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	CLIENT		IOCL Paradip Refinery	
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SPECIFICATION FOR FIRE PROOFING OF STEEL STRUCTURES

A	08-11-2019	Issued for Design	SUR	KRK	JP / KC	JMC
REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED	AUTHORIZED

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1. INTRODUCTION

INDIAN OIL CORPORATION LIMITED (IOCL) has awarded Fax of Acceptance (FOA) dated 29th August 2019 to M/s. Technip India Limited (TPIL) for Consultancy services (PMC/EPCM services) for overall project management, FEED Review / FEED, Detailed Engineering, Procurement & expediting services, Tendering & award, Construction Management & Supervision, Assistance in start-up, Commissioning & performance test runs for installation of a Standby SRU of 525 TPD capacity and execution of Additional tanks for Paradip Refinery, Odisha, India.

2. DEFINITIONS & ABBREVIATIONS

Abbreviation	Definition /Expanded form
IOCL/ CLIENT	Indian Oil Corporation Limited
PMC/ CONSULTANT	Technip India Limited
LICENSOR	Party selected by IOCL for process technology ownership for any UNIT
CONTRACTOR	Party whose services are obtained for performing the works specified as part of LSTK / packages.
EPCM	Engineering, Procurement & Construction Management Services.
LSTK	Lump Sum Turn Key portion of the work to be executed by CONTRACTOR
FEED	Front End Engineering Design
AUTHORISED REPRESENTATIVE	IOCL's/ CONSULTANT's representative authorized to act for and on behalf of them.
VENDOR	Any third party supplying the equipment/materials for setting up the Plant
PROJECT	Indicates Standby SRU and Additional tanks Project, Paradip Refinery
SITE	Indicates Paradip Refinery in Odisha, India
UNIT	Indicates any particular portion of the project to be built which can be Process related or Utilities/Offsites related
SRU	Sulphur Recovery Unit
BIS	Bureau of Indian Standards

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3. SCOPE

This specification covers the general requirements of materials and the method of application for external protection of structural steel members, vessel/column skirts, saddles and supports against fire.

This JSS covers typical General specification for some standard items only and the CONTRACTOR shall comply with the requirement as given in 080557C-000-JSD-1700-001/002 for specific cases and for any other items not mentioned/specified in this JSS. The requirement for various type of building as specified in the document 080557C-000-JSD-1700-001/002 shall be the governing one. The CONTRACTOR shall submit the detailed specification for the other items not covered in this specification for Approval by OWNER'S/ENGINEER IN CHARGE during execution.

4. APPLICABLE CODES

The Indian Standard Codes applicable to this section shall include but not limited to the following:

- IS 1566 : Hard drawn steel wire fabric for concrete reinforcement.
- IS 6433 : Specification for guniting equipment.
- UL 1709 : Rapid rise fire tests of protection of structural steel
- OISD-164 : Fire Proofing in Oil & Gas Industry

5. PRIORITY OF REQUIREMENTS

In case of any variation and discrepancy in condition between the special conditions, this specification and codes, order of priority shall be as under: -

- 1) Special conditions
- 2) This specification
- 3) Codes

6. GENERAL

6.1. Purpose

Fire proofing is aimed at providing resistance to all the load bearing steel structures and equipment supports that would collapse under fire conditions and contribute to the intensity of the fire.



This fire resistance would allow the people to be evacuated and fire to be suppressed.

Therefore, the supports of all potential fire sources shall be fireproofed.

The support of non-potential fire hazards shall also be fireproofed, if their collapse is likely to endanger other hazardous equipment's.

6.2. Fire Resistance Rating

A minimum of 2 hours fire resistance under hydrocarbon fire condition as per UL1709 and as specified in OISD-164, shall be applied, unless specified otherwise.

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7. CRITERIA FOR FIREPROOFING



7.1. Pipe Racks

- 7.1.1. Pipe rack main members such as columns, girder, beams and vertical bracings withstanding long term loads shall be fireproofed up to the first pipe support level, in the fire hazardous area, unless specified otherwise.
- 7.1.2. Pipe rack supports shall be fireproofed if they are within fire proofing zone or if they are in 20-30 feet distance from the open ditches/Drainage channels, likely to receive large accidental spills of hydrocarbons.
- 7.1.3. If a Pipe rack carries piping that has a diameter greater than 6 inches at levels above the first pipe support level or large hydrocarbon pumps are installed beneath the Pipe rack, fire proofing shall be considered up to and including the level that is nearest to 9.1 M elevation
- 7.1.4. Where equipment's such as Air Coolers are supported on top of the pipe rack, fire proofing shall be provided for all horizontal and vertical and vertical support members on all levels in Pipe rack including support members for Air Coolers regardless of its elevation, as per OISD-164.
- 7.1.5. The top flanges of beams supporting the pipes shall not be fire proofed.
- 7.1.6. Wind or earthquake bracings and non-load bearing stringer beams that run parallel to piping need not to be fireproofed.
- 7.1.7. Fire proofing shall be provided for knee and diagonal bracing that contributes to the support of vertical loads.
- 7.1.8. Pipe racks outside the fire hazardous area shall not be fire proofed.

7.2. Equipment Supporting Structures

- 7.2.1. Extent of fire proofing as per OISD-164.
- 7.2.2. Where structure supports the equipments classified to the potential fire hazard, columns shall be fire proofed from the base plates to the equipment support level.

The beams and bracings transmitting the equipment loads to the columns shall be fireproofed. Platforms, stairways and their supports shall not be fireproofed.
- 7.3. Where structure support non-fire potential Equipment within the fire proofing zone, fire proofing shall be considered for the vertical and horizontal members from Grade up to 9.1m level.
- 7.4. Fire proofing shall be considered for steel saddles that support horizontal heat exchangers, condensers and drums that have diameter greater than 760 mm.
- 7.5. For Common Chimneys or Stacks handling flue gas from several heaters, Structural support for ducts or Breeching between heaters and stacks shall be fireproofed, as per OISD-164.

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- 7.6. Anchor bolts shall be completely fireproofed using a removable box construction which allows access to the anchor bolts and securing nuts.

8. **FIREPROOFING THICKNESS**

Fire-proofing of steel structures should be with vermiculite, wherever required as per OISD-STD-164, and should be done for 2 hours fire rating as per Specifications.

Fire resistance of a material is defined by fire rating, evaluated through a fire test based on applied thickness and time taken to reach the defined critical steel temperature. Fire rating adopted is based on UL-1709 rapid rise fire tests of protection materials for structural steel, conducted by Underwriters Laboratory, USA. In this test, fire resistance of a material is evaluated on a W10x49 steel column as per UL-1709 fire curve and fire rating is published in a UL design number under XR category for thickness and time. In addition to the fire rating, under this test, material for exterior use is also evaluated for accelerated ageing, high humidity, salt spray, wet-freeze-dry cycling, acid spray, solvent spray etc.

Thickness of fireproof coating to be applied shall be based on the following,

Type 1: In-situ cement concrete for application up to 1.8m from grade level for steel structures shall be applied with minimum 65mm thickness.



Type 2: Structural steel members such as column, beam etc. which shall be protected for 2 hours from reaching critical temperature 538°C, shall be applied with vermiculite based lightweight cementitious fireproof of thickness corresponding to 2 hours fire rating as per respective UL design number under UL-1709 (XR category) subject to a minimum of 30mm.

Type 3: For equipment skirts/ saddles/ supports (which shall be protected for 2 hours from reaching critical temperature 427°C), 2 hours fire rating as per UL design is not adequate as the UL-1709 test is based on 538°C critical temperature. Therefore, for the required fire protection from reaching 427°C, higher thickness shall be necessary. For this, fireproof thickness corresponding to 3 hours fire rating as per respective UL design number under UL-1709 (XR category) shall be adopted subject to a minimum of 30mm.

9. **MATERIALS**

All materials to be used shall conform to the requirements of UL-1709/ respective BIS codes/respective acceptance criteria (as applicable). Materials shall meet the minimum acceptance criteria given under this section. Samples, test results and approval certificates for all materials shall be submitted and got approved from the Engineer-in-Charge before execution of work.

- 1) Vermiculite based lightweight cementitious fireproofing system shall have following compatible components:
 - ♦ Primer
 - ♦ Reinforcing system
 - ♦ Fireproof coating as per UL-1709

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- ◆ Curing
- ◆ Water shed sealing at terminating edges/ metal joints
- ◆ Weather barrier finish coat

2) In-situ cement concrete fireproofing system shall have following compatible components:

- ◆ Primer
- ◆ Reinforcing system
- ◆ Cement concrete
- ◆ Curing
- ◆ Water shed sealing at terminating edges/ metal joints
- ◆ Weather barrier finish coat

9.1. Vermiculite Based Lightweight Cementitious Fireproofing Material

Vermiculite based lightweight cementitious fireproof material shall be UL certified for UL-1709 (Rapid rise fire test of protection materials for structural steels), UL classified under XR category and covered under UL follow up service (indicated by UL mark/ sticker on the packing). For list of UL certified materials. UL website (www.ul.com) shall be referred. The essential criteria for the material shall be:

- 1) Must be UL-1709 certified having UL design number under XR category
- 2) Listed on UL website under specified category
- 3) Bear UL-1709 mark/ sticker on packing bags/ container

The material shall be factory-blended, supplied in single component pre-mixed dry form, non-flaking and non-dusting suitable for spray-application, with added mold and fungi inhibitor. Material shall not contain asbestos & mineral wool and shall not contain more than 1% Sulphate (expressed in SO₃). The material shall be free from toxicity release when subjected to heat.



In addition to the UL-1709 certificate, the contractor shall supply test certificate covering the information for the supplied batches of material.

Fire proofing materials shall be stored in well ventilated, dry place away from source of heat & direct sunlight. Special storage requirements such as temperature, humidity, stacking height, etc. as per manufacturer's specifications shall be ensured.

9.2. Reinforcement (for both Vermiculite based cementitious and In-situ concrete)

9.2.1. Expanded Metal Steel Sheet/ Lath

Expanded metal steel sheets shall conform to IS:412 and shall be of approved type. Size of the mesh shall be 10mm x 40mm with strands of 2.5mm width and 1.0mm thickness.

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9.2.2. Wire Fabric

Welded wire fabric to be used as reinforcement, shall conform to IS:1566 and shall be of approved type. Mesh size shall be 50mm x 50mm and 3mm thickness.

9.2.3. Attachments

1) Mild Steel Tie Wire:

MS Tie wires shall be minimum 16 SWG and galvanized (having minimum zinc coating of 100 g/m²).

2) Mild Steel Nuts:

MS Nuts shall be of mild steel and conform to IS:1367 and IS:2585.

3) Cover plates:

Cover plates shall conform to IS:2062 Grade-BR.

4) Cover blocks:

Cover blocks shall be prepared in cement coarse sand mortar (1:3) with minimum 50mmx50mm size of thickness equal to half of the fireproofing thickness with MS Tie wire of sufficient length protruding from them for tying with the wire fabric.

5) Bitumen mastic flashing

Bitumen mastic flashing shall conform to IS:3037.

9.3. Curing Compounds (for both Vermiculite based cementitious and In-situ concrete)

Membrane curing may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compounds shall be compatible and applied to all exposed surfaces by spraying or brushing as soon as possible after the material has set. Minimum film thickness of such curing compounds shall be as per the recommendation of the manufacturer so as to obtain an efficiency of 90% as specified by BS-8110. This film of curing compound shall be fully removed from the surface after the specified curing period.



9.4. Water Shed Sealing at Terminating Edges/ Metal Joints (for both Vermiculite based cementitious and In-situ concrete)

All termination of the fireproofing and steel junctions shall be sealed by non-bituminous polysulfide or silicon rubber mastic sealant. The sealing compound shall be compatible and approved by fireproofing material supplier.

9.5. Weather Barrier Finish Coat (for both Vermiculite based cementitious and In-situ concrete)

1) Sealer Coat

A sealer coat of epoxy polyamide shall be applied over the fireproofing surface as a base for the finish coat. The sealing compound shall be compatible and approved by fireproofing material supplier.

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2) Finish Coat

The finish coat shall be pre-qualified for coating system No. 1 of NORSOK Standard M-501. Two coats of acrylic elastomeric or polyurethane coating shall be used as finish coat. The sealing compound shall be compatible and approved by fireproofing material supplier.

9.6. Water

Water shall conform to the requirements of IS:456.

9.7. Vermiculite Cementitious Coating

Branded product with base as Vermiculite and mixed with ordinary Portland cement shall have a maximum loose dry density of 400kg/m³; while in moulded condition, the density shall not exceed 800kg/m³. Sulphate content in the branded product shall not exceed 1% when sulphate content is expressed as Sulphur trioxide.

9.8. Materials for In-situ Concrete

9.8.1. Cement

Type of cement to be used shall be as per specification 080557C-000-JSS-1700-005.

Fireproofing of all structures in Sulphur handling units shall necessarily be by using Sulphate resisting Portland cement conforming to IS:12330.

9.8.2. Aggregates

1) Fine aggregates (Sand)

Fine aggregates shall conform to the requirements specified in specification 080557C-000-JSS-1700-005. Sand conforming to Zone IV shall not be used.

2) Coarse aggregates

Coarse aggregates shall conform to the requirements specified in specification 080557C-000-JSS-1700-005. Maximum size of aggregates shall be 10mm.



9.8.3. Admixture

Admixture shall conform to IS:9103. The admixture shall be mixed with concrete strictly as per manufacturer's recommendation and shall also meet the requirements of IS:456.

10. SURFACE PREPARATION

10.1. Surface Cleaning

All steel surfaces to be in contact with the fire proofing coating material, shall be cleaned of all oil, grease, loose rust, scales and dust by using wire brushing and washing using detergents.

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10.2. Mesh Support System

10.2.1. Welding of Nuts and Application of Primer

Nuts of M16 bolts shall be welded with all the steel members to be fire proofed. Maximum spacing of nuts shall be 400mm center to center on a staggered diamond pitch. Nuts shall not be welded to the vessel supports/skirts (to be welded by vessel fabricator); unless directed by OWNER/ Engineer-in-Charge. Primer paint shall be applied to the MS nuts and affected surfaces of the members due to welding after proper cleaning. Primer paint shall be compatible with the primer already applied to the steel members.

10.3. Placement of Cover Blocks

Cover blocks shall be tied with the wire fabric at 300mm C/C along the span and at suitable locations along the periphery' of the member. The whole arrangement shall be placed over the Metal sheet/ lath and shall be held in position with the help of MS Tie wires wrapped at cover block locations. Cover blocks shall not be used over equipment skirts/legs, angles and box sections.

10.4. Fixing of Expanded Metal Steel Sheet

Expanded metal steel sheet shall only be used for built up sections, consisting of two members spaced apart. This shall be kept in position true to line and face, and shall be arranged firmly to structural steel member by tack welding or with the help of clips and 16 SWG tying wire at 300mm center to center. Minimum lap of 75mm shall be provided wherever required, however laps shall be avoided at bends. Stands of the expanded metal steel sheet shall slope inwards and downwards.

10.5. Placement of Wire fabric



Reinforcement shall be placed in the middle of coated material thickness. It shall be bent confirming with outlines of finished encasement and rigidly secured in place by tie wire with all the nuts. Minimum lap at ends and sides shall be 100mm and lapped wire fabric shall be tied firmly.

10.6. Cover Plate

Cover plates shall be welded to the top flange of the beams if top edges of fire proofing are not protected with bitumen mastic flashing.

11. APPLICATION

- 11.1. Application of fire proofing material coating shall be carried out by skilled and experienced operators.
- 11.2. Before start of application, pipes and equipment in the vicinity shall be covered with polythene/tarpaulin to protect them against damage. Open end of pipes shall be covered with wooden plugs or with other suitable shielding materials, to protect from splatter.
- 11.3. Steel sections up to and including 300mm depth, shall be coated by solid fill while sections more than 300mm shall be coated in the shape of profile of sections as shown in sketches. For vessel skirts, columns and saddles of horizontal vessels, the coating material shall be applied in horizontal bands working upwards from the bottom of the skirt or column / saddle base plate. All outside edges of the fire

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proofing shall be chamfered by 20mm and corners shall be rounded.

- 11.4. Thickness of fireproof coating shall be established by providing ground wires both in vertical and horizontal directions. Ground wires shall be tight and true to line, and placed in such a manner that they can be further tightened if required.
- 11.5. The fireproofing material, after application, shall be cured by keeping it in moist condition for a period of at least 14 days (or as per vendor standard) or else the surface shall be coated with a membrane of approved curing compound. Brand name, name of manufacturer, test results and method of application shall be submitted to and got approved from the OWNER/ENGINEER-IN-CHARGE prior to procurement of curing compound.

12. APPROACH, WORKING PLATFORM, SCAFFOLDING & FORM WORK

- 12.1. The CONTRACTOR shall arrange all approaches, scaffolding, stairways, ladder, working platform etc., for carrying out the entire works safely. The working area shall be neatly maintained and all the facilities required by OWNER/ Engineer-in-Charge for proper supervision of the work shall be provided. In case, any special precaution is needed for the safety of the structure till the completion of application, the CONTRACTOR shall make and provide all such arrangement to the complete satisfaction of the OWNER/ Engineer-in-Charge and shall remove the same after completion of works.
- 12.2. Form work wherever required shall be of Plywood Sheeting. It shall be adequately supported and braced to protect against deformation on account of vibration during the application. Forms shall be oiled, dampened and cleaned before use.

13. SPECIFIC REQUIREMENT FOR FIREPROOFING



13.1. In-Situ Concrete

- 13.1.1 Concrete mixing and placing shall be done as per specification No. 080557C-000-JSS-1700-001.
- 13.1.2 Steel structures shall be fire proofed with concrete up to a minimum height of 1.8m from grade for protection against mechanical damage or as directed by the Engineer-in-Charge. A suitable slope of about 30° shall be provided at the junction of concrete and vermiculite based cementitious fireproofing material to avoid accumulation of water.
- 13.1.3 Concrete shall be poured into well made forms properly oiled and made to correct dimensions. Concrete shall be vibrated as necessary to ensure smooth surface, free from voids and irregularities. Any defects, honeycomb etc. shall be made good by contractor at his own cost.

13.2. Vermiculite Cementitious coating

13.2.1 Design requirement

- a) Vermiculite cementitious coating shall restrict the temperature of a vessel/structure, below the maximum permissible temperature of 427°C for vessel supports & skirts and 550°C for structural

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steel members respectively, for a minimum time period of 2 hours. The material shall not fail till the end of the specified period.

- b) The coating shall be non-corrosive to the steel members & shall not be affected by environmental conditions, whether natural or from local leaks, spillage or pollution. It shall also be asbestos free.
- c) The coating shall be able to withstand both thermal shock and impingement of water from fire hoses and/or monitors.
- d) The coating material shall be durable and easily repairable.
- e) Application procedure of the coating shall be easy; non-hazardous and also shall not interfere with the working of the adjoining areas.
- f) The CONTRACTOR shall submit calculations of coating thickness for all structural steel sections to be fire proofed; for review/approval of the OWNER/ Engineer-in-Charge for the branded product but in no case thickness of coating shall be less than 30mm.
- g) The CONTRACTOR shall submit the application procedure of fire proofing materials for review/approval of the OWNER/ Engineer-in-Charge for the branded product.

13.2.2 Application

- a) Vermiculite cementitious coating shall be mixed with water on a clean platform or in a clean mixing box or in a suitable mixer as per manufacturer's specifications. Water cement ratio shall be adjusted so that vermiculite cementitious coating adheres properly to steel surface and does not sag or slide upon application.
- b) **Primer compatible with the vermiculite cement coating as recommended by the manufacturer's shall be applied over the steel surface after cleaning the shop primer if required as per the manufacturer's specifications.**
- c) Mixed vermiculite cementitious coating shall generally be applied, over the steel surface, with the help of spray gun except for small areas and inaccessible location, where application with conventional hand tools shall be permitted. Mixed vermiculite shall be used within the pot life specified by the manufacturer. Under no circumstances rebound material shall be used.
- d) The full-specified thickness (Minimum 30 mm thick) shall be developed in three successive coats.
 - ◆ Rending coat : Thickness as per manufacture's recommendation
 - ◆ Floating coat : Thickness as per manufacture's recommendation
 - ◆ Finishing coat : Thickness as per manufacture's recommendation

Each successive layer shall only be applied after the preceding layer has developed its initial set and is also properly scratched with steel brush to develop proper bond. If the application is interrupted and does not satisfy successive layers criteria, the coating shall be cut back to the steel surface/proceeding layer with a trowel at an inclined angle. Exposed surface of this coating shall

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be thoroughly wetted before resuming the work.

- e) Parameters like water quality, % water addition, wet density check at mixer discharge and spray head, slump test and other operating parameters like air pressure etc. shall be checked during application to ensure achievement of specified quality parameters.
- f) Application of mixed vermiculite shall not be carried out if the air temperature or the temperature of the surface to be fire proofed is 4°C or less. Provision shall be made for adequate ventilation during and after application, until the coating is dry.
- g) All patching of damaged fireproofing work shall be done by the contractor certified by the fireproofing material vendor.

14. **FINISHING AND JOINT SEALING**

14.1. Weather Barrier Finish Coat

In-situ concrete/ Vermiculite based cementitious fireproof coating shall be protected from weather damage by means of suitable coating. The weather barrier coat shall be applied after full curing (after a gap of min 28 days) and drying of the fire proofing coating. A sealer coat of epoxy polyamide @ 50-75 micron DFT shall be applied over the fireproofing surface as a base for the finish coat. The finish coat shall be UV resistant, suitable to withstand mechanical abrasion/ air erosion, shall be pre-qualified for coating system No.1 of NORSOK Standard M-501. Two coats of acrylic elastomeric or polyurethane coating shall be used as finish coat @ 100-125 µ DFT per coat. Number of coats shall be increased in case desired DFT not achieved. The coating system for finish coat shall be compatible and approved by fireproofing material vendor.



14.2. Water Shed Sealing at Terminating Edges/ Metal Joints

All termination of vermiculite based cementitious fireproofing and steel junctions shall be sloped to shed water and sealed by non-bituminous polysulfide or silicon rubber mastic sealant to prevent water ingress into the fireproofing from these joints. The sealing shall be applied by cutting a U-shaped groove approx.10mm deep and 10mm wide in to the fireproofing immediately adjacent to the junction. The sealing compound shall be approved by fireproofing material vendor.

15. **INSPECTION AND TESTING**

The finished application of the fireproofing shall conform to the approved samples submitted prior to the start of the work. Excessive abrasions or other damage to the applied fireproofing shall be replaced, if deemed necessary, and rejected work shall be corrected to the full satisfaction of the OWNER/ Engineer-in-Charge.

Thickness, strength and density of fireproofing shall conform to specifications. All records of approved test results shall be accessible immediately for inspection.

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The CONTRACTOR shall submit the certificate of test results for the vermiculite cementitious coating over structural members, from a laboratory approved by the OWNER/ Engineer-in-Charge. Test shall be performed as per the requirements laid down in IS: 3809 /UL-1709.

After completion of the work, the surface of the fireproofing shall be inspected visually on plumpness, evenness, extent of cracks if any, and thickness of fireproofing.

All defects observed on the surface of the fireproofing shall be repaired / rectified by the approved method.

16. PAYMENT (Applicable For Item rate tender)

- 16.1.** Payment shall be made on cubic meter (m³/Mt) (as per relevant SOR) basis of actually finished work or as calculated from the construction drawings, whichever is less.
- 16.2.** The rate quoted shall be inclusive of all labor, material, form work, plant & tools etc. required for the successful and satisfactory completion of work including curing, curing compound, all cleaning operations before and after the work, preparation of the surface as specified, applying the primer coat over MS nuts and effected surface of steel surfaces due to welding, finishing the surface smooth, painting the surface with sealer coat and weather barrier finish coats & sealing the joints with sealing compounds, providing required access, working platforms, props, scaffolding and other safety measures including their removal after completion.
- 16.3.** The rate shall also be inclusive of supplying and fixing of reinforcement with nuts by using tying wire (including the cost of expanded metal steel sheets, cover plates) and other required accessories for satisfactory completion of the work as specified and directed.
- 16.4.** The rates quoted shall be inclusive of the tests specified and directed to establish the quality and strength of materials.

17. FIRE PROOFING DETAILS

For Fire proofing details refer General Civil Standards doc.no. 080557C-000-LD-1790-001.