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British Standard Code of practice for

Control of undesirable static electricity

Part 2. Recommendations for particular industrial situations

Code de bonne pratique pour le contrôle de l'électricité statique indésirable
Partie 2. Recommandations relatives aux situations industrielles particulières

Richtlinie für die Vermeidung unerwünschter statischer Elektrizität
Teil 2. Empfehlungen in Hinblick auf besondere Gegebenheiten in der Industrie

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Foreword

This Part of BS 5958 was prepared under the direction of the General Electrotechnical Engineering Standards Committee.

Static electricity occurs commonly in industry and in daily life, and can be a source of danger as well as of discomfort or inconvenience. The main hazard is that of explosions and fires initiated by electrostatic discharges, but shocks to personnel can also, on occasion, cause accidents. In addition, static electricity introduces operational problems during manufacturing and handling processes, for example by causing articles to adhere to each other or to attract dust. It is generated in many operations, including the flow of liquids or powders, the production of sprays and the contact and separation of solids, and therefore gives rise to problems in a wide range of industries.

The purpose of this code of practice is to provide recommendations for the control of static electricity. In some cases static electricity is an integral part of a process, e.g. paint spraying, but more often it is an unwelcome side effect and it is with the latter that this code is concerned.

It is very seldom that an electrostatic hazard occurs in isolation. Precautions against static electricity should therefore be consistent with those taken to avoid other hazards that may be present, such as ignitions due to other causes, and toxicity. It is important that all sources of risk in a system of work are considered and that a balanced basis of safety covering all risks be considered. In particular, care should be exercised in the provision of earthing systems where they may interfere with other protective systems (e.g. cathodic protection or intrinsically safe electrical equipment).

Although lightning is a form of static electricity, it is not intended that this code should be used to obtain guidance on the protection of structures against lightning. For this purpose reference should be made to CP 326.

The code is in two Parts.

Part 1 gives basic information on the generation of undesirable static electricity in solids, liquids and gases, and also on persons, and describes how the charges produced give rise to discharges which may cause ignitions or electric shocks. It gives the methods available for minimizing such generation and for safely dissipating the charges produced. It also deals with the principles of earthing and bonding as applied to avoid static electricity hazards. An appendix gives guidance on the means of measuring or estimating the parameters that need to be taken into account when deciding upon the action to be taken to control static electricity.

Part 2 provides simple recommendations for controlling static electricity in a variety of specific operations, the justification for which should be sought in Part 1. Static phenomena are encountered so widely that it is not possible to cover all cases and, if adequate guidance is not found in Part 2, Part 1 should be consulted. If there is still doubt, expert advice should be sought; research on the subject continues and new information is still being obtained.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

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Part 2. Recommendations for particular industrial situations

1. Scope

This Part of BS 5958 deals with static electricity problems which are encountered in particular situations during the handling of different types of materials including liquids, powders, gases, sprays, explosives and electro-explosive devices. In each case, the source and nature of the electrostatic hazards and/or nuisances are identified and specific recommendations are then given for dealing with them. The static electricity problems that can occur with personnel and their clothing are also described and the precautions are given for avoiding these problems.

NOTE. The titles of the publications referred to in this code are listed on the inside back cover.

2. Definitions

For the purposes of this Part of BS 5958, the definitions given in Part 1* apply.

3. Fixed metal tanks for the storage of liquids

3.1 General. Static electricity hazards can arise in various operations connected with fixed storage tanks for liquids, including filling, gauging and sampling. Charge on the liquid may be generated within the tank, due, for example, to splashing or free fall, and/or in the pipeline system feeding the tank. Charging may also be associated with personnel undertaking tasks on the tank, such as gauging or sampling, and with cleaning operations.

An ignition hazard is created when charge is retained in the liquid, on insulated conductors or on personnel in the presence of a flammable vapour/air mixture, mist or foam. To avoid these hazards the recommendations given in 3.2 to 3.8 inclusive should be followed.

3.2 Earthing

3.2.1 The tank and its associated pipework and fittings should all be in good electrical contact with each other and with earth, so that the resistance to earth is at all points less than 10 Ω . Electrical continuity checks should be made before the equipment is brought into use, and subsequently where maintenance or modification could affect electrical continuity (see clause 14 of Part 1).

3.2.2 New tanks or tanks that have been out of service for repairs should be inspected prior to the initial fill for any potential floating objects, such as cans, that could form insulated conductors. Such objects should be removed.

3.2.3 It should be ensured that personnel working on the tanks do not present an ignition risk (see 29.3.1).

3.3 Tank filling

3.3.1 Splash filling into a tank where a flammable atmosphere may exist should be avoided, in order to prevent the formation of a charged mist. This can be achieved either by bottom entry or by the use of a fill pipe reaching to the bottom of the tank without actually touching it.

3.3.2 For liquids with conductivity up to and including 50 pS/m the inlet should be designed to minimize turbulence and the agitation of any heavier immiscible liquid or sediment on the tank bottom.

3.3.3 Entrained air or other gas should be avoided in liquids with conductivities up to and including 50 pS/m if there is any possibility of immiscible liquid or sediment on the tank bottom.

3.3.4 For liquids with conductivity up to and including 50 pS/m the linear flow velocity in the pipe entering the tank should not exceed 1 m/s until the inlet has been covered and should be maintained at 1 m/s if a second immiscible phase is present; an example is water suspended in oil. A precise value for the safe maximum linear velocity in the absence of a second phase in large tanks has not been established. However, experience indicates that the limitations on flow rates imposed by the present designs of pipeline systems have been adequate to maintain safe operations. There is no evidence that flow velocities up to and including 7 m/s are hazardous. For storage tanks of the order of size of road/rail tanks the safe maximum linear velocity should be calculated by the procedure given in 7.3.3.

3.3.5 For liquids with conductivity greater than 50 pS/m the requirements of 3.3.2, 3.3.3 and 3.3.4 can be disregarded. An antistatic additive may be used to raise the conductivity of a low conductivity liquid above 50 pS/m, provided that it is compatible with the intended use of the liquid.

3.4 Filters. Fine particle filters installed in the pipeline system upstream of the tank can produce a significant amount of charge. It is recommended that the methods for dealing with the charge given in clause 16 are followed.

3.5 Gauging and sampling. The introduction into a tank of equipment for gauging and sampling may produce additional static electricity hazards. It is recommended that the procedures given in clause 6 are followed.

3.6 Tank cleaning. Tank cleaning operations may give rise to static electricity hazards. It is recommended that the procedures given in clause 14 are followed.

* Wherever reference is made in the text to 'Part 1', it refers to BS 5958 : Part 1 : 1980.

3.7 Floating roof tanks. When a liquid with conductivity up to and including 50 pS/m is pumped into a metal tank with a floating roof, precautions for earthing (see 3.2), filling (see 3.3), fine particle filters (see clause 16) and gauging and sampling (see clause 6) are applicable until the floating roof is buoyant. Thereafter, only the earthing, gauging and sampling precautions are necessary.

3.8 Floating blankets

3.8.1 Floating blankets in tanks used for storing liquids with conductivities up to and including 50 pS/m should be fabricated from metal, from non-conducting material entirely coated with antistatic material or from antistatic material. The blanket should be adequately earthed. Tanks with such blankets should be treated as if the blanket were a floating roof (see 3.7).

3.8.2 Conducting floating spheres or balls intended to suppress evaporation loss should not be used with liquids having a conductivity up to and including 50 pS/m. Non-conducting spheres should not be used with liquid at any conductivity level if there is any possibility of the presence of a flammable atmosphere.

4. Fixed non-metallic tanks for the storage of liquids, sited partially or wholly above ground

4.1 General. The charging processes and static electricity hazards associated with fixed metal storage tanks (see 3.1) are also encountered with non-metallic tanks. If tanks are made from high resistivity materials charge may also be generated and retained on the material itself by the liquid handling operations or by internal or external rubbing. This presents additional hazards, especially if there are insulated metal components, such as bolts, flanges and valves, or if the surface is contaminated with isolated areas of conductive material, such as water or grease.

As in metal tanks, an ignition hazard is created when charge is retained on the liquid, on insulated conductors or on personnel in the presence of a flammable vapour/air mixture, mist or foam. The risk of an internal discharge from the liquid surface, for example during gauging, is enhanced with tanks of high resistivity material because the dissipation of charge from the liquid is impeded and because the distribution of the field within the tank results in a greater field strength at the surface than in a metal tank. In addition, there is increased risk outside the tank if it is situated in a hazardous area, owing to the possibility of charge on the tank itself, even when a non-flammable liquid is being handled.

Recommendations for avoiding electrostatic hazards are given in 4.2, 4.3 and 4.4. They should be considered in conjunction with measures to deal with risks from other sources, for example the general fire risk associated with the storage of large quantities of flammable liquids in non-metallic containers and mechanical strength limitations on larger containers.

4.2 Tanks made of high resistivity materials

4.2.1 The use of large storage tanks completely fabricated from high resistivity materials, such as synthetic polymers and glass reinforced plastics having a volume resistivity greater than $10^8 \Omega \cdot m$ and/or a surface resistivity greater than $10^{10} \Omega$ is not recommended. The exception is when it can be shown that the liquid handling operations do not produce dangerous levels of static electricity and that no charge generating processes exist outside the tank.

Specialist advice should be sought before installing tanks of high resistivity materials.

4.2.2 If such a tank is installed, rubbing of its surface, for example in cleaning operations, should be avoided when a flammable atmosphere may be present.

4.3 Tanks made from conductive non-metallic materials. Storage tanks made from conductive non-metallic materials (see 11.3.2 of Part 1) present no electrostatic hazards additional to those existing for metal tanks, provided that they are earthed and the precautions for metal tanks are fully implemented (see clause 3). Such tanks should be permanently marked as 'Antistatic material' or 'Conducting material'.

4.4 High resistivity tanks incorporating conducting elements

4.4.1 Electrostatic hazards in the use of tanks made from high resistivity materials can be minimized by the incorporation, on or just below the surface throughout the material, of a permanent robust conducting element, for example a metal grid, connected to earth (see 11.3.6 of Part 1). Such tanks are supplied by specialist manufacturers who will usually advise on their suitability for specific applications.

4.4.2 The recommendations for metal storage tanks in 3.2 to 3.6 inclusive apply also to tanks incorporating conducting elements. To facilitate the earthing of personnel walking on a tank, a conducting walkway should be provided.

4.4.3 The liquid in the tank should be in direct contact with earth. If the conducting element covers the inner surface of the tank this provides the necessary earth connection. If the conducting element is not in contact with the liquid an earthed metal plate should be provided in the base of the tank with an area given by:

$$A = 0.04 \sqrt{v}$$

where

A is the area of the metal plate (in m^2);

v is the volume of the tank (in m^3).

Experiments have demonstrated that this relationship is satisfactory for tanks with capacities up to and including $5 m^3$ provided that the liquid is at no point more than 2 m from the earthed plate. For larger tanks, specialist advice should be sought but there appears to be no reason why the same relationship should not be valid.

4.4.4 Although rubbing may generate sufficient charge on the tank surface to give an incendive discharge, the probability that this will occur in normal practice is low. Nevertheless, vigorous rubbing of the surface, for example in cleaning operations, should be avoided when a flammable atmosphere may be present.

5. Fixed non-metallic tanks for the storage of liquids, sited completely below ground

5.1 General. Tanks fabricated from non-metallic materials which are partly or completely above ground are considered in clause 4. The major differences when the tank is buried are in respect of tanks of high resistivity materials having a volume resistivity greater than $10^8 \Omega \cdot m$ and/or a surface resistivity greater than $10^{10} \Omega$. When buried, such tanks cannot be charged by external movement or rubbing. Also, the proximity of the earth all around the tank increases the

electrical capacitance of its contents and therefore increases the amount of charge required to produce the break-down field strength inside the tank. The liquid may, however, still be insulated from earth and the possibility of an incendive discharge from its surface cannot be wholly excluded.

Recommendations for avoiding electrostatic hazards are given in 5.2 and 5.3. They should be considered in conjunction with measures to deal with risks from other sources, for example the general fire risk associated with the storage of large quantities of flammable liquids in non-metallic containers and mechanical strength limitations on larger containers.

5.2 Tanks made of high resistivity materials

5.2.1 Large storage tanks made entirely of high resistivity materials and sited below ground should be individually designed for each specific application. Such tanks are normally supplied by specialist manufacturers and the necessary risk assessment is usually carried out in consultation with the supplier. The degree of safety derived from the presence of earth around the tank depends on the maximum charge that can be produced and on the thickness of the tank wall. To confirm the safety of the installation it is necessary to show that the maximum charge produced in filling the tank does not produce a field strength at which a discharge can occur.

5.2.2 The whole of the outer surface of the tank, including the roof, should be in contact with the earth.

5.2.3 The liquid in the tank should be in direct contact with earth by means of an earthed metal plate in the base of the tank with an area given by:

$$A = 0.04 v$$

where

A is the area of the metal plate (in m^2);

v is the volume of the tank (in m^3).

This relationship is satisfactory for tanks with capacities up to $5 m^3$, provided that the liquid is at no point more than 2 m from the earthed plate.

For larger tanks specialist advice should be sought.

5.2.4 Provided that the design of the tank is in accordance with 5.2.1, 5.2.2 and 5.2.3, the recommendations for metal storage tanks in 3.2 to 3.6 inclusive apply, except that the tank itself cannot be earthed.

5.3 Tanks made of conductive non-metallic materials.

Buried storage tanks made from conductive non-metallic materials (see 11.3.2 of Part 1) present no electrostatic hazards additional to those existing for metal tanks, provided that they are earthed and the precautions for metal tanks are fully implemented (see clause 3). Such tanks should be permanently marked as 'Antistatic material' or 'Conducting material'.

6. Gauging and sampling of tanks

6.1 General. There are static electricity hazards in the gauging and sampling of storage tanks and tanker cargo tanks. Electrostatic charge may be present on the liquid in the tank, either because it is being pumped or because it is being subjected to agitation, for example in a mixing operation (see clause 10). Charge may also be generated on the gauging or sampling equipment or on the personnel using the equipment.

An ignition hazard is created if such charges are generated in the presence of a flammable vapour/air mixture, mist or

foam. An incendive discharge may occur between the liquid and the gauging or sampling equipment as they approach each other, or between the equipment, or the personnel handling it, and the rim of the manhole or dip hatch through which the operation is taking place. To avoid these hazards the recommendations in 6.2, 6.3 and 6.4 should be followed.

6.2 Materials of construction, earthing and bonding

6.2.1 All metallic parts of gauging or sampling equipment should be connected to the tank, or if the tank is constructed of high resistivity material, directly to earth. For this purpose the connections may be metallic, giving a resistance to earth at all points less than 10Ω , or they may be of higher resistivity material, provided that the resistance to earth is low enough to relax any charge on the metal components (see clause 14 of Part 1). Thus the tape or cord may be of metal or of a natural fibre such as sisal or manila. A metal chain should not be used.

6.2.2 A high resistivity (synthetic polymer) cord or dip stick is not acceptable, unless it can be shown that a hazardous level of charge will not be generated. However, it is considered that small sampling containers of high resistivity materials are on balance safer than similar metal containers (see 12.5).

6.2.3 Gauging and sampling equipment may be constructed entirely of natural or other materials, such as wood or natural fibres, the resistivities of which are such that they are unlikely to accumulate electrostatic charges or to give rise to discharges. Such equipment should be earthed.

6.2.4 Ensure that personnel engaged in gauging or sampling operations do not present an ignition risk (see 29.3.1). The problems this may present on board ships have been mentioned in 13.2.4.

6.3 Precautions with systems containing conductive components

6.3.1 Gauging and sampling should not be carried out while any charge generating operation is going on in a tank containing a flammable vapour/air mixture, mist or foam. These operations include the pumping into a tank of liquids with conductivities up to and including 50 pS/m and many cleaning procedures.

6.3.2 If a liquid with conductivity up to and including 50 pS/m and containing a separate water phase has been pumped into a tank or has been involved in a mixing operation in a tank, the tank should not be gauged or sampled until at least 30 min has elapsed after completion of the operation, unless it can be shown that charge relaxation is complete in a shorter period.

6.3.3 If a liquid with conductivity up to and including 50 pS/m but without a separate water phase has been pumped into a tank, the tank should not be gauged or sampled immediately after the cessation of the operation. A period of, say, 10 min should be allowed to elapse before gauging or sampling.

6.3.4 After a mixing operation involving a liquid with conductivity up to and including 50 pS/m, gauging or sampling should not take place while there is any settling of the components of the mixture.

6.3.5 If the liquid, or liquids, being pumped or mixed all have conductivities greater than 50 pS/m, gauging and sampling can take place at any time.

6.3.6 After a cleaning operation, gauging and sampling should be delayed until any charged mist generated has settled. This may take several hours.

6.3.7 The recommendations in **6.3.1** to **6.3.6** inclusive need not be followed with fixed gauging equipment, or if the gauging takes place in a fixed, earthed dip pipe extending to the bottom of the tank.

6.4 Precautions in adverse weather conditions. Gauging and sampling of flammable liquids should not be undertaken during thunderstorms, snowstorms or hailstorms or where there is reason to believe that disturbed atmospheric electrical conditions could occur.

7. Metal road/rail tanks for liquids

7.1 General. Various liquid handling operations associated with road/rail vehicles can give rise to ignition risks due to static electricity. Examples are loading, gauging and sampling. Charge on the liquid may be generated within the vehicle tank and/or in the pipeline system feeding the tank. Charging may also be associated with personnel undertaking tasks on the tank, such as gauging or sampling, or with cleaning operations. Charging arising in the equipment when transferring liquid to or from the vehicle is considered in clause 9.

An ignition hazard is created when charge is retained in the liquid, on insulated conductors or on personnel in the presence of a flammable vapour/air mixture, mist or foam. The flammable atmosphere in the tank may be due to the liquid currently being handled or to liquid carried in a previous load (switch loading operations). To avoid these hazards the recommendations given in **7.2** to **7.6** inclusive should be followed.

7.2 Earthing

7.2.1 The tank and its associated metal pipework and fittings should all be in good electrical contact with each other and with the main metal structure of the vehicle. During loading, the vehicle should be earthed directly or connected to the earthed loading gantry so that the resistance to earth is at all points less than $10\ \Omega$. Electrical continuity checks should be made on the vehicle before it is brought into use, and subsequently where maintenance or modification could affect electrical continuity (see clause 14 of Part 1).

7.2.2 The tanks or compartments of new vehicles or of vehicles that have been out of service for repairs should be inspected, prior to the initial loading, for any potential floating objects, such as cans, which could form insulated conductors. Such objects should be removed.

7.2.3 It should be ensured that personnel working on the vehicles do not present an ignition risk (see **29.3.1**).

7.3 Loading

7.3.1 Splash filling into a tank where a flammable atmosphere may exist should be avoided, in order to prevent the formation of a charged mist. This can be achieved either by bottom entry or, if top loading is used, by the use of a fill pipe reaching to the bottom of the tank. Where filling is carried out through an open manhole or filling hatch not provided with an internal fill pipe, the hose or loading arm nozzle should be inserted to the bottom of the tank without actually touching it.

7.3.2 Entrained air or other gas should be avoided in liquids with conductivities up to and including $50\ \text{pS/m}$ if there is any possibility of immiscible liquid or sediment on the tank bottom.

7.3.3 For liquids with conductivities up to and including $50\ \text{pS/m}$, the linear flow velocity in a pipe used for top

loading should not exceed $1\ \text{m/s}$ if a second immiscible phase is present; an example is water suspended in oil.

In the absence of a second phase, charge generation increases with increasing flow velocity. The maximum linear flow velocity for top loading may be expressed in terms of a velocity, u , of the liquid flowing in a pipe section of diameter d . The velocity u is the lower of those given by the expressions:

$$u = 7$$

$$ud = N$$

where u is in m/s , d is in m and N is in m^2/s .

These expressions should be applied to the smallest diameter pipe section upstream of the tank or compartment being filled, except when the length of the section is less than $10\ \text{m}$ and it is only one pipe size smaller than the next larger diameter pipe (i.e. its diameter is not less than 67 % of that of the larger). If both these conditions are satisfied the velocity u should be derived for the next larger size pipe.

N is a constant with a value of $0.5\ \text{m}^2/\text{s}$ for liquid conductivities above $5\ \text{pS/m}$. The value of N which should be applied for liquid conductivities up to and including $5\ \text{pS/m}$ is a matter for debate; values of $0.38\ \text{m}^2/\text{s}$ and $0.5\ \text{m}^2/\text{s}$ have been accepted, there being only a very small degree of risk with either level. In the United Kingdom $0.5\ \text{m}^2/\text{s}$ is used.

If the length of the tank or compartment into which the single phase liquid is flowing is less than $2\ \text{m}$ the velocity u in the pipe section to which it applies determines the maximum flow rate in the system. If the tank or compartment length, L , is between $2\ \text{m}$ and $4.5\ \text{m}$ the limiting velocity, u , may be increased by a factor $\sqrt{L/2}$, while if the length L is greater than $4.5\ \text{m}$ the limiting velocity should be $1.5u$, provided that the maximum of $7\ \text{m/s}$ is not exceeded.

Bottom loading generates higher potentials at the liquid surface than top loading because of the absence of the earthed fill pipe. Therefore, unless an equivalent earthed fitting, such as a dip tube, standpipe or baffle plate, is mounted centrally in the tank, reaching from top to bottom, it is recommended that the flow rates for bottom loading should be 25 % below those for top loading, calculated as above.

The flow rate established by the above procedure may be exceeded for a particular system and liquids if many years of experience with that system and liquids has demonstrated that it is safe to do so.

7.3.4 For liquids with conductivity greater than $50\ \text{pS/m}$ the requirements of **7.3.2** and **7.3.3** can be disregarded. An antistatic additive may be used to raise the conductivity of a low conductivity liquid above $50\ \text{pS/m}$, provided that it is compatible with the intended use of the liquid.

7.4 Filters. Fine particle filters installed in the pipeline system upstream of the vehicle can produce a significant amount of charge. It is recommended that the methods for dealing with the charge given in clause 16 are followed.

7.5 Gauging and sampling. The introduction of equipment into a tank for gauging and sampling may produce additional static electricity hazards. It is recommended that the procedures given in clause 6 are followed.

7.6 Tank cleaning with high pressure water jets or steam. These cleaning operations may give rise to static electricity hazards. It is recommended that the procedures given in clause 14 are followed.

8. Non-metallic road/rail tanks for liquids

8.1 General. The charging processes and static electricity hazards associated with metal road/rail tanks (see 7.1) are also encountered with non-metallic road/rail tanks. If tanks are made from high resistivity materials charge may also be generated and retained on the material itself by liquid handling operations or by internal or external rubbing. This presents additional hazards especially if there are insulated metal components, such as bolts, flanges or valves, or if the surface is contaminated with isolated areas of conductive material, such as water or grease.

As with metal tanks an ignition hazard is created when charge is retained on the liquid, on insulated conductors or on personnel in the presence of a flammable vapour/air mixture, mist or foam. The risk of an internal discharge from the liquid surface, for example during dipping, is enhanced with high resistivity tanks both because the dissipation of charge from the liquid is impeded and because there is a greater field strength at the liquid surface. There is increased risk external to the tank if it is situated in a hazardous area, or is moved into such an area, owing to the possibility of charge on the tank itself, even when a non-flammable liquid is being handled. Also, personnel working on the tank may be insulated from earth.

Recommendations for avoiding electrostatic hazards are given in 8.2, 8.3 and 8.4. They should be considered in conjunction with measures to deal with risks from other sources, for example the general fire risk associated with the carriage of large quantities of flammable liquids in non-metallic containers and mechanical strength limitations on larger containers. In applying these recommendations it will be necessary to bear in mind relevant national and international transport regulations.

8.2 Tanks made of high resistivity materials

8.2.1 The carriage of flammable liquids is not recommended in road/rail tanks completely fabricated from high resistivity materials, such as synthetic polymers and glass reinforced plastics, having a volume resistivity greater than $10^8 \Omega\cdot\text{m}$ and/or a surface resistivity greater than $10^{10} \Omega$.

8.2.2 Such tanks can be used for the carriage of non-flammable liquids, provided that the vehicle is not in, or does not move into, an area where there may be a flammable atmosphere.

8.3 Tanks made from conductive non-metallic materials

Road/rail tanks made from conductive non-metallic materials (see 11.3.2 of Part 1) present no electrostatic hazards additional to those existing for metal tanks, provided that they are earthed and the precautions for metal tanks are fully implemented (see clause 7). Such tanks should be permanently marked as 'Antistatic material' or 'Conducting material'.

8.4 High resistivity tanks incorporating conducting elements

8.4.1 Electrostatic hazards in the use of tanks made from high resistivity materials can be minimized by the incorporation, on or just below the surface throughout the material, of a permanent robust conducting element, for example a metal grid, connected to earth (see 11.3.6 of Part 1). Such tanks are supplied by specialist manufacturers who will usually advise on their suitability for specific applications.

8.4.2 The recommendations for metal road/rail tanks in 7.2 to 7.6 inclusive apply also to tanks incorporating

conducting elements. To facilitate the earthing of personnel working on a tank a conducting walkway should be provided.

8.4.3 The liquid in the tank should be in direct contact with earth. If the conducting element is not in contact with the liquid an earthed metal plate should be provided in the base of the tank, as recommended in 4.4.3.

8.4.4 Although rubbing may generate sufficient charge on the tank surface to give an incendive discharge, the probability that this will occur in normal practice is low. Nevertheless, vigorous rubbing of the surface, for example in cleaning operations, should be avoided when a flammable atmosphere may be present.

9. Transfer of liquids to and from road/rail vehicles

9.1 General. Transfers between installations and road/rail vehicles are frequently carried out by means of fixed standpipes and/or flexible hoses and the operations can give rise to static electricity hazards. Additional ignition risks may be encountered when hose connections are made or broken, due to sparking from stray currents flowing in the hose string. Where these can occur reference should be made to appropriate industry codes of practice*.

Three types of hoses are available, as follows (see BS 1435, 3158, 4089 and 5842).

(a) *Conductive hose.* This is made of material of high electrical resistivity with an embedded reinforcing wire and/or enshrining wire braid or armouring incorporated during manufacture. These conducting components are bonded to the metal fittings permanently attached to the ends of the hose, so that when several lengths are coupled together there is a continuous low resistance electrical path along the entire run of the hose.

(b) *Semi-conductive hose.* Part of the material of which this hose is made, usually its outer layer, has a conductivity high enough to disperse static electricity but low enough to restrict stray currents to safe limits, and this layer is in contact with the end fittings. The hose may have a metal reinforcing wire and/or enshrining braid or armouring, but this is not in contact with the end fittings.

(c) *Non-conductive hose.* This is made of material of high electrical resistivity without incorporated conducting wire or braid, and is incapable of dispersing static electricity.

The recommendations given in 9.2 to 9.5 inclusive are intended to guard against external electrostatic sparks when transferring flammable liquids, including loading into a road or rail tank with a flammable atmosphere due to a previous load (switch loading operations). Charging on the liquid, giving rise to hazards within such tanks, is dealt with in clauses 7 and 8.

9.2 Earthing: the installation

9.2.1 All metal parts of the installation should be in good electrical contact with each other and with earth, so that the resistance to earth is at all points less than 10Ω . Electrical continuity checks should be made before the equipment is brought into use, and subsequently where maintenance or modification could affect continuity (see clause 14 of Part 1). Swivel joints in standpipes and metal loading arms should be electrically continuous.

* e.g. Institute of Petroleum. *Model Code of Safe Practice, Electrical*, Part 1, 1965.

BS 5958 : Part 2 : 1983

9.2.2 Whenever there is a possibility of a flammable atmosphere within or outside the vehicle tank, conductive or semi-conductive hose should be used. Non-conductive hose may itself become charged and if two or more such hoses are joined by metallic flanges these flanges may be capable of producing incendive sparks unless each is provided with a bonding cable to earth.

9.2.3 The resistance between the flanges of each length of conductive or semi-conductive hose should be checked with sufficient frequency to ensure that its conductive properties are being maintained.

9.2.4 It should be ensured that personnel working on the installation do not present an ignition risk (see 29.3.1).

9.3 Earthing: road tankers

9.3.1 Before the loading of such a vehicle is commenced, before any pipe connections are made and before any man lids are opened, its tank should be bonded to the appropriate earth point and the bond should remain in position throughout the operation. Automatic monitors are available to check the effectiveness of the earthing system.

9.3.2 In general, when a delivery is made from a road tanker to a storage tank, for example at a petroleum spirit filling station, the hose couplings to both the vehicle and the receiving tank will ensure adequate electrical continuity and earthing provided that this continuity is regularly monitored.

9.3.3 Liquefied petroleum gas road tankers, however, should be earthed during both loading and discharging by being bonded to a suitable earth point. The bond should remain in position until the operation has been completed.

9.4 Earthing: rail tankers

9.4.1 Both rails of railway tracks where loading or unloading takes place should be bonded permanently to each other and to the earthed gantry or pipeline. The railcar itself is earthed by contact between its wheels and the rails. A separate flexible bonding cable between the tank and the pipeline is therefore not required unless doubt exists concerning the electrical continuity between the tank and the running gear. If a bonding cable is used, the recommendations given in 9.3.3 should be followed. If a railcar detector system requiring a resistance between the rails is in use, the value of the resistance should not be of such a magnitude as to prevent the safe dissipation of charge.

9.4.2 If an insulating flange is installed in a loading line to prevent the passage of stray currents, the filling nozzle should be bonded to the railcar by a flexible cable to ensure that the hose assembly downstream of the insulating flange is earthed. This connection should be made before the operation commences and should remain in place until it is complete.

9.5 Fuelling of motor vehicles. External bonding of the vehicle to earth is not needed provided that the fuelling installation complies with the requirements of the Home Office Code*.

10. Liquid/liquid and solid/liquid blending and mixing

10.1 General. The mixing together of liquids or of liquids and solid particulate matter can give rise to static electricity

ignition risks. Charge may be generated when the mechanical energy of the mixing process is expended in systems containing one or more low conductivity liquids. It is then retained on the continuous liquid phase, on suspended liquid or solid particulate matter, or on any insulated metallic object. If a flammable vapour/air mixture, mist or foam is present there is an ignition hazard and to avoid this the recommendations in 10.2 to 10.5 inclusive should be followed.

10.2 Earthing

10.2.1 All metallic parts of the equipment should be connected together and earthed, so that the resistance to earth at all points is less than 10 Ω . If steam is used for inerting, the nozzle of the steam hose should be earthed by an independent bonding wire, rather than relying on the conductivity of the hose itself.

10.2.2 If a blending vessel has an internal insulating lining, relaxation of charge on the contents should be promoted by the provision of internal earthing, for example the mounting of earthed metal strips or plates on or near the bottom of the vessel. This precaution may not be necessary if the lining is thin enough to permit charge dissipation or to avoid a dangerous surface potential (see 11.2.4 of Part 1).

10.2.3 It should be ensured that personnel working in the vicinity of a blending vessel do not present an ignition risk (see 29.3.1).

10.3 In-line blending

10.3.1 In this method, mixing takes place within a pipe into which the various constituents are pumped at prescribed rates. There is therefore no vapour space in which a flammable mixture can occur, and hence no ignition risk where the mixing is taking place.

10.3.2 The recommendations in clauses 3, 4, 5, 7, 8 and 13 should be adopted, as appropriate, to avoid ignition hazards in the receiving tank arising from charge generated in the mixing operation or in subsequent flow to the tank.

10.4 Blending in vessels or tanks

10.4.1 The mixing of liquids to produce a single phase of low conductivity is not considered to be unduly dangerous, provided that the normal precautions appropriate to liquid handling operations are taken (clause 3).

10.4.2 If the resultant mixture contains dispersed liquid or solid particulate matter it is advisable to minimize the generation of static electricity by increasing the conductivities of low conductivity liquids in the system by means of antistatic additives, provided that they are compatible with the intended use of the mixture.

10.4.3 If the phases in a mixture are all liquids it is usually sufficient to raise the conductivity of the continuous phase above 50 pS/m.

10.4.4 If one or more of the dispersed phases is a solid the conductivity of the continuous phase may need to be much greater than 50 pS/m, and it may in addition be necessary to restrict the power input of the stirrer. As an example, in one operation a conductivity of 1000 pS/m was required with a power input limited to 0.37 kW/m³ of the suspension†. Each case should be considered on its merits, taking expert advice if necessary.

* Home Office. *Model Code of Principles of Construction and Licensing Conditions, Part 1. Petrol filling stations.* HMSO 1971.

† Vos, B., Douwes, C., Ramackers, L. and Van de Weerd, F.M. Electrostatic charging of suspensions during agitation. In: Buschman, C. (ed.) *Proceedings of the first international symposium on loss prevention and safety promotion in the process industries* (Arranged by the Royal Institute of Engineers in the Netherlands and the Royal Netherlands Chemical Society). published by Elsevier, paper No. 34, 1981.