

**CONSTRUCTION STANDARD**  
**FOR**  
**FIREPROOFING**

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## 1. SCOPE

**1.1** This Standard covers the methods of application of fireproofing to steel structures of process equipment, piping cable trays in fire potential areas.

**1.2** However, fireproofing should never be considered as a replacement for or relaxation of the normal fire-preventive measures and the suitability of the fire-fighting equipment available.

**1.3** This Standard is intended for use in manufacturing oil and gas, exploration and production and chemical manufacturing. It applies to all steel supporting structures in process areas and processing plants in land-based oil/gas/petrochemical (onshore) installations. It is not intended to apply to offshore platforms or floating installations.

## 2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor/Consultant/Contractor.

### ACI (AMERICAN CONCRETE INSTITUTE)

ACI-506-R-85 "Guide to Shotcrete"

### BSI (BRITISH STANDARDS INSTITUTION)

BS 5075-1982 "Concrete Admixtures"

### IPS (IRANIAN PETROLEUM STANDARDS)

IPS-C-CE-105 "Building Materials"  
Part 1 and 2

IPS-E-CE-260 "Fireproofing"

IPS-M-CE-165 "Materials for Concrete, Mortars and Admixtures"

IPS-C-TP-101 "Surface Preparation"

IPS-C-TP-102 "Painting"

### SIS (SWEDISH STANDARDS)

SIS 05 5900 "Rust Levels of Steel Structure and Quality Levels for Preparation of Steel Surfaces for Rust Protection"

## 3. ABBREVIATIONS

**AR** Authorized Representative of the Owner.

## 4. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

## 5. GENERAL REQUIREMENTS

**5.1** 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.

**5.2** The standard fireproofing material is concrete with or without admixtures. Alternative materials are available but they shall only be used if approved by the AR. Such materials may be preferred for existing structures whose strength or space limitation do not allow the use of concrete.

**5.3** If fireproofing is required for inside buildings, consideration shall be given to the use of light-weight fireproofing materials subject to approval of the AR.

**5.4** Where fixing of such system to surfaces necessitates the welding of fixtures to the surfaces, the fireproofing materials and procedures used shall be approved by the AR.

## 6. SURFACE PREPARATION AND PRIMING OF STEEL STRUCTURES

**6.1** Prior to application of fireproofing, the steel shall be cleaned (degreased) to provide a surface free from grease, oil and dirt.

**6.2** After degreasing, the loose rust or mill scale and other foreign matter shall be removed by wire brushing or by sandblasting.

**6.3** The surfaces shall be cleaned to St3 (with wire brushing) or Sa2 (with sand blasting) grades of cleanliness in accordance with SIS 05 59 00.

**6.4** Surface preparation process and materials and equipments to be used and also grades of cleanliness shall be in accordance with IPS-C-TP-101.

**6.5** After preparation of steel surfaces, two coats of lead primer shall be applied with a nominal dry film thickness (each coat) of 40 micron in accordance with IPS-C-TP-102. Any shop primer that is present need not be removed.

## 7. MATERIALS

**7.1** The materials for reinforcement of fireproofing are described in the following sub-clauses, and shall be as specified in IPS-M-CE-105/2.

**7.2** All materials shall be adequately protected against damage and from the weather during loading, transportation, offloading and storage. Bagged materials shall not be set directly on the ground and shall be kept under cover.

**7.3** The specification of materials including cement, aggregate, gypsum, brick and tiles shall be in accordance with IPS-M-CE-105/1.

**7.4** The maximum aggregate size for poured concrete shall be 10 mm (3/8 inch). The fine aggregate for gun-applied concrete shall comply with IPS-M-CE-105/1.

**7.5** Normal water reducing admixtures (see IPS-M-CE-165 or BS 5075) shall be added to poured in place concrete to maintain sufficient workability at the minimum water/cement ratio. The type of admixture shall be subject to the approval of the designer, and the dosage and mixing shall be strictly in accordance with the Manufacturer's instructions.

**7.6** The poured or troweled in place concrete shall have a minimum cement content of 350 kg/m<sup>3</sup> and a minimum characteristic strength of 20 N/mm<sup>2</sup>.

**7.7** Unless otherwise specified, gun-applied (shotcrete) concrete shall consist of 1 part cement to 3.5 part of fine aggregate proportioned by weight. The minimum equivalent cube compressive strength at 28 days shall be 28 N/mm<sup>2</sup>.

- 7.8** Mineral wool shall be approved by the designer.
- 7.9** Vermiculite shall be supplied as a dry premixed factory-controlled material in suitable containers. The mix shall be based on vermiculite and ordinary Portland cement plus additives to improve its rheological properties.
- 7.10** Water shall be clean and free of oils, acids, salts or substances injurious to the concrete. Water of drinkable quality is accepted.
- 7.11** Reinforcing fabric for poured concrete fireproofing (see 9.2) shall be galvanized weld mesh with wire size of 100 mm × 2.5 mm. Smaller pitch may be adopted where concrete is to be applied other than by pouring (see 7.12).
- 7.12** The gun-applied shotcrete, (see Clause 9.3) concrete fireproofing shall be reinforced with 50 mm × 50 mm × 3 mm dia galvanized steel welded wire fabric for all large surface areas, e.g. vessel skirts. For vermiculite cement, the galvanized mesh shall be 25 mm × 25 mm × 1.6 mm.
- 7.13** On structural steel members material shall be 25 mm × 25 mm × 2 mm dia. galvanized steel welded wire fabric maintained at 20 mm from profile by the use of 20 mm dia. carbon steel bars suitably located to maintain this space at all locations.
- 7.14** Expanded metal lath (galvanized) - For large surfaces "Expamet", "Rib-lath" or equivalent may be used.
- 7.15** Steel pins of minimum 2.5 mm diameter shall be used to hold mesh reinforcement in place.
- 7.16** Galvanized mild steel bands and buckles shall be not less than 0.6 mm thick by 13 mm wide.
- 7.17** Tie wire for attaching reinforcing mesh shall be galvanized soft iron wire, having 1.6 mm diameter.

## **8. INSTALLATION OF REINFORCEMENTS**

### **8.1 Fixing of Pins to Hold Mesh**

The pins shall be welded to the structural steelwork sections at a maximum spacing of 400 mm to suit the profile of the section. No welding shall be carried out on vessels without the approval of the AR.

Unless otherwise specified by the AR, vessels and vessel skirts shall be supplied complete with fixing pins. They shall be spaced at approximately 300 mm centers except at manholes etc., where closer spacing may be necessary.

### **8.2 Installation of Weld Mesh Fabric**

**8.2.1** The reinforcing mesh for concrete fireproofing shall be positioned so as to maintain a cover of not less than 25 mm and not more than 30 mm.

**8.2.2** In the case of vermiculite cement fireproofing, the structural members shall be wrapped in expanded metal lath if the vermiculite cement is to be applied by hand troweling or the member is to be encased, with a void between the flanges (hollow encased member). The voids behind the metal lathing in vertical runs shall be filled with mineral wool or provided with solid baffles at 3 m centers to prevent chimney action.

**8.2.3** Where the thickness of vermiculite cement exceeds 30 mm, mesh reinforcement shall be placed at the midpoint of the fireproofing in addition to the expanded metal. Additional reinforcement layers shall be used where the thickness of the concrete or vermiculite cement exceeds 80 mm.

**8.2.4** The mesh shall be firmly attached to the fixing pins with galvanized tie wire, shall overlap at least one square and be tied together at approximately 150 mm centers. Specific attention shall be given to ensure that the mesh is correctly positioned around the flange edges.

**8.2.5** Where required by the drawings or in the specification, the mesh shall be firmly held in place around vessels and vessel skirts by galvanized mild steel bands at 450 mm to 600 mm centers. On large skirts, a ribbed expanded metal may be required to give greater rigidity.

### **8.3 Bolts**

Holding down bolts for vessels and vessel skirts, which do not need fireproofing, shall be coated with a suitable protective grease, prior to being covered by fireproofing. In the case of vessel saddles that have provision for sliding on a bedplate, a specific check shall be made to ensure that the supports are left free to slide.

### **8.4 Expansion Joints**

Where provision is made in the structural steelwork for expansion or contraction, the joints shall extend through the fireproofing.

## **9. APPLICATION METHODS**

### **9.1 General**

**9.1.1** Concrete fireproofing materials shall be applied by one of the following methods:

- a)** Pouring and troweling.
- b)** Shotcreting (guniting).

**9.1.2** During application special care shall be taken that all irregular areas and corners are completely filled and that voids or air pockets are precluded.

**9.1.3** During cold weather the concrete and the surface to which it will be applied shall be kept at a temperature above 5°C both during application and curing. This shall be accomplished by providing an enclosure in which a temperature above 5°C is maintained during mixing, application and curing. The fireproofing materials containing water shall be protected against freezing, however, direct steam shall not be used for this purpose.

**9.1.4** For proprietary systems, a flexible membrane coating may be required depending on local circumstances. Coating shall be subject to approval of the AR.

**9.1.5** Joints between exposed steelwork and fireproofing shall be caulked to prevent water from entering the system at this point. (see 9.5).

**9.1.6** 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.

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

**9.1.8** 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.

**9.1.9** Once set, the fireproofing shall be resistant to frost damage, (with or without use of admixture).

**9.1.10** 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 AR.

## 9.2 Pouring and Troweling Method

### 9.2.1 Pouring in a horizontal position

This method is used for fireproofing of floor or other horizontal surfaces by pouring the material and troweling. This method permits easy inspection and requires neither skilled labour nor any special equipment.

### 9.2.2 Pouring in a vertical position

**9.2.2.1** The application of this method shall be restricted to minor repair and to those cases where guniting or horizontal pouring is not feasible. The method requires shuttering, which shall have a maximum height of 500 mm. The shuttering shall be made reasonably water-tight and the inside surface shall be sufficiently oiled, but without excess.

**Note:**

**Dry wooden shuttering may need a treatment to prevent the absorption of mixing water from the fresh concrete.**

**9.2.2.2** Fireproofing material shall be poured behind shuttering using funnels and sheet metal tubes as required, skilled labour and close supervision shall be imperative.

**9.2.2.3** The fireproofing shall be applied in a manner which will minimize material segregation.

**9.2.2.4** Each batch from the mixer shall be placed so that the full thickness of coating will be reached, using temporary weirs (shutters) as necessary. On no account shall another layer be added later to complete the coating.

**9.2.2.5** Once application has started it shall proceed without interruption until the entire coating of the part concerned has been completed. If an unavoidable interruption does occur, the wet edge of the fireproof coating shall be cutback at right angle to the surface to give an edge of full thickness. All material ahead of the cut shall be removed and discarded.

**9.2.2.6** If any surface finish is required, the surface should simply be leveled off with a screed or a wood float.

## 9.3 Shotcreting (Guniting) Methods

### 9.3.1 Description

In shotcreting or gun-applied process, concrete is pneumatically projected at high velocity on to a surface. It is classified into two processes i.e. "Dry-mix" and "Wet-mix" (see also ACI-506-R 85).

### 9.3.2 Dry-mix process

**9.3.2.1** In Dry-mix shotcrete equipment the cement-aggregate mixture (and fibers) is carried by compressed air to the gun. Water is introduced under pressure to the gun and intimately mixed with the other ingredients.

**9.3.2.2** Dry-mix shotcrete equipment is divided into two distinct types:

- a) single or double chamber gun,
- b) rotary gun.

**9.3.2.3** The water - cement ratio for dry-mix shotcrete in-place falls within a range of 0.30 to 0.50 by weight.

**9.3.2.4** In Dry-mix Shotcreting air pressure of the gun shall be maintained at not less than 2.4 bar when up to 30 meters of hose material is used (see Table 1). The pressure shall be raised at least 0.350 bar for each additional 15 meters of hose added. Uniform water pressure shall be maintained at least 1 bar greater than the air pressure at the gun.

**9.3.2.5** Only enough water shall be applied to ensure complete hydration.

9.3.2.6 After placing, the material shall be cured and protected in accordance with Clauses 9.4 and 9.5.

9.3.2.7 Work shall be stopped if high winds occur which separates the cement from the sand at the nozzle, or if rain, other than a very light sprinkle occurs.

**TABLE 1 - COMPRESSOR CAPACITIES AND HOSE DIAMETERS**

MATERIAL HOSE INSIDE DIAMETER mm	COMPRESSOR CAPACITY m <sup>3</sup> /min at 700 kPa
25	10.0
32	12.5
38	17.0
51	21.0
64	28.0

**9.3.3 Wet-mix process**

9.3.3.1 In Wet-mix shotcrete equipment, all of the ingredients, including mixing water, are thoroughly mixed, and are conveyed by compressed air to a gun. Additional air is injected at the gun to increase velocity and improve the gunning pattern.

9.3.3.2 Wet-mix shotcrete equipment is divided into two types:

- a) pneumatic feed guns;
- b) positive displacement guns.

9.3.3.3 The water-cement ratio for wet-mix shotcrete falls within a range of 0.4 to 0.55 by weight.

9.3.3.4 Pneumatic feed wet process guns require less air for a given hose size than dry equipment (see Table 1), but operate at higher back pressures.

9.3.3.5 Positive displacement wet process equipment requires a supply of at least 3m<sup>3</sup>/min at 700 kPa at the air ring for proper operation.

9.3.3.6 The inside diameter of the air supply hose from the compressor to the gun should be at least as large as the inside diameter of the material hose except for the positive displacement wet process equipment where the air hose to the nozzle is 20 mm or greater.

**9.4 Curing and Finishing**

9.4.1 Concrete shall be cured by keeping it in a damp condition for a period of seven days:

- Spraying, when employed, shall be with a fine mist to prevent the washing out of the cement.
- When membrane curing is used, the membrane curing compound shall be a solution of resin and hydrocarbon base, which has low permeability, compatibility with aluminous cements, ease of application, short drying time and long storage life.

A one-coat application of membrane compound shall be used, with contrasting color and of sufficient thickness to completely cover lining. The membrane shall be allowed to dry tack free before lining is installed in adjoining area. Adequate ventilation shall be provided during the membrane compound application and curing period.

9.4.2 Immediately after initial setup, while the concrete is still moist, all the necessary pointing up shall be done and all surfaces shall be finished with a brush coat.

**9.4.3** The desired finish texture shall be sprayed (rough, stuccolike), rolled or troweled (smooth, flat with finished corners), as specified by the AR.

**9.4.4** The top edges of the fireproofing shall be flashed with a mastic weatherproof coating, when not otherwise shielded.

**9.4.5** Painting of concrete is not recommended, as this tends to hide surface evidence of defects.

## **9.5 Caulking**

**9.5.1** Apply caulking at all exposed steel and fireproofing intersections. Slope or slant fireproofing downward from intersection to facilitate drainage.

**9.5.2** Where fireproofing terminates on a column, provide a cap plate in addition to caulking, to prevent the intrusion of moisture.

## **10. FIREPROOFING OF SUPPORT AND EQUIPMENT**

### **10.1 General**

Unless otherwise specified by the AR, for the following steel structures, either in the open or in buildings, fireproofing shall be applied:

- a) Equipment-supporting structures.
- b) Pipe-supporting structures.
- c) Support for fin-fan coolers.

### **10.2 Equipment-Supporting Structures**

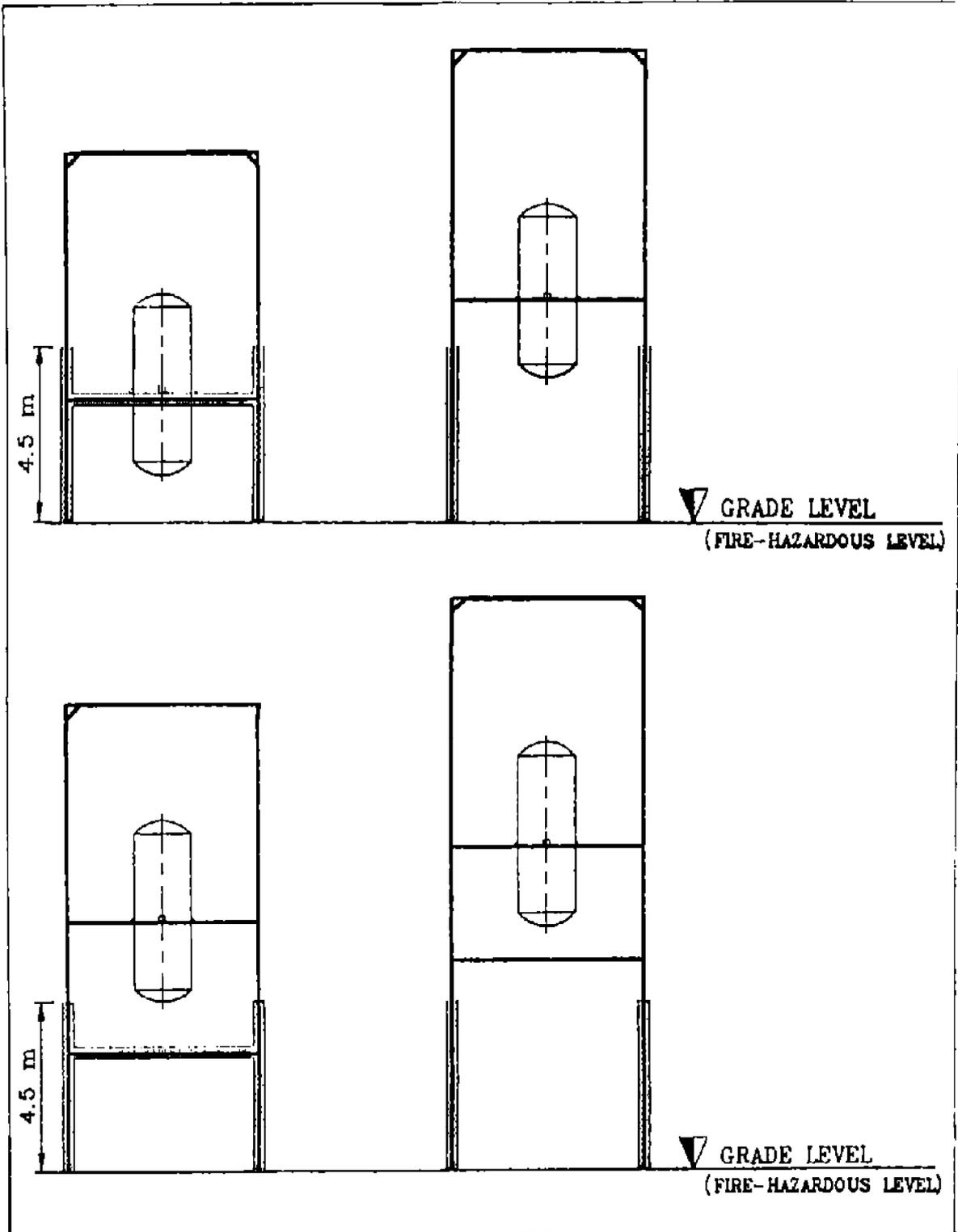
**10.2.1** For the equipment-supporting structures, fireproofing shall be applied from grade level to a height of 4.5 m. above the hazardous level, i.e. grade or elevated level.

**10.2.2** This includes all stanchions, equipment-supporting beams and also all structural members which reduce the effective buckling length of the stanchions.

**10.2.3** Some typical examples have been given in Figs. 1 and 2.

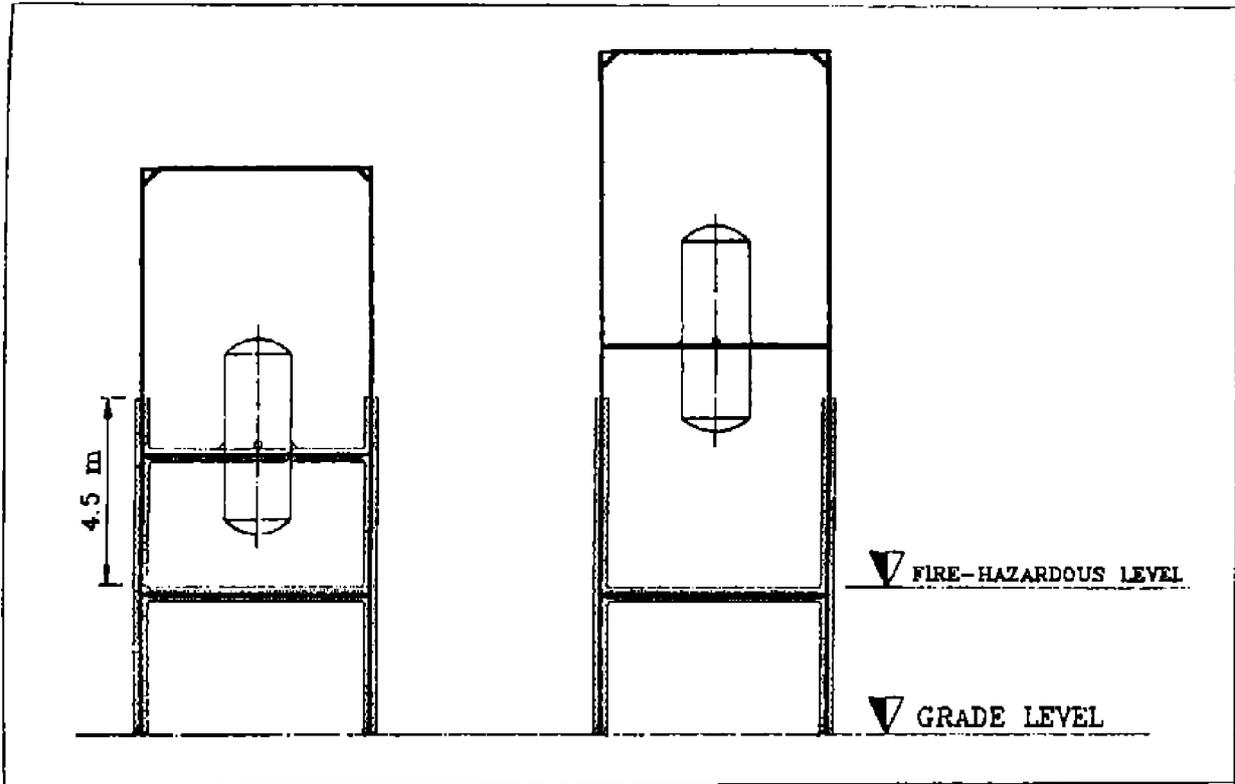
For the structures of Fig. 1, the fire hazardous level is at grade level.

For the structures of Fig. 2, the fire hazardous level is above grade level.



EQUIPMENT-SUPPORTING STRUCTURES WITH FIRE-HAZARDOUS LEVEL AT GRADE LEVEL

Fig. 1



**EQUIPMENT-SUPPORTING STRUCTURES WITH FIRE-HAZARDOUS LEVEL ABOVE GRADE LEVEL**

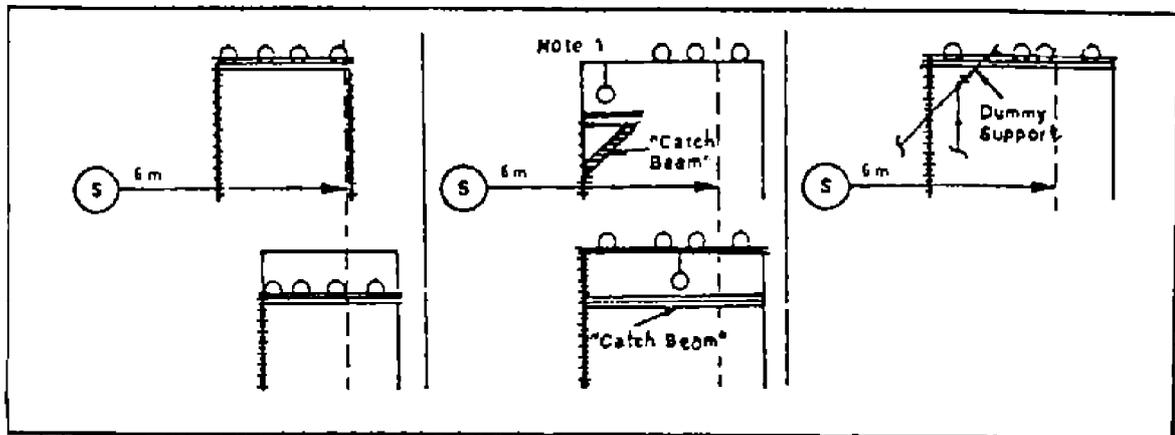
**Fig. 2**

**10.3 Pipe Supporting Structures**

**10.3.1** For the pipe supporting structures, fireproofing shall be applied to the stanchions only.

**10.3.2** Typical application of fireproofing for pipe supports, catch beams, and dummy pipe supports are illustrated in Fig. 3.

**10.3.3** If pipe supporting structures are combined with structures supporting fin-fan coolers, the stanchions, cooler supporting beams and all members which reduce the effective buckling length of stanchions shall be fire proofed from grade level up to and including the supports of the tube bundle(s) (see Fig. 4).



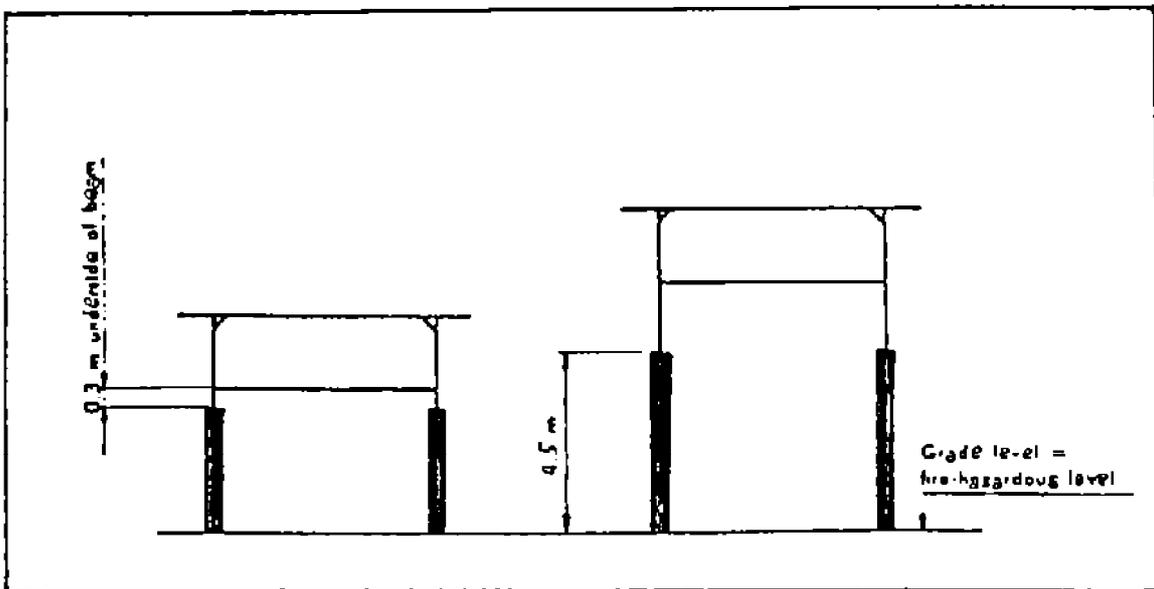
**TYPICAL APPLICATION OF FIREPROOFING FOR PIPE SUPPORTS, CATCH BEAMS AND DUMMY PIPE**

**Fig. 3**

- Legend: C Fire source  
 Fireproofed structural members

Notes:

- 1) If the pipe which is hung by rod or spring type support is the only line on the pipe support which contains flammable materials, then only the "Catch Beam" and its support (to the extent indicated) shall be fireproofed.
- 2) Fireproofing of horizontal beams shall be carried to, but not including, the next supporting column.
- 3) Exposed cross beams are to be fireproofed, bottom and two sides.
- 4) 6m is the horizontal distance measured from the nearest point of source of sustained fire.



PIPE-SUPPORTING STRUCTURES  
 Fig. 4

10.4 Support for Fin-Fan Coolers

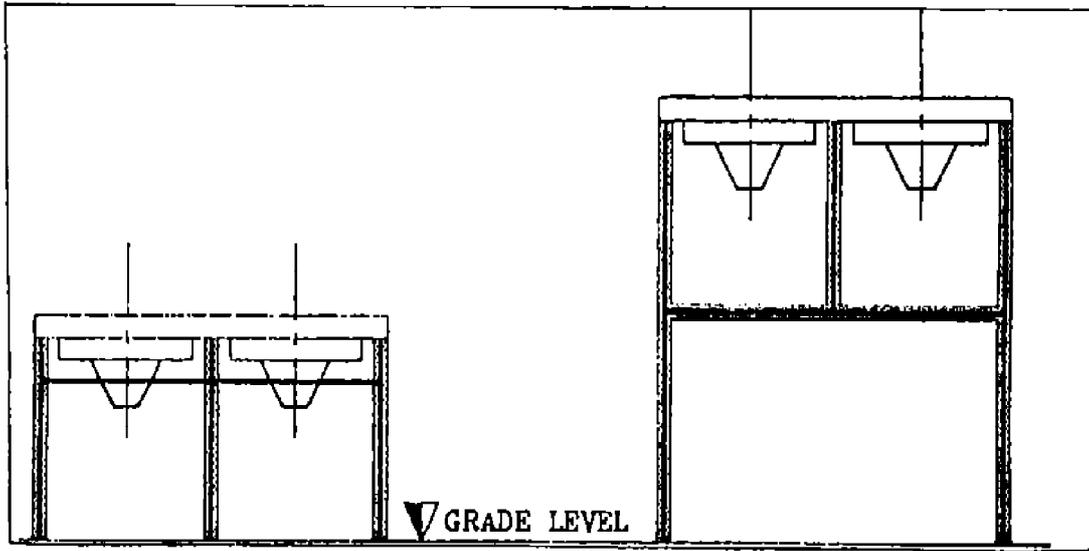
10.4.1 Steel structures supporting fin-fan coolers, shall be fireproofed from grade or elevated level up to and including the supports to the tube bundle(s) (see Fig. 5).

10.4.2 Air-cooler supporting structures shall be fireproofed when either of the following criteria applies:

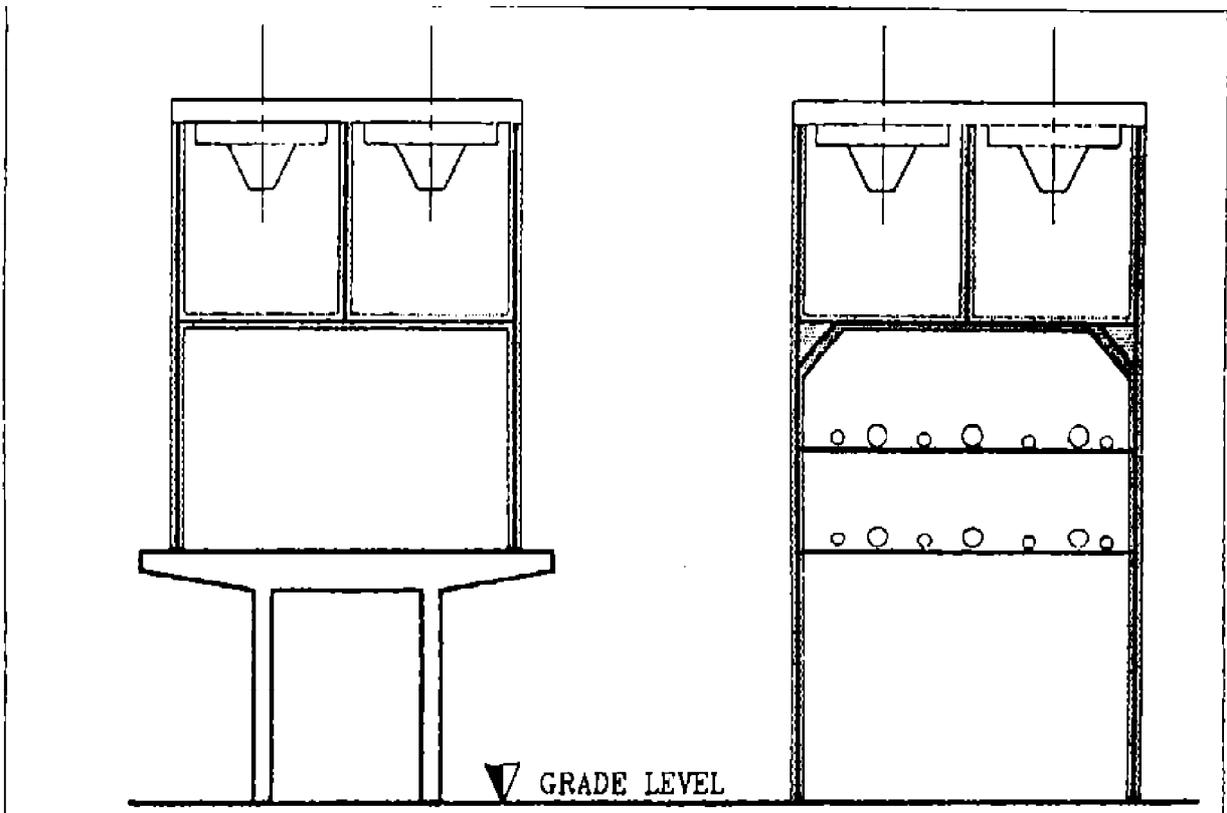
- a) The air cooler contains a total of more than 1 ton of flammable product.
- b) When one or more air coolers are installed in one structure and the total mass of the coolers and their contents exceed 2500 kg.

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

10.4.4 If fin-fan coolers with "flammable" liquids are located above pumps handling "flammable" liquids, a reinforced concrete floor shall be made underneath the fin-fan cooler.



a) FIN-FAN COOLER SUPPORTING STRUCTURE



b) FIN-FAN COOLER SUPPORTING STRUCTURE

c) FIN-FAN COOLER SUPPORTING STRUCTURE ON TOP OF OVERHEAD PIPE TRACK

Fig. 5

**11. INSPECTION AND TESTING**

**11.1** 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.

**11.2** Surface preparation shall be checked using the standard IPS-C-TP-101.

**11.3** Protective priming of steel substrate shall be checked using the standard IPS-C-TP-102.

**11.4** Dry-film thickness measurement of total fire proofing system shall be done in accordance with IPS-C-TP-102.

**11.5** Work shall not proceed to the next step in the system sequence (i.e. surface preparation, priming, fireproof coating) until the previous work has been inspected and approved.