have been primed with water.
- 5) The tank drain valves are closed.
- 6) The roof drain valve is left either open or closed in accordance with local policy.

Testing of semi-fixed foam systems prior to recommissioning offers several advantages and should be considered. It checks that the systems work, provides emergency response personnel with practice and ensures that roof drains on FRTs are tested. If drain blockage is found, it may prove necessary to re-enter the tank before commissioning in order to carry out repairs.

Only after confirmation has been obtained that all of the relevant actions on the above list have been completed and a final check has been carried out to ensure that no person or animal is in the tank, should the shell man-way covers be replaced.

After the shell man-way covers have been replaced and properly tightened, all pipework, fittings and valves may be reconnected and made operational.

If there is to be either a full or partial water test of the tank it should remain isolated from the process pipework system until the successful completion of the water test.

Annex A

GLOSSARY OF TERMS

For the purpose of this Code the following interpretations apply irrespective of any other meaning the words may have in other connections. Where used in the Code, these terms are printed in *italics*.

auto-ignition temperature: temperature at which a material will ignite without application of any *source of ignition*, under prescribed conditions of test.

bonding: provision of a low resistance electrical conductor between sections of plant, equipment or structures.

breathing apparatus: device that provides the wearer with a continuous supply of breathable air through a face mask, helmet or mouthpiece.

canister respirator: respiratory equipment consisting of a face piece attached to a canister which contains a filter absorber to remove specific contaminants. It has no separate supply of air.

carcinogens: chemical substances which, if inhaled or ingested, or if they penetrate the skin, may cause or increase the incidence of cancer.

Note: Carcinogens are classified under three categories:

Category 1: substances known to be carcinogenic to man.

Category 2: substances which should be regarded as if they are carcinogenic to man (based on strong evidence from animal studies etc.).

Category 3: substances which are possibly carcinogenic to man, but in respect of which there is insufficient information to make a satisfactory assessment.

cold work: the carrying out of any task or the use of any equipment which will not produce a *source of ignition* (see also *Hot work*). It includes cleaning with tools which are not liable to produce *incendive sparks*, and operations such as drilling, tapping and cutting carried out in such a way as to limit the heat produced and keep the temperature of the tools and work below 100°C.

Note: The use of 'non-sparking' hand tools is not recommended. Harder, spark-producing materials may become embedded in them and they have a low mechanical strength. When hand tools are used in an area where a *flammable atmosphere* may be present, *hot work* procedures should be used.

combustible gas indicator: instrument designed to measure the concentration of *flammable* gas in air.

competent person: person who has the necessary ability in the particular process, trade, plant or equipment to which the text refers, to render him/her capable of the work involved, and who has been duly authorised to undertake the work.

controlled area (radioactivity): area designated under the Ionising Radiation Regulations where dose rates and contamination levels are such that access should be restricted to designated personnel; exposures of those operating in the area should be monitored.

custodian: person responsible for the operation of a tank and for emptying it and handing it over to the cleaning organisation. This would usually be a representative of the owner or of the tenant and it equates roughly to the 'occupier' in British law.

earthing: provision of a safe path of electrical current to ground, in order to protect structures, plant and equipment from the effects of stray electrical currents and electrostatic discharge.

exothermic oxidation: oxidation which generates heat.

flammable (synonymous with **inflammable**): Refers to any substance, solid, liquid, gas or vapour, that is easily ignited. The addition of the prefix 'non' indicates that the substances are not readily ignited, but does not necessarily indicate that they are non-combustible.

flammable atmosphere: atmosphere containing a flammable vapour or gas at a concentration lying within the *flammable limits*.

flammable limits: concentration limits between which atmospheres of flammable vapours in air are combustible (see *upper flammable limit* and *lower flammable limit*).

flash point: lowest temperature at which a liquid when heated gives off sufficient vapour to form a mixture with air that can be ignited momentarily in prescribed laboratory apparatus.

gas-free: condition of a tank or confined space when the concentration of *flammable* gases is within prescribed safe limits. The term gas-free does not imply absence of toxic gases or sufficiency of oxygen for vessel entry.

hazard: physical situation with significant potential for human injury, damage to property or damage to the environment.

hazardous area: area in which a *hazardous atmosphere* exists or may exist.

hazardous atmosphere: atmosphere containing a hazardous substance.

hazardous substance: liquid, vapour, gas or solid that is potentially hazardous to life, health, property or the environment.

Note: Hazardous substances are those having characteristics such as flammability, toxicity, carcinogenicity, radioactivity, corrosivity etc. In the UK, substances hazardous to health are defined in the Control of Substances Hazardous to Health (COSHH) Regulations.

hot work: work involving welding or the use of any flame or electric arc or of any equipment likely to cause heat, flame or spark. It also includes caulking, chipping, drilling, riveting and any other heat-producing operation, unless carried out in such a way as to keep the temperature below 100°C (see also *cold work*).

incendive spark: spark of sufficient temperature and energy to ignite a *flammable* gas.

inertia reel lifeline: device used in conjunction with a safety harness that permits normal working, but arrests sudden uncontrolled movement such as in falling.

intrinsically safe: electrical circuit, system or apparatus in which any sparking that may occur, under the conditions specified by the certifying authority and with the prescribed components, is incapable of causing ignition of the prescribed *flammable* gas or vapour (see IP Electrical Safety Code).

issuing authority (Work Permit systems): person having the authority to issue a *work permit* for specified work to be undertaken.

leaded gasoline: motor spirit containing lead alkyl compounds.

low specific activity (LSA) scale: naturally occurring, low-level radioactive material found in plant and equipment exposed to oilfield formation water.

lower flammable limit (LFL): lowest concentration of flammable gas in air at atmospheric pressure and temperature which is capable of being ignited. The figure is expressed as percentage by volume.

method statement: comprehensive description of the activities to be carried out for a specific work task and typically comprising the operating procedure for the task from inception through to completion, safety precautions to be observed, information on who is responsible for the activities, which services and equipment are required, *work permit* requirements etc.

naturally occurring radioactive material (NORM): naturally occurring radioactive material that may be found in plant and equipment exposed to oilfield formation water.

OEL (occupational exposure limit): concentration of an airborne substance, averaged over a reference time period, at which, according to current knowledge, there is no evidence that it is likely to be injurious to employees if they are exposed by inhalation, day after day, to that concentration.

Note: The OEL may be approved by a regulatory authority and is applicable only to persons at work and where the atmospheric pressure is within defined limits. The OEL may also be termed OES, Occupational Exposure Standard.

performing authority (*work permit* systems): person having the authority to control specific work activities undertaken in accordance with the requirements of a *work permit*.

pyrophoric scale or deposits: material, usually comprising finely divided ferrous sulphide, that is formed inside a tank, pipeline or equipment exposed to mercaptans or hydrogen sulphide. It is capable of such rapid oxidation on exposure to air that heating to incandescence can occur.

respirator: see canister respirator.

risk assessment: assessment of the likelihood, arising from a specified activity, of injury to life or health, damage to property and damage to the environment.

source of ignition: naked lights, fires, certain electrical equipment, hot surfaces above ignition temperature or a spark or flame produced by any other means.

spontaneous ignition temperature (SIT): see auto-ignition temperature.

static electricity: electrical difference of potential or charge generated through friction or through the separation of surfaces of dissimilar materials or substances.

supervised area (radioactivity): area designated under the Ionising Radiation Regulations where radiation dose rates and contamination levels are such that suitable protective clothing should be worn; exposures of those operating in the area should be monitored.

thermal relief valve: small relief valve fitted to relieve the pressure increase due to temperature rise in a closed, liquid-filled system.

upper flammable limit (UFL): concentration of flammable gas in air at atmospheric pressure and temperature above which combustion will not occur. The figure is expressed as a percentage by volume.

work permit: document issued by an authorised person (*issuing authority*) to permit specific work to be carried out safely in a defined area under specified conditions.

Annex B

CLASSIFICATION OF CRUDE OIL AND PRODUCTS

The Institute of Petroleum and the European Model Code classify crude oil and petroleum products (except for liquefied petroleum gases, LPG) according to their closed cup *flash points* as follows:

Class I	Liquids which have <i>flash points</i> below 21°C.
Class II(1)	Liquids which have <i>flash points</i> from 21°C up to and including 55°C, handled below their <i>flash point</i> .
Class II(2)	Liquids which have <i>flash points</i> from 21°C up to and including 55°C, handled at or above their <i>flash point</i> .
Class III(1)	Liquids which have <i>flash points</i> above 55°C up to and including 100°C, handled below their <i>flash point</i> .
Class III(2)	Liquids which have <i>flash points</i> above 55°C up to and including 100°C, handled at or above their <i>flash point</i> .
Unclassified	Liquids which have <i>flash points</i> above 100°C.

It will be noted that Class II and Class III petroleum may be subdivided in accordance with the circumstances in which they are handled.

Unclassified petroleum liquids should be considered as Class III(2) when handled at or above their *flash points*.

For countries where ambient temperatures are high enough for the handling temperatures of petroleum products to rise above 21°C, or in circumstances where products are handled artificially heated, then liquids which as a consequence fall into Class II(2) or III(2), should be treated as though they were in Class I.

Annex C

HAZARDS

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C.1 GENERAL

There are potential hazards which are common to any tank cleaning operation. However, there are specific hazards associated with particular operations and products.

Incidents involving personal injury, risk to health and the environment, or material damage can result from the causes detailed below. Their likelihood in any planned tank cleaning operation should be considered in a risk *assessment*. Appropriate measures should be adopted as indicated by the assessment.

C.2 FIRE AND EXPLOSION

The contents of petroleum storage tanks are *flammable* to a greater or lesser degree depending on the material stored (see Annex B).

If a *flammable* mixture of vapour and air exists inside the tank and a *source of ignition* is also available, a fire and/or explosion may result. It is the vapours left behind after liquid removal or those rising from the surface of a *flammable* liquid which ignite and burn. If either the oxygen level can be restricted (less than 8%) or a *source of ignition* can be excluded, a fire or explosion cannot occur.

Note: Reducing the oxygen level is not a permissible option when persons are to enter the tank or confined space (see Table 6.1).

If combustion takes place in a confined space, the heat release and consequent expansion of the gaseous products of combustion may result in a pressure greater than the equipment can withstand, and an explosion of the equipment will occur. It is also possible for explosions to take place in the open air when a large volume of *flammable* vapour is ignited. Such volumes may accumulate from a release of pressurised vapour or from a spill of volatile product. The sudden expansion and turbulence caused by the ignition is an explosion and may cause injury to people as well as serious damage to structures in the path of the expanding gases from the resulting pressure wave. In practice, ignition of vapours released from the spillage of *flammable* substances onto open

ground at a temperature above the *flash point* generally results in a flash fire rather than an explosion. Although little or no over-pressure may arise, the fire could be fatal for anyone enveloped by it.

When embarking on a tank cleaning operation it is essential to know the Class of material (see Annex B) which has been stored in the tank. This will give a guide as to how the material is to be handled, but it should be appreciated that in certain circumstances, the material may be more hazardous than its classification would indicate. For example (a) Class II(1) material will ignite more readily if evaporating from soaked paper, cloth or insulation; (b) unclassified material will give off the equivalent to Class I vapour if heated by a cutting torch; (c) Class II(1) liquid will ignite more readily if in the form of a mist or fog.

C.2.1 Flammable Vapours

Mixtures of hydrocarbon vapours and air will ignite only if the hydrocarbon-to-air ratio is within certain limits. The *lower flammable limit* (LFL) and the *upper flammable limit* (UFL) for most hydrocarbon mixtures, are typically at about 1% and 10% by volume hydrocarbon vapour to air respectively.

Combustible gas indicators are normally used to measure the presence of *flammable* hydrocarbon/air mixtures. These instruments are calibrated to indicate percentage of the *lower flammable limit* of the hydrocarbon vapours present in the mixture (see 3.5.2).

Ignition will not occur where the concentration of hydrocarbon vapour is less than the LFL, nor where it is greater than the UFL. However, 'rich mixtures' (above the UFL) may be locally diluted to within the *flammable* limits by air entering the tank at tank openings, such as man-ways, hatches, vents, etc. If a *source of ignition* is present in such areas, explosion and/or fire is likely to occur.

When a volatile hydrocarbon liquid has been removed from the tank prior to commencement of cleaning operations, a 'rich mixture' will almost certainly remain in the tank. Ventilating the tank by admitting air to reduce the vapour concentration will result in the formation of a *flammable* hydrocarbon/air mixture at some point during this operation.

A fire or explosion potential will continue to exist until the concentration of vapour has been reduced to below the LFL. Similarly, when the tank has been vapour freed, but a sludge or scale deposit remains on the tank surfaces, *flammable* vapours can be formed locally when these deposits are disturbed or heated.

Flammable vapours may also enter a tank from hidden places such as cracked floor plates, pontoons and tubular leg roof supports (in floating roof tanks) from internal floating covers and from scale deposited on tank roof supports or on the underside of roof plates. Such hazards may escape detection by a *combustible gas indicator* used for a general check and will require local investigation.

For *hot work*, no reliance should be placed on readings below LFL unless all possible vapour sources in the tank structure have been considered and investigated.

C.2.2 Sources of Ignition

A *source of ignition* is any heat source having sufficient energy to ignite a *flammable* vapour/air mixture by locally raising it above its auto-ignition temperature. The amount of energy required for ignition depends on the composition of the *flammable* atmosphere. Possible sources of ignition in and around tankage are:

C.2.2.1 Electrical Equipment

Electrical discharges may become a *source of ignition of flammable atmospheres* by sparks or arcs when, for example, current carrying contacts are separated, when an electric current jumps a gap between two conductors or through a discharge of *static electricity* (see C.2.2.3). During tank cleaning, electrical ignition sources can be created by, for example, the use of electrically driven equipment, lighting, or internal combustion engines. The types and use of such equipment should therefore be strictly controlled.

C.2.2.2 Lightning

Lightning may cause ignition of *flammable* atmospheres. Hence all tank cleaning activity should be suspended during electrical storms and personnel should leave the vicinity of the tank. Where practicable, all large tank openings should be temporarily covered or closed, except those for pressure/vacuum relief.

C.2.2.3 Static Electricity

The generation of *static electricity* is a surface phenomenon associated with the contact and separation of dissimilar materials.

With liquids, including hydrocarbons, the degree of charge generation and decay is also a function of the electrical conductivity, which is affected by, e.g., the concentration of trace compounds such as asphaltenes, oxidation products, acids, etc. The presence of a second phase liquid such as water also has an influence on the generation of static charges.

The impingement of solids on solids such as occurs during grit blasting operations also results in the generation of an electrostatic charge.

An electrostatic charge can also be produced by air driven lights if the air supply hoses are not antistatic.

The generation of *static electricity* in itself does not present a hazard unless the charges reach a sufficient strength to result in a discharge with sparks of sufficient energy to cause ignition of a *flammable* atmosphere that is simultaneously present.

The best method of preventing the accumulation of electrostatic charges on bodies such as tank shells and hoses, nozzles, etc., is to ensure that they are made of electrically conductive materials and are properly bonded and earthed especially, in the case of hoses, at the nozzle (see Annex G). It is essential that all *bonding* and *earthing* connections are inspected and tested before any tank cleaning takes place.

C.2.2.3.1 Steam cleaning and water jetting

Steam and water jetting are capable of generating *static electricity*. Steam issuing from a nozzle at high velocity can cause the formation of a charged mist. This electrostatic charge is generated at the nozzle and is appreciably higher with wet steam than with dry. It is, therefore, recommended that steam cleaning in a *flammable* atmosphere should be avoided and should only be carried out when the tank is *gas-free*.

Note: Steam cleaning of small tanks (capacity up to 100 m³) has been found to be acceptable, based on experimental evidence.

An electrostatic charge can be generated when a water jet impinges on the tank shell and breaks down into fine droplets. The charge generated in this way is usually lower than that obtained with wet steam. However, it is recommended that pressure water jetting should only be carried out when the tank is *gas-free*.

C.2.2.3.2 Jetting with hydrocarbon solvents

Cleaning of tanks should not be carried out by jetting with a hydrocarbon oil since this can result in both the creation of electrostatic charges (depending on the electrical conductivity of the oil used) and the formation of hydrocarbon vapour and mist. If it is essential to use this method it should be carried out in an inert gas atmosphere or sub-surface with some oil still in the tank. Persons should not be present within the tank during the operation.

C.2.2.4 Hot surfaces

These include smoking, fires, *hot work* during repairs (whereby also sparks may be created) and also hot exhaust lines (internal combustion engines), uninsulated steam or hot oil lines, etc. Smoking and fires should not be permitted at any time in the vicinity of tankage and *hot work* should be strictly controlled and regulated by a *hot work* permit procedure. As a general rule the carrying of matches and lighters should be prohibited.

A particular type of hot surface hazard can result from pyrophoric deposits, dealt with under C.2.2.5.

C.2.2.5 Pyrophoric deposits

Pyrophoric iron sulphide deposits may occur when a tank has stored oil or a water bottom which contained hydrogen sulphide or other sulphur compounds. Reaction between the hydrogen sulphide and/or the sulphur compounds and rust from the corrosion of steel surfaces may produce iron sulphides. The subsequent reaction, when air is admitted, between the iron sulphides and oxygen is exothermic. The heat generated as the reaction proceeds can act as a *source of ignition of flammable* vapours and lead to a fire or explosion.

C.3 CHEMICAL HAZARDS

C.3.1 General

Chemical hazards can arise from:

- Skin contact with the hydrocarbon liquid stored in the tank, or from contact with certain chemicals.
- Inhalation of hydrocarbon or chemical vapours.
- Accidental swallowing of liquids or solids.

Monitoring the tank atmosphere for *hazardous substances*, such as toxic vapours, is a specialised task and should be carried out by a person who is trained and competent to do so. Such monitoring can be achieved with specific portable instruments (approved *intrinsically safe*) or with suitable chemical vapour detector tubes. It is suggested that an action level of 10% of the occupational exposure limit (*OEL*) for the substance in question is adopted in order to allow an additional safety margin. If the level of a toxic material exceeds 10% of its *OEL*, a detailed *risk assessment* should be carried out by a *competent person* before proceeding. For information on *OEL* values, reference should be made to the HSE annual publication, EH 40, *Occupational Exposure Limits*; see Annex H.

Where multiple toxic vapours are present, the advice of a specialist should be sought.

C.3.2 Lead Anti-knock Compounds

Tetramethyl lead (TML) and tetraethyl lead (TEL) compounds which are blended into gasoline's as anti knock additives are very toxic substances. When an alkyl lead compound has been blended into gasoline, there is, owing to its dilution, no longer a significant hazard provided the customary precautionary procedures for gasoline are observed during normal handling and dispensing operations. However, the hazard recurs when gasoline tank cleaning is undertaken owing to the build-up of compound in the sludge and scale deposited in the tank.

Therefore lead alkyls are amongst the most hazardous chemicals likely to be met in tank cleaning activities, and they require extensive and strict precautions. If these are taken, however, cleaning of *leaded gasoline* tankage can proceed in safety. Recommendations and references to detailed publications are given in Annex H.

C.3.2.1 Symptoms of lead alkyl poisoning

Symptoms of lead alkyl poisoning may result from one brief severe exposure or from the accumulated effects of repeated milder exposures. The effects on the central nervous system predominate. The more severe the exposure, the earlier will the symptoms appear and the more likelihood there is of severe illness. Depending on the severity of the exposure, symptoms may arise from within 6 hours to 10 days. Early symptoms and signs include sleep disturbance, unpleasant dreams, anorexia, nausea and vomiting, metallic taste, mental irritability, anxiety neurosis, loss of libido, a sense of impending death, pallor, tremor and slow pulse.

If exposure has been serious or prolonged, later symptoms may include intense anxiety and nervousness, nightmares, muscular weakness and abnormal physical movements, low temperatures, low blood pressure, exaggerated reflexes and weight loss.

The effect progresses to complete disorientation with violent mania, hallucinations and delusions followed by death in coma or convulsions.

It is essential to obtain expert medical advice as soon as any degree of lead poisoning is suspected.

C.3.3 Hydrogen Sulphide

Hydrogen sulphide (H_2S) exposure is considered to be one of the major hazards of the petroleum industry. It is extremely toxic, being comparable in this respect to hydrogen cyanide. Over-exposure to high concentrations can lead to rapid collapse, coma and death.

In low concentrations, where it is unpleasant but harmless, the gas has a typical 'bad egg' odour. At higher concentrations the sense of smell is rapidly lost and therefore should never be relied upon as an indicator of the presence or absence of the gas. The smell of H_2S may also be masked by the presence of other vapours.

All petroleum crude oils contain sulphur in varying amounts, usually combined with hydrogen and/or carbon. Some crude's contain free sulphur and H_2S . Sulphur is an undesirable element in petroleum products and various processes exist to remove it whereby H_2S is often formed during intermediate stages. Whilst the H_2S is subsequently removed, certain amounts of it may still be present in product storage tanks. Microbial activity can result in conversion of sulphur and sulphonates in petroleum products to H_2S .

H_2S may therefore be encountered during tank cleaning, for example in the vapours left behind after emptying the tank or as a result of releases from remaining liquid or sludge. Disturbance, local heating, biocide treatment or acidification of sludge may increase H_2S emission.

C 3.3.1 Precautions to be observed

It is important to ascertain, before entry of any personnel into the tank, the extent of any H_2S that may be present. Recommendations for working in such conditions are given in 6.3. In many countries occupational exposure limits are prescribed and reference should always be made to current legislation.

Whenever it is encountered or its presence suspected at levels above the occupational exposure limit, stringent precautions should be taken to prevent accidental over-exposure, and operators should wear automatic personal alarms set to operate at the short term exposure limit (in the UK the latest edition of EH 40 should be checked; in the 1994 edition the level was 15 ppm). In the event of activation of an alarm, those involved should withdraw immediately to a safe location and alert any other persons who may potentially be affected.

Apart from its toxicity, H₂S is also a *flammable gas* when mixed with air between approximately 4% and 46% by volume. This, however, generally creates no particular additional hazard for tank cleaning since these concentrations are far beyond those where toxicity is the governing factor.

C.3.4 Polycyclic Aromatic Hydrocarbons

Some heavy refinery streams or products may contain small amounts of polycyclic aromatic hydrocarbons (PCAs), sometimes referred to as PAHs. Typical streams are gas oils, fuel oils, extracts, catalytic cracker recycle oils and vacuum distillation residues.

Frequent and prolonged contact with oils and sludge's containing these materials can lead to a variety of skin problems such as dermatitis, oil-acne, cracking of the skin, skin lesions and warts. Some PCAs are *carcinogenic* to skin if it is subjected to long-term exposure. The toxicity of PCAs varies according to the particular compound involved and no generally acceptable exposure limits can be stated.

During the cleaning of tanks that have contained such products, skin contact with oil or sludge should be avoided by wearing impermeable protective clothing, gloves and boots. High standards of personal hygiene should be observed.

Note: In the UK, the Code of Practice (*Carcinogens ACOP*) should be applied where persons are exposed, or liable to be exposed, to substances that are defined as carcinogens in the Control of Substances Hazardous to Health (COSHH) Regulations 1994 (SI 1994 No 3246). In addition, under the Chemicals (Hazard Information and Packaging) Regulations 1993, such substances or preparations need to be labelled with the appropriate risk phrase:

R45: May cause cancer

or

R49: May cause cancer by inhalation.

Carcinogenic substances are listed in Appendix 9 of the 'Occupational Exposure Limits', EH40, which is published annually by the Health and Safety Executive (see Annex H).

C.3.5 Benzene

Benzene is an aromatic hydrocarbon which can be present in very low concentrations in crude oils and is produced in certain refining processes. It is also manufactured as a finished product in the petroleum industry.

Benzene is rapidly absorbed into the body by inhalation, through the intact skin or via the intestinal tract, of which the first route is by far the most important in industrial activity.

Excessive acute exposures will result in symptoms of narcosis, loss of consciousness, and ultimately death if exposure is sufficiently severe. Chronic exposure to excessive amounts may affect the blood-forming organs and result in various disorders, including leukaemia.

The cleaning of storage tanks for benzene (petrochemical material) is not covered by this Code. However, benzene is also often a minor constituent of gasoline (typically 2-3% by volume) and may occur at higher concentrations in certain gasoline components and natural gas condensates. Provided gasoline is handled and dispensed in the normal way, benzene is not known to be a significant hazard in the concentrations present. It is nevertheless necessary that, with cleaning of tanks which have contained gasoline or gasoline components, the possible presence of relatively high benzene concentrations be assessed and monitored. Specialist advice should be sought as appropriate.

It is important that exposure of people working with hydrocarbon components containing benzene should be reduced to the lowest practicable level and below the relevant exposure limit. Recommended occupational exposure limits for benzene are subject to review and the latest recommendations should be consulted; for the UK, see the current edition of HSE Guidance Note EH 40.

Monitoring procedures should be established to ensure compliance with the foregoing. Depending on the assessment of exposure, procedures for routine exposure monitoring and health surveillance on an individual and group basis may be required.

C.3.6 Miscellaneous Chemicals

C.3.6.1 Tank cleaning agents

From time to time various chemicals may be used during the tank cleaning process, for example, demulsifiers, degreasing agents, biocides, etc. The toxic nature of these chemicals should be ascertained before any arrangements are made to bring them on site.

Where a toxic risk is identified, efforts should be made to obtain a non-toxic substitute. Otherwise, procedures, including means of personal protection, should be clearly defined. Consultation with the manufacturer of the chemical agent is recommended, particularly if the mixing of agents can occur.

C3.6.2 Other chemicals

Whilst the cleaning of storage tanks for chemical products is outside the scope of this Code, a variety of chemicals may be present in oil storage tanks, as additives or blended components.

In normal dilution these additives are generally harmless, but accumulations with higher concentration may occur in sediments and scale which are to be removed during tank cleaning.

It is therefore important to assess whether such conditions could exist and to assess the degree of hazard before tank cleaning can start. Consultation with the manufacturer of the additive concerned or with the management of the tank farm (if competent on this subject) is recommended. Biocides added to stored product are particularly prone to concentration in water and sludge. The tank custodian may be unaware of previous biocide additions to stored product. This biocide may continue to migrate to water and sludge at hazardous concentrations even after several successive product movements or tank drainings. Personal protection measures should be taken as directed.

C.3.7 Dusts

Exposure to toxic dusts will normally occur when the tank interior or external shell is being cleaned or prepared for repainting by grit or shot blasting or other manual cleaning techniques. The source of toxic dust can be:

- the grit or shot blasting materials;
- additive deposits, e.g. TML, TEL;
- asbestos from lagging;
- paint coating, e.g. lead based paints.

Where grit or shot blasting cleaning techniques are employed, persons carrying out the work should wear air-fed protective hoods. Other personnel should not normally be allowed inside the tank while grit blasting is in progress. However when it is considered safe to enter, such persons should as a minimum wear efficient particulate filter masks. Filters should be changed regularly.

In the case of tanks which have held *leaded gasoline*, or where lead-based paint is being removed, air-fed protective hoods should be worn by anyone present. It is important that the Control of Lead at Work Regulations should be observed. Attention should also be paid to noise generation; see C.5.1.

Depending on the nature of the surfaces being cleaned and the techniques employed, it may be advisable to ensure that operators are subject to health surveillance by an Appointed Doctor or Employment Medical Adviser.

C.4 OXYGEN DEFICIENCY

The concentration of oxygen in normal air is approximately 21% by volume. As this concentration decreases, breathing becomes increasingly difficult, until a level is reached where human life cannot be sustained.

In workplace situations, assuming that toxic and *flammable* gases are not present, the lowest level for safe working without air-fed respiratory protection is considered to be 20% oxygen. Analysers or meters are used for determining the oxygen level in tanks or other confined spaces. Where *flammable* vapours may also be present in the atmosphere, such monitoring equipment should be certified for use in these atmospheres.

In tank cleaning situations oxygen deficiency can arise from:

- Inert atmosphere, i.e., where nitrogen or other inert gas mixtures have been used as a blanket gas above the stored liquid.
- High concentrations of hydrocarbon vapours. This situation will exist when a drained tank is opened and until dilution is effected by air circulation and ventilation.
- Internal corrosion in a closed tank. Where a tank has been cleaned and resealed, oxygen contained in the air within the tank can be consumed by corrosion of the metal surfaces of the tank. Such reactions are enhanced by heat and high humidity.

On reopening the tank, oxygen levels should be checked before allowing personal entry without appropriate respiratory protection, and at regular intervals thereafter. On no account should oxygen cylinders be used to raise the level of oxygen in the tank.

C.5 PHYSICAL HAZARDS

C.5.1 Environmental Conditions

Amongst the adverse working conditions associated with tank cleaning are heat, cold and noise. Heat and cold are to a degree, a function of the existing climatic conditions and can be regulated by air circulation to dissipate heat and by the circulation of warm air or the wearing of thermal clothing to compensate for the cold.

Excessive noise may arise from the use of cleaning equipment (such as grit blasting), air movers or generators and compressors operating in the area. In these circumstances, noise monitoring should be carried out. If the level of continuous equivalent work day noise dose is 85 dBA or above appropriate hearing protection measures should be taken. At high noise levels, or when hearing protection is used, special measures should be taken to ensure that attention is drawn to any alarm condition.

Working inside tanks exposed to solar radiation can quickly lead to heat stress, especially when the worker is wearing enveloping protective clothing. Work periods should be of short duration under such conditions, interchanging with others engaged on duties outside the tank. If necessary, impervious protective clothing should be removed outside the tank to permit perspiration to evaporate. Soft drinks should be freely available to replace lost body fluids.

C.5.2 Work Conditions

In addition to personal injury arising out of fires, explosions, exposure to toxic materials or asphyxiation, incidents may occur from such other causes as:

- structural failure of tank shell, roof, roof support trusses, or internal floating cover;
- falling tools or materials;
- falls through corroded or weakened roof plates or from ladders/scaffolds;
- tripping over pipes, hoses or tools, or stepping into tank drain sump;
- knocking heads against obstructions;
- slipping on wet or oily surfaces;
- discharge of steam, high pressure air, water or oil into the tank or surrounding work area;
- use of improper or poorly maintained tools or equipment, especially electrical equipment;
- failure to isolate electrical power, process and service lines from the tank;
- inadequate lighting;
- inadequate scaffolding;
- electrocution from faulty electrical equipment;
- inadequate securing of movable items, such as level floats.

To minimise the risk of incidents from many of the above causes it is essential that the workforce is adequately trained, that there is appropriate competent supervision at all times and that correct working methods are used. The benefit of maintaining strict good housekeeping standards is stressed.

C.6 RADIATION HAZARDS

Some crude oils, condensates, ballast water and slops may contain radioactive substances. Information on this point should be obtained from the custodian of the tank and, where appropriate, specialist advice should be sought.

The oil, gas and water mixture in an oil field reservoir, known as formation water, is relatively 'chloride-rich' and dissolves minerals from the strata, including radioactive minerals. When this solution undergoes changes in temperature and pressure and, more importantly, when it mixes with surface water, scale can be produced.

This radioactive scale is referred to either as naturally occurring radioactive material (*NORM* or, more commonly, as *low specific activity (LSA)* scale. The radioactivity of *LSA* scale is due to radium and its daughters and, as ^{226}Ra is the most restrictive nuclide present, this nuclide is selected for control purposes. *NORM* is caused by a different chemical mechanism that results in other nuclides being deposited in significant quantities. In this case, lead (^{210}Pb) is the most restrictive and therefore is used for control purposes when working with *NORM*.

The deposition of scale containing radium isotopes has been found to be most severe in items where the pressure or temperature drop takes place, such as it production tubing, valves, separator vessels, oily water treatment units and ballast/slop tanks. The scale can adhere to surfaces and also be finely dispersed in sludge's, particularly in storage vessels.

The control of work activity where *LSA scale* is present is governed in the UK by the Ionising Radiation's Regulations 1985.

The radioisotopes present in *LSA scale* for which the regulations are most restrictive is radium 226 (^{226}Ra) and the contamination figures stated below for designating 'supervised' and 'controlled' areas are those for ^{226}Ra .

C.6.1 Supervised Areas

The Ionising Radiation's Regulations state that a '*supervised area*' shall be designated if:

- a) the dose rate exceeds $2.5 \mu\text{Sv/h}$ (microsieverts/hour)
- or
- b) the contamination level exceeds 2 Bq/cm^2 (Becquerels/cm²).

A diagrammatic representation of the limits is given in Figure 3.

Vessels should be treated as *supervised areas* for vessel entry until internal monitoring has confirmed levels below these limits.

Supervised areas do not normally need special precautions other than being identified as such. However, when an area has been designated a *supervised area* because of the presence of contamination, full protective clothing (including respiratory protection) should be worn by anyone entering or remaining in the area. Changing and washing facilities should be available for anyone entering or leaving the area.

Dose rates levels are the same for *LSA* and *NORM*. However, for *NORM*, a *supervised area* is designated if **any** contamination is detected.

C.6.2 Controlled Areas

The Ionising Radiation Regulations state that an area shall be designated a '*controlled area*' if either:

- a) the dose rate exceeds $7.5 \mu\text{Sv/h}$ or
the contamination level exceeds 8 Bq/cm^2 or
- b) the dose rate exceeds $2.5 \mu\text{Sv/h}$ and
the contamination level exceeds 2 Bq/cm^2 .
- c) If *NORM* is present, a *controlled area* is designated if the contamination level exceeds 2 Bq/cm^2 .

In addition to the requirements given in C.6.1 for *supervised areas*, the following restrictions apply in *controlled areas* for the protection of personnel.

Access to the *controlled area* should be limited to classified radiation workers or to personnel entering the area under control of a permit-to-work system. In the UK, a written system of work for non-classified persons entering controlled areas is a specific requirement of Regulation 8(6) of the Ionising Radiation's Regulations 1985. A permit-to-work system may be an element of such a written system.

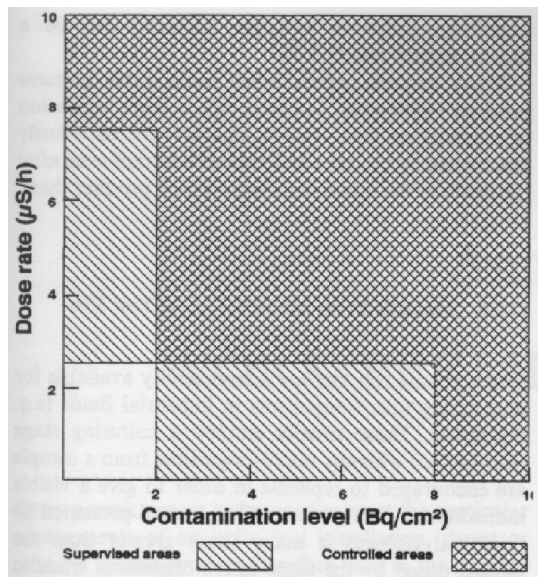


Figure 3 Radiation hazards

C.6.3 Control Levels

- a) Recommended control levels for the exposure of non-classified workers to *LSA* radiation are:
maximum dose rate - $30 \mu\text{Sv/h}$;
maximum exposure - workers should not operate in *Controlled Areas* for more than 500 h per annum.

Note: The Regulations require that non-classified workers shall not exceed a dose rate of 15 mSv per year.

- b) Plant which is to be worked on should be free of loose contamination. The quantity of fixed contamination should be as low as reasonably achievable.
- c) Radioactivity levels in bulk materials cannot normally be measured with site equipment. Bulk materials, such as tank deposits, known or expected to have radioactive contamination, should be examined by a suitable industrial laboratory. The disposal of such material should be in conformance with regulatory requirements.

C.6.4 Record Keeping

Full records should be maintained of personnel exposed to *LSA* radiation. Information on their dose rates, work hours and cumulative exposure times should be registered.

C.7 MICROBIOLOGICAL HAZARDS

C.7.1 Introduction

Some degree of microbial proliferation in petroleum product storage tanks is not uncommon. Micro-organisms require water for proliferation and hence tend to be concentrated in tank water bottoms and sludge, although they may grow as slimes on walls which entrain the water necessary for their growth. The degree of hazard is related to the numbers of micro-organisms, their type and the risk of their entry into the body. Three broad categories of micro-organisms may be present:

- bacteria

- yeasts
- moulds.

Micro-organisms can present three hazards:

- infections
- induction of an allergic response
- toxic microbial by-products

If significant microbial proliferation is suspected the likely hazard should be assessed by a trained and competent industrial microbiologist.

C.7.2 Infection Hazard

Highly infective pathogens are unlikely to be present. The presence of opportunistic pathogens is more likely; these organisms can infect people whose immune response is suppressed as a consequence of certain drug treatments or ill health. To cause infection micro-organisms should first enter the body. Most likely transmission routes are:

- Inhalation of aerosols containing micro-organisms in water droplets. The hazard is greatest where aerosols with a droplet size of $<5\ \mu\text{m}$ are produced. *Breathing apparatus* may be necessary for personnel exposed to such aerosols.
- Entry through open cuts. Protective clothing will reduce risk. Workers with cuts should not participate in manual sludge removal or cleaning operations inside the tank. Any cuts or injury sustained during cleaning operations should receive immediate medical attention.
- Accidental ingestion. Good personal hygiene should greatly reduce risk of ingestion. Operatives should avoid placing hands near their mouth and should always wash thoroughly before eating. Food should not be consumed in the vicinity of the tank cleaning operation.

Typical opportunistic pathogens which may be encountered are:

Bacteria:

Pseudomonas aeruginosa (causes wound and eye infection)

Other pseudomonads

Alcaligenes spp

Yeasts:

Candida spp (skin and systemic infections)

Moulds:

Aspergillus fumigatus (lung infections)

C.7.3 Allergenic Hazard

Many micro-organisms can induce allergenic responses, even when they are dead. The greatest risk is from inhalation of aerosols or dusts containing dried bacteria, yeasts or moulds spores. Asthma sufferers are particularly at risk.

C.7.4 Toxic Microbial By-Products

Production of H_2S by sulphide-generating micro-organisms (sulphate reducing bacteria) can be a serious hazard (see C.3.3).

Many bacteria which infect tank water bottoms produce endotoxins. Greatest risk is from inhalation of aerosols or dust. Endotoxins are not necessarily inactivated by biocides and present a hazard even after the death of the micro-organisms which produce them.

C.7.5 Hazards From Microbiological Test Kits

Many on-site test kits are commercially available for monitoring micro-organisms in industrial fluids (e.g. dip-slides). These usually employ a culturing stage (incubation) whereby micro-organisms from a sample are encouraged to replicate in order to give a visible indication of their presence. The hazard presented by microbial cultures is many times greater than the hazard posed by the same micro-organisms when in the sample or system. Care should be taken to avoid direct contact with the cultured micro-organisms. Avoid opening cultures (except for disposal) and always wash hands after handling. Training is recommended for personnel using microbiological test kits. Always follow manufacturers instructions and dispose of test kits safely employing disinfection, incineration or steam sterilisation.

Annex D

WORK PERMIT CHECKLISTS

Every permit system is designed to meet the particular requirements of an individual installation, depot or refinery. Permit systems therefore vary in the number of forms used, the form lay-out and the content of the individual forms. The Issuing Authority should satisfy him/herself before issuing the permit that the recipient has a full understanding of tank cleaning procedures, of the hazards involved in the work and of the conditions specified on the permit.

The following checklists may be used by a person who has to complete any form of permit for a tank cleaning operation.

D.1 Before issuing a permit the *Issuing Authority* should ensure that:

- the work site has been inspected;
- the tank in which work is to be carried out has been clearly identified;
- the limits of the working area have been clearly marked and when necessary appropriate safety notices have been displayed;
- the tank has been prepared for the work to be carried out, e.g. isolated, depressurised, vented and drained;
- the operational condition of adjacent facilities has been taken into account;
- the work allowed by the *work permit* does not conflict with that allowed by any other existing permit;
- where necessary sewers, surface water drains, ducts and gutters have been sealed to prevent the escape of *flammable* vapours.

D.2 The *work permits* should specify:

- the period of validity;
- the type of work for which it has been issued, e.g. *Cold Work*, Entry, Excavation, Gas-freeing, etc.;
- the tank upon which work is to be carried out;
- the location at which the work is to be carried out;
- the work to be carried out;
- the tools and equipment (including electrical equipment) which may be used in carrying out the work, noting any constraints to be observed in using the tools or in positioning and operating the equipment;
- the extent and timing of any gas testing to be carried out, i.e. periodic or continuous combustible gas detection, testing for any toxic gases which may be present or testing for oxygen excess or deficiency (see also D.11);
- the name of the *competent person* responsible for carrying out the gas tests;
- how the item or equipment has been positively isolated, both mechanically and electrically;
- the protective clothing (including respiratory protection) if any, which should be worn;
- the safety equipment, if any, to be used, or to be available at the work site;
- if a safety observer is to be present at any time during the work;
- any fire-fighting equipment to be available at the work site;
- if a member, or members, of the site fire-fighting service is required to be present at the work site at any time during the work;
- a log of personnel entry/exit times to be maintained at the controlled point of entry to the tank;
- the name of the standby person nominated to control entry to the tank;
- the name and position of the authority responsible for signing the permit;
- the name and position of the person who will be responsible for supervising the work.

Note: The permit should not be extended to cover work beyond its original scope without proper assessment of the risks of the additional work and its interaction with other work activities and permits.

D.3 When the permit is issued the *Issuing Authority* should ensure that.

- a copy of the *work permit* is retained;
- a copy of the *work permit* is issued to the person responsible for supervising the work, that the person has signed the permit and that he/she understands what may and may not be done in carrying out the work;

D.4 After receiving the permit the person responsible for supervising the work should ensure that:

- the permit has been signed by the *Issuing Authority*;
- everyone involved receives sufficient instruction on the work which is to be carried out and upon the constraints imposed by the permit;
- the copy of the permit which the supervisor receives is available at the work site whilst work is in progress;
- the *Issuing Authority* is informed as soon as the work is completed, and the *work permit* returned for cancellation;

D.5 Whilst the work is in progress the *Issuing Authority* should ensure that:

The work site is visited at appropriate intervals throughout the period that work is in progress. This should ensure that all of the requirements and constraints imposed by the permit are being observed, that only the work authorised by the permit is being carried out and that the operational conditions at the work site have not changed. The *Issuing Authority* should also ensure that those responsible for operations in the area are fully aware of all work being conducted under permit.

D.6 Suspending a Permit

If a task cannot be completed in one day or the work is interrupted for long periods, it is essential that the permit to work system incorporates a procedure to ensure that the equipment being worked on and the area of operations are retained in a safe condition and no attempt is made to use either the equipment or enter the area of work without approved supervision, permits and approval.

The key procedural steps to achieve this are:

- at the end of the shift when the work is to be suspended, the Person Responsible should, after inspecting the site, sign the permit to the effect that the work is suspended and return it to the *issuing authority*;
- the *Issuing Authority*, or one of his/her delegated operators, should inspect the site to check that the conditions are such that the work may be safely suspended and should then sign the permit accordingly;
- the permit, together with other suspended permits, should be located in a prominent position in the control room or permit office, clearly labelled as 'suspended' in order to ensure that those responsible for operations in the area are fully aware of equipment and permit status;
- to ensure that equipment on which work is suspended is not used, the permit to work system should be supported by a secure method of isolation. The security of such isolation provides against inadvertent or unauthorised de-isolation, i.e. valves etc. once locked off, cannot be accidentally or inadvertently opened;
- prior to reissuing the permit or continuation permit, the *issuing authority* should ensure that the site is inspected again to make certain all required isolations are in place and that the area operating conditions have not adversely changed.

D.7 Cross-Referencing of Permits

- Jobs which involve the interaction of separate teams of people, particularly in relation to the isolation of equipment and common work areas, the permits for those jobs should be cross-referenced one to the other to ensure that no interaction takes place which might threaten the safety of the personnel or the

installation.

- The responsibility for recognising the potential for interaction, rests with the issuing *authority* who should be supported by a good communication system on a daily basis to ensure that planned critical activities are made known to all affected personnel in addition to cross-referencing the permit forms, physical isolation of equipment or work areas should be employed.

D.8 Handover of Permits

Adequate arrangements should be in place for handover between issuing authorities at shift change and those should include specifically:

- effective means of communicating the status of an active and suspended permit;
- sufficient time is available to achieve an effective handover;
- outgoing and incoming issuing authorities should review each permit together. No handover should rely on memory alone or be solely verbal.

D.9 When informed that the work has been completed the *Issuing Authority* should ensure that:

- the work site is visited to confirm that the work has been completed satisfactorily, the site has been cleared, all tools, equipment and maintenance materials have been removed, and that all personnel have been accounted for;
- the work site is in a suitable condition for handing over safely to those who will be responsible for its recommissioning and that any remaining, abnormal hazards are identified;
- all copies of the *work permit* are returned and cancelled.

D.10 Training

Permit-to-Work systems are only as good as the care and competence of the people who operate them. It is therefore essential that:

- all persons who are required to operate the procedures and the personnel who work under permits are adequately trained;
- formal acceptance of Issuing Authorities and other authorities should take place prior to their appointment. Records of all permit to work training should be maintained.

D.11 Auditing of permit to work procedure:

- a permit-to-work system should include auditing of procedures in practice;
- the frequency of audits is determined on the basis of size of the installation, the number of permits in use at any one time and the extent of discrepancies from the laid down system found on previous audits;
- if persistent faults are discovered, the frequency of audit should be increased until the situation is satisfactory again.

D.12 Gas Test Certificates

The authorisation of entry into a confined space such as a tank or vessel, or of *hot work* involving a *source of ignition*, are examples requiring a check for *gas-free* conditions to be made. For this purpose the *work permit* will indicate the necessity for gas test certificates to be issued. Such a gas test certificate may be an integral part of the *work permit* form or may be a separate document.

It should be kept in mind that a *gas-free* test result is indicative of conditions only at the actual time of testing. Repeat gas test checks are often stipulated under the conditions of issue of a *work permit*.

Gas testing should only be permitted to be carried out by authorised persons who have received training in the use and care of gas detectors and who are knowledgeable as to their limitations. (See also HSE Guidance Note CS1, 'Industrial use of *flammable* gas detectors'.)

Annex E

TYPICAL CONTENTS OF WORK PROGRAMME

E.1 Method Statement

Work programmes should be supported by a detailed *method statement* that describes the work activities to be carried out, who is responsible for them, which services are required, *work permit* requirements etc. Activities that involve risk should be subjected to a *risk assessment*, the results of which should be reflected in the safety and environmental precautions contained in the *method statement*. The range of content of the work programme will depend on the type of work undertaken, the equipment being worked on and the area in which the work is taking place. In the case of a contractor undertaking specialist work such as tank cleaning, the contractor will usually be responsible for preparing the Method Statement in conjunction with the site owner's designated employee. The document should be agreed by all parties involved before work commences and may form an attachment to the *Work Permit*.

E.2 Subjects which may be included:

- A site plan, specifying the exact location of the tank, its identification, the boundary limits of the working area and designated access routes.
- A clear description of the responsibilities of each party involved, including both company and contractor personnel, with telephone numbers, office location, etc., as appropriate.
- A detailed description of the tank decommissioning procedures.
- A specific list of all items of mechanical and electrical isolation.
- A detailed description of the cleaning process envisaged and the safety and environmental protection procedures to be followed.
- Any special points resulting from the pre-cleaning inspections and studies.
- Handling and disposal requirements of tank sludge, sediments and any other contaminated materials and equipment.
- A list of the *work permits* that will be required throughout the work sequence.
- A time schedule taking into account the interaction of various activities.
- A list of all equipment and services required throughout the process for cleaning and support (the latter including lighting, ventilation, tool air and electricity, etc.) together with their capacities, and applicable safety standards.
- A separate list of all safety equipment required, together with quantities, capacities and testing and cleaning requirements.

E.3 Checklist

It is recommended that a checklist be established, having a fixed format, to be used for daily checks and spot checks throughout the cleaning period. The checklist should cover the following items as applicable:

- Operations involving neighbouring tanks in the same compound as, or in the vicinity of, the tank being cleaned.
- Maintenance and construction activities in the vicinity of the tank.
- Wind direction and equipment siting.
- Weather forecasts as regards heavy rain and electrical storms.
- Results of gas testing for both *flammable* and toxic gases in and around the tank.
- Check that roof drain valve of floating roof is open, drain is clean and there is no excessive accumulation of water on the roof.

- Inspection of operability of tank farm drainage and sewers.
- Pollution and cleanliness around the tank, including sludge disposal.
- Cleanliness of special clothing used, site lavatory, washing and eating facilities as applicable.
- Validity of *work permits* and compliance with *work permit* conditions.
- Presence and good working order of fire fighting, safety and personal protection equipment, including *breathing apparatus* and lifelines.
- Confirmation of electrical and mechanical isolation.
- Inspection of *earthing* of tank.
- Condition of all equipment, including electrical equipment and leads, air hoses, etc., and compliance with 3.2.5.
- Adequate records being maintained of work progress and of personnel employed.
- Location of equipment, e.g. compressors, air supply inlets.

Annex F

COMBUSTIBLE GAS INDICATORS

F.1 GENERAL

The checking for *flammable gas* concentrations is essential before authorising *hot work* or entry into equipment which has previously contained *flammable* material. This is achieved by the use of *combustible gas indicators* which are portable, battery-operated, *intrinsically safe* instruments.

Most *combustible gas indicators* work on the catalysed combustion of a gas sample over an activated filament, usually platinum. The change in temperature due to combustion produces a change in filament resistance; this, in turn, causes an imbalance in the instrument's electrical circuit which is registered as a deflection of the meter pointer on the instrument scale as a direct percentage of the *lower flammable limit*.

A sample of the atmosphere to be tested is aspirated through the instrument, and a careful note taken of the deflection of the meter pointer on the scale. The mechanics of the method of use of a *combustible gas indicator* are relatively simple, but there are a number of situations in which the instrument can give a false reading, and a high degree of experience with interpretation is required for its proper and safe use.

F.2 FALSE READINGS

Combustible gas indicators may give false readings or the operator may misinterpret the readings when assessing the vapour concentration in a storage tank prior to entry for cleaning. The following points should be borne in mind:

- a) Readings on the instrument are not instantaneous; there is a time lag between aspirating the sample and a reading appearing on the instrument scale. The delay will depend to a degree on wind conditions in open air situations and on the length of the sample probe or tube. It is important that, with respect to sampling probes or tubes, the manufacturer's instructions are adhered to.
- b) Vapours such as hydrogen sulphide, tetraethyl lead (TEL), tetramethyl lead (TML) and silicones, can poison, totally or partially, the instrument's detection system (see also F.6). *Combustible gas indicators* are available which will respond accurately in hydrocarbon atmospheres containing TML or TEL vapours.
- c) The instrument may give erroneously low readings in an oxygen-deficient atmosphere, in high humidity conditions and at ambient temperatures significantly different from that at which it has been calibrated. If oxygen deficiency is corrected by ventilation with air, further instrument readings will be necessary.
- d) In very high concentrations of *flammable* vapour, the meter needle may initially go to full scale but immediately return to zero. If the scale is not continually observed this movement will go unnoticed, thus giving rise to misinterpretation of the actual vapour concentration in the tank at the point of the test. This is usually caused by the limited air supply in the over-rich vapour phase. However, lack of response may be a result of poisoning of the filament or sensor. If the instrument will not re-calibrate, the component should be replaced and the instrument re-calibrated before further use.
- e) Where long sampling lines are found necessary to test tank atmospheres, artificially low results may be obtained owing to adsorption of the hydrocarbons on to the walls of the sampling tube (see F.7).
- f) High *flash point* products contained in the tank may give of *flammable* vapours when hot but these may condense in the instrument without being detected by the measuring circuit.

F.3 SAMPLES TAKEN FROM ABOVE FLAMMABLE LIQUIDS OR SOLID DEPOSITS

- a) Under normal ambient conditions, a gas test will not indicate the presence in equipment of combustible liquids such as kerosine and gas oil because they do not produce a *flammable* vapour concentration at such temperatures, i.e. the volatility of a liquid has to be sufficient to produce a vapour concentration at the test temperature before a reading on the indicator can be obtained.

This is important when authorising *hot work*, for example on a gas oil pipeline, since the instrument will not give a reading at room temperature. Subsequent *hot work* on the pipeline will vaporise any residual gas oil with the possibility of producing a *flammable* mixture.

Heat may also lead to the thermal cracking of heavier hydrocarbons, such as fuel oils and bitumen, with release of *flammable* gases.

- b) When testing equipment containing solid deposits, such as sludge or scale, the operator should be aware that gas is likely to be trapped beneath the surface. This gas will be released when the sludge or scale are disturbed, with the result that a *flammable* concentration of gas in air may form within the confined space unless an appropriate level of ventilation is provided. It is recommended that ventilation should be provided as a matter of course if large quantities of deposit are present that will be disturbed during cleaning work. Pre-testing before work commences may not cause the release and detection of gas, which would lead to a false sense of security.

F.4 DEFICIENCY OF OXYGEN

A test for oxygen should precede the test for any *flammable* gas sampled from within a confined space, pipeline etc. Various proprietary meters are available to measure oxygen content, many combined with *flammable* and toxic gas detection systems (i.e. dual or triple function meters).

Where an oxygen-deficient atmosphere is present, the reading for *flammable* gases will be extremely unreliable since the gas sample will contain insufficient oxygen for complete combustion. Special techniques are therefore required to determine *flammable* gases in an inert or oxygen-deficient gas mixture. Dilution tubes which enable an approximately controlled ratio of air to sample to be aspirated through the instrument can be used, but are not recommended as a precise measuring means. The technique can be useful for comparative purposes, for example throughout a purging procedure, where a combustible gas atmosphere is being diluted with an inert gas.

F.5 RICH GAS ATMOSPHERES

If a sample of gas at a concentration above its lower *flammable limit* is aspirated through a *combustible gas indicator*, the meter pointer will deflect rapidly to a full scale reading and may then fall back to zero or below. If this rapid deflection to the right is not noticed by the operator, the impression can be gained that *flammable* gas is not present. Continued aspiration of a rich gas concentration through the instrument will cause the filaments to burn out quickly, possibly in as little time as 10-20 seconds. It is therefore unwise to sample from rich gas streams which are above the *lower flammable limit*. A meter that has been or may have been exposed to a rich gas atmosphere should be immediately aspirated with clean air and then calibrated in accordance with the manufacturer's instructions.

F.6 CONTAMINATED ATMOSPHERES

- a) *Combustible gas indicators* will not function correctly if contaminants are aspirated into the instrument since these may block the inlet filter, flash-back arrestors, or flow orifice, poison or coat the detector filament or burn out the detector and compensating filaments.
- b) When sampling over liquids, care should be taken to avoid aspirating liquid into the instrument. Water, for example, will affect the inlet filter, and *flammable* liquids will burn out the filaments. A special solid-end probe and inlet line trap are available for preventing any liquid pickup reaching the instrument, but wherever possible the sampling probe should be positioned well away from liquid levels.

- c) Sampling of atmospheres which contain steam vapour should in general be avoided since erroneous results can be obtained and condensation inside the instrument will lead to failure. The test can be made, however, using an upstream trap to absorb the condensed steam; otherwise a suitable time delay should be allowed before attempting to take a gas test.
- d) Scale, rust, or any small solid particles should not be aspirated into the instrument since these will block components such as the sampling probe inlet filters, flash-back arrestors, or flow orifice. This effect will normally be noticed by the sluggish response to aspiration, and the instrument will then have to be stripped down and serviced. The avoidance of solid deposits is not always easy, for example in testing small bore pipework where the sampling probe diameter approaches that of the pipework. In practical terms, rodding through with a solid rod before inserting the sampling probe is the best approach.
- e) Some materials, if aspirated into the instrument, will poison the detector filament, and this will seriously impair the instrument response. Alkyl lead compounds, which are contained in *leaded gasoline*, will cause lead deposition on the normal detector filament resulting in a loss of response. Therefore, when *leaded gasoline* atmospheres have to be tested, either a special instrument with a high filament temperature is used, or the standard instrument can be fitted with an inhibitor filter. The latter alternative is not very effective. Other compounds of sodium, potassium, lead and halogenated hydrocarbons are among substances which will also cause poisoning of the filament.

Caution: Unstable materials, such as acetylene, for which the flashback arrestor may be inadequate, are capable of igniting a *flammable* concentration of the gas in air when aspirated into the meter.

F.7 SAMPLING LINES

Sampling lines are available made from selected materials, and these are designed for minimum adsorption on a range of gases. When sampling vapour with high solvent powers, e.g. xylenes, specialist materials with increased resistance to adsorption are required. The degree of accuracy of results should be considered in relation to the possible loss due to adsorption, which will vary with the gas being sampled, length of sample line, material and age, i.e. it may already be saturated.

When extended lengths of sampling line (standard length used is about 1.5 m) are used, the equipment manufacturer's manual should be consulted or the agent contacted for advice.

F.8 ACCURACY OF TEST CALIBRATION AND MAINTENANCE,

- a) *Combustible gas indicators* give a reasonably accurate result in terms of the *lower flammable limit* over a range of *flammable* gases. Since equal volumes of the *lower flammable limit* mixtures in air of many gases evolve similar quantities of heat of combustion, then they will have similar effects on the detector filament resistance. For exact readings the instrument should be calibrated on the gas to be tested, or a gas with the same physically relevant characteristics.
- b) *Combustible gas indicators* are not suitable for accurate quantitative analysis, except under carefully controlled laboratory conditions with calibration against the gas to be tested. They are most commonly employed as testing instruments for determining a 'go/ no-go' situation. They are also useful in making relative determinations, e.g. fall in gas concentration during purging.
- c) Instruments received from the manufacturers will be calibrated on one specific gas, for example n-pentane, which allows the use of the instrument to measure a wide range of normal petroleum derived combustion gases. Conversion curves, supplied by the manufacturer, can be used to determine the approximate concentrations of gases other than the calibration gas.
- d) Minimum response checks should be carried out on all instruments on at least a daily basis to ensure that the detector filament is satisfactory. This can be done by aspirating vapour from above a known volume of a combustible liquid, such as xylene, through the instrument, and comparing the reading obtained at the liquid temperature with the manufacturer's stated minimum response. The reading should normally be well above the minimum response.

This is a minimum response check only, and not a calibration check. Calibration checks can be done by passing a known gas concentration, say of pentane, through the instrument. In recent years, aerosol cans of methane-in-air, at known concentrations, have become available, and these can be used for a response check as well as giving a calibration. The aerosol can contents are at a concentration well below the *lower flammable limit* and therefore do not represent a hazard in themselves and checks can be done in plant areas, where a xylene check might not be allowable. The aerosol can system is also more convenient to use than liquid check methods.

It is recommended that minimum response checks should be carried out daily or at the start of each working period. Calibration should be done weekly or immediately after any known or suspected exposure to a *flammable* gas/air mixture (see F.5).

- e) Maintenance and electrical checking of instrument circuits and state of inlet filter and flame arrestors should be done monthly by a competent instrument mechanic. Batteries will probably require replacing at the same time.

F.9 CERTIFICATE OF TEST INSTRUMENT FOR INTRINSIC SAFETY

- a) The manufacturer will supply a copy of a certificate applicable to the instrument certifying that it is intrinsically safe, and this will give the groups of gases on which it can be used with safety. It is important that the instrument should not be used outside these groups; for example, an instrument not fitted with the correct type of flame arrestors would be hazardous if used on a highly *flammable* gas such as hydrogen. Guidance should therefore be obtained where gases outside the certified group are to be tested.
- b) If the gas detector is contained in an aluminium case, the outer slip-on plastics cover should not be removed in use, since the aluminium case on impact with rusty iron surfaces can produce an *incendive spark*. The plastics cover is an integral part of the certificate of approval.

F.10 TRAINING

- a) The techniques associated with gas testing appear relatively simple, but the limitation of use and problems of contamination should be known and allowed for. An important part of the training is the knowledge of where to test. The interpretation of results requires great care, and training is essential to assist the gas tester in developing expertise. Another critical aspect to be covered in training is liaison with the *issuing authority* of the *Work Permit*, who often requires a negative gas test result as part of the procedure to allow work to proceed safely.
- b) Monitoring of gas testers should continue on a regular basis, say every 6 months for occasional testers such as plant operators; regular gas testers who have had about 2 years' experience will possibly only require occasional spot checking to ensure that they are carrying out tests accurately.

F.11 ACCURACY OF INSTRUMENTS

- a) There are a considerable number of types of *combustible gas indicators* available on the market varying in accuracy and reliability. The degree of accuracy is not critical where the instruments are only being used for determining *flammable* gases in 'go/no-go' situations, such as authorising *hot work*. Where small quantities of *flammable* gases are being looked for primarily with regard to their toxic properties, then accuracy is of greater concern. In this case, toxic gas detectors are more suitable than *combustible gas indicators*.
- b) Every effort should be made through the instrument supplier to ensure that any acceptable errors in indication of gas concentrations fall on the safe side, i.e. that the instrument reads high.

F.12 INTERPRETATION OF RESULTS

Before authorising the entry of persons into, or the carrying out of work in, tanks or confined spaces or in other places where there is the possibility of a *hazardous atmosphere*, the gas concentration should be as specified in Table 6.1, page 28, for the conditions of entry or the type of work involved. Gas concentrations may vary with time. A single safe reading should not be assumed to indicate a safe atmosphere throughout the duration of the task. The atmosphere should be monitored regularly, preferably using personal gas monitors and/or fixed continuous gas monitors (see F.13). If the *combustible gas indicator* shows any increase in gas concentration above the figures specified, work should cease immediately and the persons should leave the tank or confined space until further gas-freeing has been carried out to bring the gas concentration to or below that specified.

F.13 PORTABLE GAS DETECTOR ALARMS

The atmosphere in the work area inside tanks and confined spaces should not be assumed to remain safe even if tested and found satisfactory before work commences. Gases may be released by, for example, disturbance of sludge or scale or by thermal cracking of deposits during *hot work*. Portable gas detector alarms for *flammable* gases may be used as a safeguard to detect and give a warning of the presence of gas. The detectors are normally operated by rechargeable batteries, giving several hours continuous use followed by a necessary recharge period. Gas does not have to be aspirated into these types of instruments, but enters by diffusion. The instrument's detector heads should be placed between the work being done and the most likely source of a gas leak. If the alarm sounds, work should cease and the immediate area be evacuated. These instruments, of which there are many types, can be set to give alarm conditions at a required safe percentage of the *lower flammable limit*, usually about 20 per cent.

The gas leak is indicated by:

- a) a deflection on the meter scale, then
- b) an audible alarm if the reading exceeds the preset percentage of the *lower flammable limit* and
- c) the display of a flashing light.

Annex G

EARTHING AND BONDING

Throughout the whole period of tank cleaning, the tank and all equipment involved should be adequately bonded in order to maintain everything at earth potential. The term 'earth potential' in the context of this document means the potential of objects in intimate contact with local ground. It does not imply the potential of the earth connection of the electrical grid, which may differ from that of local ground conditions. Non-electrical equipment should only be connected to grid earth if connection is approved by a competent electrical engineer. Improper connection may result in stray currents passing between the equipment and the electrical grid. These may give rise to incentive sparks on making or breaking contact and may have other, undesirable effects.

G.1 Among the items requiring earth *bonding*, using a proper *earthing* terminal, are the following:

- blowers and air eductors
- compressors
- pressure hoses, nozzles and couplings used for water or steam jet cleaning
- vacuum trucks, air pumps, hoses, nozzles and couplings
- air lines, etc.. used in conjunction with shot blasting
- ventilation lines.

G.2 To ensure an adequate earth bond to the tank shell and to minimise testing required on site the following provisions should be made

(see Annex H: IP Electrical Safety Code, BS 7671 or the latest edition of the Institute of Electrical Engineers Regulations):

- A designated earth bond connection point to be nominated for each tank.
- Earth *bonding* conductors of adequate mechanical strength to be used to bond equipment to this designated earth point. Where adequate *bonding* is inherent in the equipment, e.g. metallic braided hoses, a separate earth bond may not be deemed necessary.
- *Bonding* cable connections to be mechanically tight and provide a sound electrical connection.
- It is recommended that all connections be visually checked and tested for electrical continuity using an *intrinsically safe* instrument.

Annex H

PUBLICATIONS FOR REFERENCE

The following list includes all publications mentioned in the text and a number of others which may be useful to those responsible for the cleaning of oil storage tanks. Certain relevant UK regulations and HSE Guidance Notes are also listed. This Annex does not purport to list all publications or regulations pertinent to tank cleaning. It is the user's responsibility to observe all health, safety and environmental regulations that are in force where the tank is located and relevant to any aspect of the chosen tank cleaning procedure.

American Petroleum Institute (API)

- | | |
|----------|---|
| Std 2015 | Safe Entry and Cleaning of Petroleum Storage Tanks. |
| Std 2026 | Safe Descent Onto Floating Roofs of Tanks in Petroleum Service. |

Associated OCTEL Company Ltd

- | | |
|---|---|
| OIP No. 5
(superseding
Booklet 27/80) | Leaded gasoline tank cleaning and disposal of sludge. |
|---|---|

British Standards Institution (BSI)

- | | |
|---------|---|
| BS 4275 | Recommendations for the selection, use and maintenance of respiratory protective equipment. |
| BS 4667 | Part 3: Fresh air hose and compressed air line <i>breathing apparatus</i> . |
| BS 5345 | Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres.
Part 1: Basic requirements for all parts of the Code. |
| BS 5873 | Code of practice for access and working scaffolds and special scaffold structures in steel. |
| BS 5958 | Code of practice for the control of undesirable static electricity.
Part 1: General considerations.
Part 2: Recommendations for particular industrial situations. |
| BS 7671 | Requirements for electrical installations. IEE Wiring Regulations; Sixteenth edition. |

Engineering Equipment and Materials Users Association (EEMUA)

- | | |
|---------------|---|
| Publ. No. 107 | Recommendations for the protection of diesel engines operating in hazardous areas. |
| Publ. No. 154 | Guidance to owners on demolition of vertical, cylindrical, steel storage tanks. |
| Publ. No. 159 | Users Guide to the maintenance and inspection of above-ground vertical cylindrical steel storage tanks. |

Health and Safety Executive (HSE)

Guidance Notes and Other Publications:

CS 1	Industrial use of flammable gas detectors.
CS 15	The cleaning and gas freeing of tanks containing <i>flammable</i> residues.
EH 40	Occupational exposure limits (revised annually).
GS 5	Entry into confined spaces.
GS 29	Parts 1 to 4: Health and safety in demolition work.
(unnumbered)	Guidance on permit-to-work systems in the petroleum industry. (An Oil Industry Advisory Committee publication).
HS(G)	53Respiratory protective equipment: a practical guide for users.
HS(G) 61	Surveillance of people exposed to health risks at work
HS(G) 85	Electricity at work: safe working practices
COP 16	The protection of persons against ionising radiation arising from any work activity.
(unnumbered)	Radiation doses - assessment and recording. HSE information sheet, Ionising Radiation Protection Series No 2.
MS 23	Health aspects of job placement and rehabilitation: advice to employers
MS 24	Health surveillance of occupational skin diseases
MS 25	Medical aspects of occupational asthma
*	Approved Code of Practice: Safe Work in Confined Spaces

* Issued in 1996 as an Appendix in the HSC Consultative Document: *Proposals for replacement of the law on work in confined spaces.*

Regulations

196		
6	SI 94	Construction (working places) Regulations 1966.
198		
5	SI 1333	The Ionising Radiation's Regulations 1985.
198		
9	SI 1657	The Control of Substances Hazardous to Health Regulations (COSHH) 1989.
199		
2	SI 2051	The Management of Health and Safety at Work Regulations 1992
199		
2	SI 2932	Provision and Use of Work Equipment Regulations 1992
199		
2	SI 2966	Personal Protective Equipment at Work Regulations 1992
199-	SI *	The Confined Spaces Regulations 199-

* Issued by HSC as a Consultative Document, 1996

Institute of Petroleum

Model Code of Safe Practice in the Petroleum Industry

Part 1: Electrical Safety Code. Part 2:

Marketing Safety Code. Part 3: Refining Safety Code.

Part 15: Area Classification Code for Petroleum Installations. Part 18: Occupational Health

Other related IP publications..

Guidance on controls of organic lead in refineries and bulk storage and distribution of leaded gasoline's.

Guidance Notes on Refinery and Distribution Terminals Work Permit Systems.

Guidance on the Declassification of Tanks Previously in Leaded Gasoline Service.

Addresses for obtaining the above publications by post

American Petroleum Institute, Order Desk, 1220 L Street North West, Washington DC 20005, USA. Also available from BSI and from London Information Ltd, Index House, Ascot, Berkshire, SL5 7EU, England.

Associated OCTEL Company Ltd, 20 Berkeley Square, London, W1X 6DT, England.

British Standards Institution, Linford Wood, Milton Keynes, MK14 6LE, England.

Engineering Equipment and Materials Users Association, 14/15 Belgrave Square, London, SW1X 8PS, England.

Health and Safety Executive: publications available from HSE Books, PO Box 1999, Sudbury, Suffolk, CO10 6FS, England.

Institute of Petroleum: (a) Model Code parts from John Wiley and Sons Ltd, Distribution Centre Shripney Road, Bognor Regis, West Sussex, PO22 9SA, England; (b) Other IP publications from the Institute of Petroleum, 61 New Cavendish Street London, W1M 8AR, England.

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