MANUAL

FIRE HAZARDS AND FIREPROOFING/COLD SPLASH PROTECTION OF STEEL STRUCTURES

DEP 34.19.20.11-Gen.

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DESIGN AND ENGINEERING PRACTICE

USED BY

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The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use DEPs they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will expect them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal or its technical advisor.

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1) Operating companies having a Service Agreement with SIOP, SIEP, SIC or other Service Company. The use of DEPs by these Operating companies is subject in all respects to the terms and conditions of the relevant Service Agreement.

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NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

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1. INTRODUCTION

1.1 SCOPE

This manual provides guidance and requirements for fireproofing/cold splash protection of steel structures; it replaces Standard Specification G-8-1, dated July 1984.

It shall be used by engineers responsible for the assessment of fire hazards and the prescription of adequate fireproofing measures.

The guidance given in this manual is intended to ensure that the degree of fireproofing applied is effective and practical in terms of maintainability and reduction of risks. As there is a wide variation in the design of structures, the intent of this manual should be considered at all times when prescribing the fireproofing of structures not specifically mentioned in (3) and (4).

1.2 DISTRIBUTION, APPLICABILITY AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIPM, the distribution of this document is confined to companies forming part of or managed by the Royal Dutch/Shell Group, and to contractors nominated by them.

This manual is intended for use in Manufacturing Oil & Gas, Exploration & Production and Chemicals Manufacturing. It applies to all steel supporting structures in process areas and processing plants as well as to storage facilities, jetties and pipe bridges (including those outside the battery limits) in land-based oil/gas/petrochemical installations. It is not intended to apply to offshore platforms or floating installations.

If national and/or local regulations exist in which some of the requirements are more stringent than this manual, the contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, economic and legal aspects. It should be noted, however, that national and/or local regulations for fire protection are generally intended for civil engineering structures erected in populated areas and may therefore be inappropriate for manufacturing plants where the fire loadings and risks are different. Where these regulations seem to be incompatible with this manual, the Principal shall be informed so that acceptance of this manual can be negotiated with the authorities concerned.

1.3 CROSS-REFERENCES

Where cross-references are made, the number of the section or sub-section referred to is shown in brackets. All documents referenced in this manual are listed in (7).

1.4 DEFINITIONS

For the purpose of this manual the following definitions shall hold:

1.4.1 General

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction and commissioning for the project. The Principal may sometimes undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction.The Principal will generally specify the technical requirements.The Principal may also include an agent or consultant, authorised to act for the Principal

Shall and **Should** - the word 'shall' is to be understood as mandatory and the word 'should' as strongly recommended to comply with the requirements of this manual.

1.4.2 Technical

Flammable products are those which are easily ignited.

A **toxic** material is one which has a capacity to produce injury if it reaches a susceptible site or sites on or within the body.

Note: The above definitions are extracted from the Institute of Petroleum document IP-3, third edition, "Refining Safety Code".

2. OBJECTIVES OF FIREPROOFING

2.1 GENERAL

Fireproofing is one of the available options to limit damage caused by fire. It offers protection against the adverse thermal effects of fire for a limited period and limited degree of exposure. It should not be considered as a replacement for active fire fighting or lead to relaxation of normal design requirements (spacing and layout considerations) and precautions in operation and maintenance.

The main objective of fireproofing/cold splash protection of steel structures is to prevent the escalation of fires to an unacceptable level by providing a temporary protection until full fire-fighting capabilities can be deployed.

A sudden collapse of supporting steel structures could result in injury to personnel or in the release of large quantities of flammable products and/or toxic materials, leading to effects which might even extend beyond the property limit.

Judicious application of fireproofing will delay an eventual collapse of steel structures and allow it to occur gradually and with visible signs. This allows time for isolation of the affected equipment and for operating and fire-fighting personnel to evacuate safely.

Refrigerated or cryogenic liquiefied gases exert an intense cooling effect when escaping to atmosphere, which may expose unprotected steelwork to severe embrittlement and fractural failure. Fireproofing offers an effective and well proven means of protection against such hazards.

2.2 FIRE HAZARDS

In the petrochemical industry, fire hazards stem predominantly from ignition of accidentally leaked hydrocarbon products. All points in a plant or installation where such leakages are likely to occur, can be identified as Potential Sources of Leakage (PSL's).

Examples of PSL's are:
- small bore connections to piping and equipment, including vents, drains and instrument tappings;
- flange connections in piping and at equipment;
- seals and swivels of rotary equipment;
- valves;
- expansion bellows.

Depending on the type of hydrocarbon product released and on the process and ambient conditions a leakage may spread as a liquid pool or be dispersed as either an aerosol liquid cloud or as a vapour cloud. In case of ignition either a pool fire or a torch fire will result and these will be sustained by the leak source until the stream feeding the leak can be stopped.

Liquid pools can be formed by all hydrocarbon products containing pentane (C5) and heavier components but also by butanes/butenes (C4) at sub-zero ambient temperature. Additionally, also propane (C3) and lighter refrigerated/cryogenic liquefied gases may form liquid pools in case of accidental release while they are handled at or near their atmospheric boiling points, say at a vapour pressure below 1 bar (g). In particular, this may be the case during a prolonged release when the vapourization rate caused by heat pick-up from the surroundings does not match the rate of release. For the above categories the possibility of pool fires has therefore to be taken into account.

Liquid pools will collect on impermeable floor surfaces either at grade or at elevated table top or other closed surface decks. Such surfaces which can sustain a pool fire are further referred to as Hazard Level (HL). The concept of Hazard Level (HL) and Potential Sources of Leakage (PSL's) are used to define the extent of the Fire Proofing Zones (FPZ's, see 3.3) resulting from pool fires.

Pressurized liquefied gases will not normally form liquid pools upon accidental release but disperse as an aerosol liquid jet or as a vapour jet. They are unlikely to give rise to pool fires. Likewise, vapour releases will by nature disperse as a jet. Ignition of an aerosol liquid jet or a vapour jet results in a torch fire which may cause impinging flames with high radiation intensities. The length and width of jet flames varies as a function of the pressure

upstream of the leak, the size and geometry of the hole and the wind speed.

Measures to protect supporting steel structures from torch fires are, in descending order of preference:

- A judicious location and orientation of PSL's relative to supporting steel structures in order to avoid impact of accidentally released product jets and in case of ignition, of the resultant jet flame on the structure.
- Application of fire shielding either near the PSL or near the surfaces to be protected to deflect the jet or jet flame and thus avoid impact.
- If neither of the above is possible or practical, application of fire proofing as specified in this manual. The extent of the relevant FPZ is defined relative to the PSL's in (2.3).

2.3 FIRE PROOFING ZONE

This manual uses the concept of Fire Proofing Zone (FPZ) to define where and to what extent fireproofing of steel structures shall be applied. An FPZ is defined as a zone where leakage of a flammable product can give rise to a fire of sufficient intensity and duration to cause failure of steel supporting structures in the zone. An FPZ shall only be applied to a plant or system with a maximum operating inventory of more than 5 tonnes of flammable products. In this context, a "system" is the smallest volume of piping and equipment (including vessels) that can be "blocked in" in the event of a fire.

The extent of the FPZ is defined as a function of the type of fire as follows:
For liquid pool fires: The FPZ is a volume with a cylindrical shape. The cylinder shall have a radius of 6 m from the PSL and a height of 9 m above HL (see Appendix 1).

For liquid or vapour torch fires: The FPZ is a volume with a spherical shape. The radius of the sphere shall be 3m measured from the PSL (see Appendix 2).

2.4 GENERAL APPLICATION CRITERIA

2.4.1 Fire protection

In general, fireproofing shall be applied to all steel supporting structures whose sudden failure would lead to danger for operating personnel, escalation of the incident or unacceptable environmental pollution. Only the steel structures located within the FPZ shall be fireproofed. For details, refer to (3).

Some structures supporting specific equipment (e.g. furnaces, spheres etc.) shall be fireproofed whether or not they are in an FPZ. For those structures, refer to (4).

The protection of certain equipment which must continue to operate during a fire, such as remote-operated emergency shut-off and depressurising valves and actuators or critical electrical and instrument cables, is outside the scope of this manual.

Stairways, walkways and platforms designed mainly for live loads and top surfaces of beams supporting floor plates, gratings or equipment are normally not fireproofed.

When resistance to mechanical damage is required at the lower end of a steel stanchion or support, the fireproofing shall be made of reinforced concrete, erected from grade level up to minimum 1.8 m height. At higher levels, alternative fireproofing materials may be used.

2.4.2 Cold splash protection

Cold splash protection shall be applied on steel members when there is a danger of embrittlement of the steel due to the cooling effect of product released from a PSL. If the steel structure is located in an FPZ the requirement for cold splash protection may already be covered by the required fireproofing. If "fireproofing" is applied for the sole purpose of cold splash protection it shall be limited to steel members which support equipment having a mass of more than 10 tonnes (including contents). In that case the "fireproofing" shall be applied within a radius of 3 m from the PSL and down to HL.

2.5 RESISTANCE AGAINST FIRE AND COLD SPLASH

2.5.1 Fire

The length of time during which a steel structure needs to maintain its integrity, depends on local circumstances such as type of plant, availability of fire-fighting services, and risk of escalation.

A minimum of 30 minutes protection time against a hydrocarbon type fire is required.

It is assumed that after this period, structures can be cooled by water or plant operating staff have been evacuated. In special cases where this is not likely to occur, increasing the fire resistance to a longer duration shall be considered. Where effective water cooling is not feasible (e.g. due to the configuration of the structure), the required duration of the fire resistance depends on the estimated time to burn-out or extinguishment.

The hydrocarbon fire is defined in UL 1709. This fire is more severe than the cellulose type of fire which is usually referred to in building regulations.

A 50 mm thick concrete cover meets the above hydrocarbon fire requirement. The fire rating of alternative materials can be established by tests or by calculations. For new materials, tests shall be performed, the results of which shall be at least as good as those of concrete.

2.5.2 Cold splash protection

The "fireproofing" should give a minimum protection of 10 minutes to the effects of cold splash. The fireproofing system should be able to withstand the atmospheric boiling temperature of the product while the temperature of the steel structure should not fall below its embrittlement temperature. A 50 mm thick concrete cover meets this requirement.

2.6 DESIGN CONSIDERATIONS

In the early stage of the design, the fireproofing zones (FPZ's) defining the extent of fireproofing shall be marked on the general arrangement drawings of the plant or site.

Features which shall be considered at the design stage include :
- comparison of cost and construction time for prefabricated concrete structures versus steel structures and fireproofing;
- fire protection policy and plant availability;
- minimising the need for bracings in a framework where fireproofing is required;
- the weight of fireproofing;
- the increased overall dimensions of fireproofed members;
- the reduced allowable deflections for fireproofed members;
- prefabrication.

3. FIREPROOFING OF TYPICAL EQUIPMENT AND STRUCTURES IN AN FPZ

3.1 STRUCTURES SUPPORTING EQUIPMENT

3.1.1 Criteria

Steel structures supporting vessels, columns or exchangers located within an FPZ shall be fireproofed when one or more of the following criteria apply (see Appendix 3):

1. Sudden failure of the structure may cause danger to personnel;
2. The supported equipment contains a total of more than 2 tonnes of flammable product;
3. The supported equipment has a total mass (including contents) of more than 10 tonnes;
4. The supported equipment contains toxic material.
5. Failure of the steel structure and supported equipment may lead to consequences beyond the property limit, including environmental damage.

3.1.2 Extent

All stanchions and beams (including other structural members designed for the purpose of reducing the effective buckling length of stanchions) shall be fireproofed.

Note: Steel structures are built up from stanchions, beams and diagonals. These elements are designed and sized on the basis of strength and stability considerations. However, they contribute differently to the risk of fire escalation. Diagonals are used both to reduce the buckling length of the stanchions and to absorb the horizontal forces (mainly wind) on the structure. The diagonals designed to reduce the buckling length of stanchions shall be fireproofed. The diagonals designed only for the wind shall not be fireproofed in view of the unlikely occurrence of design wind loads and fire at the same time.

3.2 COLUMN/VESSEL SKIRTS

3.2.1 Criteria

Column and vessel skirts located within a FPZ shall be fireproofed on the outside when one or more of the following criteria applies:

1 The column/vessel contains a total of more than 2 tonnes of flammable product.
2. The total mass of the column/vessel (including contents) is more than 10 tonnes.
3 The column/vessel contains toxic material.
4. Failure of the column/vessel may lead to consequences beyond the property limit, including environmental damage.

Note: The above applies in the normal situation where there are no flanged pipe connections within the circumference of the skirt. However, should this be the case then fireproofing shall also be applied inside the skirt.

3.2.2 Extent

Fireproofing shall be applied on the skirts as indicated on Standard Drawing S 20.002.

3.3 SADDLE SUPPORTS

Saddle supports for vessels and exchangers (even if located within a FPZ) shall not be fireproofed. For the supporting structure of vessels and exchangers, see (3.1).

3.4 AIR ("FIN-FAN") COOLER SUPPORTS

3.4.1 Criteria

Air cooler supporting structures located within a FPZ shall be fireproofed when either of the following criteria applies:

1. The air cooler contains a total of more than 1 tonne of flammable product.
2. When one or more air coolers are installed in one structure and the total mass of the coolers and their contents exceed 2500 kg.

3.4.2 Extent

See (3.1.2).

3.5 PIPE RACKS AND PIPE SUPPORTS

3.5.1 Criteria

Steel structures supporting overhead pipe racks and individual pipe supports, located within a FPZ shall be fireproofed when one or more of the following criteria apply:

1. The pipe is a flare line or an emergency depressurising vent line.
2. The pipe contains a toxic material.
3. The pipe is connected to equipment which would be severely damaged by additional nozzle loading in the event of loss of pipe support.
4. The pipe runs beneath an air cooler whose steel support structure is fireproofed (including horizontal members).
5. The pipe carries fire-fighting water and/or other utilities which would reduce the fire-fighting capability in the event of loss of support.
6. The pipe is an instrument air line or hydraulic control line whose loss would interfere with the ability to shut down the plant.

3.5.2 Extent

Stanchions of pipe racks and pipe supports shall be fireproofed from hazard level (HL) up to 0.3 m below the lowest horizontal member of the structure.

4. STRUCTURES REQUIRING FIREPROOFING REGARDLESS OF FPZ

4.1 GENERAL

Structures listed below shall be fireproofed irrespective of their location relative to the FPZ.

4.2 FURNACE SUPPORT STRUCTURES

Stanchions shall be fireproofed from grade level to full height of stanchion. All structural members incorporated to reduce the effective buckling length of these stanchions shall be fireproofed.

4.3 SUPPORTS OF PRESSURIZED SPHERES AND BULLETS

Supporting legs of spheres shall be fireproofed from grade level up to 0.20 m below the intersection of the leg with the sphere.

All stanchions and beams supporting bullets and structural members incorporated to reduce the effective buckling length shall be fireproofed.

For skirts, see (3.2).

4.4 STORAGE TANK PIPE BRIDGES

At refrigerated and cryogenic storage tanks, the main frames of steel towers which support pipes and/or pipe bridges shall be fireproofed.

4.5 JETTIES

4.5.1 General

The steel supporting structure of jetty platforms shall be fireproofed. Where fireproofing could be impractical (e.g. platforms located close to sea level) alternative fire protection measures, such as water spray systems, may be considered.

4.5.2 Application

Fireproofing shall be applied to the main platform steel beams and steel piles. The piles shall be filled with concrete from a level at least 2.0 m below low water level up to the underside of the deck. Steel reinforcement to withstand normal operating loads shall be considered. Drip trays draining to a sump shall be positioned where potential leakages of flammable fluids may occur.

5. MATERIAL REQUIREMENTS AND INSTALLATION OF FIREPROOFING SYSTEMS

5.1 GENERAL

The standard fireproofing material is concrete (5.2.1). Alternative materials (proprietary systems) are available but they shall only be used if approved by Principal (5.2.2); such systems may be preferred for existing structures whose strength or space limitations do not allow the use of concrete.

5.2 FIREPROOFING SYSTEMS

5.2.1 Concrete

Concrete shall be Grade 30 (or higher grade) in accordance with BS 8110. Solid encasement of the structural member is the usual method of application. Refer to Appendices 4 and 5.

The minimum required thickness of fireproofing concrete is 50 mm.

5.2.2 Proprietary fireproofing systems

A proprietary fireproofing system shall meet the following requirements:

- it shall be asbestos-free;
- tests carried out by independent laboratories shall demonstrate that the system is adequate for the proposed application and its thickness shall have the required resistance against hydrocarbon fires;
- it shall be reliable in service and should have an effective life-span of 10 years or more with reasonable maintenance, taking into account all possible variations in ambient temperature and humidity;
- the system shall not initiate or sustain any long-term deleterious effects, such as corrosion of the painted steel work, when exposed to damp conditions;
- installation shall be carried out by specialists, according to approved procedures of the manufacturer.

5.3 FIREPROOFING SYSTEMS INSIDE BUILDINGS

If fireproofing is required, consideration shall be given to the use of light-weight fireproofing materials (proprietary systems) subject to approval of the Principal.

5.4 PREPARATION FOR FIREPROOFING

New and, if necessary, existing steel work shall be primed for corrosion protection. The primer shall be compatible with the fireproofing to be applied, and shall be in accordance with DEP 30.48.00.31-Gen. All loose dirt, oil and grease present on the steel surface shall be removed to ensure good adhesion of the fireproofing to the steel.

Mesh reinforcement should be wrapped around the steel section and retained firmly by clips. Overlaps shall be 50 mm or more and shall be wired at approximately 150 mm centres.

The longitudinal overlap shall be in the web face, and all overlaps shall be staggered so that no more than three layers of mesh are present at any one point.

5.5 INSTALLATION OF FIREPROOFING

Proprietary systems shall be applied in accordance with the instructions from the manufacturer.

Weatherproofing is not required for concrete surfaces. For proprietary systems, a flexible membrane coating may be required depending on local circumstances. Coating shall be subject to approval of the Principal.

Joints between exposed steel work and fireproofing shall be caulked to prevent water from entering the system at this point.

The top of fireproofing shall be protected by cover plates continuously welded to the steel structure in order to prevent ingress of rainwater between the members and the fireproofing. Typical details of cover plates are given in Appendix 5.

Protection from heavy rain, frost and extreme weather conditions shall be provided during the application of fireproofing.

Application shall not take place if the air temperature or the temperature of the surface to be covered is 4°C or lower.

Provision shall be made for adequate ventilation during and after application, until the materials are dry; in extremely dry and hot conditions, however, appropriate measures shall be taken to keep vermiculite-containing systems moist until set. Measures such as screening the work area from radiant sunlight and wrapping the finished work may be required, depending on the severity of the ambient conditions.

Once set, the fireproofing shall be resistant to frost damage.

Where fixing of such systems to surfaces necessitates the welding of fixtures to the surfaces, the materials and procedures used shall be approved by the Principal.

6. QUALITY CONTROL

The preparation for, and the placing of, fireproofing material shall be supervised and inspected at all stages of the application by competent personnel having the appropriate knowledge and experience.

Particular attention shall be given to at least the following:
- the condition of the steel surfaces to be fireproofed;
- the quality and placing of mesh reinforcement;
- the quality and application of the fireproofing material;
- the joints between steelwork and fireproofing where exposed to the weather;
- weatherproofing, where relevant.

An inspection scheme shall be set up in accordance with the above guidelines and be approved by the Principal.

Records of all such inspection shall be handed over to the Principal before acceptance of the work.

7. REFERENCES

In this manual, reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest issue of each publication shall be used (together with any amendments/supplements/revisions thereto).

SHELL STANDARDS

DEP's

Painting and Coating of New Construction Projects	DEP 30.48.00.31-Gen.

STANDARD DRAWINGS

Skirts with fire-proof protection	S 20.002

AMERICAN STANDARDS

Rapid Rise Fire Tests of Protection Materials for Structural Steel	UL 1709

Issued by:
Underwriters Laboratories Inc.
333, Pfingsten Rd.,
Northbrook IL60062
U.S.A.

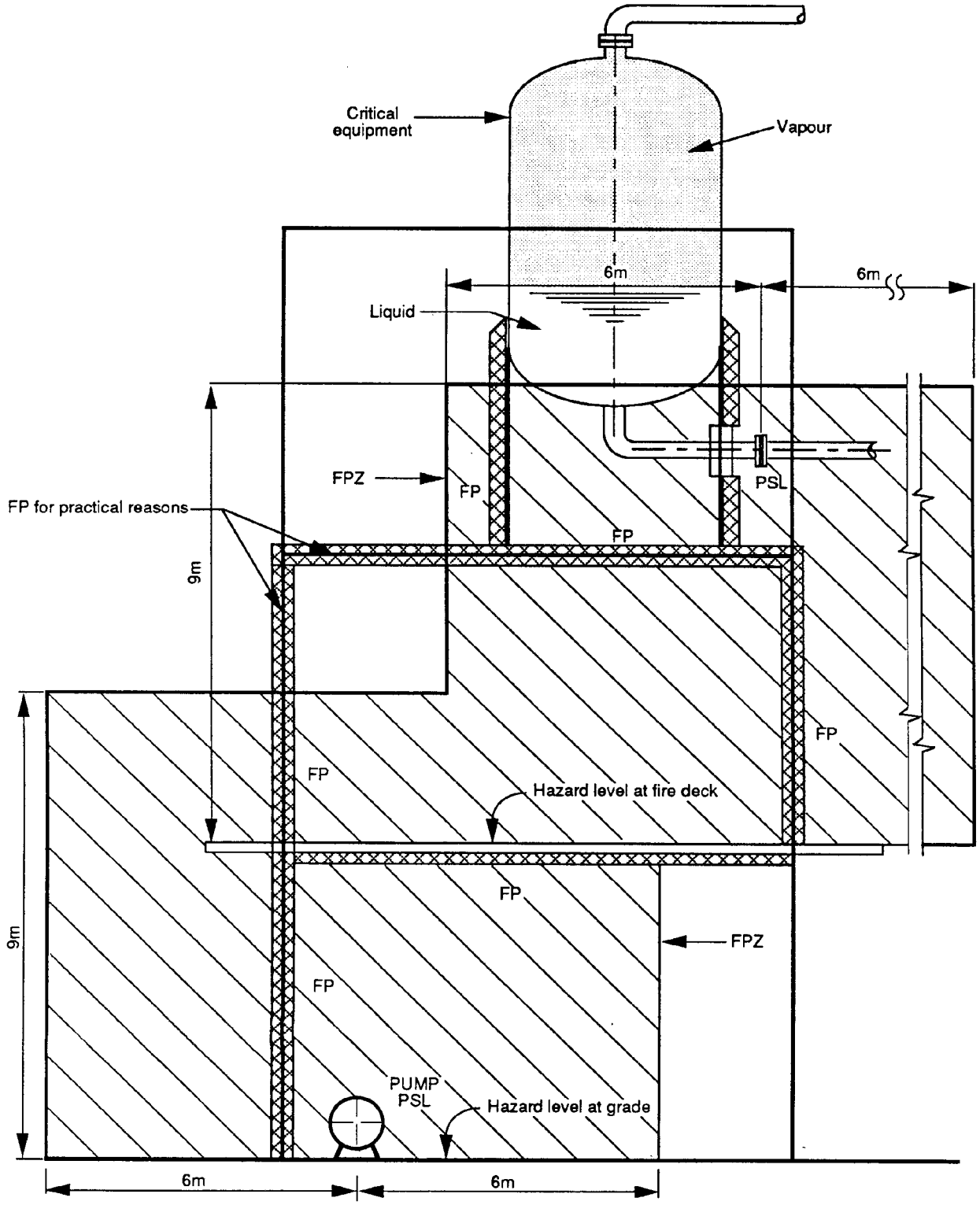
BRITISH STANDARDS

Structural Use of Concrete	BS 8110

Issued by:
British Standards Institution,
Sales Dept.,
Linford Wood,
Milton Keynes MK14 6LE
England

8. APPENDICES

APPENDIX 1 TYPICAL FIREPROOFING FOR A LIQUID POOL FIRE



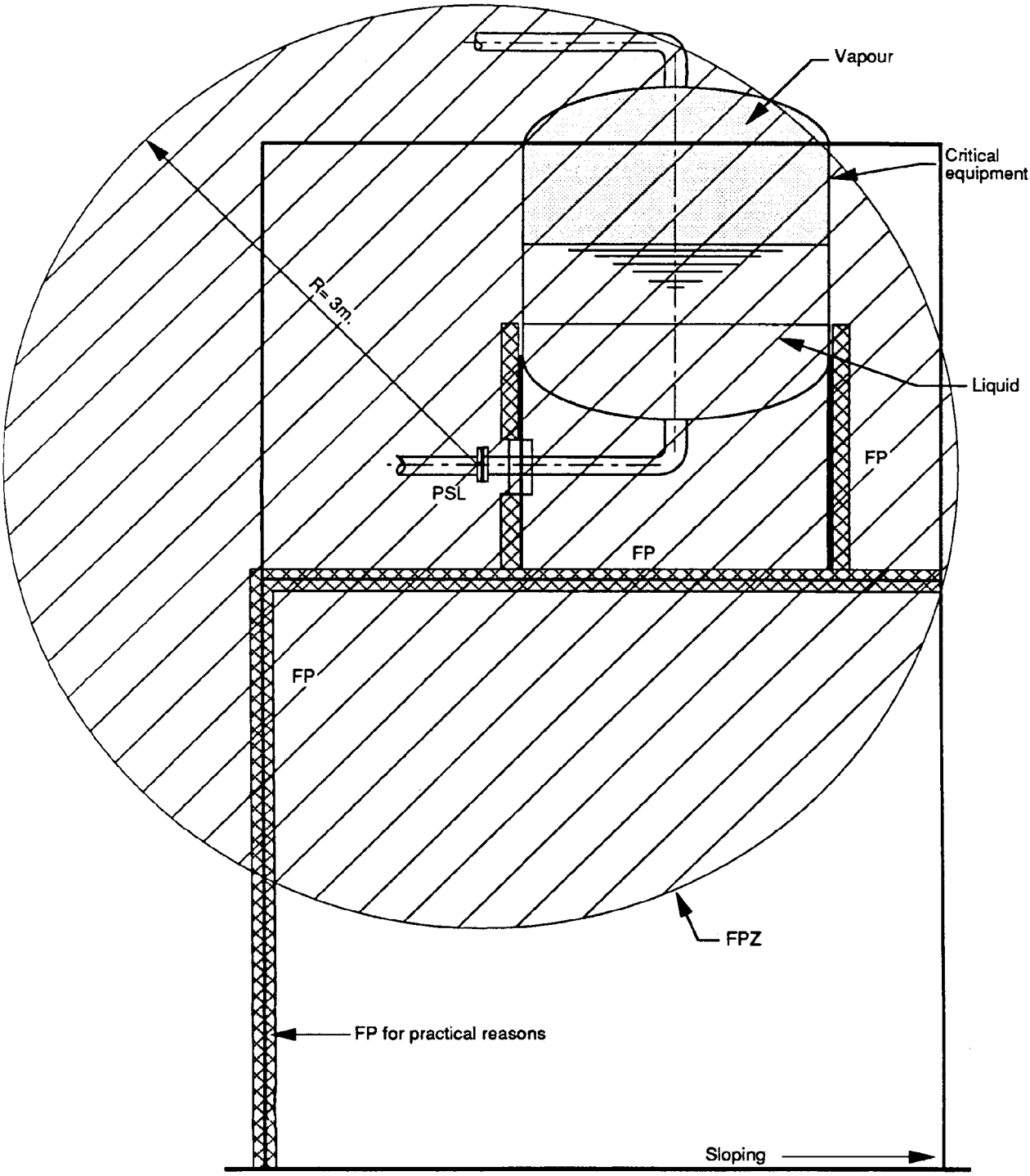
Notes:

FPZ = Fire proofing zone

FP = Fire proofing

PSL = Potential source of leakage

APPENDIX 2 TYPICAL FIREPROOFING FOR A LIQUID OR VAPOUR TORCH FIRE



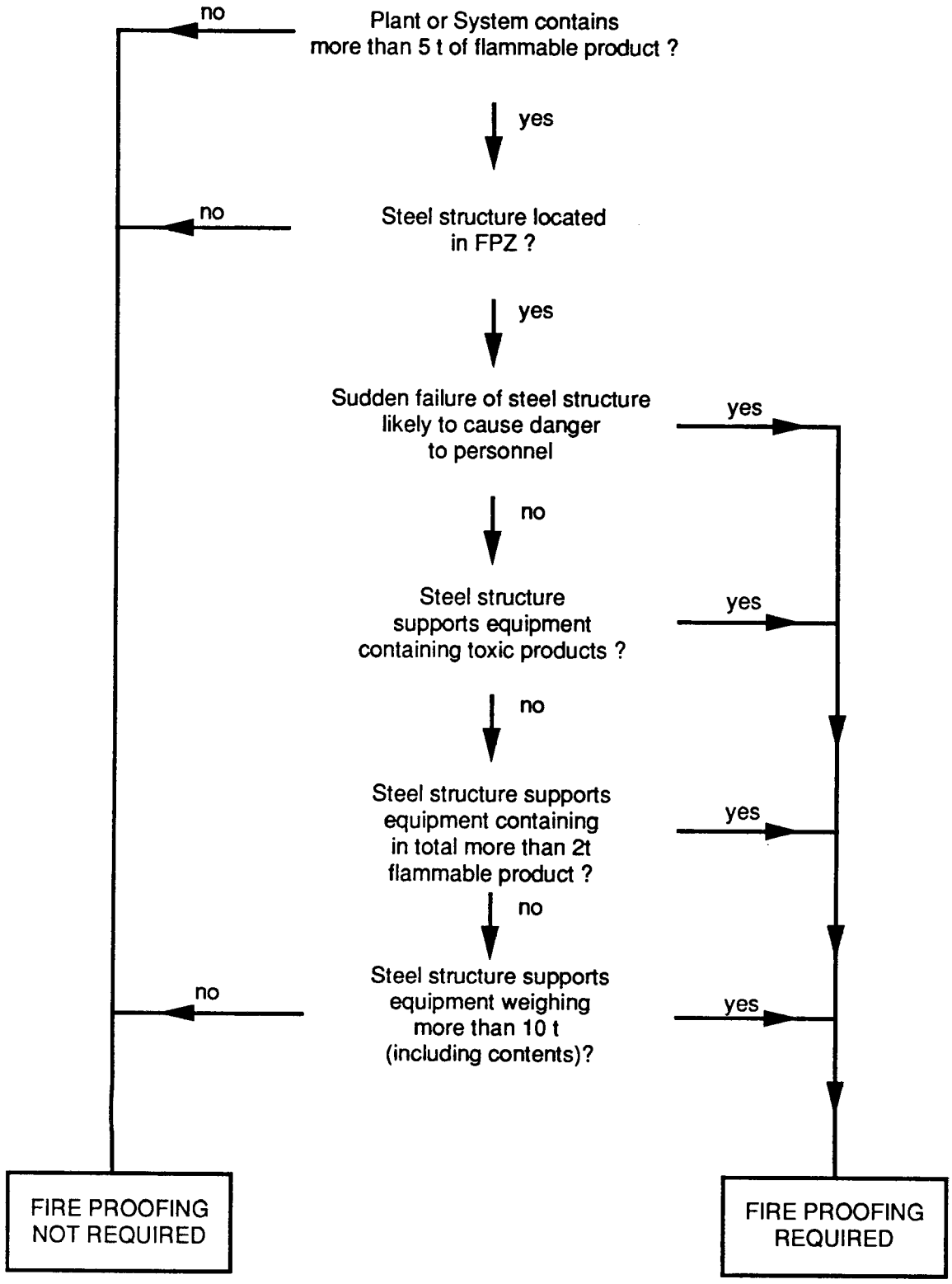
Notes:

FPZ = Fire proofing zone

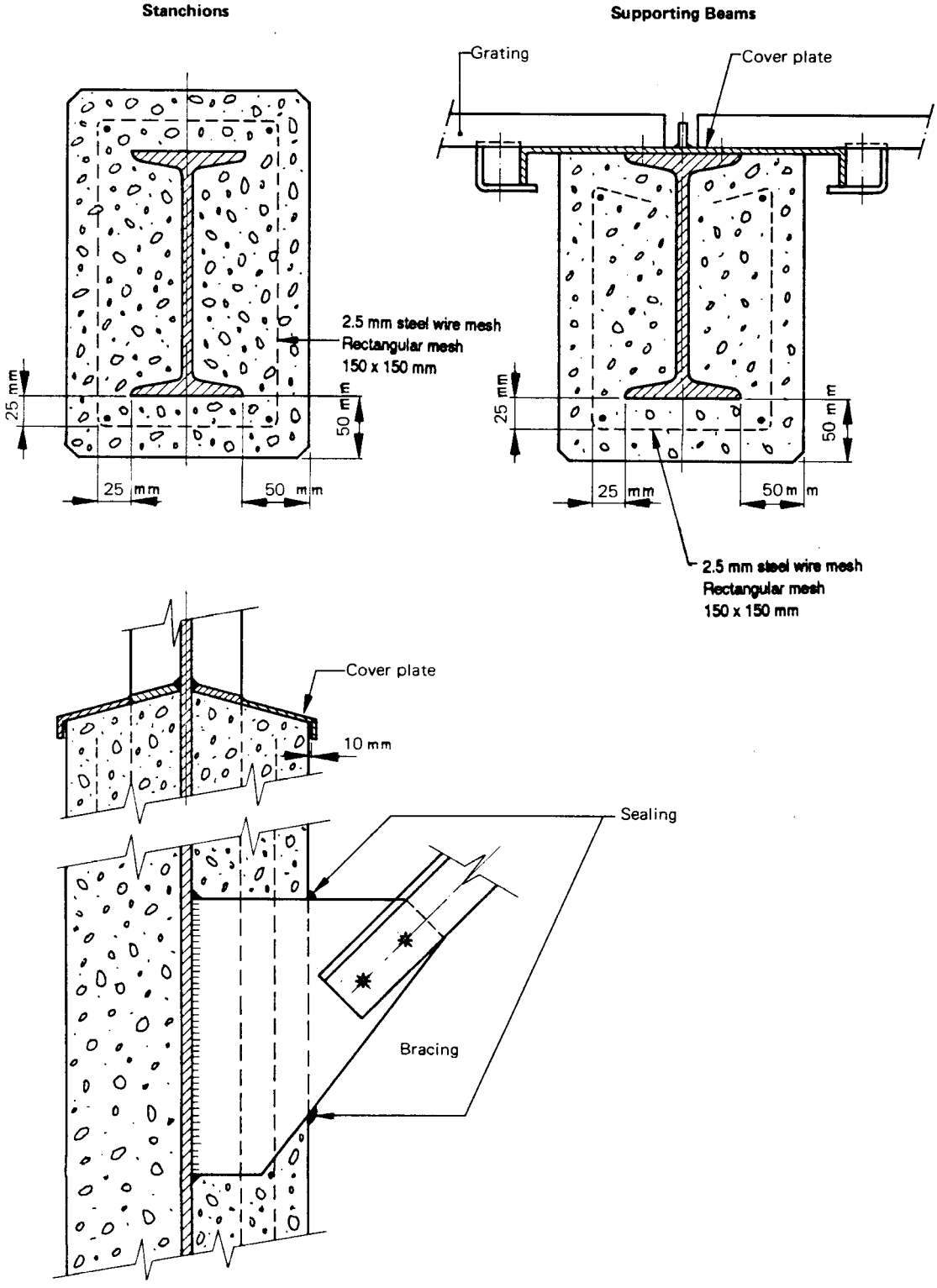
FP = Fire proofing

PSL = Potential source of leakage

APPENDIX 3 DECISION FLOW CHART FOR FIREPROOFING OF STRUCTURES SUPPORTING EQUIPMENT

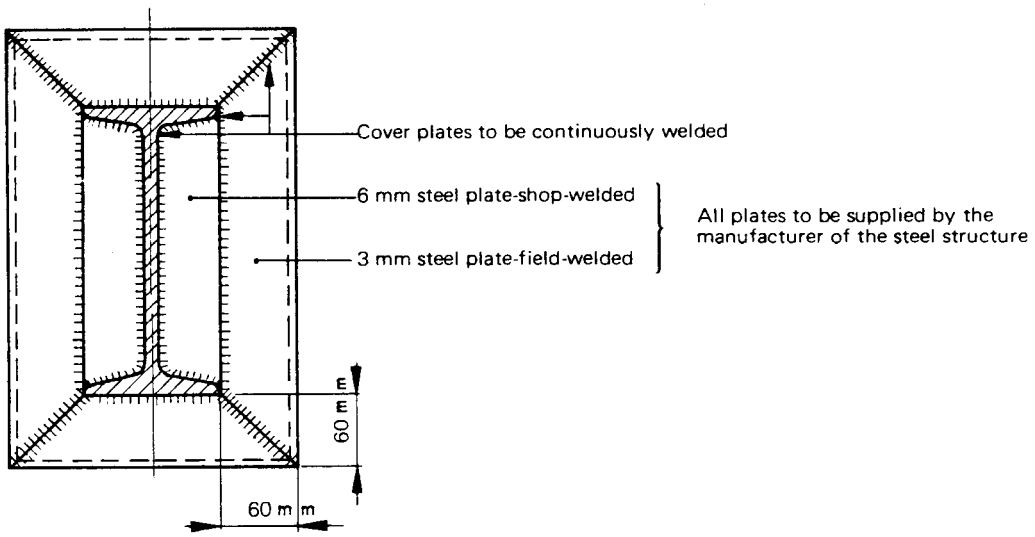


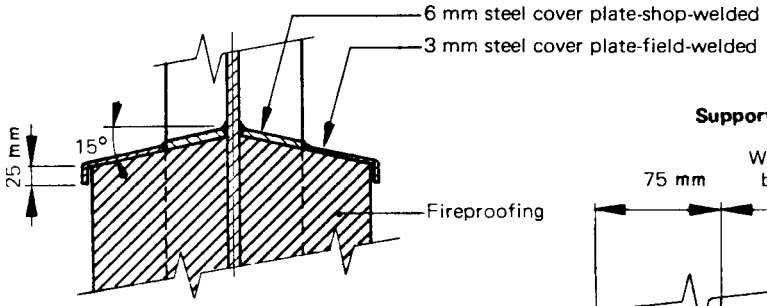
APPENDIX 4 TYPICAL DETAILS - CONCRETE FIREPROOFING - SOLID ENCASEMENT



APPENDIX 5 TYPICAL DETAILS - COVER PLATES FOR WEATHER PROTECTION

Stanchions





Supporting Beams