ENGINEERING STANDARD

FOR

FIREPROOFING

ORIGINAL EDITION

MAY 1993

This standard specification is reviewed and updated by the relevant technical committee on Aug. 1998(1) and Dec. 2005(2). The approved modifications are included in the present issue of IPS.

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0. INTRODUCTION

This Engineering Standard specifies the means of fire-resistive systems,and gives minimum required coverages to resist the destructive effect of fire and accompanying high temperatures for approved time durations.

The primary purpose of fireproofing is to minimize the possibilities of collapse, in a fire, of structures supporting equipment containing flammable or toxic materials, the release of which would add materially to the intensity of a fire and to the problems and hazards of fire fighting.

No extension to fireproofing shall be made with the object of reducing the time required to bring a unit back on stream after a fire, except in special cases approved by the AR.

The degree of fireproofing depends on circumstances and also on the material to be fireproofed. Although the degree of 2 hour rating is considered normal in the industry (in accordance with BS 476 "Fire Tests on Building Materials and Structures"), but, nevertheless, other fireproofing degrees such as 1,3 and 4 hours ratings have been known and practiced in the industry. For the discussion on the engineering requirements concerning the selection of the precise degree of fireproofing, reference is made to IPS-E-SF-380 "Fire Protection in Buildings".

For the convenience of use, this Standard is divided into two parts:

Part I FIREPROOFING OF STRUCTURES

This Part covers requirements and design features governing the fireproofing of vessels, heat exchangers and structural support members including various structural members.

Part II FIRE-RESISTIVE MATERIALS AND SYSTEMS

This Part provides information on materials and systems used for fire-resistive purposes.

Note:

Throughout this Standard, the symbol AR denotes the Authorized Representative of the Owner.

PART I

FIREPROOFING OF STRUCTURES

1. SCOPE

This Part of the Engineering Standard covers the minimum technical requirements for fireproofing of certain parts of steel structures,so as to provide adequate protection for personnel and equipment.

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.

Since the design and shape of steel structures will vary from case to case, only general guidance can be given in this Standard.

If, according to the information given in this Standard the greater part of a steel structure is to be fireproofed, it should be considered whether such a structure is economically justified, or a reinforced concrete structure should be made. In the latter case such aspects as ease of extension should be duly taken into account.

Note 1:

This standard specification is reviewed and updated by the relevant technical committee on Aug. 1998. The approved modifications by T.C. were sent to IPS users as amendment No. 1 by circular No 31 on Aug. 1998. These modifications are included in the present issue of IPS.

Note 2:

This standard specification is reviewed and updated by the relevant technical committee on Dec. 2005. The approved modifications by T.C. were sent to IPS users as amendment No. 2 by circular No 264 on Dec. 2005. These modifications are included in the present issue of IPS.

2. REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

BSI (BRITISH STANDARDS INSTITUTION)

BS 476	"Fire Tests on Building Materials and Structures"
BS 3921	"Specification for Clay Bricks"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

E 119	"Fire Tests of Building Construction and Materials"
C37	"Standard Specification for Gypsum Lath"
C36	"Standard Specification for Gypsum Wallboard"
C588	"Standard Specification for Gypsum Base for Veneer Plasters"
C587	"Standard Specification for Gypsum Veneer Plaster"
C931	"Standard Specification for Exterior Gypsum Soffit Board"

C630	"Standard Specification for Water-Resistant Gypsum Backing Board"
C35	"Standard Specification for Inorganic Aggregates for Use in Gypsum Plaster"
C29	"Standard Test Method for Bulk Density"
C126	"Standard Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick and Solid Masonry Units"
C55	"Standard Specification for Concrete Brick"
C56	"Standard Specification for Structural Clay Non-Load-Bearing Tile"
C212	"Standard Specification for Structural Clay Facing Tile"
C34	"Standard Specification for Structural Clay Load-Bearing Wall Tile"
C90	"Standard Specification for Load Bearing Concrete Masonry Units"
C145	"Standard Specification for Solid Load Bearing Concrete Masonry Units"
E163	"Standard Practice for Mixing Thermal Insulating Cement Samples"
C847	"Standard Specification for Metal Lath"
C933	"Standard Specification for Welded Wire Lath"
C1032	"Standard Specification for Woven Wire Plaster Base"
E605	"Standard Test Methods for Thickness and Density of Sprayed Fire-Resistive Material (SFRM)"
C73	"Standard Specification for Calcium Silicate Brick"
C129	"Standard Specification for Non-Load-Bearing Concrete Masonry Units"

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-GN-100	"Engineering Standard for Units"
IPS-E-SF-380	"Engineering Standard for Fire Protection in Buildings"

Note:

Wherever deemed necessary, other ASTM specifications have been referred to in this Standard. In such cases the appropriate designations are indicated within the clause where the reference is made.

UBC (UNIFORM BUILDING CODE)

UBC 1988 Edition

Chap. 43 "Fire Resistive Standards"

NFPA (NATIONAL FIRE PROTECTION ASSOCIATION)

NFPA 251 "Standard Methods of Fire Tests of Building Construction & Materials"

UL (UNDERWRITERS LABORATORIES Inc)

UL9 "UL Standard for Safety Fire Tests of Window Assemblies Seventh Edition"

3. UNITS

International System of Units (SI) in accordance with IPS-E-GN-100 shall be used.

4. SELECTION OF MATERIALS

4.1 General

To qualify as both safe and dependable, fire protection materials for modern steel framed buildings should display the following characteristics:

a) No combustibility and the added attribute of not producing smoke or toxic gases when subjected to elevated temperatures. Thermal protective capability when tested in accordance with the Standard Fire Test ASTM E119.

b) Product reliability giving positive assurance of consistent and uniform protection characteristics.

c) Availability in a form that permits efficient and uniform application.

d) Sufficient bond strength and durability to prevent either dislodgment or surface damage during normal construction operations.

e) Resistance to weathering or erosion resulting from atmospheric conditions.

Briefly discussed below are a number of acceptable fire-protection materials that meet all of the principal characteristics listed above and, in varying degrees, some special qualities.

For further comments on materials, mixes, methods and recommendations on fireproofing see Clause 5 and Table 2.

4.2 Gypsum

4.2.1 Description

Gypsum, a mineral with unusual fire-resistant qualities, slowly releases water of crystallization in quantities up to one-half its volume when subjected to high temperatures. Until this water has been completely released and the gypsum has been dehydrated, the side away from the fire remains at approximately 100°C. Gypsum plaster, machine or manually applied to metal or gypsum lath, is very satisfactory fireproofing material. It may be combined with lightweight aggregates, wood fiber, or sand. Poured or precast gypsum slabs may be used with cellular steel floors, steel deck, or other floor or roof systems. Gypsum wallboard, in the form of lath or finish material, and gypsum tile are used as components of fire-resistant constructions.

4.2.2 Gypsum lath, wall board and sheathing board

- Gypsum lath shall comply with the provisions of ASTM C 37.
- Gypsum lath shall be nailed to wood studs or joists in all constructions required to be fire resistant, with 30 mm × 2.5 mm, 7.5 mm flat head blued nails at intervals not exceeding 100 mm on centers (five nails per lath for support of 400 mm lath) or equivalent attachment.
- Gypsum wallboard shall comply with the provisions of ASTM C 36.
- Gypsum sheathing board shall comply with the provisions of ASTM C 79.
- Gypsum veneer base shall comply with the provisions of ASTM C 588.
- Gypsum veneer plaster shall comply with the provisions of ASTM C 587.
- Exterior gypsum soffit board shall comply with the provisions of ASTM C 931.
- Water resistant gypsum backing board shall comply with the provisions of ASTM C 630.

4.3 Vermiculite and Perlite

4.3.1 Description

Vermiculite and perlite are lightweight aggregates possessing high thermal insulation qualities. They are used both in gypsum and cement plaster and in concrete. The weight of these aggregates is one tenth that of sand.

They are also used as ingredients in acoustical plaster with excellent fire-resistant as well as acoustical and insulating properties. Acoustical plaster usually consists of a colloidal clay or gypsum binder, vermiculite or perlite aggregate, mineral fibers, and a foaming agent added to create porosity. The plaster may be machine-applied directly to the underside of light-gage steel floors or roof decks, columns or beams, or to gypsum or metal lath.

4.3.2 Comments on application

a) Vermiculite

Vermiculite, when used as an aggregate with plaster, shall conform in particle size to ASTM C 35. The weight of vermiculite shall be not less than 1 nor more than 1.6 kN/m3 as determined by measurement in a cubic box of 300 mm dimensions, using the shoveling procedure as outlined in ASTM C 29. See also clause 5 and Table 2.

b) Perlite

Perlite, when used as an aggregate with plaster, shall conform in particle size to ASTM C 35. The weight of perlite shall be not less than 1.20 nor more than 2.40 kN/m3 as determined by measurement in a cubic box of 300 mm dimensions, using the shoveling procedure as outlined in ASTM C 29. See also Clause 5 and Table 2.

4.4 Portland Cement Concrete

Portland cement concrete continues to be useful as a fireproofing material. When subjected to high temperatures, it releases water in a manner similar to gypsum, although to a lesser degree. The selection of aggregate is critical to the fire resistance of concrete. Aggregate containing 60 percent or more of quartz, chert, or granite is not as fire-resistant as limestone or trop rock and therefore the concrete must be increased in thickness to obtain a comparable fire rating. The use of light aggregates instead of stone greatly improves the fire resistance of concrete. Concrete is now used largely for fire protection in reinforced concrete, over steel floor and roof decks, and for steel columns (where it also provides protection from abrasion due to traffic). See also Clause 5 for more detail.

4.5 Masonry

4.5.1 Description

Masonry (brick clay tile, concrete or cinder blocks, gypsum tile) is mainly used for walls and partitions, for protection to spandrels, and as backup for curtain walls. Its weight and thickness have caused it to be less used than formerly in steel framed buildings.

4.5.2 Bricks

Bricks should be of "ordinary quality" bricks or blocks to BS 3921 "Specifications for Clay Bricks". set in cement mortar.

Where these are used for the protection of vessel skirts, they should be built close around the skirt and reinforced with 2 strands of 2 mm reinforcing wire in the mortar between courses at every third course up from the bottom. Concrete brick shall conform to ASTM C55. Sand-lime brick shall conform to ASTM C 73. Ceramic glazed structural facing tile and facing brick shall conform to ASTM C 126.

4.5.3 Clay or shale tiles

Hollow clay or shale tile shall be laid in gypsum or cement/sand mortar. Clay or shale tile used in non bearing partitions and for fire protection shall meet the requirements of ASTM C 56. Clay or shale tile used in exterior walls and in all load bearing walls shall comply with the requirements of ASTM C 34 and ASTM C 212.

4.5.4 Concrete blocks

Hollow concrete masonry units used in exterior walls and in all walls or partitions shall comply with ASTM C 90 and C 129. Solid load bearing concrete masonry units shall comply with ASTM C 145.

4.5.5 Glass block

Glass block shall be labeled to conform to ASTM E 163 or UL 9. [(1)]

4.6 Metal or Wire Lath

4.6.1 Metal lath shall comply with the provisions of ASTM C 847. Wherever metal lath, or wire lath and plaster are used as required protection against the spread of fire, the weight of lath shall be not less than 14 N/m^2 when used in vertical position, and not less than 15 N/m^2 when used in horizontal position. Wire lath shall not be lighter than 2.5 meshes per 25 mm or equivalent.

4.6.2 Weight tags shall be left on all metal lath or wire lath until inspected and approved by the AR.

4.6.3 Metal lath for ceilings below wood joists in construction which is required to be fire resistant shall be attached with 38 × 3 mm, 11.11 mm head barbed roofing nails spaced at intervals not to exceed 150 mm on centers, or equivalent attachment.

4.6.4 Welded wire lath shall comply with the provisions of ASTM C 933.

4.6.5 Woven wire lath shall comply with ASTM C 1032.

4.7 Sprayed Fire Resistant Materials

4.7.1 Description

a) Mineral fiber

Mineral fiber, (preferably Rockwool) combined with a mineral binder, air, and water, forms a very efficient and extremely lightweight fireproofing material. Applied with a special spray gun, the material will bond directly to steel, metal lath, and to most other clean rigid surfaces such as gypsum lath and concrete. In some constructions an adhesive is applied to the surface, and then the mineral fiber is sprayed on while the adhesive is still tacky, to increase the bond to the backing material.

(1) UL = Underwriter's Laboratories

Mineral fiber has excellent fire-resistant qualities as well as acoustical qualities when

applied to the underside of floors and roofs and also to steel structural members, such as columns, beams, girders, and trusses. Mineral fiber acoustical tile has also demonstrated excellent fire-resistant qualities when densely packed, tongued and grooved, and faced with a finish coating.

b) Portland cement

Portland cement plaster is also used for fire protection. Mixing it with lightweight aggregates and mineral fiber greatly improves its fire resistance. It is preferred to gypsum plaster if there is exposure to the weather or high humidity. (See also Clause 5 and Table 2.)

4.7.2 Thickness and density

4.7.2.1 Sprayed fibrous and cementitious materials used for structural fire resistance and fire protection shall provide the fire resistance ratings set forth in this Standard. The density and thickness shall be determined in accordance with Sub-clauses 4.7.2.2 and 4.7.2.3 below.

4.7.2.2 Thickness measurement and acceptance criteria

a) 25% of the structural frame, columns and beams in each story shall be inspected for thickness determination in accordance with ASTM E 605.

b) 10% of beams (other than structural frame members) on each floor shall be selected at random and shall be measured for thickness as required by these methods.

c) Floor thickness measurements, where required, shall be taken on a random basis for each 930 sq. meters of area.

d) The average thickness as determined by this procedure shall not be less than that specified in millimeters subject to a tolerance of ±3 mm. The acceptance of measurements with a minus tolerance greater than 3 mm shall not be permitted. Measurements greater than 3 mm above the required shall not be used to determine the thickness average.

e) Where thicknesses are less than that required, the condition shall be corrected. The location of any uncorrected areas shall be reported to the AR.

4.7.2.3 Density measurement and acceptance criteria

a) There shall be density test specimens taken from a column, a beam and a deck for each 930 sq. meters of floor area or fraction thereof or from each floor if the floor area is smaller than 930 sq. meters in accordance with ASTM E 605.

b) Density sample shall have a density not less than 5% below the specified density according to ASTM E 605.

Where the density is less than the 5% tolerance allowed above, the work shall be corrected to the satisfaction of the AR.

5. SUMMARY OF FIREPROOFING REQUIREMENTS

This Clause provides information regarding fireproofing requirements. It includes the protection of structural parts (Table 1, Sec. 1), the protection of walls and partitions (Table 1, Sec. 2), and the protection of reinforced-concrete floors (Table 1, Sec. 3).

Also in this Clause, general information concerning the materials, mixes, methods and recommendations for fireproofing has been summarized in Table 2.

TABLE 1 - FIREPROOFING REQUIREMENTS *

SECTION 1 PROTECTION OF STRUCTURAL PARTS					
MEMBER TO BE PROTECTED	FIREPROOFING MATERIAL	MINIMUM THICKNESS FOR HOUR RATING ** mm			
		1	2	3	4
STEEL COLUMNS EQUAL OR GREATER THAN 150 × 150 mm	GROUP 1 CONCRETE +	65	50	40	25
	GROUP 2 CONCRETE +	75	50	40	25
	BRICK, CLAY (WITH BRICK FILL)	95	95	95	60
	CONCRETE BLOCK HOLLOW (MOTOR AND BROKEN BLOCK FILL).	75	75	75	75
	CLAY TILE (TWO 51 mm LAYERS)	100	50 ¥	50	50
	SOLID GYPSUM BLOCK WITH TIES	2pl	2pl	50	50
	HOLLOW GYPSUM BLOCK WITH TIES	3pl	3pl	75	75
	POURED GYPSUM MESH	50	40	25	25
	GYPSUM - VERMICULITE ON SELF-FURRING METAL	45	35	35	35
	ON GYPSUM LATH-REINFORCEMENT	40	38	38	38
	GYPSUM - PERLITE ON SELF-FURRING METAL	45	35	25	25
	ON GYPSUM LATH-REINFORCEMENT	40	40	25	25
	SPRAYED FIBER-DIRECTLY TO STEEL	---	50	40	40
STEEL BEAMS, GIRDERS, AND TRUSS MEMBERS (INDIVIDUALLY PROTECTED)	GROUP 1 CONCRETE	50	50	40	25
	GROUP 2 CONCRETE	65	65	50	40
	BRICK OF CLAY, CONCRETE, OR SAND LIME	95	95	60	60
	GYPSUM BLOCKS, SOLID	2pl	2pl	50	50
	GYPSUM BLOCKS, HOLLOW	3pl	75	50	50
	GYPSUM POURED	50	50	40	25
	GYPSUM - VERMICULITE ON SELF-FURRING METAL LATH CAGE	---	---	20	20
	GYPSUM - PERLITE ON SELF-FURRING METAL LATH CAGE	40	40	25	25
	SPRAYED FIBER-DIRECTLY TO ADHESIVE COATED STEEL	80	50	50	50
STRUCTURAL MEMBERS WITH FLOOR AND CEILING PROTECTION	FLOOR=65 mm CONCRETE SLAB ON METAL LATH AND GYPSUM VERMICULITE CEILING	25	20	20	20
	FLOOR=50 mm PRECAST GYPSUM SLAB +½ COVER OF MORTAR AND GYPSUM VERMICULITE CEILING	25	20	20	20
	FLOOR=50 mm CONCRETE SLAB ON METAL LATH AND GYPSUM PERLITE CEILING	25	15	15	15
	FLOOR=50 mm CONCRETE SLAB ON METAL LATH AND GYPSUM VERMICULITE CEILING	---	25	25	25
	FLOOR=70 mm CONCRETE PLANK AND GYPSUM VERMICULITE CEILING	---	25	25	25
	FLOOR=50 mm CINDER CONCRETE SLAB ON STEEL CELLULAR UNITS AND GYPSUM VERMICULITE CEILING	20	20	20	20
	FLOOR=50 mm PERLITE CONCRETE ON STEEL CELLULAR UNITS AND GYPSUM PERLITE CEILING	25	25	25	25
	FLOOR=50 mm REINFORCED CONCRETE ON STEEL CELLULAR UNITS AND GYPSUM PERLITE CEILING	20	20	20	20
	FLOOR=50 mm CONCRETE ON STEEL CELLULAR UNITS AND SPRAYED FIBER CEILING	30	30	30	30
	FLOOR=40 mm CONCRETE +13 mm CEMENT MORTAR FINISH ON STEEL CELLULAR UNITS AND GYPSUM VERMICULITE CEILING	25	25	25	25
	FLOOR=50 mm CONCRETE ON STEEL CELLULAR UNITS AND GYPSUM PERLITE OR GYPSUM VERMICULITE CEILING	---	20	20	20

(to be continued)

TABLE 1 - (continued)

SECTION 1	PROTECTION OF STRUCTURAL PARTS				
REINFORCED-CONCRETE BEAMS, GIRDERS AND TRUSSES-REINFORCING BARS	COARSE AGGREGATE AIR-COOLED SLAG, EXPANDED SLAG, CRUSHED LIMESTONE, CALCAREOUS GRAVEL, SILICEOUS GRAVEL, OR TRAPROCK	40	40	40	40
REINFORCED-CONCRETE SLABS - REINFORCING BARS	GROUP 1 CONCRETE	25	25	20	20
REINFORCED-CONCRETE COLUMNS - REINFORCING BARS	GROUP 1 CONCRETE (300 mm OR LARGER ROUND OR SQUARE COLUMNS). NOT INCLUDING CINDER AGGREGATE	40	40	40	40
	GROUP 2 CONCRETE (430 mm OR LARGER ROUND OR SQUARE COLUMNS). NOT INCLUDING CINDER AGGREGATE	65	40	40	40

(to be continued)

TABLE 1 - (continued)

SECTION 2	PROTECTION OF WALLS AND PARTITIONS								
		BEARING ¦				BEARING			
		MINIMUM THICKNESS FOR HOUR RATING ** mm				MINIMUM THICKNESS FOR HOUR RATING ** mm			
		4	3	2	1	4	3	2	1
BRICK OF CLAY SHALE,CONCRETE OR SAND LIME	SOLID UNPLASTERED	200	200	100	---	--	--	--	100
	SOLID PLASTERED ONE SIDE	200	200	200	100	--	--	100	100
	SOLID PLASTERED BOTH SIDES	200	200	100	100	--	--	100	100
	HOLLOW CAVITY	250	250	250	250	--	--	--	--
HOLLOW STRUCTURAL TILE, CLAY OR SHALE	UNPLASTERED	300	300	300	200	--	--	150	100
	PLASTERED ONE SIDE	300	300	200	200	--	---	--	---
	PLASTERED BOTH SIDES (SEE NOTE 3)	300	200	200	200	--	150	100	100
HOLLOW STRUCTURAL TILE, CLAY OR SHALE BONDED TO 100 mm BRICK FACING	UNPLASTERED	200	100	---	---	--	---	---	----
	PLASTERED TILE SIDE	100	----	----	----	--	----	----	---
HOLLOW STRUCTURAL FACING TILE	UNPLASTERED	---	---	----	----	--	150	----	---
	PLASTERED ONE SIDE	---	---	---	----	--	150	100	100
GYPSUM BLOCK	SOLID UNPLASTERED	---	---	---	---	130	75	75	50
	HOLLOW UNPLASTERED	---	---	---	---	---	----	---	75
	HOLLOW PLASTERED	---	----	---	---	100	75	75	75
HOLLOW CONCRETE MASONRY UNITS	AGGREGATE EXPANDED BURNT CLAY OR SHALE, CRUSHED [UNPLASTERED								
	[PLASTERED								
	LIMESTONE, EXPANDED SLAG, OR CINDERS	250	200	200	---	---	---	150	100
	EXPANDED SLAG OR PUMICE AGGREGATE [UNPLASTERED	200	200	---	---	150	150	100	75
	[PLASTERED	200	150	---	---	----	150	150	75
		150	---	---	---	150	150	75	---
	CALCAREOUS SAND AND GRAVEL [UNPLASTERED	--	---	---	250	---	---	---	---
	[PLASTERED	250	---	---	---	----	---	---	100
	SILICEOUS SAND AND GRAVEL [UNPLASTERED	300	¾	¾	¾	¾	¾	¾	¾
	[PLASTERED	300	¾	¾	¾	¾	¾	¾	100
PLAIN CONCRETE	SOLID MONOLITHIC WALLS	190	165	140	---	---	----	----	100
REINFORCED CONCRETE (MONOLITHIC)	SOLID WALLS [GROUP 1	165	150	130	90	---	---	---	---
	[GROUP 2	190	165	140	---	---	---	---	100
	UNPLASTERED SOLID WALLS PLASTERED BOTH SIDES [GROUP 1	130	100	---	---	---	---	75	75
	[GROUP 2	150	130	100	---	---	---	---	75
STONE MASONRY	SOLID WALLS	300	300	300	200	---	---	---	---

(to be continued)

TABLE 1 - (continued)

SECTION 2	REINFORCED CONCRETE FLOORS
4-HR. RATING	115 mm slab, expanded slag aggregate (20 mm protection to reinforcement). 150 mm slab, air-cooled slag aggregate (25 mm protection to reinforcement). 130 mm slab, limestone aggregate and 25 mm gypsum vermiculite plaster ceiling, metal lath (electrical raceways and junction boxes in slab). 75 mm slab, limestone aggregate and 25 mm gypsum vermiculite plaster ceiling, metal lath.
3-HR. RATING	150 mm slab, traprock, or crushed limestone, or calcareous gravel, or siliceous gravel aggregate (25 mm protection to reinforcement). 100 mm slab, limestone aggregate hung ceiling of 20 mm gypsum vermiculite plaster metal lath (electrical raceways and junction boxes in slab). 50 mm slab, limestone aggregate hung ceiling of 20 mm gypsum vermiculite plaster, metal lath.
2-HR. RATING	120 mm slab, traprock, or siliceous gravel aggregate (20 mm protection to reinforcement). 120 mm slab, calcareous gravel, or crushed limestone aggregate (25 mm protection to reinforcement).
1-HR. RATING	100 mm slab, siliceous gravel aggregate (20 mm protection to reinforcement).

Note 1 : For more detail information see chapter 6, 7: IBC –2000.

Legend

***** Based on National Board of Fire Underwriters (NBFU) Publication, "Fire Resistance Ratings".

For further details on construction and materials, see NBFU Publication, "Fire Resistance Ratings".

****** Fire Resistance Rating. The time in minutes or hours, that materials or assemblies have withstood a fire exposure as established in accordance with the test of NFPA 251 "Standard Methods of Fire Tests of Building Construction and Materials".

+ Not more than 10% unburned coals and not over 5% ash.

¥ With fill and ties.

! Steel cellular units or other steel structural units.

q 25 mm for calcareous aggregate.

f None or noncombustible members framing into wall.

pl = Ply, layer.

Notes:

1) Group 1 concrete aggregates are blast-furnace slag,limestone, calcareous gravel, traprock, burnt clay or shale, cinders containing not more than 25% of combustible material and not more than 5% of volatile material, and other materials meeting the requirements of these specifications and containing not more than 30% quartz, chert, flint, and similar materials.

2) Group 2 concrete aggregates are granite, quartzite, siliceous gravel, sandstone, gneiss, cinders containing more than 25% but not more than 40% of combustible material and not more than 5% of volatile material and other materials meeting requirements of these specifications, and containing more than 30% of quartz, chert, flint, and similar materials.

3) For number of units and cells see NBFU "Fire Resistance Ratings".

TABLE 2 - SUMMARY OF MATERIALS, MIXES, METHODS AND RECOMMENDATIONS

MATERIALS	MIX	METHODS	ADVANTAGES	DISADVANTAGES	RECOMMENDED APPLICATION
1. CONCRETE (MOULDED)	250 KG/m^3 (CEMENT) (a)	MEMBERS TO BE ENCASED IN CONCRETE.	VERY GOOD RESISTANCE TO FIRE, FIREWATER AND OF GOOD QUALITY, LITTLE OR NO MAINTENANCE IS REQUIRED.	COST HIGHER THAN FOR ANY OTHER FIREPROOFING METHOD. HEAVY WEIGHT AFFECTING SIZES OF STRUCTURAL MEMBERS TIME-CONSUMING WORK.	TO BE SELECTED FOR LOWER PART OF STANCHIONS AND FOR WHER MECHANICAL DAMAGE CAN BE EXPECTED.
2. VERMICULITE CEMENT	6:3:2:1 (b)	1. PREFABRICATED SHEETS OR BLOCK WITH PLASTER FINISH. 2. PLASTERED OR SPRAYED ON METAL LATH FIXED TO THE STEEL SECTION WITH PLASTER FINISH.	GOOD RESISTANCE TO FIRE. LOW CAST IN COMPARISON WITH CONCRETE. LIGHT WEIGHT SHORT INSTALLATION TIME EASY TO REPAIR.	NOT VERY RESISTANT TO FIRE WATER AND MECHANICAL DAMAGE. STEEL WORK MAY CORRODE OWING TO CONDENSATION AND INGRESS OF WATER THROUGH CRACKS OF FINISHED LAYER.	FOR STEELWORK INSIDE BUILDINGS.
4. CEMENT/SAND	1:2	RENDERING ON CLAY LATH			TO BE CONSIDERED FOR INSIDE BUILDING ONLY.

Notes:

1) The above-mentioned methods have been selected because they are the most commonly used.

2) Composition of the mixes referred to above:

(a) Concrete: 1 part portland cement, 2 parts sand and 4 parts gravel (by volume).

(b) Vermiculite: 6 parts coarse vermiculite, 3 parts fine vermiculite, 2 parts Portland cement and 1 part diatomite (by volume).

6. AREAS WHERE FIREPROOFING SHALL BE APPLIED

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

Note:

Fire proofing of important building shall be taken into consideration & specified by the A.R.

6.1 Equipment Supporting Structures

(Including pressure storage spheres and shell & tube heat exchangers)

Fireproofing of equipment supporting structures, shall be applied in those areas where "flammable" liquids are processed, with the possibility that a sustained fire arises.

In those areas where "non-flammable" liquids are processed and which are directly adjacent to the above-mentioned areas, fireproofing can be omitted when, owing to lay-out and/or design of floors, e.g. slope, diversion wall, elevations etc., the possibility of a sustained fire may be considered remote.

6.1.1 For heat exchangers fireproofing of structural steel support members shall cover all columns, beams, saddles, struts, skirt sheets, and other members required for static strength bracing, up to and including those at the support level of the vessel. Other bracing members which are intended solely to absorb wind, earthquake or surge forces shall not be fireproofed.

For pressure storage spheres, fireproofing encasement shall not cover any portion of the supports at points where they are welded to the shell.

6.1.2 Fireproofing of structural steel support members (such as columns, beams, saddles, struts, skirt sheets) for vessels containing flammable liquids or flammable materials is required to the extent indicated in Table 3 of Part II.

6.1.3 Fireproofing of the inside surface of vessel skirt sheets is not required where: the skirt rests on a concrete pedestal constructed as a solid or continuous base and the skirt (or continuous base pedestal) is provided with a single opening no larger than 500 mm or equivalent diameter. Skirt vents, which are required for internally insulated vessels operating at fluid temperatures above 260°C are considered as openings.

The cylindrical steel skirts of vertical vessels shall be fireproofed with an internal and external protection of at least 50 mm of reinforced concrete, or 112 mm of brickwork or 40 mm of reinforced vermiculite cement except that the skirts of vessels 760 mm diameter or less need not be protected internally.

6.1.4 Skirt openings for piping shall have a 13 mm maximum clearance between the pipe OD and the skirt, when the inside of the skirt is not fireproofed.

Internally insulated vessels operating at fluid temperatures above 260°C shall not have the top 300 mm of their supports or skirt sheet fireproofed.

6.1.5 The fireproofing system on the outside surface of vessel skirt sheets shall include a continuous cap ring or flashing to prevent water from entering between the fireproofing and the skirt.

6.1.6 Fireproofing of supports for spheres and foundations of tanks storing liquids with atmospheric boiling points below 45°C shall be designed to withstand the thermal shock encountered in a spill. Such designs shall be approved by the AR.

6.1.7 Structural members supporting fired heaters above grade shall be fireproofed for heaters handling flammable materials. Structural steel members supporting fired heaters in other services shall be fireproofed if within 6m horizontally of a fired heater handling flammable liquid in the tubes.

6.1.8 Fireproofing of fired heater supports shall cover only support columns from the foundation to the bottom of the heater. Horizontal support beams in contact with the fired heater floor shall not be fireproofed, except at the junction point with a vertical column. Horizontal supports with a clearance of 300 mm or more below the underside of the heater floor shall be fireproofed.

6.1.9 Structural supports for elevated equipment associated with fired heaters, such as coke drums, transfer line exchangers, air preheaters, air inlet stacks, forced draft fans and ducts, shall be fireproofed if located within 6 m horizontally of a fired heater handling flammable liquid in the tubes.

6.1.10 Fireproofing of supports for elevated compressors shall cover columns and cross beams only, and shall extend up to and including the support level of the compressors.

6.1.11 Anchor bolts located above ground level for elevated vessels should be covered with an un-reinforced weak mix cement or vermiculite cement.

6.2 Pipe Supporting Structures

Steel structures for overhead pipe tracks, with a height of 1.5 m and more, shall only be fireproofed when located within a distance of 6 m or 3 m from a source of fire hazard, for "inside plot" and "outside plot" conditions respectively.

A source of fire hazard will be considered to be any location, either at grade or elevated level, where hydrocarbons, e.g. from leaking pump and valve glands, drains, flanged joints, etc., may cause fire owing to:

- self-ignition;

- ignition from contact with hot equipment, piping, etc.

6.2.1 Pipe supports, "catch beams", and dummy pipe supports require fireproofing for the following conditions:

6.2.1.1 Columns; cross beams, and those longitudinal beams and other support members which carry a direct pipe load, shall be fireproofed if:

a) The piping contains flammable material or nonflammable toxic material (e.g. acids, bases, chlorine) and the pipe supports are located within 6m horizontally of a fired heater handling flammable liquids.

b) Pipe supports are located within a diked enclosure of refrigerated tanks. The fireproofing shall be designed to withstand the thermal shock encountered in a spill when the liquid stored has an atmospheric boiling point below -45°C. Such designs shall be approved by the Iranian Oil Industries.

6.2.1.2 Additional fireproofing of pipe supports may be required as indicated by the Iranian Oil Industries where there may be potential for prolonged severe fire exposure and piping contains flammable material or non-flammable toxic material. These areas are:

a) Within 6 m horizontally of a source of sustained fire;

b) beneath air-cooled heat exchangers which have their structural members fireproofed per Sub-clause 6.3.1.

6.2.1.3 Catch beams

Where piping containing flammable materials is hung by rods or spring type supports from a fireproofed member a "catch beam" shall be provided. The "catch beam" and its support members shall be fireproofed.

6.2.1.4 Dummy pipe supports or equivalent structural members, which are attached to or resting on fireproofed members shall be fireproofed if the supported pipe contains flammable materials or if failure of the supported pipe will damage other equipment handling flammable materials.

6.2.2 Unless otherwise specified, the extent of fireproofing applied to pipe supports shall be governed by the following:

a) fireproofing of columns and cross beam members shall extend up to the support level of the piping;

b) fireproofing of horizontal beams shall be carried to, but not including, the next supporting column.

6.3 Supports for Air-Cooled Heat Exchangers

Structural members supporting air-cooled heat exchangers shall be fireproofed to the extent indicated:

6.3.1 All supports when the exchanger unit handles flammable liquids with an inlet temperature above 310°C.

6.3.2 If the structural members are within 6 m horizontally of a source of sustained fire.

6.3.3 If the exchanger unit is located above a vessel or equipment that contains flammable material.

6.4 Parts not to be Fireproofed

The following parts of the supporting structures mentioned in Sub-clauses 6.1, 6.2 and 6.3 above need not be protected:

- bracings for wind load only,
- crane tracks and trolley beams,

- supporting beams for pipelines,
- platforms designed for live load only,
- stairways and walkways,
- anchor bolts at ground level,
- bottom flange of lintels spanning not over 1.8 m,
- shelf angles or plates that are not a part of the structural frame,

Note:

If a supporting structure as mentioned above is to form part of a steel building, the trusses or roof beams and the purlins should not be fireproofed.

7. DESIGN FEATURES FOR STRUCTURES TO BE FIREPROOFED

7.1 Bracings

With regard to bracings in structures which are to be fireproofed, the following shall be taken into account in the design stage:

a) wind bracings shall preferably be installed in such places where adjacent members need not be fireproofed;

b) load-carrying bracings shall be avoided in parts of structures which are to be fireproofed in accordance with this Standard.

7.2 Equipment Supporting Beams

The lay-out of equipment supporting beams shall be made in such a way that in the case of fireproofing the number of beams to be protected is kept to a minimum.

7.3 Protection of Fireproofing

The top of any fireproofing shall be protected by cover plates which are continuously welded to the steel structure so as to prevent ingress of rain water between structure and fireproofing.

7.4 Marks on Drawings

All members to be fireproofed are to be marked "FP" on relevant drawings.

8. ENVIRONMENT AND WEATHER PROTECTION

8.1 Effective flashing and sealing is essential to prevent rainwater or other fluids from percolating behind the fireproofing material.

Cement capping alone on top of brickwork and hard coating finished off against a steel surface are both unreliable means of protection. An acceptable method is to finish the concrete casing with a 30° fall away from the steel column and to seal the steel/concrete joint with a bitumastic or similar sealing compound poured or troweled into a formed channel at the top of the concrete; flashing should be provided wherever practicable.

8.2 Additional measures to protect both the fireproofing materials and the steelwork beneath are necessary in chemically corrosive environments and these are to be discussed with the AR.

PART II

FIRE-RESISTIVE MATERIALS AND SYSTEMS

1. GENERAL

Materials and systems used for fire-resistive purposes shall be limited to those specified herein, unless accepted under the procedure given in Sub-clause 1.1 or 1.2.

For the purpose of determining the degree of fire resistance afforded, the materials of construction listed in this Part shall be assumed to have the fire resistance rating indicated in Table 1.

1.1 Qualification by Testing

Material or assembly of materials of construction tested in accordance with the requirements set forth in National Board of Fire Underwriters (NBFU) Publication," Fire Resistance Ratings", shall be rated for fire resistance in accordance with the results and conditions of such tests.

1.2 Calculation Fire Resistance

The fire resistive rating of a material or assembly may be established by calculations in accordance with the tests of NFPA 251 "Standard Methods of Tests of Building Construction and Materials".

2. DEFINITIONS

Flammable Liquids

Low flash liquids (flash point below 55°C) and high flash liquids (flash point 55°C or higher) when handled at temperatures above or within 8°C of their flash points. (See Table 3)

Flammable Materials

Flammable liquids; hydrocarbon vapors; and other vapors, such as hydrogen, carbon disulfide and gas fuel that are readily ignitable when released to atmosphere. (See Table 3)

Source of Sustained Fire

Equipment which would involve both a high potential for fire, and added factors which limit the rapid control of or the extinguishment of the fire. Such services and conditions are as follows:

a) Specific equipment with a high potential for fire:

1) Pumps with a rated capacity over 45 m^3/h handling flammable liquids.

2) Gas compressors over 150 kW handling flammable materials.

3) Fired heaters handling flammable liquid in the tubes.

4) Vessels, heat exchangers, and other equipment containing flammable liquids at a temperature over 315°C including combustible liquids or vapor or both.

b) Added factors to create a potential for sustained fire would need to include at least two of the following conditions as might occur where new facilities are to be located within an existing process unit:

1) Congestion resulting from spacing inadequacies.

2) Inaccessibility to good cooling from at least one fixed location fire monitor or a fixed firewater spray system.

3) Lack of rapid isolation.

Carbonate Aggregate Concrete

Concrete made with aggregates consisting mainly of calcium or magnesium carbonate, e.g., limestone or dolomite.

Cellular Concrete

A lightweight insulating concrete made by mixing a preformed foam with portland cement slurry and having a dry unit weight of approximately 4.8 kN/m^3.

Lightweight Aggregate Concrete

Concrete made with aggregates of expanded clay, shale, slag,or slate or sintered fly ash, and weighing 13.6 to 18.4 kN/m^3.

Perlite Concrete

A lightweight insulating concrete having a dry unit weight of approximately 4.8 kN/m^3 made with perlite concrete aggregate. Perlite aggregate is produced from a volcanic rock which, when heated, expands to form a glass like material of cellular structure.

Sand Lightweight Concrete

Concrete made with a combination of expanded clay, shale, slag, or slate or sintered fly ash and natural sand. Its unit weight is generally between 16.8 and 19.2 kN/m^3.

Siliceous Aggregate Concrete

Concrete made with normal weight aggregates consisting mainly of silica or compounds other than calcium or magnesium carbonate.

Vermiculite Concrete

A lightweight insulating concrete made with vermiculite concrete aggregate which is laminated micaceous material produced by expanding the ore at high temperatures. When added to a portland cement slurry the resulting concrete has a dry unit weight of approximately 4.8 kN/m^3.

Glass Fiber Board

Fibrous glass roof insulation consisting of inorganic glass fibers formed into rigid boards using a binder. The board has a top surface faced with asphalt and kraft reinforced with glass fiber.

Mineral Board

A rigid felted thermal insulation board consisting of either felted mineral fiber or cellular beads of expanded aggregate formed into flat rectangular units.

Ceramic Fiber Blanket

A mineral wool insulation material made of alumina-silica fibers and weighting 0.64 to 1.6 kN/m^3.

TABLE 3 - CONDITIONS GOVERNING EXTENT OF FIREPROOFING REQUIRED

EQUIPMENT TYPE OR CONFIGURATION	LOCATION W - WITHIN PROCESS UNIT AREA O - OUTSIDE PROCESS UNIT AREA	SERVICE FL - FLAMMABLE LIQUID FM - FLAMMABLE MATERIAL	OTHER LIMITING FACTORS
a) SINGLE HORIZONTAL VESSEL SUCH AS DRUM OR SHELL AND TUBE EXCHANGER	W	FM	FIREPROOF SUPPORTS IF BOTH CONDITIONS EXIST: 1) VESSEL DIAMETER > 750 mm AND 2) SUPPORT MEMBERS HIGHER THAN 300 mm AT THE LOWEST POINT OF MEASUREMENT.
	O	FL ONLY	
b) STACKED HORIZONTAL DRUMS OR SHELL AND TUBE EXCHANGERS	W	FM	FIREPROOF THE SUPPORTS FOR THE BOTTOM VESSEL AND ALL INTERMEDIATE VESSELS. FIREPROOF THE SUPPORTS FOR THE TOP VESSEL ONLY IF BOTH CONDITIONS EXIST: 1) VESSEL DIAMETER > 750 mm AND 2) SUPPORT MEMBERS HIGHER THAN 300 mm AT THE LOWEST POINT OF MEASUREMENT.
	O	FL ONLY	
c) SINGLE VERTICAL TOWER, DRUM, OR SHELL AND TUBE EXCHANGER	W	FM	FIREPROOF ALL SUPPORTS INCLUDING INSIDE OF VESSEL SKIRTS. CASES WHERE INSIDE OF VESSEL SKIRT NEED NOT BE FIREPROOFED ARE DEFINED IN SUB-CLAUSE 6.1.3 OF PART I
	O	FL ONLY	
d) ANY VESSEL OR AUXILIARY EQUIPMENT SUCH AS STEAM DRUMS, WASTE HEAT BOILERS, AND CATALYST HOPPERS.	W	NOT FM	FIREPROOF SUPPORTS IF VESSEL OR AUXILIARY EQUIPMENT IS LOCATED WITHIN 6 m HORIZONTALLY OF EQUIPMENT CONTAINING FLAMMABLE MATERIALS.

3. PROTECTION OF STRUCTURAL MEMBERS

3.1 General

Structural members having the fire-resistive protection set forth in Table 1 shall be assumed to have the fire resistance ratings set forth therein.

3.2 Protective Coverings

3.2.1 Thickness of protection

The thickness of fire-resistive materials required for protection of structural members shall be not less than set forth in Table 1, except as modified in this section. The figures shown shall be the net thickness of the protecting materials and shall not include any hollow space back of the protection.

3.2.2 Unit masonry protection

Where required, metal ties shall be embedded in transverse joints of unit masonry for protection of steel columns. See also Sub-clause 4.6 of Part I.

3.2.3 Reinforcement for cast-in-place concrete column protection

Cast-in-place concrete protection for steel columns shall be reinforced at the edges of such members with wire ties of not less than 4.5 mm in diameter wound spirally around the columns on a

pitch of not more than 200 mm or by equivalent reinforcement.

3.2.4 Embedment of pipes

Conduits and pipes shall not be embedded in required fire protection of structural members.

3.2.5 Ceiling protection

Where a ceiling forms the protective membrane for fire-resistive assemblies, the constructions and their supporting horizontal structural members need not be individually fire protected except where such members support directly applied loads from more than one floor or roof. The required fire resistance shall be not less than that required for individual protection of members.

3.2.6 Plaster application

Plaster protective coatings may be applied with the finish coat omitted when they comply with the design mix and thickness requirements of Table 1.

3.2.7 Truss protection

Where trusses are used as all or part of the structural frame and protection is required, such protection may be provided by fire-resistive materials enclosing the entire truss assembly on all sides for its entire length and height. The required thickness and construction of fire-resistive assemblies enclosing trusses shall be based upon the results of full-scale tests or combinations of tests on truss components or upon approved calculations based on such tests which satisfactorily demonstrate that the assembly has the required fire resistance.

3.3 Protected Members

3.3.1 Attached metal members

The edges of lugs, brackets, rivets and bolt heads attached to structural members may extend to within 25 mm of the surface of the fire protection .

3.3.2 Reinforcing

Thickness of protection for concrete or masonry reinforcement shall be measured to the outside of the reinforcement except that stirrups and spiral reinforcement ties may project not more than 25 mm into the protection.

3.3.3 Bonded prestressed concrete tendons

For members having a single tendon or more than one tendon installed with equal concrete cover measured from the nearest surface, the cover shall be not less than that set forth in Table 1.

For members having multiple tendons installed with variable concrete cover, the average tendon cover shall be not less than that set forth in Table 1 provided:

a) The clearance from each tendon to the nearest exposed surface is used to determine the average cover.

b) In no case can the clear cover for individual tendons be less than one half of that set forth in Table 1. A minimum cover of 20 mm for slabs and 25 mm for beams is required for any aggregate concrete.

c) For the purpose of establishing a fire-resistive rating, tendons having a clear covering less than that set forth in Table 1 shall not contribute more than 50 percent of the required

ultimate moment capacity for members less than 2260 cm^2 in cross-sectional area and 65 percent for larger members. For structural design purposes, however, tendons having a reduced cover are assumed to be fully effective.

3.4 Spray Applied Fireproofing

The density and thickness of spray applied fireproofing shall be determined following the procedures set forth in Subclause 4.7.2 of Part I.

4. WALLS AND PARTITIONS

4.1 General

Fire-resistive walls and partitions shall be assumed to have the fire resistance ratings set forth in Table 1.

4.2 Combustible Members

Combustible members framed into a wall shall be protected at their ends by not less than one half the required fireresistive thickness of such wall.

4.3 Exterior Walls

In fire-resistive exterior wall construction the fire resistive rating shall be maintained for such walls passing through attic areas.

4.4 Penetrations

Penetrations in walls requiring protected openings shall be fire stopped. Firestopping shall be of an approved material securely installed and capable of maintaining its integrity when subjected to test temperatures prescribed in NFPA 251 Standard Methods of Tests of Building Construction and Materials" for the specific wall or partition. Openings in walls nd partitions shall be protected by means of fire-resistive assemblies. These are the assemblies of fire doors, fire windows, r fire dampers, including all required hardware, anchorage, frames and sills. The fire-protecting rating of all ypes of required fire assemblies shall be determined in accordance with the requirements specified in UBC Standards 3.2, 43.4 and 43.7. For more detail information see chapter 6 , 7: IBC-2000

5. FLOOR-CEILINGS OR ROOF-CEILINGS

5.1 General

Fire-resistive floor ceiling or roof ceiling construction systems shall be assumed to have the fire resistance ratings set orth in Table 1 of Part I.

Penetrations in floors and ceilings requiring protected openings shall be fire stopped. Firestopping shall be of an approved aterial, securely installed and capable of maintaining its integrity when subjected to the time temperature curve f NFPA 251 "Standard Methods of Fire Tests of Building Construction and Materials" for the specific floor-ceiling or oof-ceiling construction.

5.2 Floors

Fire-resistive floors shall be continuous and all openings for mechanical and electrical equipment shall be enclosed. Openings extending vertically through floors shall be enclosed in a shaft of fire-

resistive construction.

5.3 Roofs

Fire-resistive roofs may have the same openings as permitted for floors and may contain other openings as permitted by his Standard.

5.4 Ceiling Panels

Where the weight of lay-in roof-ceiling panels, used as part of fire-resistive floor-ceiling assemblies is not adequate to esist an upward force of 4.8 N/m^2, wire or other approved devices shall be installed above the panels to prevent vertical isplacement under such upward force.