

- f) Deviation from the specified thickness of bed-joints, cross joints or pretends shall not exceed +/- 3 mm.

Table 2: Frequency of sampling and testing

Sl. No.	Type of material/work	Nature of test / characteristics of test	Method of test	No. of samples and frequency	Remarks/ acceptance norms
1	2	3	4	5	6
1.	Burnt clay bricks/Fly ash bricks	(a) Dimensions	Clause No.5.2.1 of IS:1077		Max. 8% deviation for non-modular bricks. For modular bricks as per Clause no.5.2 of IS: 1077. For face bricks as per IS: 2691.
		(b) Compressive strength	IS:3495 (Part-1)		As specified
		(c) Water absorption	IS:3495 (Part-2)	A set of 20 bricks (min.) for each lot of 50,000 or part thereof for all tests (a to c)	Max. 20%. However, 15% for face bricks only.
		(d) Efflorescence	IS:3495 (Part-3)		Moderate. However for face brick nil.
		(e) War page	IS:3495		For face brick 2.5 mm (max.)

Sl. No.	Type of material/ work	Nature of test / characteristics of test	Method of test	No. of samples and frequency	Remarks/ acceptance norms
1	2	3	4	5	6
II.	Stone	a) Type of stone by petro graphic examination	IS:1123	One set of stones of each type and from each source.	As specified.
		b) Shape & size	Physical measurement	Random	As specified
		c) Crushing strength	IS:1121 (Part-I)	One set of stones of each type and from each source.	As specified
		d) Water absorption	IS:1124	One set of stones of each type and from each source.	As specified
		e) Durability	IS:1126	One set of stones of each type and from each source.	As specified
III.	Sand	a) General quality	Visual	One set of samples from each source of material per 100 Cum. or part thereof.	As specified
		b) Deleterious material	IS:2386 (Parts-I & 2)	One set of samples from each source of material per 100 cum. or part thereof.	Clause 3.3 of IS:2116

Sl. No.	Type of material/work	Nature of test / characteristics of test	Method of test	No. of samples and frequency	Remarks/ acceptance norms
1	2	3	4	5	6
		c) Grading	Sieve analysis as per IS:2386 (Part-I)	One set of samples from each source of material per 100 cum. or part thereof.	Table-1 of IS:2116
IV.	Cement	a) Setting time	IS:4031	One set of sample for each lot of material received	No separate testing is required in case cement is tested for preparation of concrete mix
		b) Compressive strength	IS:4031	One set of sample for each lot of material received	No separate testing is required in case cement is tested for preparation of concrete mix
V.	Water	a) Harmful substances, pH value	IS:3025	Once a month for each source	No separate testing is required in case water is tested for concrete mix
		b) Initial setting time	IS:4031	Once a month for each source	No separate testing is required in case water is

Sl. No.	Type of material/ work	Nature of test / characteristics of test	Method of test	No. of samples and frequency	Remarks/ acceptance norms
1	2	3	4	5	6
					tested for concrete mix
		c) Compressive strength	IS:516	Once a month for each source	No separate testing is required in case water is tested for concrete mix
VI.	Mortar	a) Compressive strength	Appendix-A of IS:2250	One sample (consisting of min 3 specimens)	Table-1 of IS:2250
		b) Consistency	Appendix-B of IS:2250	One sample for each type of mix	Clause 7.2 of IS:2250
		c) Water retentively	Appendix-C of IS:2250	One sample for each type of mix	Clause 7.3 of IS:2250
VII.	Masonry construction	a) Workmanship	Visual & Physical measurement	All work	As per specification and Cl. No.11.0 of IS:2212 for brickwork
		b) Verticality and alignment	Physical measurement	All work	As per specification and Cl.No.6.3.4 of IS:1905

Section - C5
**Technical specification for plastering and allied
works**

Section - C5

Technical specification for plastering and allied works

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Section - C5: Technical specification for plastering and allied works

5.1 Scope

This part of the specification covers the requirements for plastering and allied works for all types of masonry and concrete surfaces.

5.2 General requirements

The Concessionaire shall furnish all skilled and unskilled labour, plant, equipment, scaffolding, materials, etc. required for complete execution of the work in accordance with the drawings and as described herein and/or as directed by the Engineer.

The Concessionaire shall follow all safety requirements/rules during execution of the work.

I.S:1661 shall be followed as a general guidance for plastering work.

5.3 Codes and standards

All applicable standards, acts and codes of practice referred to shall be the latest editions including all applicable official amendments and revisions. A complete set of all these documents shall generally be available at Site with the Concessionaire.

In case of any conflict between this specification and those (IS Standards, Codes etc.) more stringent shall prevail.

Some of the applicable Indian Standards, Codes, etc. are referred to here below:

IS:383	-	Coarse and fine aggregates from natural sources for concrete.
IS:712	-	Building limes.
IS:1542	-	Specification for sand for plaster
IS:1635	-	Code of practice for field slaking of Building lime and preparation of putty
IS:2250	-	Code of practice for preparation and use of masonry mortar.
IS:2333	-	Plaster-of-paris
IS:2402	-	Code of practice for external rendered finishes

IS:2547	-	Gypsum building plaster
IS:3150	-	Hexagonal wire netting for general purpose

5.4 Materials

Materials namely, cement, sand, water, Coarse aggregate, shall be in accordance with Technical Specifications for properties, storage and handling of common building materials.

Lime for preparation of putty or neeru for punning work shall be according to class B& C of IS: 712.

For rough cast plaster, coarse aggregate of size 6 to 12 mm shall be used in the finishing coat. Coarse aggregate shall be as per IS: 383.

Gypsum, for use in plaster-of-paris punning work shall be according to IS:2333.

For lath plastering, galvanised hexagonal wire netting with wire 0.9mm dia and 12.5 mm mesh conforming to IS:3150 shall be used.

5.5 Mortar

Unless otherwise specified cement & Fly ash (20% replacement ratio of cement with fly ash): - sand mortar shall be used. Cement mortar shall be prepared by mixing cement & fly ash (20% replacement ratio of cement with fly ash): and sand in specified proportions by volume. Sand shall be measured on the basis of its dry volume using gauge boxes. Suitable allowance in quantity shall be made to cater for the bulkage. Cement and fly ash shall preferably be measured by weight. For the purpose of determining the corresponding volume, one cubic metre of cement shall be taken to weigh 1440 Kg and one cubic metre of fly ash shall be taken to weigh 641 Kg (i.e. coal ash)

The mixing of mortars shall be done in mechanical mixer. However, depending on nature, magnitude and location of the work, the Engineer may relax the condition of use of mechanical mixer and allow hand mixing.

Cement, fly ash and sand in the specified proportions shall be fed into the mixer and mixed dry thoroughly in the mixer. Water shall then be added gradually and the wet mixing

continued for at least 3 minutes. Hand mixing shall be carried out on a clean, water tight platform. Only that quantity of mortar, which can be used within 30 minutes of its mixing, shall generally be prepared at a time. Care shall be taken, not to add more water than that which shall bring the mortar to the consistency of a stiff paste. IS: 2250 and IS:1661 shall be referred for ascertaining the quantity of water.

In case of cement mortar, the mortar that has stiffened because of evaporation of water from the mortar may be retempered under special circumstances, with the approval of the Engineer, by adding water as frequently as needed to restore the requirements of consistency but this retempering shall be permitted only upto one hour from the time of addition of cement.

Cement mortar shall be used as soon as possible after mixing and before it begins to set, preferably within half an hour from the time water is added to cement during mixing and in any case within one hour thereof.

Sweep mortar shall not be used.

5.6 Plastering

5.6.1 Mix proportion and plaster thickness

The mix proportion and thickness of plaster for various surfaces shall be as specified or shown in the drawings. Unless otherwise specified the following shall be adopted.

i.	Ceiling plaster	minimum 6mm thick cement mortar (1:4)
ii.	Plaster on external / rough face of masonry work or concrete surface	18mm thick, cement mortar* (1:6)
iii.	Plaster on plain face of masonry work or concrete surface.	12mm thick, cement mortar*(1:6)

*In case of special application like water proofing surface, base course of decorative finish etc., richer mix proportion not leaner than 1:4 shall be used.

5.6.2 Preparation of surface

The surface shall be cleaned of all dust, loose mortar droppings, traces of algae, efflorescence and other foreign matter by water or by brushing. Smooth surfaces shall be roughened by wire brushing, if it is not hard and by hecking when it is hard. In case of concrete surface, if a chemical retarder has been applied to the framework, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned off and care shall be taken that none of the retarders is left on the surface.

Trimming of projections, wherever necessary shall be done to achieve an even surface. Ranking of joints in case of brickwork where necessary shall be done. The masonry shall be allowed to dry out for sufficient period before plastering.

For ceiling plaster, the concrete surface shall be pock marked with a pointed tool to ensure a proper key for the plaster.

The wall shall be dampened evenly and not soaked before application of plaster. If the surface becomes dry in spots, such areas shall be moistened again.

5.6.3 Sequence of plastering operations

For external plaster, the plastering operations shall be started from the top and carried downwards. To ensure even thickness and a true surface, plaster about 15 x 15 cm shall be first applied horizontally and vertically, at not more than 2m intervals over the entire surface to serve as gauges. The surfaces of those gauged areas shall be truly in the plane of the finished plastered surface. For internal plaster, the plastering operations may be started wherever the building frame and cladding work are ready; the temporary supports of the ceiling resting on the wall have been removed.

The first undercoat shall then be applied to ceilings. After the ceiling plaster is completed and scaffolding for the same removed, the first undercoat on walls shall then be applied.

After a suitable time interval as detailed under application of plaster, the second coat (finishing coat) shall be applied, first to the ceiling and then to the walls.

Where corners and edges have to be rounded off, such rounding off shall be completed alongwith the finishing coat to prevent any joint marks.

5.6.4 Application of plaster

➤ **Wall / vertical surface plaster**

Unless otherwise stated, the plastering above 12mm thick shall be carried out in two coats only.

i) The backing or first coat

The backing coat shall be 10 to 12 mm thick and carried to the full length of the all or to natural breaking points like doors and windows. Before the rendering coat hardens, it shall be roughened to provide mechanical key for the second coat.

Masonry walls on which plaster is to be applied directly, shall be properly set and cured with the joints raked to a depth of at least 10 mm. The rendering coat shall be troweled hard and tight, forcing it into surface depressions to obtain a permanent bond.

On smooth concrete walls, the surface shall be roughened and the rendering coat shall be dashed on to ensure adequate bond. The dashing of the rendering coat shall be done using a strong whipping motion at right angles to the face of the wall, or it may be applied with a plaster machine or cement gun.

ii) Finishing coat

Before starting to apply the finishing coat, the surface of the backing coat shall be dampened evenly. The final plastered surface shall be cured and kept continuously damp for minimum 7 days.

➤ **Ceiling plaster**

Stage scaffolding shall be provided for ceiling plaster. This shall be independent of the walls.

Projecting burrs of mortar formed due to gaps at the joints is shuttering shall be removed. The surface shall be scrubbed clean with wire brushes. In addition, the concrete surfaces shall be pock marked with a pointed tool at a spacing of not more than 50 mm centres, the pocks being made not less than 3 mm deep, to ensure a proper key for the plaster. The mortar shall be washed off and all surface cleaned of all oil, grease, etc. and well wetted before the plaster is applied.

Ceiling plaster shall not be commenced until the slab above has been furnished and centering has been removed. The average thickness of plaster shall not be less than 6 mm. The minimum thickness over any portion of the surface shall not be less than 5 mm.

The Surface shall be cured atleast twice a day for a minimum period of seven days.

➤ **Grooves in plaster**

Where specified in drawings, rectangular grooves 12 to 20 mm wide and 8 to 10 mm deep shall be provided in external plaster by means of timber battens or metal strips, fixed on plaster when plaster is still green. Battens or strips shall be carefully removed after initial set of plaster and broken edges and corners made good. All grooves shall be uniform in width and depth and shall be truly plumb and correctly aligned.

➤ **Drip course**

Drip course wherever indicated in the drawings shall be provided at the time of plastering to prevent travelling of water drops from the projections. Unless otherwise, specified, projected strip form drip course shall be provided.

➤ **Metal lathing**

The lathing shall be tightly stretched with the long way of the mesh across the supports before nailing. This shall be secured with 25 mm galvanised steel staples or nails at 200 mm centres, if the studding is of wood and with 0.90 mm iron tying wire, if the studding is of steel. Edges of lathing shall be lapped not less than 25 mm at the sides and ends and wired together with galvanised wire of diameter not less than 1.25 mm, every 100 mm between supports.

Before plastering, the surface of metal lathing shall be brushed over with thin cement slurry or given a protective coat of bitumen oil paint.

Plastering to lathing

It shall be carried out in two coats. Mortars for the first coat shall be of stiff consistency and applied as evenly as possible to give a uniform good cover to the lathing. It shall be allowed to dry until all shrinkage movement has ceased before the second coat is applied. Too much pressure shall not be used in applying plaster to lathing to guard against its deflection.

➤ **Rough cast finish**

The plaster base over which the rough cast finish is to be applied shall be done in general as per Clause no. 5.6.2 under sub head "Application of Plaster".

It shall be ensured that the base surface which is to receive rough cast mixture is in plastic state. Coarse aggregate of size 6 to 12 mm shall be used in the finishing coat. The grading and size shall vary according to the texture required.

The rough cast mix shall be wetted and shall be dashed on the plaster base in plastic state by hand scoop so that the mix gets well pitched into the plaster base. The mix shall again be dashed over the vacant spaces, if any, so that the finished surface represents a homogeneous surface of sand mixed with gravel. The surface shall be cured for a minimum period of 7 days.

5.6.5 Punning work

➤ **Lime punning or Neeru finish**

Materials

Lime putty: It shall be obtained by slaking lime with fresh water and sifting it. The slaking shall be done in accordance with IS: 1635.

Neeru: It shall be obtained by mixing lime putty and sand in equal proportion and chopped jute @ 4 Kg. per cu.m. of mortar. The mixture shall be properly ground to a fine paste between two stones.

Application of punning

Lime punning consists in finishing the interior with a thin coat (3 mm) of fat lime putty mixed with an equal amount of sand. Before actual use, putty shall be matured for 2 to 3 days.

The mortar for punning shall be applied in 3 mm thick layer just after the undercoat has hardened. It shall be finished to a smooth surface by means of a plaster's trowel.

The curing shall be started as soon as the punning has hardened but in any case not earlier than 24 hours after the punning has been completed. The punning shall be kept wet for a period of seven days.

➤ **Plaster of paris punning**

The plaster of paris (gypsum Anhydrous) conforming to IS: 2547 shall be used for plaster of paris punning. The plaster of paris shall be mixed with water to a workable consistency and shall be applied on the plastered surface and finished to a smooth surface by steel float. The finished surface shall be smooth and true to plane, slopes or curves as required. The nominal thickness of the punning shall be 2 mm.

➤ **Neat cement punning**

The plastered surface over which neat cement punning is to be done, shall be uniformly treated over its entire area with a paste of neat cement and rubbed smooth, so that the whole surface is covered with neat cement coating. The quantity of cement applied shall be 1 kg. per sq. metre. Smooth finishing shall be completed with a float immediately and in no case later than half an hour of adding water to the cement.

5.6.6 Trueness of plastering system

The finished plastered surface shall not show any deviation more than 4 mm when checked with a straight edge of 2 metre length placed against the surface.

5.6.7 Thickness of plaster

The thickness of the plaster shall be measured exclusive of the thickness of key i.e. grooves or open joints in brickwork. The average thickness of plaster shall not be less than the specified thickness. The minimum thickness over any portion of the surface shall not be less than the specified thickness by more than 3 mm for plaster thickness above 12 mm and 1 mm for ceiling plaster. Extra thickness required in dubbing behind rounding of the corners at junctions of wall or in plastering of masonry cornices etc. shall be ignored.

5.6.8 Inspection and testing

- a) The plastered surface shall be checked for following defects and the remedial measures for the same shall be adopted as per IS: 1661.
 - i) Blistering
 - ii) Bound failure or loss of adhesion
 - iii) Cracking
 - iv) Crazeing
 - v) Efflorescence
 - vi) Grinning
 - vii) Irregularity of surface texture
 - viii) Popping or blowing
 - ix) Recurrent surface dampness
 - x) Softness or chalkiness
- b) Trueness of the plaster shall be checked as per Clause no. 5.6.6
- c) Thickness of the plaster shall be checked as per Clause no. 5.6.7

5.7 Pointing

The materials, preparation of mortar etc. shall be same as specified for cement plaster works. The mix proportion shall not be leaner than 1:3, unless otherwise specified. For all exposed brickwork or stone masonry work, self supporting double scaffolding, having two sets of vertical supports shall be provided so as to avoid openings in the wall.

5.7.1 Preparation of surface

The joints shall be raked out properly to such a depth that the minimum depth of the new mortar measured from either the sunken surfaces of the finished pointing or from the edge of the brick shall not be less than 10 mm. Dust and loose mortar shall be brushed out. Efflorescence, if any shall be removed by brushing and scraping. The surface shall then be thoroughly washed with water, cleaned and kept wet before commencement of pointing.

5.7.2 Application of mortar and finishing

The mortar shall be pressed into the raked out joints, with a pointing trowel, either flush, sunk or raked, according to the type of pointing required. The mortar shall not spread over the corner, edges or surface of the masonry. The pointing shall then be finished with the proper tool according to the type of pointing required.

5.7.3 Type of pointing

➤ Ruled pointing

Unless otherwise specified ruled pointing shall be adopted for all exposed brick/block masonry work. However, for rubble masonry works, recessed pointing shall be adopted.

The mortar shall be pressed into the raked out joints and shall be finished off flush and then while the mortar is still green, a groove of shape and size as shown in drawings shall be formed by running a forming tool straight along the centre line of joints. This operation shall be continued till a smooth and hard surface is obtained. The vertical joints shall also be finished in a similar way. The vertical joints shall make true right angles at their junctions with the horizontal lines and shall not project beyond the same. For recessed pointing in rubble masonry recess shall be provided along the centre line of the joint profile.

➤ Flush pointing

The mortar shall be pressed into the joints and shall be finished off flush and level with the edges of the brick, tiles or stones so as to give a smooth appearance. The edges shall be neatly trimmed with a trowel and straight edge. Unless otherwise specified, flush pointing shall be adopted for drains and brick on edge paving.

➤ **Raised and cut pointing**

Raised and cut pointing shall project from the wall facing with its edges cut parallel so as to have a uniformly raised band about 6 mm raised and width 10 mm or more as directed. The superfluous mortar shall be cut off from the edges of the lines and the surface of the masonry shall also be cleaned off all mortar. Unless otherwise specified, raised and cut pointing shall be adopted for stone masonry pointing, and shall be provided along the Centre line of the joint profile.

5.7.4 Curing

The pointing shall be kept wet for 7 days.

Sub section - C6
**Technical specification for flooring and other
allied works**

Sub section - C6

Technical specification for flooring and other allied works

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Sub section - C6: Technical specification for flooring and other allied works

6.1 Scope

This specification cover the supplying, installation, finishing, curing, testing, protecting, maintaining until handling over of various types of floor finishes and allied items of works as listed below :

6.1.1 In situ finishes

Integral finishes to concrete base.

Terrazzo finish.

Metallic hardener like “Ironite” finish.

6.1.2 Tile finishes

Terrazzo tile

Glazed tile

Rubber based vinyl tiles

6.1.3 Base

The base to receive the finish is covered under other relevant specifications.

6.1.4 Sequence

The commencement, scheduling and sequence of the finishing works shall be planned in details and must be specifically approved by the Engineer, keeping in view the activities of other agencies working in the area. However, the Concessionaire shall remain fully responsible for all normal precautions and vigilance to prevent and damage whatsoever till handling over to the Executing Agency.

6.2 Installation

6.2.1 Special materials

Materials required for individual finishing items are specified under respective items. In general, all such materials shall be in accordance with the relevant IS Codes (Latest edition) where applicable. In all cases these materials shall be of the best indigenous quality unless specified otherwise.

The materials for finishing items must be procured from well-reputed specialized manufactures and on the basis of approval of samples by the Engineer. The materials shall be ordered, procured and stored well in advance to avoid possible delays to the construction programme.

6.2.2 Workmanship

Workers specially experienced in particular items of finishing work shall carry out the work. Where such workers are not readily available, experienced supervisors recommended by the manufacturer shall be engaged with the prior permission of the Engineer. In particular cases, Engineer may desire the installation of finishing items by the manufacturer. This arrangement shall be made by the Concessionaire.

6.2.3 Preparation of the base surface

The surface to be treated shall be thoroughly examined by the Concessionaire. Any rectification necessary shall be brought to the notice of the Engineer and his approval shall be obtained regarding the method and extent of such rectification required. For all types of flooring, skirting, dado and similar locations, the base to receive the finish shall be adequately roughened by chipping, raking of joints and thoroughly cleaning of all dirt, grease etc., using water hard brushes and detergent as required, unless otherwise directed by the manufacturer of any special finishing materials, or specifically indicated in this specification under the individual item. To prevent absorption of water from any wet finishing treatment, the base shall be thoroughly soaked with water and all excess water mopped up. However, the surface shall be dry where adhesive are used for fixing the finishes. The actual finishing work shall not commence until the Engineer has approved the surface.

6.2.4 In-situ-finishes

➤ **Integral finishing to concrete base**

While the surface of the concrete laid in accordance with the specification for ‘‘Cement Concrete’’ has been fully compacted and levelled but the concrete is still green, a thick slurry made with neat cement shall be applied evenly and worked in with iron floats. When the slurry starts to set, it shall be pressed with iron floats, to achieve a firm, compact and smooth surface without any trowel marks or undulations. The finish shall be as thin as possible by using 2.2 kg. of cement per sq.m. of area. The surface shall not be subjected to any loads or abrasion for at least 21 days after laying.

When desired by the Engineer, the surface while still ‘green’ shall be intended by pressing strings. The markings shall be of even depth, in straight lines and the panels shall be of uniform and symmetrical patterns.

➤ **Terrazzo finish: In-situ**

It shall consist of an underbed and a topping laid over an already laid and matured concrete base.

(a) Thickness

Unless otherwise specified, the total thickness of the finish shall be a minimum of 40 mm for horizontal surfaces and 25 mm for vertical surfaces of which the topping shall be not less than 10 mm. The topping shall be of uniform thickness but the underbed shall vary in thickness as necessary to provide any slopes. The finished vertical surface shall project 6 mm from the adjacent plaster or other finishes. The surface receiving the finish shall be cut back as necessary to accommodate the specified thickness. All junctions between vertical and horizontal surfaces shall be rounded neatly to a uniform radius of 25 mm.

(b) Mix

i) Underbed

The underbed for floors and similar horizontal surfaces shall consist of a mix of 1 part cement, 1 part sand and 3 parts sand by volume. The sand shall be coarse.

The stone chips shall be 10 mm down well graded. Only sufficient water shall be added to provide a mortar of workable consistency.

ii) Topping

The mix for the topping shall be composed of cement, colour pigment, marble dust and marble chips. The proportions of the ingredients shall be such as to produce the terrazzo of the colour, texture and pattern approved by the Engineer. The cement shall be white or grey or a mixture of the two in which the pigment shall be added to achieve the desired colour. To 3 parts of these mixture, 1 part marble powder by volume shall be added and thoroughly mixed dry to 1 part of this mix, 1 to 1.5 parts of marble chips by volume shall be added and thoroughly mixed dry again.

The pigment must be stable and non-fading. It must be very finely ground. The marble powder shall be from white marble and shall be finer than I.S. Sieve No. 30. The size of marble chips may be between 1 mm to 20 mm but at least 5 mm smaller than the topping thickness.

Sufficient quantity to cover each visible area shall be prepared in on lot to ensure uniform colour. Water to make it just workable shall be added to a batch immediately before it is laid. The size of batch shall be such that it can be laid before it starts setting.

(c) Laying

The underbed shall be laid in panels. The panels shall not be more than 5 sq.m. in area of which no side shall be more than 2.5 m long. For locations exposed to the sun, the maximum area of a panel shall be 2.0 sq.m. The panels shall be laid in alternate bays or chequered board pattern. No panel shall be in contact with any other already laid until the later has contracted to the full extent.

Dividing strips made of aluminium 40 mm wide and 2 mm thick (min) shall be used for forming the panels. The strips shall exactly match the total depth of underbed plus topping.

After laying, the underbed shall be levelled, compacted and brought to proper grade with a screed or float. The topping shall be laid after about 24 hours while the underbed is still 'green' but firm enough to receive the topping. Slurry of the mixture of cement and pigment already made shall be spread evenly and brushed in just before laying and topping. The topping shall be rolled for horizontal areas and thrown and pressed for vertical areas of extract all superfluous cement and water and to achieve a compact dense mass fully bonded with the underbed. The surface of the topping shall be trowelled over, pressed and brought to a smooth dense surface showing at least 75% exposure of marble chips in an even pattern of distribution over the area covered.

(d) Curing

The surface shall be left for curing for 12 to 18 hours and then cured by allowing water to stand on the surface or by covering with wet sack for four days.

(e) Grinding and polishing

When the surface has sufficiently hardened it shall be watered and ground evenly with rapid cutting coarse grade (No. 60) grit blocks till the marble chips are exposed and the surface is smooth. Then the surface shall be thoroughly washed and cleaned. A grout already prepared from a mixture of cement and pigment shall be applied to fill up all pinholes. This surface shall be cured for 7 days by keeping it moist and then ground with fine grit block (No. 120). It shall again be cleaned with water, the grout reapplied to fill up any more pinholes that might have appeared and allowed be cured again for 5 days. Finally the surface shall be ground a third time with very fine grid blocks (No. 320) to achieve a smooth surface free from pinholes. Where a grinding machine cannot be used, hand grinding may be allowed where the first rubbing shall be with carborundum stone of coarse grade No. 60, the second rubbing with medium grade NO. 80 and the final rubbing and polishing with fine grade (No. 120). The surface shall be cleaned with water, dried and covered with oil free clean saw dust if directed by the Engineer. The final polishing shall be postponed if desired by the Engineer and shall be taken up just before handing over to the Executing Agency.

Just before handing over to the Executing Agency, the surface shall be dusted with oxalic acid at the rate of 0.33 gm per sq.m., water sprinkled on to it and finished by buffing with felt or hessian mops. The floor shall be cleaned with soft moist rag and

dried, if desired by the Engineer, wax polish shall be applied. However, all excess wax polish has to be wiped off and the surface left glossy but not slippery.

➤ **Metallic hardener like “ironite” finish**

It shall consist of an underbed and a topping (incorporating iron particles) laid over an already laid and matured concrete base.

(a) Thickness

Unless otherwise specified the total thickness of the finish shall be minimum of 52 mm for horizontal surfaces of which topping shall not be less than 12 mm. The topping shall be of uniform thickness, but the underbed shall vary in thickness to provide and slopes. Vertical surfaces shall project 6 mm from adjacent plaster or other finishes. The surface receiving the finish shall be cut back as necessary to accommodate the specified thickness.

(b) Material

The hardening compound shall be uniformly graded iron particles, free from non-ferrous metal impurities, oil, grease, sand, soluble alkaline compounds or other injurious materials. When desired by the Engineer, actual samples shall be tested for impurities.

(c) Mix

- i) The underbed for floors and similar horizontal surfaces and for vertical surfaces shall be prepared in accordance with Clause 6.2.4(b).
- ii) The Proportion of the metallic hardener shall be as specified or as indicated by the manufacturer. However, in absence of any such direction 1 part metallic hardener shall be mixed dry with 4 parts cement, by weight. To this mixture 6 mm nominal size stone chips shall be added in proportion of 1 part cement (mixed with hardener) to 2 parts of stone chips by volume and uniformly mixed. A minimum quantity of water shall be added to make it workable.

(d) Laying

The concrete floor shall be laid in panels of 1m x 1m or as directed by the Engineer. Alternate panels shall be laid on the same day followed by the other group of alternate panels the next day. The edges of the panels shall be supported either by wooden strips or flat angle iron pieces fixed securely in position. The underbed shall be laid to the required grade. The forms, if any, shall remain sufficiently projecting to take the topping. The surface of the underbed shall be roughened by wire brush as soon as possible.

The junction of floor and walls, floors and dado or skirting shall be rounded off as directed.

The Wooden strips or flat iron pieces shall be removed from their places before the succeeding alternate layers are laid.

The topping shall be laid while the concrete underbed is still 'very green' about 3 hours after laying of the later. The topping shall be of uniform thickness and even dense surface without trowel marks, pinholes, etc. The topping layer shall be pressed firmly, worked vigorously and quickly to secure full bond with the underbed. Immediately after the initial setting starts, the surface shall be finished smooth with a steel trowel.

The finished floor shall be cured for 7 days by keeping it wet.

6.2.5 Tile finishes

These shall included tiles, stone slabs and similar manufactured or natural items over an already, laid and matured base of concrete or masonry by means of an underbed or an adhesive layer.

➤ Terrazzo tiles

This tiles finish shall consist of precast terrazzo tiles laid over an underbed.

(a) Thickness

The total thickness including the underbed shall be a minimum of 40 mm for floors and 30 mm for walls unless otherwise specified.

The skirting, dado and similar vertical surfaces shall project 6 mm uniformly from the adjacent plaster or other wall finishes. The surface receiving the finish shall be cut back as necessary to accommodate the specified thickness.

(b) Tiles

The tiles shall be composed of an underbed and topping. The topping shall be of uniform thickness not less than 10 mm. The total thickness including the topping shall be as specified but not less than 20 mm. The underbed shall be composed of 1 part ordinary grey cement and 3 parts of stone chips by weight, mixed with water.

(c) Topping

The tiles for the topping shall be as specified under Clause 6.2.4 (b).

The tiles shall be cured at the shop for at least 14 days before delivery to the site. First grinding shall be given to the tiles in the shop before delivery. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be stored carefully to prevent staining by damp, rust, oil, grease or other chemicals.

Tiles made in each batch shall be kept and used separately so that the colour of each area of the floor shall be uniform. The manufacturer of the tiles shall also supply the grout mix containing cement and pigment in the exact proportions as used in finishing the tiles. The containers for the grout mix shall be suitably marked to ensure that they can be related to the particular type and batch of tiles.

(d) Mix-underbed

The underbed for floors and similar horizontal surfaces shall be 1 part lime putty; 1 part surkhi; 2 parts coarse sand by weight mixed with sufficient water to form a stiff workable mass. For skirting and dados and all vertical surfaces it shall be about 10 mm thick and composed of 1 part cement and 3 parts sand by weight.

(e) Laying

The underbed mortar shall be evenly spread and brought to the appropriate grade and consolidated to a smooth surface. The surface shall be roughened for better bond with the

tiles. While the underbed is still fairly moist but firm, cement shall be hand dusted over it or cement slurry applied. The tiles shall immediately be placed in position and firmly pressed by wooden mallet on to the underbed so that the tile surface achieves the desired level. The tiles shall be soaked in water for about 10 minutes just before laying. The joints between tiles shall be as narrow as possible and not more than 1.5 mm wide.

Special care shall be taken to check the level, the surface and the lines of the joints frequently so that these are perfect.

When tiles are required to be cut to match the dimensions, they shall be sawn and edges rubbed smooth. The location of cut tiles shall be planned in advance and approved by the Engineer.

At the junction of horizontal surface with vertical surfaces the tiles on the former shall enter at least 12 mm under the later.

After fixing, the floor shall be kept moist and allowed to mature undisturbed for 7 days. Heavy traffic shall not be allowed.

If desired, diving strips as specified under Clause 6.2.4 (c) may be used for dividing the work into suitable panels.

(f) Grinding and polishing

The procedure shall be the same as specified in Clause 6.2.4 (e) but grinding shall not commence until 14 days have elapsed after laying of tiles.

➤ **Glazed tiles**

This finish shall be composed of glazed, earthen, coarse tiles with an underbed laid over a concrete or masonry base.

(a) Thickness

The total thickness shall be between 20 mm and 25 mm including the underbed.

The tile finish on vertical surface shall project 6 mm uniformly from the adjacent plaster or other wall finishes. The surfaces receiving the finish shall be cut as necessary to accommodate the specified thickness.

(b) Tiles glazed

The tiles shall be earthenware, covered with glazed, white or coloured, plain or with designs, of this size approved by the Engineer and 6 mm thick. The tolerance shall be +/- 1.5 mm for length and breadth and +/-0.5 mm for thickness. Specials like internal and external angles, beads, covers, cornices, corner pieces etc., shall match. The top surface of the tiles shall be glazed with an unfading stable gloss finish as desired by the Engineer. The tiles shall be flat and to shape. The colour shall be uniform and a fractured section shall be fine grained in texture, dense and homogenous. The tiles shall be strong and free from flaws like cracks, chips craze, spacks, crawlings etc., and other imperfections. The edges and the underside of the tiles shall be completely free from glaze and the underside shall have ribs or indentations for better anchorage with the fixing mortar.

The coloured tiles, when supplied, shall preferably come from one batch to avoid difference in colour.

(c) Mix-underbed

This mix for the underbed shall consist of 1 part cement and 3 parts coarse sand by weight mixed with sufficient water or any other mix if specified.

(d) Laying

The under and tiling shall be laid as specified in Clause 6.2.4 (e).

(e) Finishing

The joints shall be cleaned and flush pointed with white cement and cured for 7 days by keeping it wet. The surface shall be cleaned with soap or suitable detergent, washed fully and wiped with soft cloth to prevent scratching immediately before handing over to the Executing Agency.

➤ **PVC tiles and rolls as per IS-3462-1986**

This covers PVC based vinyl Tiles and Rolls set with adhesive on to a concrete or masonry base. An underbed may be required to secure a desirable surface and grade.

Tiles

Unless otherwise mentioned the tiles shall be squares of approved dimensions. The tolerance of dimensions shall be +/-1.5 mm.

The tiles should be clandered laminated solid resilient unbreakable and flexible PVC Vinyl tiles in sizes of 305 mm x 305 mm x 3 mm thick. This shall have properties of a high wear resistance and resilience, designed to withstand high traffic and abrasion. All edges shall be cut true and square. The colour shall be non-fading and uniform in appearance, insoluble in water and resistant to alkalies cleaning agents and usual floor polishes.

Rubber based adhesive to be used for fixing tiles shall be Dunlop S-758 or Fevicol SR-998 or equivalent or a recommended by the manufacture. The adhesive shall have a short drying time and long life. Each container shall show the shelf life, date of manufacture and over age container shall be immediately removed from the site.

Rolls

It should be clandered laminated solid resilient unbreakable and flexible PVC Vinyl Flooring of size 1.5 mtrs. (Width) x 20 mtrs (Length) x 3 mm thick with inherent characteristics of wear resistance, dimensional stability, elegance etc.

Each packet of tile or roll shall be legibly and indelibly marked with the manufacturer's trade mark, thickness, size batch number and date of manufacture.

Tiles shall be delivered securely packed and store in clean, dry, well ventilated places.

Joint welding

This can be provided where ever the PVC Rolls are installed in order to avoid dust accumulation leakage of water and prevention from wear and tear in joints. In this, a PVC

cord is put into the joint after making grooves with machine and is welded with hot thermo welding machine.

(a) Mix Underbed

The underbed, where required to make up the specified thickness or to achieve the required grade of the right type of surface shall be composed of 1 part cement, 2 parts sand and 4 parts stone chips mixed with just sufficient water to make the mix workable.

(b) Laying

The tiles shall be stored in the room to be tiled for atleast 24 hours to bring them to the same temperature as the room. In air conditioning spaces, the air conditioned space, the tiles shall be stored in the room to be tiled for at least 24 air conditioning shall be fully operational before the tiling is laid.

The surface to receive this finish shall be firm, even textured but not too smooth, without undulations and other deficiencies. If an underbed is laid, the same shall be cured for at least 7 days by keeping it moist and then is shall be fully dried.

The surface shall be thoroughly cleaned. All loose dust particles shall be removed. Oil and grease, if any shall be removed completely by the use of detergent.

The adhesive shall be applied uniformly to the fully dry surface in the desired thickness. The adhesive shall also be applied to the backs and edges of the tiles and surface shall be allowed to dry. The tiles shall then be placed neatly on the surface exactly to the approved pattern and set with a suitable tool. If the edges tend to curl up, weights are to be applied to keep the edges down. Special care shall be taken to avoid the formation of air pockets under the tiles. The joints shall be very fine. Any adhesive squeezed out through the joints shall be removed immediately.

(c) Finishing

Any adhesive marks on the surface shall be removed by wiping with a soft cloth soaked in solvent. The surface shall be cleaned with soft soap dried and then polished with approved type of polish just before handling over to the Executing Agency.

6.2.6 Ground floor with earth subgrade

For ground floors having an earthen subgrade, the floor finish shall consist of the following:

➤ **Compacted Earth**

- i) 150 mm thick dry rubble soling on rammed earth. Rubble shall be hand packed as directed by the Engineer. This shall be laid closely in position on the subgrade. All interstices between the stones shall be wedged in with smaller stones of suitable size well driven to ensure tight packing and complete filling of the interstices. The filling shall be carried out simultaneously with the placing in position of the rubble stone and shall not lag behind. The small interstices shall be filled with hard clean sand well watered and rammed.
- ii) 100 mm thick sand cushion.
- iii) PVC sub-base 75 mm thick, 1:4:8 mix.
- iv) Floor finish with underbed as specified elsewhere.

➤ **Acceptance criteria**

The finish shall be checked specially for:

- (a) Level, slope, plumb as the case may be (The surface of the finish shall be smooth and within +/-5 mm of the specified level or position. Local irregularities shall be within +/-3 mm when measured against a 3 metre straight edge. Abrupt changes of alignment shall not exceed 2 mm).
- (b) Pattern and symmetry
- (c) Alignment of joints, dividing strips, etc.
- (d) Color, texture
- (e) Surface finish
- (f) Thickness of joints
- (g) Details of edges, junctions, etc.
- (h) Performance
- (i) Precautions specified for durability

➤ **External wall treatment**

Madrasi danna, vineratex, granotex, etc.

Madrasi Danna, Vineratex, or Granotex finishes, where indicated shall be applied with materials as manufactured by the approved agencies. Stone finish, unless otherwise specifically mentioned, shall be used.

Samples of materials shall be submitted to the Engineer to approval before the bulk purchase is made. The Concessionaire shall prepare test panels 1m x 1m in size and obtain approval from the Engineer before commencing actual application of each type of finish.

The thickness of the finish shall not be less than 3 mm.

All surfaces to be finished shall be smooth and level and shall be thoroughly cleaned to remove any grease, dirt or loose particles and shall be free from surface water.

Extremely porous surfaces shall be pre-sealed with a thin coat of suitable primer. Previously painted surfaces shall be prepared by scrapping off all loose paints, washing with a suitable detergent and rinsing thoroughly with clean water. The finish shall be applied strictly in accordance with the manufacturer's instructions.

After application, the Concessionaire shall protect the surfaces against rain & sun until complete hardness of the finish is achieved without any extra cost to the Executing Agency. This type of work shall be carried out by specialized agencies only.

➤ **I.S. codes**

Some of the important applicable Indian Codes for this section are listed below. Latest editions of these codes shall be follows:

IS : 777 - Glazed earthenware tiles

IS : 1237 - Cement concrete flooring tiles

IS : 1433 - Code of practice for laying and finishing of cement concrete flooring tiles.

IS : 2114 - Code of practice for laying in situ terrazzo floor and finishes.

Sub section - C7
**Technical specification for roof waterproofing
insulation and allied works**

Sub section - C7

Technical specification for roof waterproofing insulation and allied works

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Sub section - C7: Technical specification for roof waterproofing insulation and allied works

7.1 Scope

This specification covers furnishing, installing, finishing, curing, testing, protecting, maintaining till handing over of roof waterproofing, thermal insulation and allied works for buildings.

7.2 General requirements

The Concessionaire shall furnish all skilled and unskilled labour, plant, equipment, scaffolding, materials etc., required for complete execution of the work in accordance with the drawings and as described herein and / or as directed by the Engineer.

The Concessionaire shall follow all safety requirements / rules during execution of the work.

The Concessionaire should have adequate experience in execution of such works. Alternatively, he should engage specialized agency for executing the work after obtaining approval from the Engineer.

7.3 Codes and standards

All applicable standards, acts and codes of practice referred to shall be the latest editions including all applicable official amendments and revisions. A complete set of all these documents shall generally be available at site, with the Concessionaire.

In case of any conflict between this specification and those (IS Standards, Codes etc.) more stringent shall prevail.

Some of the applicable Indian Standards, Codes, etc are referred to here below:

IS : 702	-	Specification for industrial bitumen
IS : 1203	-	Methods of testing tar and bitumen
IS : 1237	-	Specification for cement concrete flooring tiles

IS : 1322	-	Specification for bitumen felts for water proofing and damp proofing
IS : 1346	-	Code of practice for water proofing of roofs with bitumen felts
IS : 1580	-	Specification for bituminous compound for waterproofing and caulking purposes
IS : 3067	-	Code of practice for general design details and preparatory work for damp- proofing and water proofing of buildings
IS : 3384	-	Specification for bitumen primer for use in water proofing and damp- proofing
IS : 5916	-	Safety code for construction involving use of hot bituminous materials
IS : 6598	-	Specification for cellular concrete for thermal insulation

7.4 Materials

Bitumen felt for waterproofing treatment shall be Hessian base self - finished felts of specified type and grade conforming to IS: 1322

Bitumen primer shall conform to IS: 3384

The bonding material between the felt and the roof surface and between the successive felts shall be industrial blown type bitumen of specified grade (s) conforming to IS: 702

Cellular concrete (foam concrete) for insulation of roof shall be cast - in - situ of specified type conforming to IS: 6598

Materials for cement mortar under bedding and cement sand plaster over cellular concrete shall be as specified for plastering and allied works

Materials for cement concrete under bedding work shall be as specified for concrete and allied works

7.5 Layers of treatments

Various layers of treatment required for roof waterproofing and insulation work shall be as given below

However different layers which are to be actually provided for various areas shall be as shown in the drawings and directed by the Engineer.

- a) Grading underbed
- b) Insulation (Cellular concrete)
- c) Cement plaster and
- d) Waterproofing treatment

7.6 Grading underbed

The underbed shall be laid to provide an ultimate run-off gradient not less than 1 in 100 or as specified in the drawing and as directed by the Engineer. Upto an average thickness of 25mm the underbed shall usually be composed of cement and sand plaster. For higher thickness the underbed shall be made with cement concrete. However actual thickness and other details shall be as per approved drawings well defined cracks other than hair cracks in the roof structure shall be cut to 'V' section, cleaned and filled up flush with cement - sand slurry or with cold applied bituminous caulking compound conforming to IS: 1580. The roof surface shall be cured prior to the application of underbed.

The surface of roof and that part of the parapet, gutters, drain mouths etc., over which the underbed is to be applied shall be roughened and thoroughly cleaned of all foreign matter namely fungus, moss and dust, with wire brushing and dusting. Oil patches if any shall be removed with detergent. The surface shall be soaked with water and all excess water removed just before laying of the underbed.

The underbed shall not be laid under direct sunlight and shall be kept in shade immediately after laying, so as to avoid quick loss of water from the mix and separation from the roof surface. The underbed shall be cured under water twice a day for at least 7 days.

The underbed shall be finished to receive the waterproofing treatment directly or insulation as the case may be.

7.6.1 Cement mortar underbed

The grading plaster shall have an average thickness of 25mm. It shall consist of cement and sand in the ratio of 1:4 by volume. The sand and cement shall be thoroughly mixed dry before water is added. Each batch of mix shall be consumed before the initial set starts.

The plaster shall be laid to proper grade in continuous operation and fully compacted. The surface shall be even and reasonably smooth. For detailed specification of plastering work Section -C5 shall be followed.

7.6.2 Cement concrete underbed

The concrete shall be used where the underbed is more than 25mm (average) thick. It shall consist of cement concrete 1:2:4 mix by volume (1 cement: 2 sand: 4 graded stone aggregate. 12.5 mm down stone nominal size). The aggregate shall be thoroughly mixed dry and minimum quantity of water shall be added to make the mix workable.

The mix shall be laid to proper grade in continuous operation and full consolidated. The surface shall be even and smooth. For detailed specification of concrete work Section C3 shall be followed.

7.7 Insulation

Insulation shall consist of cast-in-situ cellular concrete conforming to IS: 6598.

The cellular concrete of thickness 40 mm (minimum) shall be laid over the grading underbed over precast/cast-in-situ RCC roofs. The cellular concrete shall be laid directly over the surface of the roof without separate under bedding and the slope be provided by cellular concrete, wherever shown in the drawings and / or as directed by the Engineer.

7.8 Cellular concrete

It shall consist of cast - in - situ light weight concrete formed by producing gas or air bubbles in cement slurry or a cement - sand slurry. The cement slurry or cement - sand slurry. The material shall be cured under natural conditions i.e., under ambient pressure and temperature by water. The material shall have a density of 320 kg/cu.m. crushing

strength of minimum 2.5 kg/sq.m. value of thermal conductivity of maximum 0.7 mW/cm deg at 50 degree Centigrade mean temperature i.e., Type A.

Before start of the laying of the cellular concrete, samples shall be prepared at site got tested. The approval of the Engineer shall necessarily be obtained.

Cellular concrete laid shall be sufficiently strong to take the usual workloads and standard loads expected on the roof. Any damaged portion shall be removed and replaced forthwith.

While laying the cellular concrete, samples from each batch of the mix shall be kept for test, if so desired by the Engineer.

The approval of the Engineer shall be taken before laying the layer of cement plaster over the cellular concrete.

7.9 Cement plaster

After laying the insulation (cellular concrete), the surface shall be regarded with cement plaster and made ready as required to receive the waterproofing treatment.

The top surface of insulation shall be finished, with 12mm (minimum) thick, or as specified in the item 1:4 cement - sand plaster by volume to get an even and smooth surface. The sand and cement shall be thoroughly mixed dry before water is added to it. Each batch of the mix shall be consumed before the initial set starts. It shall be cured twice a day for at least seven days before laying the waterproofing course. For detailed specification of plastering work MODULE / shall be followed.

7.10 Waterproofing treatment

7.11.1 Preparatory work

IS: 3067 shall be followed as a general guidance for preparatory work.

Waterproofing treatment shall be carried out into the drain pipe or outlets by at least 100mm. The waterproofing treatment laid on the surface shall overlap the upper age of the waterproofing treatment in the drain outlets by at least 100 mm.

Drain outlets shall be suitably placed with respect to the roof gradient to ensure rapid drainage and prevent local accumulation of water on the roof surface. Masonry drain mouths shall be widened two and a half times the diameter of the drain and rounded with cement mortar.

Forecast iron outlets a groove shall be cut all round to tuck the treatment.

When a pipe passes through a roof on which waterproofing treatment is to be laid, a cement concrete angle - fillet shall be built round it and the waterproofing treatment taken over the fillet.

In case of parapet walls above 450mm in height, for tucking in the waterproofing treatment a horizontal groove at a minimum height of 150mm above roof level shall be left in the vertical face at the time of construction. This groove shall be 75mm wide and 65mm deep. The horizontal face of the groove shall be shaped with cement mortar 1:4.

In case of low parapets, where the height does not exceed 450mm, no groove shall be provided and the waterproofing treatment shall be carried right over the top.

In the case of existing RCC and stone walls, cutting the chase for tucking in the waterproofing treatment is not recommended.

At the junction between the roof and the vertical face of the parapet wall, a fillet 75mm (min) in radius shall be constructed.

At the drain mouths, the fillet shall be suitably cut back and rounded off for easy application of the waterproofing treatment and easy flow of water.

Outlets at every low dividing wall, about less than 300mm in height, shall be cut open to full depth and the bottom and sides shall be rendered smooth and corners rounded off for easy application of waterproofing treatment.

The surface to be coated with bitumen primer shall be cleaned with wire brushes and cotton or gunny cloth. All loose materials shall be removed and surface shall be further cleaned with a piece of cloth lightly soaked in kerosene oil. The surface shall be painted when it is completely dry.

Bitumen primer (priming coat) shall be used prior to the application of the first mopping coat of hot molten bitumen to promote the bonding of the bitumen with the surface. The bitumen primer shall be liquid bitumen of low viscosity which shall penetrate into the prepared surface upon application. It shall be free from water and it shall conform to IS: 3384. It shall preferably be made from the same grade of bitumen as used in bonding.

The bitumen primer shall be brushed over the surfaces and allowed to dry. Generally, a quantity of 0.27 litres per sq.m. (Minimum) is recommended.

The bonding material between the felt and the roof surface and between the successive felts shall be industrial blown type bitumen of Grade 85/25 or 90/15 conforming to IS: 702 to withstand local conditions of prevailing temperature and gradient of roof surface. For top dressing bitumen used shall be industrial blown type of allowable penetration not more than 40 when tested in accordance with IS : 1203.

For vertical surface upto 1 meter height blown type bitumen of grade 85/25 or 90/15 and above 1 metre height grade 115/25 shall be used.

Bitumen tar felt of type 3, grade 1 conforming to IS: 1322 shall be used for roof waterproofing and the treatment shall be done as per IS: 1346.

The Concessionaire shall state the source from where he proposes to procure the materials. The Concessionaire shall satisfy the Engineer that the bonding material proposed to be used is suitable for the particular job. Test certificates for the bonding material shall also be submitted and samples, if desired by the Engineer shall be provided for confirmatory tests. Sample of the self - finished felt shall be submitted in advance to the Engineer along with test certificates for his review. Samples of stone grit shall be submitted if instructed by the Engineer. The stone grit shall be 6mm and down size and shall be devoid of fine sand. Test certificates shall be furnished with each batch of bulk supply for Engineer's approval.

7.11.2 Course of treatment

The waterproofing treatment shall consist of a seven course treatment. Each layer of bonding materials, self - finished bitumen felt or stone grit is counted as one course.

Brief description of various courses of treatment shall be as follows:

Heavy treatment - seven courses for severe conditions:

- 1 Primer conforming to IS : 3384 at the rate of 0.27 litre / sq.m minimum
- 2 Hot applied bitumen at the rate of 1.2 kg/sq.m minimum
- 3 Hessian - base self finished felt, Type - 3, Grade 1
- 4 Hot applied bitumen at the rate of 1.2 kg/sq.m minimum
- 5 Hessian - base self finished felt, Type 3, Grade 1
- 6 Hot applied bitumen at the rate of 1.2 kg/sq.m, minimum and
- 7 Grit, devoid of fine sand, at the rate of 0.006 cu.m/sq.m

7.11.3 Surface finish

When the roof surface is subjected to foot traffic or used as a working area, a cement mortar (1:4) shall be applied over the top most layer of roofing treatment. Over this, a layer of cement concrete flooring tiles conforming to IS: 1237 shall be provided in place of stone grit and cement painted. The tiles shall be laid as per IS: 1443. Alternatively, a screening of proportion of 1:4 of cement and sand 45mm thick can be laid over the roof treatment wherever shown in the drawing and marked off into square of 600mm made with expansion joints provided at a distance of 3 metre which shall be properly caulked with bituminous sealing compound conforming to grade A of IS: 1834.

Waterproofing treatment shall be carefully carried out from the time the surface is prepared to receive the felt to the finishing of the treated surface. Special attention and strict supervision shall be necessarily paid to overlapping of joints in felts, treatment around drainage openings in the roof and treatment of the parapet walls. The sticking of the felt to the roof by means of hot bitumen also requires skill. In order to achieve this, the waterproofing treatment shall be laid by a specialist firm with long experience in this particular line. The surface to receive the waterproofing treatment must be cleaned of all foreign matter, namely fungus, moss, dust etc by wire brushing and dusting and dried satisfactorily and the approval of the Engineer taken before starting the work. If any existing top course shall be completely removed and all damaged felts or other defects repaired. The Engineer may instruct the Concessionaire to lay part of the stipulated course at the first instant to be followed later on with the balance courses. This interim finish shall be done with a course of hot applied bitumen. While doing the balance, hot bitumen shall be applied again to start with after repair of all damages to the already laid courses.

The bitumen bonding material of specified grade shall be prepared by heating to the correct working temperature specified by the manufacturer and maintained at that temperature. It shall then be conveyed to the point of work in a bucket or pouring can, poured and spread on the surface in a uniform continuous coating at the specified rate. For very large roofs, use of a spray machine is recommended to secure even spreading. The surface shall be carefully examined for gaps or pin holes, which on location shall be carefully filled up with the bitumen. Bitumen shall be applied carefully so that the exposed faces are not disfigured by splashing or spattering the bitumen all over.

The coat of bitumen shall be continued at least 15cm along the vertical surfaces joining the roof. In case of parapet walls, it shall be continued upto the drip course.

The self finished felt shall be cut to the required lengths, brushed clean of dusting material and laid out flat on the roof and allowed to soften, to eliminate curls and subsequent stretching. The felt shall normally be laid in lengths at right angles to the direction of run-off gradient, commencing at the lowest level and working upto the crest so that the overlaps of the adjacent layers of felt shall offer minimum obstruction to the flow off of water. The felt shall not be laid in single piece of very long lengths as they are likely to shrink. Six to eight metres are suitable lengths. Each length of felt prepared for laying as described above shall be laid in position and rolled up for a distance of half its length. The hot bonding material heated to correct working temperature as specified by the manufacturer, shall be poured on to the roof across the full width of the rolled felt as the latter is steadily unrolled and pressed down. The excess bonding material which squeezes out at the ends shall be removed as the laying proceeds. The pouring shall be so regulated that the correct weight of bonding material per unit area is spread uniformly over. When the first half of the strip of felt has been bonded to the roof, the other half shall be rolled up and then unrolled on to the hot bonding material in the same way. Subsequently strips shall also be laid in the same manner. Each strip shall overlap the preceding one by at least 75mm at the sides of strip of felt and at least 100mm at the ends. All overlaps shall be firmly bonded with hot bitumen. Streaks and trailings of bitumen near edges of laps shall be levelled by heating the overlaps with a blow lamp and leveling down unevenness.

In a seven course treatment the fourth and sixth layers of bonding material and the fifth layer of self-finished felt shall be laid in the manner already described, taking care that the joints are staggered with those in the layer beneath it i.e., third layer. The sixth layer shall be carried out after the flashing is done.

Immediately after application of top layer of bitumen stone grit shall be evenly spread and levelled over the surface when the bitumen is still hot.

After completion, the surface shall be cleaned taking care that loose gravels, felt cuttings, etc. do not find their way into rain down corners.

The surface level shall be such as to allow quick draining of rains without leaving any pool anywhere. The finishing course shall be fully secured and shall have an even density. There shall not be any bubble formation or crushed or squeezed insulation or underbed.

For heat reflecting surface or for aesthetic reasons bitumen based aluminium paints or coloured bituminous emulsions may be used as directed by the Engineer.

7.11.4 Flashing

Felt shall be laid as flashings in widths wherever junctions of vertical and horizontal structures (i.e., roof surface and parapet wall or any other vertical structure) occur with minimum overlap of 100mm. The lower layer of flashing felt in seven course treatment shall overlap the roof waterproofing by not less than 200mm while upper layer shall overlap the roofing felt by 100mm. On the vertical and sloping faces last course of flashing should not be of stone grit or pea-sized gravel, but it shall be replaced by providing two coats of bituminous paint at the minimum rate of 0.1 litres/sq.m per coat or a single coat of bituminous emulsion at the rate of 0.5 litre/sq.m may be applied.

The lower edge of flashing shall overlap the felt laid on flat portion of the roof and the upper edge of the flashing shall be tucked into the horizontal groove 75mm thick wide 65mm deep, provided at a minimum height of 150mm from top of the roof surface. The flashing treatment shall be firmly held in place in the grooves with wooden wedges at intervals and the grooves shall be filled with cement mortar 1:4 (1 cement: 4 coarse sand) or cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 graded stone aggregate 6 mm nominal size) and surface of flashing.

After the top flashing felt layer has been laid, the penultimate layer of bonding material shall be applied over the roofing felt and horizontal overlaps and vertical and sloping surfaces of flashing at the specified rate. Then grit or gravel shall be spread uniformly over the hot bonding material on the horizontal surface and pressed into it with a wooden roller.

Where waterproofing treatment is required to be isolated from the roof structure, bitumen saturated felt shall be spread over the roof surface and tucked into the flashing grooves. To keep these felts free from the structure, no bonding material shall be used below these felts.

7.11.5 Fillets

All along the junction of the roof surfaces and vertical walls cement mortar (1:4) fillet shall be provided. The fillets shall be 150mm x 150mm in size unless otherwise shown on drawing or instructed by the Engineer. The shape of the fillet shall slightly be concave.

Cast-in-situ cement concrete (1:2:4 with 12.5mm down aggregate) or cement mortar 1:4 shall be used to provide fillet.

7.11.6 Expansion joints

Expansion joints shall be designed to suit the requirements of each roof. Expansion joint coverings shall be of bitumen felt. In this case, a minimum of two layers of bitumen felt, Type 2, Grade 2 as specified in IS: 1322 shall be used with top dressing gravel or other suitable finish.

7.11 Acceptance criteria

The surface level shall be such as to allow quick draining of rains without leaving any pool anywhere. The finishing course shall be fully secured and shall have an even density. There shall not be any bubble formation or crushed or squeezed insulation or underbed.

7.12 Guarantee

The Concessionaire shall give a guarantee in writing for all works executed under this specification supplemented by a separate and unilateral guarantee from the specialized agency for the roof waterproofing treatment work. The Concessionaire shall give a guarantee for materials and workmanship and satisfactorily functioning of the waterproofing treatment for a period of (6) six years from the date of completion of work or the date of handing over the site to the Engineer whichever is later. The specialist agency / Concessionaire shall endorse the guarantee, beyond the defect liability period as indicated, in favour of the Executing Agency. The Concessionaire shall replace / rectify defects, if any, observed in the waterproofing treatment to the satisfaction of the Engineer.

Sub section - C8
**Technical specification for painting, white
washing, etc.**

Sub section - C8

Technical specification for painting, white washing, etc.

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Sub section - C8: Technical specification for painting, white washing, etc.

8.1 Scope

This specification covers painting, white washing, etc. of both interior and exterior surfaces of masonry, concrete, plastering, plaster of Paris, rain water down comers, floor and roof drains, waste and service water pipes and other items, as directed by the Engineer.

If the surface to be finished cannot be put in a suitable condition for painting by customary preparatory method, the Concessionaire shall notify the Engineer in writing and assume responsibility for any rectification and unsatisfactory finishing that might result.

Before commencing painting, the Concessionaire shall obtain the approval of the Engineer in writing regarding the scheduling of work to minimise damage, disfiguration or staining by other trades. He shall also undertake necessary precautions to prevent damage, disfiguration or staining of other trades or other installations.

8.2 Materials

Materials shall be the highest grade products of well known approved manufacturers and shall be delivered to the site in original sealed containers, bearing brand name, manufacturer's name and colour shade, with labels intact and seals unbroken. All materials shall be subject to inspection and approval by the Engineer. It is desired that materials of one manufacturer only shall be used as far as possible and paint of one shade be obtained from the same manufacturing batch. All paints shall be subjected to analysis from random samples taken at site from the painter's bucket, if so desired by the Engineer.

All primer coats shall be compatible to the material of the surface to be finished as well as to the finishing coats to be applied.

All unspecified materials shall be of the highest quality available and shall conform to the latest IS standards. All such materials shall be made by reputable recognised manufacturers and shall be approved by the Engineer.

All colours shall be as per the painting schedule and tinting and matching shall be done to the satisfaction of the Engineer. In such cases, where samples are required, they shall be executed in advance with the specified materials for the approval of the Engineer.

8.2.1 Synthetic enamel paint

Shall be made from synthetic resins and drying oil with rutile titanium dioxide and other selected pigments to give a smooth, hard, durable and glossy finish to all exterior and interior surfaces. White and pastel shades shall resist yellowing and darkening with ageing, The paint shall conform to IS:2932 and IS:2933.

8.2.2 Waterproof cement paint

Shall be made from best quality white cement and lime resistant colours with accelerators, waterproofing agents and fungicides. The paint shall conform to IS:5410.

8.2.3 Dry distemper

Dry distemper of required colour conforming to IS: 427 of approved brand and manufacturer shall be used. The primer where used shall be cement primer or distemper primer. These shall be of same manufacturer as that of distemper.

8.2.4 White washing

White washing shall be done from pure shell lime or fat lime, or a mixture of both as instructed by the Engineer and shall conform to IS:712 (latest edition) Samples of lime shall be submitted to the Engineer for approval and lime as per the approved samples shall be brought to site in an unslaked condition. After slaking, it shall be allowed to remain in a tank of water for two days and then stirred up with a pole, until it attains the consistency of thin cream. 100 grams of gum to 6 litres of white wash water and a little quantity of indigo or synthetic ultramarine blue shall be added to the lime.

8.2.5 Colour wash

Shall be done with mineral colours not affected by lime added to white wash. No colour wash shall be done until a sample of the colour wash to the required tint or shade has been approved by the Engineer. The colour shall be of even tint or shade over the whole surface. If it is blotchy or otherwise badly applied, it shall be redone by the Concessionaire at his own cost.

8.2.6 Acrylic emulsion paint

Shall be water based acrylic copolymer emulsion with rutile titanium dioxide and other selected pigment and fungicide. It shall exhibit excellent adhesion to plaster and cement surface and shall resist deterioration by alkali salts. The paint film shall allow the moisture in wall to escape without pelling or blistering the paint. After it is dried, the paint should be able to withstand washing with mild soap and water without any deterioration in colour or without showing flaking, blistering or peeling.

8.2.7 Oil bound distemper

Oil bound distemper (IS:428-1969) of approved brand and manufacture shall be used. The primer where used be cement primer or distemper primer. These shall be of same manufacturer as that of distemper. The distemper shall be diluted with prescribed thinner in a manner recommended by the manufacturer. Only sufficient quality of distemper required for a day's work shall be prepared.

8.2.8 Chemical resistant paint

Chemical resistant paint as per IS:157 of approved brand and manufacture shall be used. Primer coat to be used shall be as per manufacturer's specifications.

8.2.9 Fire resistant paint

Fire resisting paint (silicate type) shall be as per IS:162 and of approved brand and manufacture. Primer to be used shall be as per manufacturer's specifications.

8.2.10 Oil resistant paint

Oil resistant paint shall be as per IS:161 and of approved brand and manufacturer. Primer coat shall be as per manufacturer's specifications.

8.3 Storage

The Concessionaire shall arrange for safe and proper storage of all materials and tools. Paints shall be kept covered at all times and mixing shall be done in suitable containers. All necessary precautions shall be taken by the Concessionaire to prevent fire.

8.4 Preparation of surface

Before starting the work, the Concessionaire shall obtain the approval of the Engineer regarding the soundness and readiness of the surface to be painted on.

8.4.1 Masonry, concrete and plastered surface

The surface shall be free from all oil, grease, efflorescence, mildew, loose paint or other foreign and loose materials. Masonry cracks shall be cleaned out and patch filled with mortar similar to the original surface and uniformly textured. Where this type of resurfacing may lead to the finishing paint being different in shade from the original surfaces, the resurfaced area shall be treated with a minimum of one coat of cement primer and should be continued to the surrounding area for a distance of atleast 100mm.

Surfaces with mildew or efflorescence shall be treated as below:

a. Mildew

All mildewed surfaces shall be treated with an approved fungicide such as ammonical wash consisting of 7 gm. of copper carbonate dissolved in 80 ml liquor and diluted to 1 liter with water or 2.5 percent magnesium silica fluoride solution and allowed to dry thoroughly before paint is applied.

b. Efflorescence:

All efflorescence shall be removed by scrubbing the affected surface with a solution of mariatic acid and in water (1:6 to 1:8) and then washed fully with clear water and allowed to dry thoroughly.

8.4.2 Metal

All metal surfaces shall be absolutely clean, dry and free from wax, grease and soap films. All steel and iron surfaces in addition shall be free from rust. All galvanised iron surfaces shall be pretreated with a compatible primer according to the manufacturer's direction. Any abrasion in shop coat shall be touched up with the same quality of paint as the original coat.

8.5 Application

8.5.1 General

The method of application shall be as recommended by the manufacturer. In case of selection of a special shade and colour (not available in standard shades) the Concessionaire shall prepare test panels in different shades of minimum size 1 metre square as instructed by the Engineer and obtain his approval prior to applications of the finishing paints.

Proper tools and implements shall be used. Scaffolding if used shall be independent of the surface to be painted to avoid shade differences of the freshly repaired anchor holes. Painting shall be done by skilled labour in a workman like manner. All materials shall be evenly applied, so as to be free of sags, runs, crawls or other defects. All coats shall be of proper consistency. In case of application by brush, no brush marks shall be visible. The brushes shall be clean and in good condition before application of the paint.

All priming undercoats for painting shall be applied by brush only. Roller and spray equipment, etc., shall not be used.

No work shall be done under conditions that are unsuitable for the production of good results. No painting shall be done when plastering is in progress or is drying. Paint which seals the surfaces to moisture shall be applied only after the moisture on and below the surface has dried out.

All coats shall be thoroughly dry before being sand papered or before the succeeding coat is applied. Coats of painting as specified are intended to cover surfaces perfectly. In case the surface is not covered properly by applying the specified number of coats, further coats shall be applied by the Concessionaire when so directed by the Engineer.

All primers and under coats shall be tinted to approximate the colour of the finishing coats. Finished coats shall be of exact colour and shade as approved samples and all finish shall

be uniform in colour and texture. All parts of mouldings and ornaments shall be left clean and true to finish.

8.5.2 Synthetic enamel paint

Shall be applied on properly primed surface. Subsequent coat shall not be applied till the previous coat is dry. The previous coat shall be lightly sand papered for better adhesion of subsequent coats.

8.5.3 Waterproof cement paint

Surface to be coated with cement paint shall be washed and brushed down. As soon as the moisture has disappeared, the surface shall be given one coat of paint. Care shall be taken so that the paint does not dry out too rapidly. After 4 to 6 hours, the water shall be sprinkled over the surface to assist curing and prevent cracking. After the first, coat has dried (24 to 48 hours), the second coat shall be applied.

In a similar manner the finished surface shall be kept moist by occasional sprinkling with water for seven days after painting.

8.5.4 Dry distemper

New plastered surface shall be allowed to dry for atleast two months. New lime or lime plastered surface shall be washed with a solution of 1 part of vinegar to 12 parts water or 1:50 sulphuric acid solution and left for 24 hours after which the wall shall be thoroughly washed with clean water. For cement plastered surface, the surface shall be washed with a solution of 100 gms of zinc sulphate to 1 litre of water and then allowed to dry.

Dry distemping shall be done as per manufacturer's instruction. In applying the distempers, the brush should first be applied horizontally and immediately crossed off perpendicularly. Brushing shall not be continued too long as otherwise brush marks may result.

8.5.5 White washing

The surface where white washing is to be applied shall be cleaned of all loose material and dirt. All holes and irregularities of the surfaces shall be filled up with lime putty and shall be allowed to dry out before application of the lime solution.

One coat of white wash shall consist of one stroke from top downwards, another from bottom upwards over the first stroke and another from left to right and right to left before the vertical stroke dries out. A second coat shall be applied and similarly a third coat shall be applied whenever the Engineer feels that more than two coats are required and the Concessionaire shall do so without any extra cost to the Executing Agency. No brush marks shall show on the finished surface.

8.5.6 Colour wash

For new work, the priming coat shall be of white wash with lime or with whiting. Two or more coats shall then be applied on the entire surface till it represents a smooth and uniform finish. The finished dry surface shall not be powdery and shall not readily come off on hand when rubbed. Indigo or synthetic ultramarine blue shall, however, not be added.

8.5.7 Acrylic emulsion paint

Lime gauged cement plastered surfaces shall not be painted for at least one month after plastering. All sample patch shall be painted to check alkali reaction if so desired by the Engineer. Painting shall be strictly as per manufacturer's specification.

8.5.8 Oil bound distemper

Any unevenness in surface shall be made good by applying putty. The patched surface shall be allowed to dry thoroughly before the coat of distemper is applied. One coat of distemper properly diluted with thinner as specified by the manufacturer shall be applied by brush in horizontal strokes followed immediately by vertical ones which together will constitute one coat. Two or more coats of distemper as found necessary shall be applied to obtain even shade.

8.5.9 Chemical resistant, fire resistant and oil resistant paints

In general, method of application of these paints shall be strictly as per manufacturer's specification.

8.6 Painting of iron work

Paint to use for various items of work shall be of best quality and shall be obtained ready mixed in sealed containers from approved manufacturer. The Concessionaire shall obtain the Engineer's approval for the make and colour of the paint he proposes to use.

All surfaces shall be thoroughly cleaned of all dirt, loose particles and rust and approved prior to application of paint. Workmanship shall conform to IS:1477 (Part I & II)

Specified number of coats shall be applied and atleast 24 hours shall elapse between the application of successive coats. No painting shall be carried out on exterior work in wet weather or on surfaces which are not entirely dry.

Painting rate shall include all necessary scaffolding, cradles and plant.

8.7 Protection

Furniture and other movable objects, equipments, fittings and accessories shall be moved, protected and replaced upon completion of the painting work. All stationary items of equipments shall be well covered so that no paint can fall on them. Work finished by other agencies shall be well protected. All protection shall be as per instruction of the Engineer.

8.8 Cleaning up

The Concessionaire shall upon completion of painting etc. remove all marks and make good surfaces, where paint has spilled, splashed or splattered, including all equipments, fixtures, glass furniture, fittings, etc. to the satisfaction of the Engineer.

8.9 Acceptance criteria

All painted surfaces shall be uniform and pleasing the appearance.
The colour, texture etc. shall match exactly with approved samples.

All stains, splashes and splatters of paint shall be removed from surrounding surfaces.

8.10 Painting of structural steel / miscellaneous steel

8.10.1 Scope

The specification covers painting of the structural/ miscellaneous steel supplied and erected either by other agencies or by the Concessionaire for work under the scope of this contract. One shop coat of red oxide zinc chromate primer including necessary touching up has already been completed by the concerned agency. One coat of red oxide zinc chromate primer followed by a coat of undercoating and two or more finishing coats of synthetic enamel paint as described hereunder are only required to be provided under the item for painting structural / miscellaneous steel.

8.10.2 Type of structures to be painted

Painting shall be done on all exposed surfaces (including undersides wherever exposed) of various structural steel members like columns, trusses, beams, roof girders, oil tanks, trestles, bracings, crane girders, chequered plates, gratings, brackets, base plates etc. in the plant as directed by the Engineer. It should be clearly noted that all structures are already erected / placed in position or are under erection, hence the quoted rate by Concessionaire shall account for all aspects involved in painting keeping in view the heights, available access to members etc. It is advised that the Concessionaire should visit the site and get himself acquainted with the nature of work completely including the extent and type of scaffoldings etc, required, before quoting his rate.

8.10.3 Material

Paint shall be synthetic enamel paint conforming to IS:2932 of approved colour and brand.

8.10.4 Painting

In general, painting work shall be in accordance with IS:1477 (Part I & II).

Surface of steel work to be painted shall be thoroughly cleaned of all grease, oil dirt, rust, foreign matter like cement splashings, etc. by suitable solvent and mild rubbing with abrasive paper/ hand scrapping to the full satisfaction of the Engineer. Clearing with solvents/ scrapping shall be limited to the affected areas only.

In cases where the existing primer is removed while cleaning the surface as detailed in 12.4.2, damaged portions shall be provided with a coat of wash or etching primer on suitable chemical pretreatment solutions and another coat of red oxide Zinc chromate primer. The payment for red oxide primer will be made as per relevant item of Schedule of items.

After the surface is prepared in a manner described above, the primer coat shall be dry cut without scratching or in any way damaging the primer coats and clean the surfaces from dust.

Over this dry surface apply an optimum coat of undercoating (synthetic enamel paint) by brush or spray with minimum brush marks. Allow the film to dry hard, wet rub, cutting down to a smooth finish (ensuring that at no place the undercoat is completely removed) Allow the water to evaporate.

The total dry film thickness of each coat shall be not less than 25 microns.

The paint shall be applied by brushing / spraying. Spraying shall be adopted with prior approval of Engineer generally on large surface areas. Paints shall be stirred frequently to keep the pigment in suspension. Paint shall be ready mixed in original sealed containers as packed by the paint manufacturers and no thinners shall be permitted. No painting shall be done in frosty/ foggy / rainy weather or when humidity is high enough to cause condensation on the surface to be painted. Paint shall not be applied when the temperature of the surface to be painted is 5 deg or lower.

Concessionaire shall provide and use sufficient number of drop clothes, covers, tarpaulins and other screens to protect adjacent surfaces and shall remove all splatter and stains from such surfaces. The Concessionaire shall also protect his own work.

Any and all damage to adjacent work or any part of the premises due to painting carelessness or accidental performance of the Concessionaire shall be repaired or made good at the Concessionaire's expense.

Painting shall be discontinued when exposed to rain and dust storm and shall not commence until the surfaces are perfectly dry and clean. Wherever practicable. Surfaces shall be painted when in shade or when temperature is falling.

8.10.5 Cleaning up

The Concessionaire upon completion of painting etc. shall remove all marks and make surfaces good, where paint has been spilled, splashed or splattered, including all equipment, fixtures, glass, furniture, fittings, etc. to the satisfaction of the Engineer.

8.10.6 Acceptance criteria

- a. All painted surfaces shall be uniform and pleasing in appearance.
- b. The colour, texture, etc. shall match exactly with the approved samples.
- c. All stains, splashes and splatters of paints shall be removed from surrounding surfaces.

Sub section - C9
**Technical specification for fabrication and
erection of structural steel works**

Sub section - C9

Technical specification for fabrication and erection of structural steel works

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Sub section - C9: Technical specification for fabrication and erection of structural steel works

9.1 Scope

This section of specification deals with the technical specifications needed for the fabrication and erection of structural steel works coming under the scope of this contract. All connections shall be of welded type unless specifically approved by the Engineer otherwise.

The specification cover providing, fabrication, erection, alignment etc. complete including preparation of fabrication drawings of structural steel work involving rolled sections, pipes and built up sections fabricated out of plates, rolled section and or combination of plates and rolled sections in columns, beams, gantry girders, roof trusses, portals, purlins, space frames, shear connector, monorails, galleries, wall beams, brackets, stub columns bracings, trestles, base plates, chequered plate floorings, gratings with binders, walk way platform, ladders, stairs complete with stringers, treads, landings, hand rails posts, erection bolts and nuts, permanent bolts and nuts, dismantling, modification and re-erection of fabricated/erected steel, etc. including all sampling and testing as given in Annexure-B for the areas of work as specified above.

9.2 General requirements

The Concessionaire shall furnish all structural steel material, labour, plant, equipment, consumables, scaffolding, tools, tackles, materials and everything that is required for complete executions of the work on schedule in accordance with the drawings and as described herein and/or as directed by the Engineer.

9.2.1 Reference points and bench marks

The Concessionaire shall make his own arrangements for locating the coordinates and positions of all work and reduced level (RL) at these locations based on two reference grid lines and one bench mark which shall be furnished by the Executing Agency. The Concessionaire has to provide at site all the required survey instruments to the satisfaction of the Engineer so that the work can be carried out accurately according to the specifications and drawings.

9.2.2 Safe working

The Concessionaire shall strictly follow, at all stages of fabrication, transportation and erection of steel structures, the stipulations contained in the Indian standard safety code for erection of structural steel work IS:7205 and the provisions of the safety rules as specified in the general conditions of the contract for ensuring safety of men and materials. This shall include proper approach and working platform during erection of the structures.

9.2.3 Drawings

The fabrication drawings are to be prepared and furnished by the Concessionaire. These shall be based on the design drawings. These drawings shall indicate complete details of fabrication and erection including all splicing details, lacing details, weld sizes of lengths, detailing of all joints, and bill of materials in the proforma approved by the Engineer, and all other customary details in accordance with standard structural engineering practice whether or not given by the Executing Agency. He shall furnish along with the fabrication drawings, necessary calculations regarding design of joints viz. Size and length of welds, dia and number of bolts, and calculations justifying other fabrication details as well as design of erection and fabrication splices in accordance with IS:800 and other relevant standards. He shall also furnish scheme of erection.

The fabrication drawings shall indicate identification (erection) marks for purposes of despatch and erection etc.

In addition, the total quantity as well as abstract of quantities is indicated in the fabrication drawings. The Concessionaire shall prepare a consolidated schedule of permanent bolts and nuts, showing the length, size, weight and numbers required for each fabricated member.

Three copies of the detailed fabrication drawings including bolts and nuts schedule shall be submitted by the Concessionaire for approval in the first instance along with Bill of materials showing the description of members, their erection marks, quantity, etc. (Proforma to be approved by the Engineer). In case the approval accorded to the fabrication drawings is subject to any modifications, additions, and alterations, the Concessionaire shall submit two sets of the revised drawings for final approval after incorporating these changes.

In case the drawings are approved as submitted, he shall submit thirteen additional prints of such approved fabrication drawings. In addition, the Concessionaire shall also be required to furnish one reproducible copy of final fabrication drawings (as actually fabricated).

The design drawings may require revision either before or after the preparation and approval of fabrication drawings. Such revision shall be duly incorporated in the fabrication drawings and nothing extra shall be payable on this account for preparation / revision of fabrication drawings. The Concessionaire is expected to make his own assumptions regarding the quantum of such revisions involving preparation/revision of fabrication drawings, while quoting.

The fabrication work shall start only after the approval to the fabrication drawings is accorded by the Engineer.

Such approval shall, however, not relieve the Concessionaire of his responsibility for the safety of the structure, good connections, erectability, etc.

9.2.4 Samples

Samples for checking the quality of materials procured by the Concessionaire and workmanship in the execution of the works may be called for at any time by the Engineer. In case such samples are found to be of sub standard/unacceptable quality, the Concessionaire shall immediately discontinue use of such materials and workmanship and get fresh samples approved by the Engineer. Nothing shall affect the liberty of the Engineer to reject whole or portions of structures where such defective materials and workmanship has already been used before detection.

9.2.5 Test at works

The Concessionaire shall arrange for all materials procured by him to be tested as and when required and in the presence of the representative of Engineer.

For structural steel test samples shall be cut out of the materials from the locations indicated by the Engineer and samples shall be prepared in accordance with the requirements of Indian Standards Specifications for conducting such tests. For each set of tests three

samples shall be taken for tensile strength test and bend test. One set of tests will include test of three individual specimens of samples.

9.2.6 Fabrication shop at project site

Fabrication shop of the Concessionaire at project site shall have all facilities required for carrying out the work. The Concessionaire shall get the details of the shop approved by the Engineer.

9.3 Applicable standard and codes

Except where otherwise specified herein or authorized by the engineer, all items of work shall conform to the requirements of relevant latest Indian standards. Any item of work, for which there is no Indian Standard available, shall conform to the latest British standard (B.S.). The item of work shall be best of its kind and subject to approval of the Engineer. In case of conflict between this specification and those referred to in the standard, the former shall prevail.

List of certain important codes and standards applicable to this work is given below. However the applicable standards and codes shall be as per but not limited to the list given below.

9.3.1 Materials

IS : 808	Rolled steel, beam, channel and angle sections
IS : 2062	Structural steel (fusion welding quality)
IS : 1363	Hexagon head bolts, screws and nuts of production grade C.
IS : 1364	Hexagon head bolts, screws, and nuts of production grade A & B.
IS : 1367	Technical supply conditions for threaded fasteners.
IS : 1161	Specification of steel tubes for structural purposes.
IS : 2016	Specification for plain washers.
IS : 814	Specification for covered electrodes for metal arc welding for weld steel.
IS : 1852	Specification for rolling and cutting tolerances for hot rolled steel products.
IS :2074	Ready mixed paints, red oxide zinc chromate primer.
IS : 3502	Specifications for chequered plate.

- IS : 383 Specification for coarse and fine aggregates from natural sources for concrete.
- IS : 1566 Specification for hard-drawn steel wire fabric for concrete reinforcement.
- IS : 3757 Specification for high strength structural bolts.

9.3.2 Codes of Practice

- IS : 800 Code of practice for construction in steel.
- IS : 816 Code of practice for use of metal arc welding for general construction.

- IS : 9595 Code of procedure of manual metal arc welding of mild steel.
- IS : 817 Code of practice for training and testing of metal arc welders
- IS : 1811 Qualifying tests for metal arc welders (engaged in welding structures other than pipes).
- IS : 1182 Recommended practice for radiographic examination of fusion-welded butt joints in plates.
- IS : 1477 Code of practice for painting of ferrous metal in buildings and allied finishes.
- IS : 3696 Safety code of scaffolds and ladders.
- IS : 7293 Safety code for working with construction machinery.
- IS : 7205 Indian Standard safety code for erection of structural steel.
- IS : 7215 Tolerances for fabrication steel structures.
- IS : 12843 Tolerance for erection of structural steel.
- IS : 4353 Recommendation for submerged arc welding of mild steel and low alloy steels.
- SP : 6 ISI Hand book for structural engineers. (Part 1 to 7)

9.3.3 Standards for testing

- IS: 1608 Method of tensile testing of steel products other than sheets, strip, wire and tube.
- IS : 1599 Method of bend tests for steel products other than sheets, strip, wire and tube.
- IS : 228 Methods of chemical analysis of pig iron, cast iron and plain carbon and alloy steel
- IS : 2595 Code of practice for radio graphic testing.

- IS : 1182 Recommended practice for radiographic examination of fusion welded butt joints in steel plates.
- IS : 3664 Code of practice for ultrasonic testing by pulse echo method.
- IS : 3613 Acceptance tests for wire flux combination for submerged arch welding.
- IS : 3658 Code of practice for liquid penetrant flow detection.
- IS : 5334 Code of practice for magnetic particle flaw detection of welds.

9.4 Materials

Structural steel rolled sections and plates shall conform to specified grade of IS:2062. However rolled sections and plates upto 20mm conforming to IS:226 may be used in place of grade-A of IS:2062. Pipes used in Handrails, embedments etc. Shall conform to IS:1161. Chequered plate shall conform to IS:3502. High strength steel shall conform to IS:8500 of specified grade. All other materials shall be as per the list of standards codes given above or mentioned elsewhere in the relevant sections.

All steel sections and plates shall be straight, sound, free from twists, cracks, flaws, laminations, rough, jagged and imperfect edges and other defects.

In case any defect like laminations is noticed in the steel sections and plates during fabrication and erection, the same shall be brought to the notice of the Engineer. These sections and plates shall be rejected unless specifically approved for acceptance by the Engineer.

9.5 Fabrication

The fabrication and erection of works shall be carried out generally in accordance with IS:800 as well as the stipulations contained in this specification. All materials shall be completely fabricated at his own shop or at the shop established by him at project site and finished with proper connection materials for ready assembly in the field. Check list format, inspection certificate for fabrication, erection, alignment and protocol for handling over of structural steel shall be submitted by the Concessionaire in the form as agreed to by the Engineer. Fabrication work shall be taken up based on the approved fabrication drawings.

9.5.1 Cutting plans

Fabrication work shall be taken up based on the fabrication drawings duly approved by the Engineer-in-Charge. The Concessionaire shall prepare necessary cutting plans before commencement of fabrication for all fabrication drawings.

9.5.2 Straightening

All steel material shall be straight and free from bends or twists. If the sections are distorted or twisted during transit, storage, etc. They shall be straightened and/or flattened by straightening machine at ambient temperature, though minor kinks or bends may be corrected by limited heating under careful supervision.

9.5.3 Bending

The bending of plates and sections to specially required shapes shall be done either on appropriate machine or by angle smithy and black smithy processes.

9.5.4 Cutting

Cutting may be effected by shearing, cropping, sawing or by gas cutting by mechanically controlled torch. Gas cutting by hand may only be used when specifically authorized in writing by the Engineer. The edges of all plates shall be perfectly straight and uniform throughout. Shearing, cropping and gas cutting shall be clean, square and free from distortion and burrs, and should the Engineer find it necessary the edges shall be ground afterwards by the Concessionaire.

9.5.5 Grinding

All the edges cut by flame shall be ground before they are welded. Ends of all bearing stiffeners shall be ground to fit tightly at both top and bottom. The maximum permissible gap between the bearing stiffeners and the flanges shall not be more than 0.2 mm locally.

In case of gantry girders, the bottom of the knife-edge support shall be accurately ground to provide effective bearing on the column bracket with a clearance not exceeding 0.2 mm locally at any place. The top surface of the column bracket shall also be ground similarly. The column splices and butt joints of struts and compression members shall be accurately ground and closely butted over the whole section with tolerance not exceeding 0.2 mm

locally at any place. Notwithstanding the above, full load shall be transferred through welds.

The ends of shafts together with attached gussets, angles, channels, etc. After welding together shall be accurately ground so that the parts connected, butt over the entire surface of contact. Care shall be taken to see that these connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by grinding by more than 1 mm.

The slab bases shall be similarly ground over the bearing surface and shall have effective contact with the end of the shaft. The bearing face which is to be grouted direct to a foundation need not be ground if such face is true and parallel to the upper face. To facilitate grouting and escape of air, holes shall be provided wherever necessary in column bases.

9.5.6 Clearances

The erection clearance for cleated ends of members connecting steel to steel shall not be greater than 2 mm at each end unless specifically approved by the Engineer.

9.5.7 Holes

Holes through more than one thickness of material for members, such as compound stanchion and girders, flanges, shall where possible, be drilled after the members are assembled and tightly clamped or bolted together. Sub-punching may be permitted before assembly, provided the holes are punched 3 mm less in diameter than the required size and reamed after assembly to the full size. Punching shall not be adopted where the thickness of metal exceeds 16 mm.

When holes are being drilled in one operation through two or more separable parts, those parts, when so specified by the Engineer, shall be separated after drilling and burrs removed.

Holes in connecting angles and plates, other than splices, also in roof members and light framing, may be punched full size through material not over 12 mm thick, except where required for close tolerance.

Matching holes for rivets and black bolts shall register with each other so that a gauge of 1.5 mm or 2.0 mm (as the case may be, depending on whether the diameter of the bolt is

less than or more than 25 mm) less in diameter than the diameter of the hole will pass freely through the assembled members in a direction at right angles to such members. Finished holes shall not be more than 1.5 or 2.0 mm (as the case may be) larger in diameter than the diameter of the black bolt passing through them unless otherwise specified by the Engineer.

Holes for bolts shall not be formed by a gas cutting process, except in special cases with specific permission of the Engineer. Wherever a horizontal member is likely to collect water, suitable holes for drainage shall be provided.

9.5.8 Notches

The ends of all joints, beams and girders shall be cut truly square unless required otherwise and joist flanges shall be neatly cut away or notched where necessary, the notches being kept as small as possible.

9.5.9 Assembly

The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified chamber, if any, is provided. In order to minimize distortion in a member the component parts shall be positioned by using clamps, clips, dogs, jigs and other suitable means and fasteners (bolts and welds) shall be placed in a balanced pattern. If the individual components are to be bolted, parallel and tapered drifts shall be used to align the parts so that the bolts can be accurately positioned.

Items like roof trusses, galleries, plate girders etc. shall be trial assembled keeping in view the actual site conditions, prior to despatch to site for erection so that they can be conveniently preassembled before erection or conveniently preassembled during erection. Necessary match marks shall be made on these components before disassembly in the shop and despatching.

For columns which are fabricated in two or more parts, controlled assembly shall be carried out in the fabrication yard before despatch to the erection site.

9.5.10 Bolting

Every bolt shall be provided with a washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.

Flat washers shall be circular of a diameter 2.5 times that of bolt and of suitable thickness. Where bolt heads/nuts bear upon the beveled surfaces they shall be provided with the square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.

All bolts and nuts shall be of steel, with well-formed hexagonal heads unless specified otherwise, forged from the solid and shall be dipped in hot boiled linseed oil as soon as they are made. The nuts shall be good fit on the bolts and two clear threads shall show through the nut when it has been finally tightened up.

Notwithstanding anything to the contrary contained in IS:1363, IS:1364, and IS:1367, the unthreaded length of the bolt shall be equal to total thickness of metal being bolted together plus 2 mm. The threaded length shall be equal to at least the diameter of bolts plus 6 mm.

9.6 Welding

The works shall be done as per approved fabrication drawing which would clearly indicate various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld. Symbols for welding on fabrication drawings shall be according to IS:813. Efforts shall be made to reduce site welding so as to avoid improper welding due to constructional difficulties.

9.6.1 Welding of structural steel work

Welding of Structural Steel shall be done by an electric arc process. The procedure to be followed, materials, plant and equipment to be used, testing and inspection procedures to be applied shall be subject to the approval of the Engineer and shall conform generally to relevant acceptable standards viz. IS:816, IS:9595, IS:814, IS:4354 and Indian Standard Hand Book for metal arc welding, and other standard codes of practice internationally accepted.

Submerged-Arc-Welding/MIG (using Carbon dioxide) welding process employing semi-automatic welding machine and fully automatic welding machine (of approved make) shall be used for welding all butt joints and longitudinal fillet welds (connecting flange with

web) respectively for fabrication of columns, framing beams & crane gantry girders, unless manual arc welding is specifically approved by the Engineer. Necessary jigs & fixtures and rotation of structures shall be so arranged that vertically down-hand position of welding becomes possible.

‘Open-Arc-Welding’ process employing coated electrodes shall be employed for fabrication of other welded connections not covered under 6.02.02 and field welding.

Wherever welding is done for assembling the components of structures, the job shall be so positioned that down hand welding is possible. In cases where positioning of job is not possible other manual welding positions could be resorted to.

Any structural joint shall be welded only by those welders who are qualified for all welding procedures and positions required in such joint that is welded. The entire weld of any structure joint shall be made by one welder.

Each welder shall be assigned an identification mark and such mark shall be marked on the structure adjacent to the weld on completion of any structural welded joint.

The Concessionaire shall maintain records of all the welders identification marks, the joints welded by each welder, the welding procedure adopted, welding machine employed, pre and post heating done & any non destructive test done and stress relieving heat treatment performance on such joints. All such records for entire welding operation shall be accessible to the Engineer for scrutiny & such record shall be countersigned by Engineer for welding work accomplished in the preceding months as token of acceptance. But such acceptance shall not relieve the Concessionaire of his responsibility regarding adequacy & safety of welding operation.

9.6.2 Edge preparation for welding

Proper edge preparation shall be made for jointing of materials before welding. Suitable edge preparation shall be done for all processes of welding except for square-butt welds. Type of edge preparation shall depend on the thickness of parent materials that are to be joined. The edge forms shall be chosen to suit the design, technology and production conditions and shall be subject to the approval of the Engineer. The edge form of weldments shall be prepared either by machines or by automatic gas cutting with surface

roughness of the welding area not exceeding Rs.50/- All edges cut by flame shall be ground before they are welded.

9.6.3 Electrodes

The electrodes used for welding shall be of suitable type and size depending upon specifications of the parent materials, the method of welding, the position of welding and quality of welds desired e.g. normal penetration welds or deep penetration welds. However, only low Hydrogen electrodes shall be used for plates thickness above 40 mm for IS:2062 steel and for all thickness of high strength steel conforming to IS:8500.

All low hydrogen electrodes shall be baked and stored before use as per manufacturers recommendation. The electrodes shall be rebaked at 250°C - 300°C for one hour and later on cooled in the same oven to 100°C. It shall be transferred to an holding oven maintained at 60°C - 70°C. The electrodes shall be drawn from this oven for use. Rutile type electrodes shall not be kept in the same oven.

Where coated electrodes are used they shall meet the requirements of IS:814 and relevant ASME-SEC IX and IIC. Coating shall be heavy to withstand normal conditions of handling and storage. They shall be free from all defects which would interfere with performance of electrodes.

Only those electrodes which give radiographic quality welds shall be used for welds which are subjected to radiographic testing.

Where bare electrodes are used these shall correspond to specification of the parent material. The type of flux-wire combination for submerged arc welding shall conform to the requirements of IS:3613. The electrodes shall be stored properly and the flux shall be baked before use in an oven in accordance with the manufacturer's requirements as stipulated.

Specific approval of the Engineer shall be taken by the Concessionaire for the various electrodes proposed to be used on the work before any welding is started.

9.6.4 Preheating inter-pass temperature and post weld heat treatment

Mild steel plates conforming to IS:2062 and thicker than 20 mm, may require preheating of the parent plate prior to welding as mentioned in Table - 1. For high strength steel conforming to IS:8500 the minimum preheat temperature shall be as specified in Table - 1. However, higher preheat temperature may be required as per approved welding procedure and same shall be followed. In welding materials of unequal thickness, the thicker part shall be taken for this purpose.

Base metal shall be preheated, notwithstanding provisions of IS:9595 to the temperature given in Table - 1 prior to welding or tack welding. When base metal not otherwise required to be preheated is at a temperature below 0 deg. C it shall be preheated to at least 20 deg.C, prior to tack welding or welding. Preheating shall bring the surface of the base metal to the specified preheat temperature and this temperature shall be maintained as minimum interpass temperature while welding is in progress.

Table - 1: Minimum Preheat Interpass Temperature for Welding

		Welding	used	
Thickness of thicker part at point of welding	Other than low hydrogen electrode IS:2062 steel	IS:8500 steel	Low hydrogen electrodes/ or submerged arc welding IS:2062 steel	IS:8500 Steel
1	2	3	4	5
Upto 20 mm including	None	welding by this	None	None
Over 20 mm including	66°C	electrode not allowed	20°C	66°C
Over 40 mm to 63 mm including	not allowed	-	66°C	110°C
Over 63 mm	not allowed	-	110°C	150°C

Preheating may be applied by external flame which is non-carbonising like LPG, by electric resistance or electric induction process such that uniform heating of the surface extending upto a distance of four times the thickness of the plate on either side of the welded joint is obtained.

Thermo-chalk, thermo-couple or other approved methods shall be used for measuring the plate temperature.

All butt welds with plater thicker than 50 mm require post weld heat treatment as per procedure given in AWS D-1.1. Post heating shall be done upto 600 deg c and rate of application shall be 200 deg C per hour. The post heat temperature shall be maintained for 60 minutes per 2.5 cm thickness. For maintaining slow and uniform cooling, asbestos pads shall be used for covering the heated areas. The Concessionaire shall submit and finalize post weld heat treatment procedure at the time of finalization of quality plans.

9.6.5 Sequence of welding

The sequence of welding shall be carefully chosen to ensure that the components assembled by welding are free from distortion and large residual stresses are not developed. The distortion should be effectively controlled either by a counter effect or by a counter distortion. The direction of welding should be away from the point of restraint and towards the point of maximum freedom.

Each case shall be carefully studied before finally following a particular sequence of welding.

Butt weld in flange plates and/or web plates shall be completed before the flanges and webs are welded together.

The beam and column stiffeners shall preferably be welded to the webs before the web and flanges are assembled unless the web and flanges to the beam or column are assembled by automatic welding process.

Approval of welding sequence and procedure shall not relieve the Concessionaire of the responsibility for the correct welding and for minimizing the distortion in the finished structure which in no case shall exceed that laid down in Indian Standards.

All welds shall be finished full and made with correct number of runs, the welds being kept free from slag and other inclusions, all adhering slag being removed from exposed faces immediately after such run.

Current shall be appropriate for the type of electrode used. To ensure complete fusion, the welding procedure should go proper and rate of arc advancement should not be so rapid as to leave the edges unmelted.

Puddling shall be sufficient to enable the gases to escape from the molten metal before it solidifies.

Non-uniform heating and cooling should be avoided to ensure that excessive stresses are not locked up resulting ultimately in cracks.

The welding shrinkage shall be minimized by adopting the correct welding procedure and method. In long and slender members extra length should be provided, at the time of fabrication, for shrinkage.

The ends of butt welds shall have full throat thickness. This shall be obtained on all main butt welds by the use of runoff and run on pieces adequately secured on either side of main plates. Additional metal remaining after the removal of extension pieces shall be removed by grinding or by other approved means and the ends and surface of the welds shall be smoothly finished.

The fusion faces shall be carefully aligned. Angle shrinkage shall be controlled by presetting. Correct gap and alignment shall be maintained during the welding operation.

All main butt welds shall have complete penetration and except where it is impracticable they shall be welded from both sides, back surface of the weld being gauged out clean before first run of the weld is given from the back. However, partial penetration butt weld shall be permitted, when specifically shown in the fabrication drawings.

Intermittent welds shall not be permitted without the approval of the Engineer. These shall be permitted only when specifically approved in the fabrication drawings.

9.6.6 Testing of welders

All the welders to be employed for the job shall have to qualify the appropriate tests laid down in IS:817 and IS:1181. If the welder fails in these tests, two further set of tests shall be undertaken and the welder to qualify must pass both these sets of tests.

The Engineer also reserves the right to have any welder retested at any time. All the necessary arrangements required for the testing of welders are to be provided by the Concessionaire.

9.6.7 Inspection of welds

➤ Visual inspection

100 percent of the welds shall be inspected visually for external defects. Dimensions of welds shall be checked. The lengths and size of weld shall be as per approved fabrication drawings. It may be slightly oversized but should not be undersized. The profile of weld is affected by the position of the joint but it should be uniform. The welds should have regular height and width of beads. The height and spacing of ripples shall be uniform. The joints in the weld run shall as far as possible be smooth and should not show any humps or craters in the weld surface. Welds shall be free from unfilled craters on the surface, undercuts, slags on the surface and visible cracks. Such inspection shall be done after cleaning the weld surface with steel wire brushes and chisel to remove the spatter metal, scales, slag etc. If external defects mentioned above are noticed, there is every possibility of internal defects and further radiographic / ultrasonic examination shall be undertaken as per Indian Standards. Weld gauges shall be used to measure the size of the welds.

➤ Mechanical testing

Test plates shall be incorporated on either side of 10% of main butt welds & the weld shall be continuous over the test plate. The test plate shall be cut from extensions of the main plates and shall be fixed so that metal lies in the same direction as that of the main plate. Test plates shall be prepared and tested in accordance with the accepted Standards, in the presence of the Engineer or his authorized representative. All testing equipment and facilities for carrying out these tests shall be provided by the Concessionaire should any of these tests fail, further radiographic examination of the welds in question on the main members, shall be undertaken by the Engineer as specified in the specification. These tests for the test plates and radiographic examination are additional to those contemplated under routine inspection and testing. The Concessionaire shall carry out these additional radiographic tests as per normal testing procedure.

➤ Non-destructive and special testing

In addition to the normal supervision and testing procedure, radiographic/ultrasonic or other non-destructive examination shall be carried out, as stipulated in the Fabrication/Erection checklist on butt or fillet welded joints and/or on test specimens, as

per Annexure - B. All test of welds shall be carried out by the Concessionaire at his own cost as per Annexure - B. However, for checking the quality of weld, the Executing Agency shall carry out additional tests at his own cost. The Concessionaire shall provide necessary supporting facilities free of cost, as may be required by the Engineer, including cordoning of radiation zone while Radiography testing is in progress. Prepared etched section of the welds may be required for examination. The Concessionaire shall, at his own cost, provide these prepared sections.

The case of failure of any of the tests, the cost of re-test of that portion of the test shall be recovered from the Concessionaire. Rectification of such components shall also be carried out by the Concessionaire at his own cost.

Rectification of defective welding work wherever defects like improper penetration, extensive presence of blow holes, undercuts, cracking, slag inclusion, etc. are noticed by visual inspection / other tests, the welds, in such location shall be removed by gouging process. The joints shall be prepared again by cleaning the burrs and residual matters with wire brushes and grinding, if necessary, and rewelded. The gouging shall as far as possible be done using gouging electrodes. Flame gouging shall be resorted to only in special cases with specific permission of the Engineer.

9.7 Acceptance of welded structures

The acceptance of the welded work shall depend upon current dimensions and alignment, absence of distortion in the structure, satisfactory results from the inspection and testing of the joints and the test specimens as per quality check list and upon general workmanship being good meeting the tolerance requirements given in the quality check list as per Annexure - B.

9.8 Erection procedure

9.8.1 Erection marks

The erectability of the structures shall be checked by the Concessionaire before commencement of the fabrication work to avoid future modification.

Before any steel work leaves the Concessionaire's fabrication site, it shall be suitably marked in accordance with the approved fabrication drawings and according to an approved marking plan.

The erection marks assigned to various components of the structural steel work, excepting secondary beams, shall also contain an erection sequence number indicating the sequence in which the various components are to be erected.

Erection marks shall be clearly painted on the work item, each piece being marked in at least two places. Each piece shall also have its weight marked thereon. In order to help identification, each erection piece, i.e. erection mark item, shall bear its items erection mark and erection sequence number. Erection marks shall be painted on the structures, during the process of fabrication to facilitate their identification during inspection. Where a number of components are identical and bear the same erection mark, these components shall be further identified by assigning numerals in addition to the common erection mark.

The centre lines of all column, elevations and girder bearings shall be marked on the sections with the utmost care to ensure proper alignment and assembly of the pieces at site.

9.8.2 Erection

The Concessionaire shall submit for approval of the Engineer his Erection Scheme for the erection of all types of structures. Erection shall commence only after approval of the Concessionaire's proposed erection scheme.

The erection scheme shall give full details of the method of handling, transport, hoisting and erection including false work/staging, temporary bracing, guying temporary strengthening etc. It will also give the complete details of the quantity and capacity of the various items of erection equipment that will be used. Any modifications to the erection

scheme as directed by the engineer for various reasons or due to the interference with the work of other agencies shall be incorporated by the Concessionaire.

The Concessionaire shall examine the site conditions and transportation clearances before deciding whether columns are to be fabricated and erected in one piece or more than one piece. Erection of structures is to be carried out preferably with a crane and in case this is not possible, only the upper portion of the columns can be erected with a derrick. Further, the erection of columns and portals etc. shall be carried out in one single piece as far as practicable. No column shall be fabricated and erected in more than 3 pieces. Proper splicing shall be provided at the erection joints indicated in fabrication drawings. When erection joints are provided in columns, their location shall generally be just above a floor level.

The structural steel shall as far as practicable be erected frame wise. Thereafter, the frames shall be progressively aligned and all erection welding completed. The secondary beams shall thereafter be erected, aligned and welded completely as per the approved schedule of work. Touch up painting in these areas shall be completed and as soon as a particular portion of the structure/floor is completed in all respects, it shall be handed over to other Concessionaires for carrying out other civil works as well as mechanical/ electrical erection works. Conveyor galleries shall generally be erected as a completely fabricated box, i.e. the bottom chord and bracings, top chord and bracings, side vertical posts and bracings, end portals and roof-trusses shall be completely welded prior to erection. The inside sheeting runners and roof sheeting purlins may be erected individually.

9.8.3 Protection against damage in transit

All steel work shall be efficiently and sufficiently protected against damage in transit to site from any cause whatsoever. All projecting plates or bars and ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surfaces shall be suitably packed and all bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit. Should there be any distortion of fabricated members the Concessionaire shall immediately report the matter to the Engineer. Distorted steel received from stores or distorted during transport from stores to the fabrication yard shall not be used in fabrication unless the distortions are minor which in the opinion of the Engineer can be removed by acceptable methods.

These distortions shall be rectified by the Concessionaire by cold-bending. If heating is necessary to rectify the defects, the details of the procedure shall be intimated to the Engineer whose approval shall be taken before such rectification. The temperature of heat treatment shall not exceed the limits beyond which the original properties of the steel are likely to be impaired.

If in the opinion of the Engineer the steel has been unduly bent in transit from the project stores to the fabrication yard or during handling by the Concessionaire which cannot be rectified in the opinion of the Engineer, such steel shall be counted as wastage and the cost of such steel shall be recovered from the Concessionaire as per the provisions of the Contract.

9.8.4 Stability of structures

The Concessionaire shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations. Guying and bracing shall be done in such a way that it does not interfere with the movement or working of other agencies working in the area. For the purpose of guying, the Concessionaire shall not use other structures in the vicinity which are likely to be damaged by the guy.

➤ Setting column bases

Column bases shall be set so that the column load is uniformly transmitted to the foundation. The Concessionaire shall carefully check the location and layout of anchor bolts embedded in foundations constructed to ensure that the structures can be properly erected as shown on the drawings.

The Concessionaire shall be responsible for the correct alignment and leveling of all steel work on site to ensure that the columns are in plumb. The permissible erection tolerances for the structural members are given in Table 'A' given at the end of this specification.

Before erection of columns on their foundations, the top surface of base concrete shall be thoroughly cleaned with wire brushes and by chipping to remove all laitance and loose material. The Concessionaire shall also be responsible to provide all packing and shim, plates. No steel structure shall be erected on their foundation unless such foundations have

been certified fit for erection of steel by the Engineer. Adequate number of air release holes and inspection holes shall be provided in the base plate. The grouting/under pinning of base plate and chipping of foundation to desired level are also in scope of Concessionaire.

9.8.5 Painting

After inspection and issue of test and acceptance certificate, all steel surfaces shall be painted or otherwise treated. Except where encased in concrete, all steel work shall be given one coat of approved metal protection as may be specified, applied evenly and thoroughly and well worked into the joints and other open spaces.

Materials

- i) The touch-up primers and paints shall consist of Red oxide Zinc Chromate conforming to the requirements of IS:2074 with a pigment to be specified by the Executing Agency. However, the Concessionaire may have to use other type of primer wherever specified.
- ii) The contents of paint drums shall be thoroughly mixed so that no material remains at the bottom before the paint is used and the paint shall be stirred at regular intervals while being applied.
- iii) The primers should not be diluted or thinned except as hereinafter specifically provided. Where the paint has thickened due to loss of Solvent by evaporation in partially used tins it may be brought to consistency for application, in consultation with the manufacturer who shall give necessary information particularly with regard to appropriate viscosity.
- iv) Material shall be of best quality available and procured directly from approved manufacturers. Samples shall be submitted to the Executing Agency or approval before procurement.

➤ **Preparation of surface**

- i) The surface preparation shall be done in accordance with IS:1477 (Part I) Code of Practice for Finishing of Ferrous Metals in Buildings: Painting and Allied Finishes: Part I (Operation and Workmanship).
- ii) The surface shall be cleaned and degreased in accordance with one or more of the methods given in Clause 6.1 of IS:1477 (Part I).
- iii) The surface shall be derusted and de-scaled either mechanically or chemically by one or more of the methods given in Clause 6.2 of OS:1477 (Part I) to the satisfaction of the Executing Agency. However flame cleaning, sand, blasting, and shot blasting are excluded from the scope of Concessionaire.
- iv) While cleaning with power wire-brush, care shall be taken not to do it excessively, since mill scale easily gets burnished to a smooth even surface to which paints does not adhere, and this will be detrimental to the performance of paint. All accessible weld flux and splatter shall be removed by power tools.

➤ **Application of priming coat, touch-up paint**

- i) Primers are generally applied by brushing. In areas which are difficult to reach either by brushing or spraying, daubers, mops or both may be used by dipping the same in paints and pulling or pushing them through the narrow spaces unless otherwise specified one coat of primer of 25 micron thickness shall be applied in shop.
- ii) During the painting, the air temperature shall be well above the dew point and not less than 4 C and relative humidity not greater than 80%. The time of painting shall be such that moisture does not condense on the structure before or during painting or until the painting is dry.
- iii) Primer coats shall be applied without any time lag after the pre-cleaning or pretreatment and care shall be taken to ensure that paint is not applied to damp surface (in early morning, under humid conditions dew etc.)
- iv) Surfaces of fabricated steel where shop priming coat has been removed or damaged during transit or defaced during welding including site welded locations shall be cleaned and applied with touch up primer coat of paint.

➤ **Shop connections**

- i) Surfaces to be permanently in contact shall receive a priming coat immediately prior to being jointed together at the works except where jointed by welding.
- ii) Galvanised steel shall not be prepared or painted at site.

Machined, sliding or rocking surfaces of casting blocks, slabs or pins shall be coated with a mixture of white lead and tallow after the work has been inspected and approved by the Executing Agency. Molybdenum disulphate (grease) will be used in rider pin connections.

Surfaces not in contact, but inaccessible after shop assembly shall receive two coats of shop paints, positively of different colours or such material to prove use of two coats before assembly. This does not apply to the interior of sealed hollow sections.

Shop contact surfaces shall be cleaned by effective means before assembly, but not painted.

In the case of surface to be welded, the steel shall not be painted or metal coated within minimum 50 mm distances of any edges to be welded, if the paint specified or the metal coating would be harmful to welders or impair the quality of the welds. Welds and adjacent parent metal shall not be painted prior to deslaggings, inspection and acceptance.

Site preparation of contract surface

- i) The paint, on all contact surfaces, which was applied in the fabrication shop shall be carefully removed and a fresh coat of priming paint shall be applied to all surfaces in permanent contact, and the surfaces shall be brought together while the paint is still wet.
- ii) The Concessionaire shall provide and use sufficient number of drop cloths, covers, tarpaulin and other screens to protect adjacent surfaces and shall remove all spatter and stains from such surfaces. The Concessionaire shall also protect his own work.
- iii) The Concessionaire shall provide and use sufficient number of drop cloths, covers, tarpaulin and other screens to protect adjacent surfaces and shall remove all spatter and stains from such surfaces. The Concessionaire shall also protect his own work.
- iv) Painting shall be discontinued during rain and dust-storm and shall not commence until the surfaces are perfectly dry and clean. Wherever practicable, surfaces shall be painted when in shade or when the temperature is falling.
- v) Welds and adjacent metal shall not be painted or touched up prior to deslagging inspection and approval.

- vi) Parts of the steel structures to be encased in concrete shall not be painted.
- vii) One coat of primer and touch-up paint shall be applied except for the item which shall be not dip galvanized.

9.9 Steel grading

All grating units shall be rectangular in pattern and welded grating assembly. The size and the spacing of the bearing bars and cross bars shall be as approved in detailed drawings. The detail fabrication drawings for gratings shall be prepared by Concessionaire on the basic of approved design for grating.

The gratings shall be made up in panel units designed to coincide with the span of the structural steel framing as indicated in the drawings or as directed by the Engineer. The size of each panel shall be as approved by Engineer.

The grating unit shall be accurately fabricated and finished, free from wraps, twists or any defects that would impair their strength, serviceability and appearance.

Grating work shall include cut outs and clearance opening for all columns, pipes, ducts, conduits or any other installation penetrating through the grating work. Such cut outs and clearances shall be treated as follows.

The gratings shall be notched, trimmed and neatly finished around flanges and webs of the columns, moment connections, cap plates and such other components of the steel structures encountered during the placement of the gratings. In all such cases, the trimming shall be done to follow the profile of the components encountered. After trimming, the binding strip shall be provided on the grating to suit the profile so obtained.

Opening in gratings for pipes or ducts that are 150 mm in size or diameter or larger shall be provided with steel bar toe plates of not less than 5 mm thickness and appropriate width, set flush with the bottom of the bearing bars.

Penetrations in gratings that are more than 50 mm but less than 150 mm in size or diameter shall be welded with plates of size shown in the detailed drawings set flush with the bottom of the grating panel.

Unless otherwise indicated on the drawings, grating units to all penetrations shall be made up in split section, accurately fitted and neatly finished to provide for proper assembly and erection at the job site.

Grating units shall be provided with all necessary clips, bolts, nuts and lock washers required for proper assembly and rigid installation and fastening to abutting units and supporting structural steel framing members.

All fabricated grating section and accessories shall be primed and finish painted in the shop prior to erection at site. Painting shall consist of two coats of red lead primer and two coat of black enamel finish.

Prior to painting all surfaces shall be cleaned free from rust, millscale, grease, oil, or any other foreign matter that might affect the adherence of the paint by sand blasting. While the primer shall be applied by spray guns or by brushes, the final coat of finished paint shall necessarily be applied by means of spray guns only.

The applied coatings shall be uniform, free from voids and streaks, drilled or punched holes shall be touched up prior to erection or assembly.

Maximum deviation in linear dimension from the approved dimension shall exceed 12 mm.

9.10 Stairs, railings and ladders

All stairs and intermediate landings shall be constructed to size dimensions and design, as indicated on the detailed drawings. Such stairway shall be fabricated as a complete unit which shall include struts, hangers, posts, cross bracings, cleats and accessories, as required for connection to structural steel framing and concrete.

Stair treads shall be furnished complete with punched and slotted carrier plates attached ready to bolt to stair stringers. Treads shall be provided with antislip nosing using chequered plate and set flush with the stair treads.

Pipe handrails, as specified in detailed drawings shall be assembled with flush type fittings and welded joints, ground and polished smooth. Railings shall be provided with all necessary fittings posts brackets, bolts, plates and similar accessories as shown on the approved drawings and as required for proper installation.

Hand rails shall be of standard weight black steel pipes of flush welded construction, ground smooth using 32 mm nominal bore medium class pipes with double rail about 1 metre above platform level and pipe posts spread not more than 1.5 metres apart.

Smooth uniform curves and bends are to be provided at stair returns and also wherever specified/required. The open ends of all pipe posts shall be plugged and welded. A minimum radius of 3 times the pipe diameter shall be provided at all points of direction changes in the hand rails.

Vertical ladders shall be as called for on the approved drawings. The ladders shall be provided with support arms formed of bent steel plate or clip angles. Where shown on the drawings the ladders shall have loose neck supports, designed to form hand grabs and end brackets for fastening to abutting construction. Maximum deviation in the linear dimensions of railings, stairs and ladders, from the approved dimensions, shall not exceed 12 mm.

9.11 Chequered plate

Chequered plates shall be fixed to supporting members by welding as specified in relevant drawings or as directed by the engineer. The edges shall be made smooth and no burrs or jagged ends shall be left. While splicing care should be taken so that there is continuity in pattern between the two portions. Care should also be taken to avoid distortion of the plate while welding of stiffening angles/vertical stiffening ribs.

9.12 Ash storage silo / intermediate hopper

Shape of the silo/intermediate hopper shall be circular in plan. Bottom hopper portion shall be of conical shape and/or flat bottom type as specified in mechanical section.

For general requirements, fabrication and construction details, including design criteria, IS:9178 (Pt.I, II & III) shall be followed as general guidance.

Side walls shall be made of mild steel plates having horizontal and vertical stiffeners at regular interval as per the design requirements. Stiffeners shall be provided on the external face. Joints between the walls inside the silos should be continuously welded to ensure complete sealing. However, for the stiffeners provided on the outer shell, intermittent welding may be adopted.

Bending of plates and rolled sections to the required shape for fabrication shall be done by plate bending machine or cold bending process without resorting to heating, hammering, angle smithy and black smithy process.

Poking hole and 10 mm thick striking plate shall be provided to facilitate ash flow. Poking holes shall have circular m.s. pipe and cover cap as shown in the drawing.

9.12.1 Lining

To cater for corrosion, abrasion or smoothness lining shall be provided in sloping/conical portion as specified in mechanical section. Lining shall generally be in the form of stainless steel sheet of 3 mm thickness of grade SS 316 or 10 mm thick alloy C.I. liners of 300-350 BHN (min.).

9.12.2 Intermediate/buffer and storage silos hoppers

The hoppers shall be conical in shape with valley angle as 55 degrees and the details of hopper specifications are covered elsewhere in these specifications.

9.13 Sampling, testing and quality control

9.13.1 General

- a) The Concessionaire shall carry out all sampling and testing in accordance with the relevant Indian Standards and/or International Standards and shall conduct such tests as called for by the Engineer. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Engineer. Tests shall be done in the field and at a laboratory approved by the Engineer and the Concessionaire shall submit to the Engineer, the test results in triplicate within three days after completion of a test. The Engineer may, at his discretion, waive off some of the stipulations given for small and unimportant operations.

- b) Material / work found unsuitable for acceptance, shall be removed and replaced by the Concessionaire. The work shall be redone as per specification requirements and to the satisfaction of the Engineer.

- c) Radiography and ultrasonic testing of welds shall be carried out by specialist agency only. In case, the Concessionaire does not have the required expertise, he shall engage specialist agency for this purpose.

An indicative programme of Inspection and testing for raw materials, welds and dimensional tolerances for fabrication & erection of steel structures are given in Annexure - B. The Concessionaire shall draw-up a comprehensive programme for executing the works based on this indicative programme.

Annexure - B
Inspection, testing and quality check list

1 Inspection & testing

The Concessionaire shall carry out a comprehensive inspection and testing programme of inspection / testing on the basis of details given below. The testing of all the materials supplied by the Concessionaire shall be carried out by him. This is however, not intended to form a comprehensive programme as it is the Concessionaire's responsibility to draw-up and carry out such a programme duly approved by the Engineer. Such approval shall not relieve the Concessionaire of the responsibility about the correctness and adequacy of workmanship, materials etc.

1.1 Raw material inspection

1.1.1 Steel

i) Conformity with specifications

- a) The conformity of the materials with the specification and the availability of the relevant test certificates shall be checked. Carbon equivalent value shall also be made available.
- b) Plates above 25 mm thickness shall be subjected to ultrasonic test as per ASTM A435 or equivalent to check the presence of lamination.

ii) Physical conditions:

- a) Steel shall not be pitted and should be free from scales and rust.
- b) If the rolled sections and plates are bent or distorted, bend or distortion shall normally be removed by cold treatment etc.
- c) Straightening under hot stage shall be resorted only under specific permission from the Engineer.

- d) If any rolling defects, viz. lamination, cracks etc. are discovered in the steel during the processing, it is to be rejected.

iii) Storage

- a) Steel plates of different specifications shall be stacked separately.
- b) Steel of IS:2062 (different grades) and IS:8500 quality shall be given distinctive identification mark.
- c) Rolled sections shall be stacked profile-wise separately.
- d) Steel sections shall be stacked over spacers supported on posts of about 50 cm. height above ground. Passages and space between the stacks shall be sufficient for rigging operations.

1.1.2 Electrodes

- i) Electrodes for all welding shall be procured as envisaged in the welding procedure sheet predetermined before actual welding operation starts/
- ii) Electrodes shall be properly stored dry as required by the IS Code or by the manufacturer.
- iii) Electrodes shall bear the ISI or equivalent Certification mark.
- iv) The approval for all the consumables for welding shall be specifically obtained beforehand.

1.1.3 Nuts, bolts etc.

- i) The quality of these shall be as per relevant IS codes.
- ii) They shall be stored properly according to grade, diameter and length. However, special bolts like HSFG shall be stored separately as per the relevant clause.
- iii) Bolts of well known manufacturers are acceptable with manufacturer's test certificates. However, in case the Concessionaire is not able to produce the test certificate, the bolts

can be accepted only after satisfactory cold bend and flattening tests. For the purpose of these tests, the inspecting officer should select at random 3 specimens each for cold bend and flattening tests. For the purpose of these tests, the inspecting officer should select at random 3 specimens each for cold bend and flattening tests out of each consignment of 1000 Nos. or less and instruct the Concessionaire to carry out the tests in his presence. Cost of testing shall be borne by the Concessionaire.

1.1.4 Paints/primers

- i) The relevant IS or equivalent mark on sealed tins shall be checked.
- ii) A few tins shall be opened at random to check the condition of the paint. Paint from old stock and showing signs of solidification shall not be accepted.

1.1.5 Cement

- i) The quality of cement shall conform to relevant IS code.
- ii) Cement is to be stored in a place of easy access for proper inspection and identification. It should be placed in a weather tight building, so that dampness and loss due to other causes is minimum.

1.2 Welding procedure qualification

Welding procedure shall be established as per ASME Section IX or equivalent Indian Standards. Welding procedure, specifications shall be submitted by the Concessionaire for review and approval of the Executing Agency. Typical welding procedure data sheet is given in Proforma A.P-1.

1.3 Welders qualification test

Welders qualification test shall be as per ASTM Section IX or equivalent Indian Standards.

1.4 Inspection for tack assembly set up :

- i) Bevel
- ii) Gap
- iii) Off-setting
- iv) Shrinkage allowance
- v) Fitment Sequence
- vi) Principal overall size

1.5 Preheating:

Temperature control by Thermochalk or suitable equivalent method.

Inspection of main welds of principal components for columns, crane girders, framing beams, trusses, etc.

I) Fillet welds for :

- i) Check size
- ii) Macrotech examination of production test coupons for main fillet weld.
- iii) 100% visual examination
- iv) 100% dye penetration test/magnetic particle test - Major welds (including welds subjected to tension) like web to flange connection, splice plates, moment/shear connection.
- v) 10% All other areas.

II) Butt welds :

- a) Columns, Beams etc.
 - i) 100% Visual examination
 - ii) 100% Dye penetration test after back gouging shall be carried out. Final weld shall also be tested.
 - iii) Mechanical testing of production test coupons - Minimum one joint per column/built up beam and crane girder etc. The Engineer may reduce the frequency of this test, after getting consistently satisfactory results for initial 10 tests.

- iv) 100% Radiography test on tension zone (bottom flange of the girder) welds and 10% spot Radiography on compression zone for minimum 300 mm length (top flange of the girder) welds of crane girder shall be carried out. Where Radiography test is not possible, ultrasonic test shall be carried out after grinding the surface wherever required with prior approval of the Engineer.
 - v) All other butt welds and full penetration welds shall be subjected to 10% spot Radiographic test and for the balance ultrasonic test. Wherever Radiography is not possible, ultrasonic testing shall be carried out with prior approval of the Engineer.
- b) **Dry ash silo :**
- i) Dye penetration test after back gouging and for all finished welds.
 - ii) 10% spot Radiography test on fabrication shop butt welds and 10% spot Radiography test on site erected butt joints shall be carried out where access is available.
- c) In case of failure of any weld in spot radiography the percentage for retesting shall be doubled at that particular location.

1.6 Final inspection

- i) Dimensional check as per fabrication check list detailed elsewhere.
 - ii) Marking for holes for fitments or connection and hole sizes.
 - iii) Erection mark
 - iv) Painting
- a) Dressing and surface preparation.
- b) Final painting including dry film thickness (DFT) by using Elcometer or any other approved method. In addition, the rate of application (coverage) as per manufacturer's recommendation shall be checked.

1.7 Inspection during fabrication and erection

- a) All structural components/members shall be checked for dimensional tolerance during fabrication and erection.
- b) Tolerance on dimensions for fabrication of structures shall be according to IS:7215 and check list given under table A-1 to A-5. In case of any conflict between the provisions of IS:7215 and those mentioned under the table, the stipulation of the latter shall govern.
- c) Tolerance on dimensions for erection of steel structures shall be according to IS:12843. Relevant portion of the same is given under Table A-6 for ready reference.

1.8 Welding tests on welds and weld defects

Mechanical testing of welds (destructive tests): Butt welds having one or more of the following defects are not acceptable.

- i) Bend Test : No crack on root/face on being bent through 180 degree with mandrel of $4t$ where t is the thickness of plate.
- ii) Tensile Test : Weld strength not less than parent metal's strength.

1.8.1 Radiographic examination

Sections of welds that are shown by Radiography to have any of the following type of imperfections shall be judged unacceptable:

- 1) Any type of crack or zone of incomplete fusion or penetration.
- 2) Any elongated slag inclusion which has length greater than :
 - i) 6mm for t upto 20 mm
 - ii) 8mm for t from 20 mm to 32 mm
 - iii) ' t ' = thickness of weld
- 3) Any group of slag inclusion in line that have an aggregate length greater than ' t ' in a length of $12t$, except when distance between the successive imperfections exceed $6L$ where ' L ' is length of longest imperfection in group.

- 4) Rounded indications in excess of that specified by the acceptance standard given in Appendix 4 of ASME section VIII Div. 1.

1.8.2 Ultrasonic examination

The welded joints will be tested by suitable combination of Angle and Normal beam probe techniques to ensure scanning of the entire cross-section of weldments.

Acceptance standard

All indications which produce a response greater than 20% of the reference level shall be investigated to the extent that operator can determine the shape, identify and location of all such reflectors and evaluate them in terms of the acceptance standards given in (a) and (b) below:

- a) Discontinuities are unacceptable if the amplitude exceeds the reference level and discontinuities have lengths which exceed.
 - i) 6 mm for 't' upto 20 mm inclusive
 - ii) 8 mm for 't' from 20 mm to 50 mm inclusive
 - iii) 20 mm for 't' over 50 mm

Where 't' is thickness of weld being examined. If a weld joins two members having different thickness at the weld, 't' is thinner of these two thickness.

- b) Where discontinuities are interpreted to be cracks, lack of fusion, or incomplete penetration, they are unacceptable regardless of discontinuities or signal amplitude.

1.8.3 Visual examination:

Following defects are not allowed:

1. Unsatisfactory appearance
2. Incomplete weld
3. Molten metal flow

4. Pits
5. Surface crack, lack of penetration
6. Insufficient length
7. Surface defects exceeding 5% of weld seam area

1.8.4 Dye penetration test:

All surfaces to be examined shall be free of:

- a) Relevant linear indications
- b) Four or more rounded defects in a line separated by 1.5mm or less (edge to edge) except where the specification for the material establishes different requirements for acceptance so far as defects are concerned.

Evaluation of indicators

- i) Linear indications are those indications in which the length is more than 3 times the width. Only indicators with major dimensions greater than 1.5 mm shall be considered relevant.
- ii) Rounded indications or indications which are circular or elliptical with length less than 3 times the width.
- iii) Any questionable or doubtful indications shall be tested to verify whether or not actual defects are present.
- iv) Localised surface imperfections may occur from machining work surface conditions or an incomplete bond between base metal & cladding may produce similar indications which are relevant to the deletions of unacceptable discontinuities.

Table:1 - Tolerable deviation from designed linear dimensions in mm in the parts processed for fabrication

S. No.	Characteristic	Deviation / tolerances in mm					
		1.5m & Below	1.5m to 2.5m	2.5m to 4.5m	4.5m to 9.0m	9m to 15m	15m & above
1	2	3	4	5	6	7	8
1a	Deviation in length and width of part cut out by:						
	i) Manual gas cutting	2.5	3.0	3.5	4.0	4.5	5.0
	ii) Gas cutting by automatic and semi-automatic machines	1.5	2.0	2.5	3.0	3.5	4.0
	iii) Shear or saw cutting	1.5	2.0	2.5	3.0	3.5	4.0
	iv) Parts machined by edge-planning or milling machines	0.5	1.0	1.5	2.0	2.5	3.0
b	Difference in diagonal lengths of sheet parts:						
	i) For butt welding	4.0	4.0	4.0	5.0	6.0	6.0
	ii) For lap welding	5.0	5.0	5.0	8.0	10.0	10.0
c	Deviation in distances between hole centres, formed as per:						
	i) Marking of extreme ones	2.0	2.0	2.5	3.0	3.5	4.0
	ii) marking of adjacent ones	1.5	1.5	1.5	1.5	1.5	1.5
2	Deviation in the dimensions of structural despatch members after finishing:						
a	When assembled upon assembly benches as per marking.	3.0	4.0	5.0	7.0	10.0	15.0
b	When assembled in the jig and other devices fastening with fixtures.	2.0	2.0	3.0	5.0	7.0	10.0

S. No.	Characteristic	Deviation / tolerances in mm					
		1.5m & Below	1.5m to 2.5m	2.5m to 4.5m	4.5m to 9.0m	9m to 15m	15m & above
1	2	3	4	5	6	7	8
c	Dimensions (length and breadth) between milled surface (after finishing)	0.5	1.0	1.5	2.0	2.5	3.0
3	Distance between groups of erection holes (in finished members):						
a	Formed during machining of separate parts installed when assembling as per marking.	3.0	4.0	5.0	7.0	10.0	15.0
b	Formed during machining of parts, installed when assembling with the help of fixtures.	2.0	2.0	3.0	5.0	7.0	10.0
c	Drilled with the help of templates in finished members.	0.5	1.0	1.5	2.0	2.5	4.0

Fabrication Check List

Table 2 : Tolerable deviations of fabricated members from designed geometrical shape

Sl. No.	Characteristic	Deviation / Tolerance	Remarks
1.	Curvature of assembly Parts		
	a) Gap between a sheet and a steel rule face over 1 m length	1.5 mm	
	b) Gap between a taut string and vertex face of an angle flange or web of channel and joist.	0.001 L, but not greater than 10 mm.	L-length of member
2.	Deviation of edge line steel sheet parts from theoretical profile:		
	a) During butt and toe welding	2 mm	
	b) During lap welding	5 mm	
3.	Deviation of radius of the bend:		

Sl. No.	Characteristic	Deviation / Tolerance	Remarks
	a) Clearance between template and the surface of rolled sheet flange or face of cold bend profile.	2 mm	Template length (1.5m along the curve)
	b) -do- for hot bend profile	3 mm	-do-
	c) Ellipticity (difference of diameters) in space sheet structures.	0.005D	D-diameter of circumference
	d) -do- in erection joints	0.003D	-do-
4.	Deformation of dispatch members:		
	a) Inclination of flanges with the web:		
	i) at junction	0.005b	b-width of flange
	ii) at other places	0.01b	-do-
	b) Transverse bending of flanges:		
	i) at junction with members	0.005b	b-width of flange
	ii) at other places	0.01b	-do-
	c) Warping of the web	0.003h	h-depth of the member
	d) Sag of member	L/750 but not more than 15 mm	L-length of the member
5.	Other deviations:		
	a) Shifting of axes of riveting/ bolting lines for lattice structures from theoretical eccentricity.	3.0 mm	
	b) Inclination of the milled surface from designed position.	1/1500	

Fabrication Check List

Table 3: Acceptance deviations in as fabricated steel structures

S. No.	Characteristic	Deviation / Tolerance
1.	Columns	
	a) Deviation in length 'L' measured distance from bottom surface of the column footings, to the group of	

S. No.	Characteristic	Deviation / Tolerance
	holes for 'trusses', fasteners, collar beams, purlins and other elements to be connected to column.	
	When L is under 10 m	± 10 mm
	When L is over 10 m	± 15 mm
	b) Deviation in distance 'L' from bottom surface of the column footing to the top of crane bracket.	
	When L is under 10 m	± 5 mm
	When L is over 10 m	± 10 mm
	c) Deviation in distance from bearing surface of the bracket to the first fastener of the element to be connected to column.	± 1 mm
	d) Deviation in distance between any group of holes for connection of bracings to columns.	± 2 mm
	e) Sag of column element (curvature)	1/1000 of length element but not more than 15 mm.
	f) Difference in web depth of column	
	i) At splice joint	± 2 mm
	ii) At any other location	± 10 mm
	g) Deviation in distance from supporting surface of milled end of the dispatched element of column to the clear or heating plate or column to the cleat or seating plate for fastening of collar beams, purlins, girders etc. (Fish plates, brackets).	± 3 mm
2.	Trusses	
	a) Deviation in span 'L' of the truss between end erection holes in gussets of supporting units or between external planes of supporting gussets or angles when trusses are resting on brackets or supports:	
	When L is under 25 m	± 7 mm
	When L is over 25 m	1/2500 but not more than 10 mm
	b) Deviation in distance between the centres of holes or webs of angles for fastening bracing, purlins, monitors, etc.	± 3 mm

S. No.	Characteristic	Deviation / Tolerance
	c) Deviation in distance between the first row of erection holes and the	more than 15 mm.
	d) Distance between holes for fasteners to top and bottom chords of trusses on supports.	± 3 mm
	e) Sag of separate elements between node points.	1/1500 of length of element but not more than 10 mm.
3.	Beams	
	a) Deviation in span L of beams between bend erection holes, outer surfaces of end plates:	
	When L is under 25 m	± 10 mm
	When L is over 25 m	$\pm 1/2500$ length but not more than 15 mm
	b) Deviation in the height of beam as measured from the bearing surface to the top of upper flange	± 3 mm
	c) Deviation in distance between the group of holes for fastening of purlins, monitors, bracings, bracing grids etc.	± 3 mm
	d) Sag (curvature) of the girder despatch member	1/1000 length but not more than 15 mm
4.	Elements of framework	Bracings, purlins etc.
	a) Deviation in distance between end erection holes, determining the span of element.	± 3 mm
	b) Sag of despatch members	1/1000 length but not more than 15 mm
	c) Deviation in distance between the groups of erection holes of the element	± 3 mm
	d) Gratings, Stair, Railings, ladders, etc.	± 12 mm
5.	Shop assembly (before for erection)	Despatch
	a) Columns weighing more than 20 T	i) Every first and further every tenth set of identical structure to be put for control assembly.
	b) Roof trusses of 30 m or more span	
	c) Crane girders with span more than 18 m	

S. No.	Characteristic	Deviation / Tolerance
	d) Bunkers	i) Number of erection bolts shall be atleast 30% of the total No. of holes.

Fabrication check list

Table 4: Acceptable deviation in holes or bolts

S. No.	Characteristic	Deviation	Tolerance No. of deviation in each group
1.	a) Deviation of dia of holes for rivet and bolts:		
	Upto 16 mm	± 1 mm	No limit
	Over 16 mm	± 1.5 mm	
	b) Deviation of dia of turned and fitted bolts:		
	Nominal dia of bolts and holes	Upper limit: + 0.125 mm	
		Lower limit: 0.00	No limit
2.	Ovalness (difference between the greatest and lesser dia)		
	Upto 16 mm hole dia	+ 1 mm	No limit
	Upto 16 mm hole dia	+ 1.5 mm	
3.	Deformity in size greater than 1.5 mm and cracks in the edge of holes.	Not permitted	
4.	Misalignment of holes in separate plates in the joints:		
	i) Upto 1 mm		Upto 50%
	ii) From 1 to 1.5 mm		Upto 10%

Note: In holes shall be removed, the depth and width of countersunk hole shall not deviate from the standard by more than 1.5 mm.

Fabrication check list

Table 5: Permissible fabrication deviation of structural steel

S. No.	Type of structures and constructions	Name of deviations	Value of deviation (Tolerance)
1.	Column	Assembly fits	

S. No.	Type of structures and constructions	Name of deviations	Value of deviation (Tolerance)
		a) Base plate and column	0.1 mm
		b) Frame Joints	2.0 mm
		c) Web and flange	1.5 mm
		d) Web & stiffeners	1.5 mm
		e) Flange & stiffeners Intermediate stiffeners& Bearing stiffeners	1.5 mm
		f) Cap plate & column	0.1 mm
		g) Crane girder seat	0.1 mm
		h) Beam brackets	2.0 mm
2.	Beams	(c), (d), (e) of S.No. 1 above	1.5 mm
3.	Crane Girders	(c), (d), (e) of S.No. 1 above and knife edge supports	0.1 mm
4.	Silos & hoppers	a) Ring beam and wall	1.5 mm
		b) Stiffeners and walls	1.5 mm
		c) Stiffeners and ring beams	1.5 mm
		d) Deflection of straight section of compression cord from the plane of truss, collar beam or girder.	1/1500 of span but not more than 10mm
5.	Purlin	Deviation in distance between purlins.	5 mm

Erection check list

Table 6: Maximum permissible tolerances in steel structures

S. No.	Description	Tolerance
1.	Erected steel columns:	
	i) Deviation of column axis at foundation top level with respect to true axis:	
	a) in longitudinal direction	± 5 mm
	b) in lateral direction	± 5 mm
	ii) Deviation in the level of bearing surface of columns at foundation top with respect to true level	± 5 mm
	iii) Out of plumbness (verticality) of column axis from true vertical axis as measured at column top:	
	a) For columns without any special requirements:	
	1) upto and including 30 m height	$\pm \frac{H}{1000}$ or ± 25 mm

S. No.	Description	Tolerance
		1000 whichever is less
	2) over 30 m height	$\pm \frac{H}{1200}$ or ± 35 mm 1200 whichever is less
	b) For column with special requirements like cranes or such similar requirements:	
	1) upto and including 30 m height	$\pm \frac{H}{1000}$ or ± 25 mm 1000 whichever is less
	2) over 30 m height	$\pm \frac{H}{1500}$ or ± 25 mm 1500 whichever is less
	iv) Deviation in straightness in longitudinal and transverse of column at any point along the height.	$\pm \frac{H}{1500}$ or ± 10 mm 1500 whichever is less
	v) Difference in the erected positions of adjacent pairs of columns along length or across width of building prior to connecting trusses/beams with respect to true distance.	± 5 mm
	vi) Deviation in any bearing or seating level with respect to true level.	± 5 mm
	vii) Deviation in difference in bearing levels of a member on adjacent pair of columns both across and along the building.	± 5 mm

Notes:

1. Tolerance specified under iii (a) and iii (b) should be read in conjunction with iv and v.
2. 'H' is the column height in mm.

Table 6 (Contd.)

S. No.	Description	Tolerance
2.	Erected steel trusses	
	i) Shift, at the centre of span of top chord member with respect to vertical plane passing through the centre of bottom chord.	$\pm \frac{1}{250}$ of height of truss in mm at centre of span or ± 15 mm whichever is less.
	ii) Lateral shift of top chord of truss at the centre of span from the vertical plane passing through the centre of supports of the truss.	$\pm \frac{1}{1500}$ of span of truss in mm or ± 10 mm whichever is less.

S. No.	Description	Tolerance
	iii) Lateral shift in location of truss from its true axis in plan.	± 10 mm
	iv) Lateral shift in location of purlin from true position.	± 5 mm
	v) Deviation of difference of bearing levels of trusses from the true difference.	$\pm \frac{1}{1200}$ of span of truss in mm or ± 20 mm whichever is less.
3.	Erected Crane Girder and Rails	
	i) Shift in the centre line of crane rail with respect to centre line of web crane girder.	$\pm \frac{(\text{Web thk in mm}) + 2 \text{ mm}}{2}$
	ii) Shift in plan of alignment of crane rail with respect to true axis of crane rail at any point.	± 5 mm
	iii) Deviation in crane track gauge with respect to the gauge:	
	a) For track gauge upto and including 15 mm	± 5 mm
	b) For track gauge more than 15 mm	$\pm (5 + 0.25(S-15))$ mm subject to a maximum of ± 10 mm, where S in meters is true track gauge.
	iv) Deviation in the crane rail level at any point from true level	± 10 mm
	v) Difference in levels between crane track rails at:	
	a) Supports of crane girders	15 mm
	b) Mid span of crane girders	20 mm
	vi) Relative shift of crane rail surface at a joint plan and elevation.	2 mm subject to grinding of surfaces for smooth transition.

Proforma - A.P.1

Typical welding procedure data sheet

Concessionaire.....Address.....

Quality of weld.....Specification.....

Material Specification.....Thickness.....Batch/

Cast No.....Joint preparation (Fig).....

Gap.....Location of Specimens.....

Whether condition.....Type of Day.....

Wind break used.....

Electrode Group No.....Make.....Specimen.....

Pre and Post Heating.....

Welding position.....

Size of reinforcement.....Whether removed.....

Welding Sequence.....

Backing strip used.....Type.....

Welding process.....

Current conditions Polarity.....

Size of electrode.....

Amperage and Voltage.....

Number of Electrodes used per run.....

Cleaning method.....

Remarks.....

Welding Engineer

Executing Agency

(Inspecting Authority)

Signature

For and behalf of Concessionaire

Date:_____

Sub section - C10
Technical specification for glass and glazing

Sub section - C10

Technical specification for glass and glazing

Contents

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Sub section - C10: Technical specification for glass and glazing

10.1 Scope

The work in general shall consist of supplying and fixing all glass and glazing including all clips, putty, mastic cement, etc. wherever required.

10.2 Installation

10.2.1 General

The Concessionaire shall supply and install all glass and glazing as required for various doors, windows, sashes, ventilators and fixed louvers, miscellaneous glazing and partitions, as approved by the Executing Agency, having very high optical clarity, brighter appearance, uniform thickness, consistent product quality manufactured out of molten glass coming out of the furnace floats on molten tin, thus being formed into float glass. The glass shall be delivered to site in containers with the maker's name, guarantee, type of glass and thickness, or weight of glass attached to the outside of the containers. Glass cut to size shall be straight and free from chips, spalls or any other damage on any cut edge.

10.2.2 Materials

- (a) Clear glass shall be flat drawn sheet glass and shall be atleast 4 mm thick conforming to IS:2835. Sheet glass for doors shall be minimum 5.5 mm thick.
- (b) Wired glass shall be thick rolled glass with centrally embedded 24G wire mesh of Georgian type. This may be of clear or coloured glass as shown in drawings and shall conform to IS:5437.
- (c) Composite double glazing shall be made of double glazing of two 6 mm thick sheet glass either both sheets of tinted glass or one glass tinted & other plain or both sheets of plain sheet glass. Both the glasses shall be separated by an air gap of 12 mm. The trapped air shall be kept dry by means of suitable desiccant. The sealing shall be under strict quality control. The composite glazing shall be procured as finished product from reputed manufactures. Toughen glass conforming to IS:2553 shall be used.
- (d) Obscure glass shall have a cast surface on one side.

- (e) Coloured and figured glass shall be as per the approved sample.
- (f) In general, the putty shall conform to IS:410 latest edition and be of best quality from an approved manufacturer. It shall be brought to site in the manufacturer's original packing. Quick setting putty shall be used for windows and sashes except when glare reducing glass is used where it shall be of non-setting type.
- (g) Neoprene gaskets with snap-fit glazing shall be fixed as per manufacturer's instructions and shall fit firmly against the glass to give a leak proof installation.

10.3 Glazing, setting and finish

All glazing clips, bolts, nuts, putty, mastic, cement, etc., shall be supplied by the Concessionaire.

All glass shall be thoroughly cleaned before placing in position. Each glass pane shall be held in place by special glazing clips of an approved type. Four glazing clips shall be provided per glass pane, except for large panes where six or more clips shall be used as instructed by the Engineer. All holes that may be necessary for holding the clips, glazing beads and all other attachments shall be drilled by the Concessionaire.

Glass panes shall be set without springing, and shall be bedded in putty and back puttied, except where mouldings or gaskets are specified. Putty, mastic cement etc., shall be smoothly finished to a true even line. Obscure and figured glass shall be set with smooth side out.

After completion of glazing work, the Concessionaire shall remove all dirt, stains, putty, etc., clean the glass panes and leave the work in perfectly acceptable condition. All broken, cracked or damaged glass shall be replaced by new at the Concessionaire's own cost.

10.4 Acceptance criteria

- (a) All installations shall be free from cracked, broken or damaged glass. Edges of large panes of thicker glass and heat absorbing glass shall be inspected carefully for chipped, cracked or unground edges.
- (b) Glazing shall be carefully done to avoid direct contact with metal frames.

- (c) All glass shall be embedded in mastic or fixed by neoprene gaskets to give a leak-proof installation.
- (d) At completion the panes shall be free from dirt, stains, excess putty, etc., to the complete satisfaction of the Engineer.

10.5 IS codes

Some of the important applicable Indian Codes for this section are listed below. Latest editions of these codes shall be followed:

IS:3548	Code of Practice for glazing in building.
IS:1083	Code of practice for fixing and glazing metal doors, windows and ventilators.
IS:419	Putty for use on window frames.

Sub section - C11
**Technical specification for MS doors, windows,
ventilators, louvers, etc.**

Sub section - C11

Technical specification for MS doors, windows, ventilators, louvers, etc.

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Sub section - C11: Technical specification for MS doors, windows, ventilators, louvers, etc

11.1 Scope

The work in general shall consist of supplying, erecting and installing of all MS doors, windows, ventilators, louvers, glazed partitions etc. as required with all materials, complete excluding supply of glass and glazing. Supplying and/or fixing of all door and window accessories and hardware are also included in the scope.

11.2 Installation

11.2.1 Materials

Steel sections used for fabrication of doors, windows, etc. shall be standard rolled steel sections specified in IS:1038 and IS:1361. Mild Steel sheets for frames, shutters, louver blades, etc. shall be of the gauge mentioned in this specification.

Hardwares and fixtures of the best quality from approved manufacturers only shall be used. The Bidder shall specifically state the particular manufacturer's materials, he proposes to use. All hardware and fixtures shall be able to withstand repeated use. Door closers shall conform to IS:3564 latest edition and shall be suitable for doors weighing 61-80 kg unless otherwise stated. Each closer shall be guaranteed against manufacturing defect for one year and any defect found within this period shall be rectified or the closer replaced free of charge. Concealed doors closers shall be either floor mounted or transform mounted suitable for installation with metal doors. They shall conform to the performance requirements and endurance test stated in Appendix A of IS 3564 (latest edition).

Aluminium sections for fabrication of doors, windows, partitions etc. shall be extruded section conforming to IS:1948 and 1949 or as manufactured by Indian Aluminium Company Ltd. or approved equivalent. The alloy used shall conform to IS designation HE-9-WP of IS:733. Heavy duty double acting floor springs where specified shall conform to IS:6315, shall be suitable for door shutters weighing upto 125 kg. shall be hydraulically regulated, shall be constructed of cast brass casting cover and shoe, gun metal piston player and all other parts of mild steel.

The Concessionaire shall submit samples of each type of hardware to the Engineer. The approved samples shall be retained by the Engineer for comparison of the bulk supply. The

samples shall be returned to the Concessionaire towards the end for incorporation in the job.

The mastic for caulking shall be of best quality from a manufacturer approved by the Engineer. In general the mastic for fixing of metal frames shall be as per IS:1081 latest edition and/or as approved by the Engineer.

11.2.2 Fabrication

➤ Steel doors, windows, ventilators, louvers, etc.

(a) Door frames :

Frames shall be fabricated from 16 G sheets. They shall be mortised, reinforced, drilled and tapped for hinges, lock and bolt strikes. Where necessary, frames shall be reinforced for door closers. Welded construction with mitred corners shall be used. Rubber door silencers shall be furnished and for the striking jamb, Loose 'T' masonry anchors shall be provided. Frames shall finish flush with the floor and adjustable floor anchors shall be supplied. Frames shall be brought to site with the floor ties/weather bars installed in place.

(b) Double plate flush door shutter

Door shutters shall be 45 mm thick completely flush design and shall comprise of two outer sheets of 18G steel sheets rigidly connected and reinforced inside with continuous vertical 20 G stiffeners, spot welded in position at not more than 150mm centres. Both edges of doors shall be joined and reinforced to full height by steel channels placed immediately inside and welded to the door faces. The tops and bottoms of doors shall be reinforced horizontally by steel channels running to the full width of the door. Doors shall have proper level on lock stiles and rails to operate without bending and shall be reinforced at the corners to prevent sagging or twisting. Pairs of double doors shall have meeting stile edges bevelled or rebated. Wherever required the doors shall be sound deadened by filling the inside voids with mineral wool or other suitable approved materials.

Door shall be mortised, reinforced, drilled and tapped in the shop for hinges, locks and bolts. They shall also be reinforced for closers, push plates and other surface hardware where necessary.

Any drilling and tapping required on the surface shall be done at site. Wherever required provision shall be made for fixing glazing, vision panels, louvers, etc. Glazing mouldings shall be of 18 g steel as directed by the Engineer. Louvre blades shall be V or Z shaped and made out of 16 G sheets.

(c) Single sheet door shutters

Single sheet doors shall be made from best quality 18 G mild steel sheets and shall present a flush surface on the outside. The inside shall be stiffened with a semitubular edge and central stiffening rail which shall support the lock and other furniture. The frames shall be made from best quality 16 G mild steel sheets.

Wherever required provision for fixing glass panels, louvers, etc. shall be made. Fabrication shall be as specified in 2.02.01 (b) “Double Flush Door Shutters”.

(d) Sliding doors

Sliding doors shall be either double plate or single plate construction as required and made out of 18 gauge steel sheets with adequate stiffeners.

The Concessionaire shall specify the weight of the door in his shop drawing and submit the manufacturer’s catalogue of the sliding gear he proposes to use. The Concessionaire shall make provisions where necessary for openings in the door for monorail beams. Doors shall close positively to exclude rain water from seeping in. Sliding doors shall withstand specified wind loads without buckling or jamming. The door shall slide freely under all ambient conditions.

(e) Steel windows, sashes, ventilators, etc.

These shall conform in all respects to IS:1038 and IS:1361 latest editions. The details as called for in the above codes shall be applicable for coupling mullions, transoms, weather bars, pivot arrangements for ventilators, etc.

All welds shall be flush butt welded to form a solid fused joint, so that all frames are square and flat.

Where composite unit openings are envisaged the individual windows units shall be joined together with requisite transom and mullions. All windows shall be outside glazed fixed with putty or metal glazing beads. Where aluminium glazing beads are specified they shall be extruded aluminium channel 9.5 mm x 9.5 mm x 1.6 mm (Indal section No.2209) aluminium beads shall be given one coat of zinc chromate primer before fixing to windows.

➤ **Welding**

The joints for steel doors, windows, ventilators, etc. shall be electrically flash butt welded joint at all corners and junctions to form a solid fuses right angle joint.

➤ **Fabrication of aluminium doors, windows, frames, etc.**

Extruded sections shall have a minimum 3 mm wall thickness. All sections shall be approved by the Engineer before fabrication is taken up. Doors, windows, frames, mullions, transformers etc. shall be anodized in bath of sulphuric acid to provide a clear coating of minimum 10 micro-meter. The anodized materials shall then be sealed by immersing in boiling water for 15 minutes. A protective transparent coating shall be applied to the sections before shipment from the factory.

Fabrication drawings shall be submitted by the Concessionaire which shall also include the weights of the materials used and got approved from the Engineer.

11.2.3 Shop coat of paint

The shop paint for steel doors, windows, etc. shall be best red oxide, zinc chromate primer paint from approved manufacturer conforming to IS:2074, latest edition. All surfaces shall be thoroughly cleaned of rust, grease, loose mill scales, etc. and given one coat of shop paint. Portions like mullions transoms, etc. which will be inaccessible after assembly of units shall be given an extra coat of paint before assembly.

11.2.4 Handling and storage of fabricated material

All metal doors, windows, etc. shall be packed and crated properly before despatch to ensure that there will be no damage to the fabricated materials. Loading into wagons and trucks shall be done with all care to ensure safe arrival of materials at site in an undamaged condition. All metal doors, windows, etc. shall be stored under cover and handled in a way to prevent damage or distortion. Special care shall be taken to prevent staining of aluminium products by rust, motor etc.

11.2.5 Assembly and erection at site

In general the fixing of steel doors, windows, ventilators, louvres, etc. shall conform to IS:1081 latest edition. The Concessionaire shall assemble and install all steel doors, windows, sashes, fixed metal louvres, etc. including transoms and mullions for composite units in respective places keeping proper lines and levels, and in an approved workman like manner to give a trouble free and leak proof installation. If required by the Engineer, the installation shall be carried out under the supervision of the manufacturer's staff.

After installation of steel doors, windows, etc., all abrasions to the shop-coat of paint shall be retouched and made good with the same quality of paint.

All coupling mullions, transoms, frames, etc. in contact with adjacent steel and other members shall be well bedded in mastic. The Concessionaire shall bring to site the mastic cement in original sealed containers of the manufacturer and shall apply it as per the manufacturer's instructions.

Floor, shutters, partitions, hardware fixtures, etc. shall be fixed only after the major equipment has been installed in the rooms.

Wherever required, nylon cords of approved quality shall be supplied along with pivoted sashes. These shall be adequate length to terminate one metre from the floor. Loose ends of cords shall have a metal or plastic pull as approved by the Engineer.

11.3 Acceptance criteria

11.3.1 For fabricated items

- (a) Overall dimensions shall be within $\pm 0.5\text{mm}$ of the size.
- (b) Mullions, transoms, etc. shall be in one length and permissible deviations from straightness shall be limited to plus minus 0.5 mm from the axis of the member.
- (c) Door and window shutters shall operate without jamming. The clearance at head and jamb for door shutters shall not exceed 1.5mm. For double leafs the gap at the meeting stiles shall not be more than 1.5mm.
- (d) Door leafs shall be undercut wherever required.
- (e) Doors, windows, frames, etc. shall be on a true plane, free from warp or buckles.
- (f) All welds shall be dressed flush on exposed and contact surfaces.
- (g) Correctness of hardware and smoothness of operation of all shop installed hardware and fixture.
- (h) Provisions for hardware and fixtures to be installed at site.
- (i) Glazing beads shall be cut with mitred corners.
- (j) Shop coats shall be properly applied.
- (k) Exposed aluminium surface shall be free from scratches, stains and discolouration. Anodized surfaces shall present a uniform and pleasing look.

11.3.2 For installed items

- (a) Installation shall be at the correct location, elevation and in general on a true vertical plane.

- (b) All frames of external walls shall be mastic caulked to prevent leakage through the joint between frames and masonry.
- (c) All openable sections shall operate smoothly without jamming.
- (d) Locks, fasteners, etc. shall engaged positively. Keys shall be non-interchangeable.
- (e) Cutting to concrete or masonry shall be made good and all abrasions to shop paint shall be touched up with a paint of the same quality as the shop paint.
- (f) Aluminium doors, windows etc. shall be free scratches, stains or discolouration.
- (g) It shall be the responsibility of the Concessionaire to see that the material is protected from mortar, paint, plaster, terrazzo framing members to the satisfaction of the Engineer before handing over to the Executing Agency.

11.4 Information to be submitted

Before starting fabrication of any metal doors, windows, etc. the Concessionaire shall submit detailed fabrication drawings to the Engineer for approval. The fabrications shall be started only after approval of the drawings.

11.5 IS codes

The important IS codes to be followed are listed below:

IS:1083	Steel doors, windows and ventilators.
IS:1361	Steel windows for industrial buildings.
IS:1451	Steel door frames.

Sub section - C12
Technical specification for rolling steel shutters /
grills

Sub section - C12

Technical specification for rolling steel shutters / grills

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Sub section - C12: Technical specification for rolling steel shutters/grills

12.1 Scope

This specification covers the design, supply of materials, fabrication, delivery and erection of rolling shutters grills with motor drives and/or manual operation during all accessories as hereinafter specified. All electrical work shall be in strict accordance with the latest Indian Electricity Rules.

12.2 Installation

12.2.1 Components

- a) States for rolling shutters shall be made from tested bright, cold rolled, annealed M.S. strips, not less than 0.9 mm thick for shutters upto 3.5 m wide and not less than 1.24 mm thick for shutters 3.5 m wide and above, machine rolled at 75 mm rolling centres, interlocking with each other. The profile will be such as to prevent excessive deflection under specified wind load.
- b) Rolling grills shall be constructed out of 6 mm dia. rods at 35 mm centres running horizontally flexibly connected with vertical links spaced not more than 200 mm centres. Alternatively, rolling grills shall be made from perforated slats of approved design, reinforced with 6 mm dia rods.
- c) End locks shall be heavy type M.C.I./C.I. and shall be provided at each end of alternate slats.
- d) Bottom bars shall be finished with two angles not less than 6 mm thick for external shutters. When shown on drawings, a flexible weather strip shall be applied to make tight contact with the floor.
- e) Guide shall be of such depth as to retain the shutter under a wind pressure of 150 kg/sq.m. The minimum thickness of guide shall be 126.
- f) Shafts shall be of steel pipes of sufficient size to carry the torsional load with a maximum deflection of 1/360th of span. Grease packed ball bearings or bushings shall be provided for smooth trouble, free operation.
- g) Hoods shall be formed of not less than 20 gauge steel, suitably reinforced to prevent sag.
- h) Locks shall be side belt and hasp or cylinder lock operable from one or both sides. Provision for securing hand chain with pad-lock, provision for removable handle for hand cranks etc. shall be made as desired by the Engineer.

- i) Power unit shall be suitable for 3 phase, 50 cycle, 400 volt A.C. Power supply and shall be either floor or wall mounted unit. The motors shall be of sufficient capacity to move the shutter in either direction at a speed of 0.3 metres per second. In addition to the gear motor, each standard power unit shall include a magnetic brake, reversing starter with built-in overload protection, a geared limit switch and one push button station located inside the building unless otherwise stated. It is desirable that the button bar or motor operated doors shall be provided with a sensitive edge, electrically connected to stop the travel of the door on meeting an obstruction.
- j) Operating chains shall be of tested quality, heavily galvanized and with all ends rounded to assure smooth operation and hand protection.
- k) Reduction gears shall be of high strength grey cast iron, machine moulded from machine cut patterns.

12.2.2 Manually operated shutters/grills

Manually operated shutters shall be easily operable by one person. The speed of operation shall be about 0.3 metres per second.

In general, manually operated shutters shall be push-pull type for opening upto 9 sq. metre in area. Larger shutters shall be either chain and gear operated or crank and gear operated. The crank handle shall be removable. All shutters shall be lockable from one or both sides as desired by the Engineer.

12.2.3 Power operated shutters/grill

These shall be operable from a push button station conveniently located beside the door or as shown on drawings. One emergency hand chain-crank operation shall also be provided for use in case of failure of the electrical system.

12.2.4 Shop coat

Shutters shall be painted with one coat of red lead or zinc chromate primer. Where specified, doors shall be galvanized and subsequently painted with one coat of zinc chromate for adhesion of field coat.

12.3 Acceptance criteria

12.3.1 Shop inspection

After completion the manufacture of different components of the rolling shutter, an arrangement for shop inspection by the Engineer shall be made to check the conformity with approved shop drawings.

12.3.2 Field inspection

After installing the shutters, the Concessionaire shall test the performance of the shutter in the presence of the Engineer. The doors shall be smoothly operable under all ambient conditions. All control and locking devices shall give fault- free performance.

12.3.3 Guarantee

The Concessionaire shall give one year's guarantee for the successful operation of the shutters.

12.4 IS codes

IS:6248 Metal rolling shutters and rolling grills.

Section - WS1
Technical specifications for laying of pipes and fittings / specials

Section - WS1

Technical specifications for laying of pipes and fittings / specials

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Section - WS1: Technical specifications for laying of pipes and fittings / specials

1. Scope

The work shall include providing of materials, all necessary plant and equipment, providing adequate engineering supervision and technical personnel, skilled and unskilled labour, etc. as required to carry out the entire work as indicated on the drawings and/or described herein subsequently and/or as directed by the Engineer. The Concessionaire shall carry out all works meant within the intent of this specification even if not explicitly mentioned herein.

All works shall be executed to the satisfaction of the Engineer.

2. Applicable codes

The laying of pipes and fittings/specials shall comply with all currently applicable statutes, regulations, standards and codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the standards/codes shall be referred to. If requirements of this specification conflicts with the requirements of the standards / codes, this specification shall govern.

Any approval, instructions, permissions, checking, review, etc. whatsoever by the Engineer, shall not relieve the Concessionaire of his responsibility and obligation regarding adequacy, correctness, completeness, timely completion, safety, strength, quality & workmanship etc.

The Concessionaire shall make his own surveying arrangements for locating the coordinates and positions of all work and establish the reduced levels (RLs) at these locations, based on two reference grid lines and one bench mark which will be furnished by the Executing Agency. If need be the Executing Agency reserves the right to have the Concessionaire re-verify the coordinates at no cost to Executing Agency. The Concessionaire has to provide at site, all the required survey instruments, along with qualified surveyors, to the satisfaction of the Engineer so that the work can be carried out accurately and according to the specifications and drawings.

2.1 Codes of practice

All applicable standards, specifications, etc. and codes of practice shall be the latest editions, including all applicable official amendments and revisions. A complete set of all these documents shall generally be available at site, with the Concessionaire.

All work shall be carried out as per the stipulations contained in various sections of these specifications and the latest Indian Standards, Act, Codes and best practices.

In case of conflict between the stipulations contained in various sections of these specifications and stipulations of Indian Standard Codes, etc. the requirements of stipulations contained in various sections of these specifications shall prevail over that of Indian Standards, Codes, etc. Concessionaire is responsible to notify Executing Agency in writing well in advance of such conflicts prior to execution of the work.

Some of the applicable Indian Standards, Codes are referred to herein below:

- (a) IS.783 - Code of practice for laying of concrete pipes
- (b) I.S. 3114 - Code of practice for laying of cast iron pipes
- (c) I.S. 3764 - Excavation work - code of safety
- (d) I.S. 5822 - Code of practice for laying of electrically welded steel pipes for water supply
- (e) I.S. 6530 - Code of practice for laying of asbestos cement pressure pipes
- (f) I.S. 1726 - Specifications for Cast Iron Manhole covers & frames
- (g) I.S. 5455 - Specifications for C.I. steps for manholes.
- (h) I.S.4111(Part -1) - Code of practice for ancillary structures in sewerage system (manholes)

3. Carting & handling

Pipes and fittings/specials shall be transported to all the work sites at places along the alignment of pipe line as directed by Executing Agency/Engineer. Concessionaire shall be responsible for the safety of pipes and fittings/specials in transit, loading/unloading storage etc. Every care shall be exercised in handling pipes and fittings/specials to avoid possible damage. While unloading, the pipes and fittings/specials shall not be dropped down from the truck on to any hard surfaces. They should be unloaded on timber skids with steadying ropes or by any other approved means. Padding shall be provided between coated pipes, fittings/ specials and timber skids to avoid damage to the coating. Suitable gaps between

pipes/stacks of pipe should be left at intervals in order to permit free access from one side to the other. In case of spigot & socket pipes care should be taken regarding orientation of pipes while unloading. As far as possible pipes shall be unloaded on one side of the trench only. The pipes shall be checked for any visible damage (such as broken edges, cracking & spalling of pipe etc.) while unloading and shall be sorted out for replacement. Any pipe which shows any damage to preclude it from being used shall be discarded. Dragging of pipes and fittings/specials along concrete and similar pavement with hard surfaces shall be prohibited.

4. Storage

- 4.1 Each stack of pipes shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape or the pipes laid lengthwise and crosswise in alternate layers. The pyramid stack shall be made for smaller diameter pipes for conserving space in storing them. The height of the stack shall not exceed 1.5 m. Also necessary security arrangements should be provided to avoid these till the pipes are finally used.
- 4.2 Fittings/specials shall be stacked under cover and separated from pipes and with suitable security measures.
- 4.3 Rubber rings shall be stored in a clean & cool store away from windows, boiler, electrical equipment and petrol, oils or other chemicals. Particularly in the field where the rubber rings are being used it is desirable that they do not be left out on the ground in the sun or overnight under heavy frost or snow conditions.

5. Laying

5.1 General

The Concessionaire shall visit the site before tendering and get himself acquainted with site conditions and the regulations regarding the laying of pipes in congested areas, heavy traffic areas etc. The successful bidder shall take the necessary permission and clearance of all the local authorities like department of roads, traffic, water supply and drainage, electricity" board, telephone company etc. wherever necessary.

Road reinstatement shall not be included in backfilling unless specified.

General lighting for worksite, warning lights, sign boards, fencing & barricading etc. shall be provided by Concessionaire at his own cost.

5.2 Excavation

Before excavating the trench the alignment of pipeline shall be approved by Executing Agency / Engineer. The excavation of trenches and pits for manholes/chambers shall be carried out in accordance with the specifications contained herein below and shall be done in such a manner that IT DOES NOT GET FAR AHEAD OF THE LAYING OPERATION as approved by Executing Agency / Engineer.

After excavation of trenches, pipes shall not be lowered in position unless the dimensions of trenches and bedding work at the bottom of the trenches are approved and measured by Engineer / Executing Agency. Pipes and fittings shall be carefully lowered in the trenches. Special arrangements such as cranes, tripods with chain pulley block etc. for lowering the pipes and fittings shall be made by Concessionaire at his own cost. In no case pipes shall be dropped. Slings of canvas or equally **NON ABRASIVE MATERIAL** of suitable width and strength or special attachment to fit the ends of pipes and fittings shall be used to lift and lower the coated pipes and fittings. The pipes and fittings shall be inspected for defects and, be struck with light hammer preferably while in suspended position to detect presence of any cracks. If doubt persists, further confirmation shall be done by pouring a little Paraffin on the inside of the pipe at the suspected spot and after doing vigilant investigation whether the Paraffin is leaking on to the external side of the pipe or not then only the non leaking pipe should be considered fit for use. Pipes and fittings damaged during lowering or aligning shall be replaced by Concessionaire at no extra cost.

To protect the persons from injury and to avoid any damage to property, adequate barricades, construction signs, red lanterns and guards, as required for smooth functioning of work and to avoid any minor or major accidents, shall be placed and maintained during the progress of the construction work and until it is safe for the traffic to use the roadways. The relevant Indian Standards and the rules and regulations of local authorities in regard to safety provisions shall be observed.

Suitable fencing/barricades shall be provided along the sides of trenches and pits. The posts of fencing shall be of timber securely fixed in the ground not more than 3 m apart and they

shall not be less than 75 mm. in diameter or less than 1.2 m. above the surface of the ground. There shall be two rails, one near the top of the posts and the other about 450 mm. above the ground and each shall be from 50 mm. to 70 mm. in diameter and sufficiently long to run from post to post to which they shall be bound with strong rope. The method of projecting rails beyond the posts and tying them together where they meet will not be allowed on any account. All along the edges of the excavated trenches a bund of earth about 1.2 m. high shall be formed where required by Executing Agency/Engineer (but due care shall be taken while stacking the excavated stuff to cause least inconvenience for day to day site activities) for further protection. The above work shall not be paid for separately and the Concessionaire shall take into account the costs of such works and quote accordingly.

Total quantity of water required for entire work including for testing- pipes and fittings at work site shall be arranged by Concessionaire at his own cost. Dragging of pipes and fittings along concrete and similar pavements with hard surfaces shall be prohibited.

The road metal and also the rubble packing obtained out of road surface excavations etc. shall first be stripped off for the whole width and entire length of the trench/pit and separately deposited in such place or places as may be determined by Executing Agency/Engineer. In case of the metal packing or "Khandkies" not being so deposited or being mixed up with excavated materials and not available for backfilling and making good the excavation, the cost of the new metal, packing or "Khandkies" required shall be charged to the Concessionaire.

The portions of trenches in stony or rocky ground are to be excavated all along to the entire length and for the full depth such that the bottom of the excavation shall not be higher at any point than the bottom of the concrete' bedding layer below the sewer pipe.

During excavation, large stones and rubble shall be separated and removed from the excavated soil and stacked separately. The material from excavation shall be deposited on either side of the trench leaving adequate clear distance from the edges of the trench and pit or as may be necessary to prevent the sides of the trench/pit to "cave-in" or at such a distance and in such a manner as to avoid covering fire hydrants, sluice valves, manhole covers etc., and so as to avoid abutting the wall or structure or causing inconvenience to the public and other service, organization or otherwise as Executing Agency/ Engineer may direct.

Concessionaire also shall take into account while quoting his rates for possible additional excavations for trial pits of such sizes and depths that may be required to be undertaken by him as per the instructions of Executing Agency/Engineer for determining the locations of various existing underground service line such as water pipes, drains, sewers, gas pipe lines, electric and telephone cable etc. which may be met with. Concessionaire should also as per the instructions of Executing Agency/Engineer backfill and thoroughly compact all such additional excavations and make the area as original after the purpose of locating is served. No additional payment will be considered by the Executing Agency on this account.

During the pendency of the contract the Concessionaire should take all due precautions for proper maintenance and protection against damage of all such service lines if met with during excavation, by means of shoring, strutting, planking over, padding- or otherwise as Executing Agency / Engineer may direct. Also all precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structures. In case if any such damages have occurred then those shall be made good either by Concessionaire or by other agency, as Engineer / Executing Agency may decide and wholly in either case at the expense of Concessionaire.

If the work for which the excavation has been made is not completed by the expected date of the setting of monsoon or the setting in of rain whichever is earlier, or before the day fixed by Executing Agency/Engineer for filling in any excavation on account of any festival or special occasion, Concessionaire shall backfill such excavation and consolidate the filling at his own expenses as directed by Engineer/Executing Agency and shall re-excavate when required at his own cost.

Engineer/Executing Agency may order portions of shoring to be left in the trenches at such places, where it is found absolutely necessary to do so as to avoid any damage which may be caused (because of pulling out shoring from the- excavated trench/pit) to buildings, cables, gas mains, water mains, sewers etc. in close proximity of the excavation. Concessionaire shall be paid at the negotiated rate for the shoring left in the trenches / pit if directed by Engineer / Executing Agency. Concessionaire shall not claim, for any reasons whatsoever for the shoring which may have been left in position by him at his own discretion. Concessionaire shall not be paid for shoring left in the portions of the rakers, struts, or other timber cut off and not permanently left in the work.

Utmost care shall be taken to see that the width of the trench at the top of pipe is not more than that as specified. In case additional width is required it shall be provided only in the

top portion from the ground level upto 300 mm. above the crown of pipe. If any extra width is provided in the area below this portion because of mistake on part of the Concessionaire, Concessionaire shall have to provide remedial measures in the form of lime concrete or rubble masonry or otherwise at the discussion and to the satisfaction of Executing Agency / Engineer. Concessionaire shall not be paid any additional for extra excavation as well as for the resulting remedial measures adopted to make up for the additionally done excavation. If rock is met with, it shall be removed to 15 cm. below the bottom of pipes and fittings / specials and the space resulting shall be refilled with granular materials and properly consolidated. No compensation will be paid to the Concessionaire on this account and financial implications for the same should be included by the Concessionaire in his rates. Bottom of trenches / pits shall be saturated with water and well rammed wherever Executing Agency / Engineer may consider it necessary to do so.

Wherever a socket or collar of pipe or fitting / special is to be accommodated a strip sufficient enough for this purpose is to be cut in the bottom of the trench or concrete bed to a depth of at least 75 mm. below the bed of the pipe so that the pipe may have a fair bearing on its shaft and does not rest upon its socket. Such strip shall be of sufficient size in every respect to admit the free movements of hand holding necessary tools of the skilled worker, all around the socket in order to make the joint completely water tight and the strip shall be maintained clear until the joint has been approved by Executing Agency / Engineer.

All the pipes are to be laid perfectly true both in alignment and to the gradient specified.

When welding is to be carried out with the pipes and specials in the trench, additional excavation of not more than 60 cm. in depth and 90 cm. in length shall be made at joints in order to facilitate welding. The excess volume of this excavation should be brought to the acceptable level by making good with necessary fill material as directed by Executing Agency / Engineer. The charges on this account should be included in his rates by the Concessionaire.

The excess excavated material shall be carried away from site of works to a place up to a distance as directed by Executing Agency / Engineer. This shall be done immediately so as not to cause any inconvenience to the public or traffic. If the instructions from Engineer are not implemented within seven- days from the date of instructions to cart the materials and to clear the site, the same shall be 'carried out by Executing Agency/Engineer at the risk and cost of the Concessionaire and any claim or dispute shall not be entertained in this respect.

5.3 Dewatering

During the excavation, if subsoil water or water mixed with- clay/slush- is met with Concessionaire shall have to provide necessary equipment and labourers for dewatering the trenches/pits by bailing out water or clay/slush; if pumping out subsoil water is found to be necessary, Concessionaire shall provide pumps in sufficient numbers/type for the same. In both the above cases the excavation shall be done to the required level and the pipes shall be laid to proper alignment and gradient. Concessionaire shall also make foolproof necessary arrangement for the disposal of drained water to nearby storm water drain or in a pit if allowed by Executing Agency/Engineer. In no case the water shall be allowed to- spread indiscriminately over the adjoining area. Before discharging this water into public sewer/drain, Concessionaire shall take necessary permission from all the local authorities before implementing the draining arrangements.

5.4 Special foundation in poor quality soil

Where the bottom of the trench at subgrade is found to consist of material which is unstable to such a degree that in the opinion of Executing Agency/Engineer, it cannot be removed and replaced with an approved material thoroughly compacted in place to support the pipe properly, a suitable foundation for the pipes, consisting of piling, timbers or other materials, in accordance with relevant drawings and as instructed and approved by Executing Agency/Engineer shall be constructed.

When the work of constructing the pipe lines has to be carried out in soft underground strata, such as puddle etc. or in a reclaimed land, a good foundation shall be provided for the pipes and manholes. For the former, excavation in the trench shall be taken 75 mm. deeper than what is ordinarily required and for this depth the whole of the trench shall be covered over with M-150 bed concrete of the required width, reinforced with B.R.C. fabric No.9 or any other fabric- approved-by the Engineer.

The fabric shall be suitably cut to the requirement and securely joined together with adequate laps which should not be less than 200 mm. The fabric in the pipe line must also be securely jointed together. The rates in both the cases shall be held to include all lapping, jointing and also any probable wastage.

5.5 Wooden shoring

Concessionaire shall suitably design polling boards, walling and struts to meet different soil conditions that might be encountered in excavating trenches/pits. The horizontal and vertical spacing of struts shall, be such that not only the sides of trenches shall be prevented from collapse but also easy lowering of pipe in trenches shall be ensured without creating undue obstructions for the excavation of the work. Any inconvenience and/or delay that might be caused in lowering pipes in trenches as a result of adopting improper spacing of struts by Concessionaire shall be his sole responsibility. No part of shoring shall at any time be removed by Concessionaire without obtaining permission from Executing Agency/Engineer. While taking out shoring planks the hollows of any form must simultaneously be filled in with soft earth well watered & rammed with rammers.

Executing Agency/Engineer may order portions of shoring to be left in the trenches/pits at such places, where it is found absolutely necessary to do so as to avoid any damage which may be caused to the adjacent buildings, cables, gas-mains, water mains, sewers etc. in close proximity of the excavation, by pulling out the shoring from the excavations. Concessionaire shall not claim, on any reason, whatsoever for the shoring which may have been left in by him at his own discretion.

5.6 Steel plate shoring

Where the subsoil conditions are expected to be of a soft and unstable character in trench/pit excavation the normal method of timbering may prove insufficient to avoid subsidence of the adjoining road surfaces and other services. In such circumstances Concessionaire will be required to use steel trench sheeting or sheet piling adequately supported by timber struts, walling etc., as per the instructions, manner and method directed by Executing Agency/Engineer. Concessionaire shall supply, pitch drive and subsequently remove trench sheeting or piling in accordance with other items of the specification.

5.7 Boning staves and side rails

In laying the pipes and fittings/specials the centre for each pipe line shall be marked by a peg. Concessionaire shall dig holes for and set up two posts (about 100 mm. x 100 mm. x 1800 mm.) at each junction of pipe lines at nearly equal distance from the peg and at sufficient distances there from to be well clear of all intended excavation, so arranged that a side rail when fixed at a certain level against the post shall cross the centre line of the manhole / chamber or pipe lines. The side rail shall not in any case be more than 30 m apart, intermediate rails shall be put up if directed by Executing Agency / Engineer.

Boning staves of 75 mm. x 50 mm size shall be prepared by Concessionaire in various lengths, each length being of a certain whole number of metres and with a fixed tee-head and fixed intermediate cross pieces, each about 300 mm. long. The top-edge of the cross piece must be fixed below the top-edge of this tee-head at a distance equal to the outside diameter of the pipe or the thickness of the concrete bed to be laid as the case may be. The top of cross pieces shall indicate different levels such as excavation for pipe line, top of concrete bed, top of pipe etc. as the case may be.

The side rail of size 250 mm. x 40,mm. shall be screwed with the top edge resting against the level marks. The centre line of the pipe shall be marked on the rail and this mark shall denote also the meeting point of the centre lines of any converging pipes. A line drawn from the top edge of one rail to the top edge of the next rail shall be vertically parallel with the bed of the pipe and the depth of the bed of pipe at any intermediate point may be determined by letting down the selected boning staff until the tee head comes in the line of the sight from rail to rail.

The post and rails shall be perfectly square and planed smooth on all sides and edges. The rails shall be painted white on both sides, and the tee heads and cross piece of the boning staves shall be painted black.

For the pipes converging to a manhole / chamber at various levels, there shall be a rail fixed for every different level. When a rail comes within 0.60 M. of the surface of the ground, a higher sight rail shall be fixed for use with the rail over the next point.

The posts and rails shall be in no case be removed until the trench is excavated, the pipes are laid and Executing Agency / Engineer gives permission to proceed with the backfilling.

5.8 Encasing / being / hunching etc.

The pipes shall be provided with encasement / bedding / hunching etc. as specified in drawings.

5.9 Laying of pipes and fittings / specials

All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure / pipe line of water, gas, etc. and excavation to proceed in accordance with the relevant of Clause of this specifications.

All the pipes are to be laid perfectly true both in alignment and to gradient specified In case of spigot and socket pipe the socket end of the pipe shall face upstream **EXCEPT WHEN THE PIPE LINE RUNS UPHILL IN WHICH CASE THE SOCKET ENDS SHOULD FACE THE UPGRADE**. The laying of pipes shall always proceed upgrade of a slope. After placing a pipe in the trench, the spigot end shall be centered in the socket and the pipe forced home and aligned to required gradient. The pipes shall be secured in place with approved backfill material tamped under it except at the socket. Pipes and fittings / specials which do not allow a sufficient and uniform space for joints shall be removed and replaced with pipes and fittings/ specials of proper dimensions to ensure such uniform space: Precaution shall be taken to prevent dirt from entering the jointing space. At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by Executing Agency / Engineer. During the period that the plug is on, the Concessionaire shall take proper precautions against flotation of the pipe owing to entry of water into the trench: Wherever it is necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or where long radius curves are permitted, the deflection allowed at joints shall not exceed $2\frac{1}{2}^{\circ}$. In the case of pipes, with joint to be made with loose collars, the collars shall be slipped on before the next pipe is laid. The pipes shall be laid such that the marking on pipes appears at the top of the pipes.

The cutting of pipe for inserting valves, fittings or closure pieces /specials shall be done in a neat and workmanlike manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. For this purpose, pipe cutting machine shall be used and skilled labourers only should be allowed to achieve this task.

5.10 Thrust blocks

Thrust blocks shall be provided as directed by Executing Agency / Engineer to counteract hydraulic thrust, at places wherever directed and as per relevant drawing.

Where the hydraulic thrust is in an upward direction, anchor blocks as per the relevant drawing shall be provided to which the pipes shall be secured with steel straps.

5.11 Jointing of pipes

Jointing for pipes and fittings / specials shall be done in accordance with: the relevant specifications depending on type of pipes being used.

5.12 Testing and commissioning

Testing and commissioning of pipes shall be done in accordance with the relevant specifications.

5.13 Backfilling

Trenches shall be backfilled with approved selected excavated material only after the successful testing of the pipe line. The tamping around the pipe shall be done by hand or other hand operated mechanical means. The water content of the soil shall be as near the optimum moisture content as possible. Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that the level of filling rises gradually and unequal pressure does not occur on the pipe. Back filling shall be done in layers not exceeding 30 cm. Each layer shall be consolidated by watering, ramming, care being taken not to damage to the pipe line. In case of mild steel pipes / specials, the spiders provided during assembly and welding shall be retained until the trench is refilled and consolidated. Where timbers are placed under the pipe line to aid alignment, these timbers shall be removed before backfilling.

5.14 Reinstatement of road / footpath

Reinstatement of road / footpath shall be done as per requirements of local authorities and the relevant specifications after the completion of work.

5.15 Clearing of site

All surplus materials, and all tools and temporary structures shall be removed from the site as directed by Executing Agency/ Engineer and the construction site left clean to the satisfaction of Executing Agency/Engineer.

6. Measurement

The measurements for excavation in trenches shall be done in following manner and will be paid accordingly.

- (i) Length (L) As per the actual length of pipe and fittings / specials laid at work site.
- (ii) Width (B) O.D. + 600 mm. only where O.D. is the outside dia. of pipes in mm.
- (iii) Depth (D) Average depth of trench from ground level to invert of pipe and fittings.

Excavation of asphalt road and reinstatement of road shall be measured on per square metre basis and the length and width at top of trench shall be considered same as those mentioned for excavation of trench.

The rate for this item should be inclusive of all excess excavated material to be transported from site of work to a place upto a maximum distance of 5 km. as directed by Engineer / Executing Agency immediately after his instructions so as not to cause any inconvenience to the public or traffic.

In case the excavation is done in wet condition either by bailing out water or by resorting to pumping, the respective items shall be paid according to the items in schedule of quantities and rates. The measurement for these items shall be made as per the units for relevant item(s) in schedule of quantities and rates. However, Engineer will decide on site the mode of dewatering and his decision shall be final and binding on Concessionaire.

Shoring (open/ close) if to be paid separately shall be measured on the square metre basis of the actual area of trenches shored.

The measurement for removal of excess excavated material upto a specified distance shall be as per the relevant item(s) in the Schedule of Quantities and Rates and shall be measured on cubic metre basis. In case of soil 30% deduction shall be done to take account for voids where as it will be 40% in case of rubble.

Measurement for pipes and fittings / specials shall be in accordance with the relevant clause(s) of specification for particular type of pipes.

7. Notes

Fencing provided along the sides of trenches and pits shall not be paid for separately and Concessionaire shall take into account the costs of such works and quote accordingly.

In case of the road metal packing or dressed stones not being deposited as specified or being mixed up with excavated materials and not available for the reinstatement of road / pavement, the cost of the new metal packing or dressed stones required shall be charged to Concessionaire by Executing Agency / Engineer.

Service lines if damaged during excavation shall be made good either by Concessionaire or by other agency as Executing Agency / Engineer may decide and wholly in either case at the expense of Concessionaire.

Concessionaire shall not be paid any additional compensation for excess excavation over what is specified as well as for any remedial measures that are specified.

The excess excavated material shall be carried away from site of works as specified, failing which in view of public safety and traffic convenience Executing Agency / Engineer may carry out the work by any other agency at Concessionaire's risk and cost.

Portion of shoring left in the excavated trenches or pits shall be measured and paid separately, if instructed by Executing Agency / Engineer to do so.

8. Data Sheet – A

- Hydrostatic Test Pressure at Work Site - 30 m.
- Leakage Test Pressure at Work Site - 30 m.
- Bedding - As per drawing
- Width of trench - O.D. + 600 mm. only where O.D is the outside dia. of pipes in mm

Section - WS2

**Technical specifications for laying of jointing of
cast iron pipes and fittings (cast iron)**

Section - WS2

Technical specifications for laying of jointing of cast iron pipes and fittings (cast iron)

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Section - WS2: Technical specifications for laying of jointing of cast iron pipes and fittings
(cast iron)

1. Scope

This specification covers the requirements for collecting from stores / warehouses as suggested by the Executing Agency, transporting to work sites, laying, jointing and field testing of cast iron pipes and fittings for the water distribution and transmission Network.

2. Applicable codes

Various operations such as transporting to work sites, lowering in trenches, laying, jointing and field testing of cast iron pipes and fittings shall comply with all currently applicable standards. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the standards shall be referred to. If requirements of this specification conflict with the requirements of the standards, this specification shall govern.

- a) Cast Iron Pipes - LA Class - IS : 1536
- b) Specials (Tees, crosses, bends etc.) - IS : 1538
- c) Property connections & Fittings - IS: 1239 (Part I & II)
- d) Laying of C.I. pipes -IS: 3114
- e) Sluice Valves - IS : 780 and IS : 2906
- f) Butterfly Valves (Double flanged long body) - BS : 5155 / IS: 13095
- g) Kinetic Double Air Valves with isolating sluice valve - IVC make
- h) Fire Hydrants - IS : 908
- i) Rubber Gasket for Flanged Connection - IS : 638
- j) Ferrules - IS: 2692
- k) Specification for rubber sealing rings for gas mains, water mains and sewers. IS:5382
- l) Scour valve including C.I. L.A class drain pipe of dia. equivalent to that of Scour valve and 6 m. length IS:780 & IS:2906

3. Laying

For Clauses No.3.0 i.e. Carting and Handling, 4.0 i.e. Storage and 5.0 i.e. Laying - please refer Sub-Section WS-1 for "Technical Specifications for Laying of Pipes and Fittings / Specials" which are common for this item also.

4. Valves

4.1. General

- i. Valves shall be as per internationally recognized standards. Flanges shall be machined on faces and edges and conform to ISO 7005, IS 6392 or BS 4504.
- ii. Valves shall be double flanged type and the face shall be parallel to each other and flange face should be at right angles to the valve centerline. Back side of valve flanges shall be machined or spot faced for proper seating of the head and nut.
- iii. Valve buried or installed in underground chamber, where access to a hand wheel would be impractical shall be operated by means of extension spindle and / or keys.
- iv. Valve of diameter 450 mm. and above shall be provided with lifting eyes and shall have detachable bolted covers for inspection, cleaning and servicing.
- v. Valve shall be suitable for frequent operation as well as operation after long periods of idleness in either open or closed position.
- vi. The valve stem, thrust washers, screws, nuts and all other components exposed to the water shall be of a corrosion resistant grade of stainless steel.
- vii. Valves shall be free from sharp projections.

4.2. Butterfly valves

- (a) Butterfly valve shall be as per IS 13095 / BS 5155. Valve shall suitable for mounting in any position.
- (b) The valve seat shall be secured to the valve body. When the valve is fully closed, a seal shall seat firmly so as to prevent leakage. The seat surfaces shall be machined smooth to provide a long life for the seal.
- (c) The valve seal shall be replaceable and securely clamped to the edge of the disc by stainless steel seal retention members, or equivalent so as to prevent leakage and to hold the seal securely during operation. The seal retention member shall be securely

clamped with stainless steel fasteners. All fasteners shall be set flush so as to offer the least resistance possible to the flow-through the valve.

- (d) Valve shall be suitable for throttling purpose.
- (e) All valve spindles and hand wheels shall be positioned to give good access for operational personnel.
- (f) Valve of diameter 450 mm. and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.
- (g) All hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels

4.3. Sluice valves

- (a) Sluice valve shall conform to IS 780 and IS 2906 or relevant internationally recognized standards.
- (b) They shall be of rising or non-rising spindle type depending on application. The valve shall be furnished with a bushing arrangement for replacement of packing without leakage. They shall also have renewable channel and shoe linings. The gap between the shoe and channel shall be limited to 1.5 mm.
- (c) The gate face rings shall be screwed into the gate or alternatively securely pegged over the full circumference.
- (d) Valves of 450 mm. and above shall be provided with thrust bearing arrangement for ease of operation.
- (e) Valves of diameter 450 mm. and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess

of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.

- (f) AJ1 valves, spindles and hand wheels shall be positioned to give good access for operational personnel.
- (g) All hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.

4.4. Non-return valve

- (a) The valve shall be suitable for mounting on a horizontal pipeline and flow direction shall be clearly embossed on the valve body.
- (b) The valves shall possess high speed closing characteristics and be designed for minimum slam condition when closing.
- (c) In case of multi door swing type check valve, the non-slam characteristic shall be achieved by providing suitable combination of door and hydraulic passages without any external damping arrangements or passages. The angle of sealing and door weight shall be designed to provide the most efficient working with least restriction to flow.
- (d) Valve of diameter greater than 450 mm. shall be provided, in addition to others, feet and jacking screws. Hinge pins / shaft shall preferably be square in section to ensure positive location of flaps and provide for secure fixing.

4.5. Air valves

- (a) The valve shall be capable of exhausting air from pipe work automatically when being filled. The air being released at a sufficiently high rate to prevent the restriction of the inflow rate. Similarly the valve shall be capable of ventilating pipe work automatically when being emptied, the air inflow rate being sufficiently high to prevent the development of a vacuum in the pipelines. The valve shall also automatically release air accumulating in pipe work during normal working conditions.

- (b) Air valve shall be of the double orifice type with a large orifice for ventilation or exhaust of the pipeline and smaller orifice for automatic release of air under normal working pressure.
- (c) Air valve shall be designed to prevent premature closure prior to all air having been discharged from the line. The orifice shall be positively sealed in the closed position but the float (ball) shall only be raised by the liquid and not by a mixture of air and liquid spray. The seating shall be designed to prevent the floats sticking after long periods in the closed position.

4.6. Pressure relief valves

1. Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurized in excess of a preset maximum allowable pressure. The valves shall be drop tight under normal operating conditions.
2. The valve operation shall be achieved by the interaction of the inlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valves.
3. The pilot valve or relay system shall be actuated by a diaphragm connected to the inlet pressure on its underside and a constant pressure on its upper side derived either from weight or from a spring.

5. Jointing

5.1. Tyton joints

The rubber rings shall be stored in a cool dark, dry and dust free environment. The storage location shall not be exposed to direct sunlight or any heat radiating appliances. The rings shall not be allowed to come in contact with any fuels and shall be stored free of tension.

Rubber rings shall be clearly labeled in bundles to indicate the type of ring, the size of pipe which they are to be used, the manufacturer's name or trademark and the month and the year of the manufacture.

The rings shall comply with IS:5382 regarding their material finish, tolerance in dimensions and physical requirements. Rubber ring bundles from every lot shall carry with them manufacturer's test certificate showing the results of following tests:

- [a] Hardness
- [b] Tensile Strength
- [c] Compression test
- [d] Oil immersion test
- [e] Water absorption test
- [f] Stretch test and visual examination

The test procedures, the scale of sampling and the criteria for acceptance shall be as per IS:5382 and IS:3400.

The rubber rings shall be such that they shall not show any signs of deterioration for any reasons during the contract period plus the defects liability period. Entire expenses associated with correcting defects in this regard including replacement of rubber rings shall be fully borne by the Concessionaire.

In jointing cast iron spigot and socket pipes and fittings with tyton flexible joints, the Concessionaire shall take into account the manufacturer's recommendations as to the methods and equipment to be used in assembling the joints, in particular the Concessionaire shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly chamfered, that the rubber ring as per IS::5382 is correctly positioned in the socket and that the two pipes are accurately in line, before the joint is made. The rubber rings and any recommended lubricant shall be procured only through the reputed pipe supplier or as directed by the Engineer.

5.2. Flanged joints

In case of flanged joints, the jointing material used between flanges of pipes and fittings shall be compressed fibre board or rubber conforming to IS:638 of thickness between 1.5 mm. to 3 mm. The fibre board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per sq.m. shall be not less than 112 g./mm. thickness. Each bolt shall be tightened a little at a time taking care not to tighten the bolt which is located immediately adjacent to the tightened bolt and the bolt which is located diametrically opposite each other should alternatively be tightened.

The practice of fully tightening the bolts one after another shall not be allowed. The bolts shall be of mild steel unless otherwise specified.

5.3. Lead caulking joint

The jointing shall be done with molten lead and spun yarn. Pig lead shall be of uniform quality, clean and free from any impurities and any foreign materials. It shall be of uniform softness capable of being easily caulked or driven. It shall conform to IS:782. Spun yarn shall be of clean hemp and of good quality. It shall conform to IS: 65S7. The quantity of lead and spun yarn to be used for jointing of different diameters of C.I. pipes and fittings shall be as per Table 1 of IS:3114.

Lead shall be heated in a melting pot kept in easy reach of the joint to be poured so that the molten metal will not be chilled in being carried from the melting pot to the joint and shall be brought to a proper temperature so that when stirred it will show a rapid change of colour. Before pouring, all scum shall be removed. Each joint shall be made with one continuous pour filling in the entire joint space with solid lead. Spongy or imperfectly filled joints shall thoroughly cleaned by heating/burning till all the contents of the imperfectly filled lead in the joint are cleared. After clearing the joint it should be re-poured as per the original procedure.

The joint runner shall fit snugly against the face of the socket and a bund of clay should be made on outside of the pipe to form a pouring lip to provide for filling the joint flush with the face and to the top of the socket.

The jointing is done by first caulking in spun yarn, then filling the remainder of the joint space by running in molten lead, taking care that no dross enters the joint, and then thoroughly caulking the lead. The spun yarn shall be used to centre the spigot in the socket and to prevent the flow of molten lead into the bore of the pipe.

After the lead has been run into the joint the lead shall be thoroughly caulked. Caulking of joints shall be done after a convenient length of the pipes shall been laid and leaded. The leading ring shall first be removed and any lead outside the socket shall be removed with a flat chisel and then the joint caulked around three times with caulking tools of increasing thickness and hammer of 2 kg weight. Lead run joints shall be preferably finished 3 mm. behind the socket face. The joints shall not be covered till the pipe line has been tested

under specified hydrostatic test pressure, though the rest of the pipe line should be covered up to prevent expansion and contraction due to variation in temperature.

5.4. Proposed jointing of C.T. pipes

It is proposed to use spigot and socket pipes with rubber ring tyton joints and flanged joints for valves and other appurtenances.

The pipeline shall be laid such that the socket ends should face the upstream on level ground. When the line runs uphill the socket end should face the upgrade.

Whenever valve or hydrant connection is to be made socket and flanged specials or T specials as shown in the drawings shall be used.

In case of rubber ring joints, the groove and the socket shall be thoroughly cleaned before inserting the rubber gasket. While inserting the gasket, it shall be made sure that it takes the proper direction and that it is correctly seated in the groove. After cleaning dirt or foreign materials from the plain end, lubricant shall be applied in accordance with the pipe manufacturer's recommendations. The plain end of the pipe shall be pushed into the socket of the pipe and while pushing, the pipe shall be kept straight. If any deflections are to be made in the alignment, it may be made after the joint is assembled.

For joints between pipe and valve, socket and flanged specials shall be used. The gasket used between flanges of valves and pipe shall be compressed fibre board or natural / synthetic rubber (IS::63S) of thickness between 1.5 to 3.0 mm. The fibre board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per square meter shall be not less than 112 g/mm thickness. Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternatively. The practice of fully tightening the bolts one after another is highly undesirable.

5.5. Property connections

A property connection should consist of following parts

- (i) Brass ferrule
- (ii) Communication pipes with couplings, bends, elbows, union etc. (Length as per drawings)

- (iii) Cap at the end of the communication pipe near the plot boundary.

The plot Executing Agency is expected to construct and connect the remaining portion of property connections at plot boundary. The desired arrangement of property connection is shown in Drawing No.15-A-101.

5.6. Connection at main

Boring on water main should be done on top of main to reduce possible entry of silt into pipe and subsequently damaging of meters. A manual drilling and tapping machine should be used for this purpose. A bore shall be drilled and tapped on CI main and a ferrule shall be screwed directly into the bore. Upto 38 mm size of property connections, ferrules shall be used where as for higher size property connections, T connection shall be given. Ferrule shall be of gunmetal or brass as per IS: 2692. The ferrule should be so set in the main that the communication pipe leads off in line with the main before curving round right handed into its proper course as show in Drawing No. 15-A-I01. G I. Pipes to be used as property connections shall confirm to IS: 1239. Class C. the pipe should be provided, external protection of bitumen coating with hession cloth wrapped over it. It should be provided with PVC sheathing wherever they are exposed such as in case of drain crossings.

The specials to be used at crossing of pipelines, T joints, 90 deg. bends and valve joints are shown in the Drawing No. 15-A-101.

5.7. Testing

After the pipes and specials are laid, jointed and the trench partially back filled except at the joints the stretch of pipe line as directed by Engineer shall be subjected to pressure test and leakage test. Where any section of the rising main is provided with concrete thrust blocks or anchorages, the pressure test shall not be made until atleast five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the test shall not be made until atleast two days have elapsed after concreting.

Each section of pipe line shall be slowly filled with water and all air shall be expelled from the pipe by tapping at points of highest elevation before the test is made and plugs inserted after the test have been completed. Specified pressure as per Data Sheet A, based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge, shall be applied by means of a pump connected to the pipe as directed by

Engineer. The duration of test shall not be less than 5 minutes. Where the field test pressure is less than two-third the work test pressure, the period of test should be increased to atleast 24 hours. If a drop in pressure occurs, the quantity of water added in order to re-establish the test pressure should be carefully measured. This should not exceed 0.1 litre/mm, dia. per km. of pipe line length per day for each 30 m. head of pressure applied. The exposed joints shall be carefully examined and all such joints showing visible leaks shall be rectified until it becomes fully water tight. Any cracked or defective pipes and fittings as a consequence of this pressure test shall be removed from site and replaced by acceptable quality of pipes by Concessionaire and the test shall be repeated to the satisfaction of Engineer/Executing Agency.

After the satisfactory completion of pressure test, the section of pipeline shall be subjected to leakage test at a pressure as specified in Data Sheet A. The duration of test shall be 2 hrs. No pipe installation shall be accepted until the leakage is less than the number of CUM./hr. as determined by the formula;

$$qL = \frac{ND \sqrt{p}}{3.3}$$

where,

q L = the allowable leakage in CUM./hr.

N = number of joints in the length of the pipeline

D = diameter in mm. and

p = the average test pressure during the leakage test in kg./sq.cm.

Should any test of pipe laid disclose leakage greater than that specified above the defective joints shall be repaired by Concessionaire at no extra cost to the Engineer until the leakage is within the specified allowance.

Necessary equipment and water used for testing shall be arranged by Concessionaire at his own cost. Damage during testing shall be Concessionaire's responsibility and shall be rectified by him at no extra cost to the Engineer/Executing Agency. Water used for testing shall be drained out from the pipe to safe location and should not be released in the excavated trenches.

After the tests mentioned above are completed to the satisfaction of Engineer/Executing Agency, the backfilling of trenches shall be done as per specification.

5.8. Disinfection of water mains

The mains intended for potable water supplies should be disinfected before commissioning them for use.

After pressure testing the main, it should be flushed with water with sufficient velocity to remove all dirt and other foreign materials. When this process has been completed the process of disinfection (using liquid chlorine, sodium or calcium hydrochloride) can proceed by one of the following methods.

5.9. Continuous feed

In this method, water from the distribution system or other approved source and the chlorine are fed at a concentration of atleast 20 to 50 mg./litre. A properly adjusted hydrochloride solution injected into the main with a hydro chlorinator, or liquid chlorine injected into the main through a solution feed chlorinator and booster pump shall be used. The residual chlorine should be checked at intervals to ensure that the proper level is maintained. Chlorine application should continue until the entire main is filled. The water should remain in the main for a minimum of 24 hours, during which time all valves, hydrants, etc. along the main should be operated to ensure their proper disinfection. Following the 24 hours period not less than 10 mg./l. residual chlorine should remain in the main.

5.10. Slug method

In this method a continuous flow of water is fed with a constant dose of chlorine but with rates proportioned to give a chlorine concentration of atleast 300 mg./l. The chlorine is applied continuously for a period of time to provide a column of chlorinated water that will contact all interior surface of the main for a period of atleast three hours. As the slug passes tees, crosses etc., valves must be properly operated to ensure their disinfection. This method shall be used principally for large diameter mains.

Regardless of the method used, it is necessary to make certain that back flow of the strong chlorine solution into the supplying line does not occur. The' chlorinated water should be flushed to waste until the remaining water has a chlorine residual approximating to 0.2 tng./l. that throughout the rest of the system bacteriological tests should be taken and if the

result fails to meet minimum standards, the disinfecting procedure must be repeated and the results again tested before placing the main in service.

6. Measurement

The measurement for pipe laying shall be on running metres of net length along the centre line of pipe as laid including specials. The length of pipes shall not include the portion of spigots within the sockets of fittings and pipes.

The rate for providing and laying of C.I. pipes shall be deemed to include the extra excavation required for ordinary bedding of pipes as per IS: 783 and also for sockets or flanges if any and cost of jointing material.

6.1. Procedure of measurements

- i. Length (L): As per the actual length of pipe and fittings / specials laid at work site.
- ii. Trench Width (B): For payment of excavation, the width of trench shall be considered as O. D. + 600 mm. only where O.D. is the outside diameter of the pipe in mm.
- iii. Depth (D): Average depth of trench from ground level to invert of pipe and fittings.

7. Data sheet - A

7.1. Hydrostatic test pressure at work site - 30 m

7.2. Leakage test pressure at work site - 30 m.

7.3. Bedding - As per drawing

8. Notes

Fencing provided along the sides of trenches and pits shall not be paid for separately and Concessionaire shall take into account the costs of such works and quote accordingly.

In case of the road metal packing or dressed stones not being deposited as specified or being mixed up with excavated materials and not available for the reinstatement of road / pavement, the cost of the new metal packing or dressed stones required shall be charged to Concessionaire by Executing Agency / Engineer.

Service lines if damaged during excavation shall be made good either by Concessionaire or by other agency as Executing Agency / Engineer may decide and wholly in either case at the expense of Concessionaire.

Concessionaire shall not be paid any additional compensation for excess excavation over what is specified as well as for any remedial measures that are specified.

The excess excavated material shall be carried away from site of works as specified, failing which in view of public safety and traffic convenience Executing Agency / Engineer may carry out the work by any other agency at Concessionaire's risk and cost.

Portion of shoring left in the excavated trenches or pits shall be measured and paid separately, if instructed by Executing Agency / Engineer to do so.

Section G4.1

General mechanical specifications

Section – G4.1

General mechanical specifications

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Section G4.1: General mechanical specifications

1. Double entry split casing pumps

The pumping unit shall consist of a horizontal split-case, single stage and double suction impeller directly connected through a flexible coupling to a horizontal induction motor. The pump shall be designed such that the rotating element can be removed without disturbing the pipework or the pump motor. All rotating parts individually and in assembly shall be statically and dynamically balanced to prevent vibration through a range of normal and reverse speeds.

The pumps shall be designed to operate satisfactorily without detrimental surges, vibration noise, or dynamic imbalance over the required head range. The head-capacity curve of the pump shall have a continually rising head characteristic with decreasing capacity over the whole range of total head.

The Concessionaire shall guarantee that adequate required Net Positive Suction Head (NPSH) is available to ensure that pumps can operate without cavitation under the worst operating conditions. The required NPSH at duty point shall be at least 0.5 M less than the available NPSH at the lowest water level in the sump.

Each pump must be capable of running satisfactorily in parallel with 3 to 5 other sets in the system without throttling and by itself, without cavitation or overload under all operating conditions within the system resistance indicated.

The unit shall be designed to operate safely at the maximum speed attainable in the reverse direction of rotation due to water returning through the pump at times when the power supply to the motor is interrupted and the discharge valve fails to close.

Pumps shall run smooth without undue noise and vibration. The velocity of vibration shall be within the 4.5 mm / sec. Noise level shall be limited to 85 dBA at a distance of 1.86 m.

Automatic float type air valve with cock shall be fitted in the highest part of the casing to assist priming.

Small bore pipework shall be provided for gland water drainage. Gland water drainage shall be piped to the drainage channel.

All the pumps shall be supplied with machined pads to allow the fitting of portable vibration monitoring transducers.

The pump casing shall be of the double suction type. Either single or double volute type could be adopted, to produce smooth flow with gradual changes in velocity. Unbalanced, hydraulic, radial thrust acting upon rotating elements shall be kept minimum.

Flanges shall be machined on faces and edges and conform to ISO 7005, IS 6392 or BS 4574. Back faces of flanges shall, where necessary, be machined to ensure they are parallel to the front faces and that flange bolts can be fitted flush to the flanges.

The pump casing shall be provided with removable and renewable wearing rings where there are close-running clearances between the impeller and the casing. Suitable tapped holes shall be provided for air vents and for drains. The casing shall be so constructed that the drains will unwater the entire casing. One tapped hole shall be provided in the discharge flange and the suction flange for connection of pressure gauges.

The casing stuffing box and gland shall be designed to be suitable for easy maintenance of the conventional gland packings.

The pump base, or the supporting bracket, shall be drilled in the shop for doweling to the baseplate at the site.

The impeller shall be the enclosed type and shall be fastened to the shaft in such a manner as to make it readily removable. The water passages of the impeller shall be hand finished to remove rough spots and excessive irregularities. Removable and renewable wearing rings shall be provided on the impeller where there are close running clearances between the impeller and the casing. Materials and hardness of the casing and impeller wearing rings shall be selected to ensure that they are not susceptible to galling and premature wear.

The shaft shall be provided with replaceable stainless steel sleeves with proper hardness where it passes through the stuffing boxes and water passages. Water deflectors shall be provided on the shaft to prevent water from passing along the shaft and entering the pump bearings.

A stationery guard shall be provided for the coupling conforming to all relevant safety codes and regulations. Guard shall be designed for easy installation and removal, complete with necessary support, accessories and fasteners.

The stuffing box shall be provided with a readily accessible soft packings of conventional type. The material of packing shall be of technically advanced and commercially available type.

The pump shaft shall be supported by two bearings of anti-friction type, one located on each side of the pump. Bush bearing will not be accepted. The bearings may be of the oil or grease lubricated, ball or roller bearing type. One bearing on the pump shall be of the thrust type, designed to withstand the unbalanced axial hydraulic thrust. Suitable fittings shall be furnished for the type of lubrication provided. Bearings shall have a minimum life of 40,000 hours of operation.

It is desired that bearings be furnished which do not require water for cooling. If the bearings are water cooled, the water shall be taken from the pump discharge and returned to the pump suction. Suitable cooling water supply piping and return drain piping shall be supplied, and a y-type strainer with blow off shall be provided in the cooling water supply piping.

Seals shall be provided to prevent loss of lubricant and entrance of moisture and dirt.

The pumping unit shall be provided with a structural / steel baseplate. The pump and motor may be mounted on a common baseplate or on separate baseplates. The baseplates shall be of sufficient size and rigidity to maintain the pump and motor in proper alignment and position. All contact surfaces between the pump and baseplate and between the motor and baseplate shall be machined. Means shall be provided for transmitting the entire load due to discharge shutoff pressure to the concrete structure. After the unit has been installed and properly aligned, the baseplates will be drilled and reamed for the dowels. The necessary dowels shall be furnished with the pumping unit.

2. End Suction Pumps

End suction pumps shall be horizontally mounted complete with drive motor on a common base plate. The pump / drive coupling shall be of the spacer type to facilitate removal of the pump rotating element and bearing housing without dismantling the pump casing, adjoining pipework or drive motor.

The bedplate shall be of substantial fabricated steel construction with floor fixing bolt holes ready drilled. All holding down bolts etc. shall be supplied with the units.

Impellers shall be provided with means to prevent abrasive matter reaching the glands and with fully shrouded impellers, to prevent the trapping of matter between the impeller vanes and the casing.

The speed of any pump shall not exceed 1,500 rpm.

Glands may be fitted with suitable mechanical seals or conventional soft packing. The gland arrangement shall be designed for ease of adjustment or removal of the seal or packing material. Shafts shall be sleeved around the area of the gland when soft pack glands are used.

Flushing facilities shall be provided for mechanical seals or packed glands, where pump fluid may be contaminated with abrasive material. Where soft packed glands are used, means shall be provided for collection of the gland leakage water, which shall be piped into the drainage system through adequately sized ports.

Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.

The pumps and associated pipework shall be, wherever possible, arranged so that air can be completely expelled during priming. Where this is not possible, facilities shall be provided for the removal of the trapped air. Adequate facilities shall be provided for drainage of the pumps for inspection purposes.

Tappings shall be provided at both the suction and discharge flanges for pressure gauge equipment.

3. Submersible pumps

Submersible pumps shall be of the totally submersible centrifugal or mixed flow type capable of operating below a 15m. head of water. The pumping unit shall be suitable for continuous operation, designed to meet the desired performance and capable of handling the pumped medium without undue wear and tear.

A built-in cooling system must allow the motor to operate continuously at its rated output regardless of whether the electric motor is submerged or not.

The motor shall be direct coupled to its pump and rated for continuous full load operation above or under water.

The insulation rating of the motor shall be Class F rated to run at Class B and supply rated output at deviations of upto $\pm 5\%$ of the rated frequency and voltage. The motor shall be to IP68 BS 5490.

The cable termination shall be water tight and provided with a cable sleeve and strain relief.

The motor shall have ball type bearings permanently greased and maintenance free.

The pump and motor shall be separated by two mechanical face seals. The lower seal shall rotate in the water medium and the upper seal shall rotate in an oil bath medium.

The pump shall have a non-overloading performance characteristic and its efficiency shall be high at the duty point and remain at a reasonably high level over the duty range of the pumping system.

Rotating assemblies of pumps shall be statically and dynamically balanced.

The pump wear rings shall be easily replaceable.

4. Induction motor

4.1 Design Requirements

The motors shall generally conform to IS:325 or relevant, equivalent internationally approved standards. Additionally the specific requirements mentioned in the following clauses shall also be met.

4.2 Performance and Characteristics

- (a) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions :
 - (i) Variation in supply voltage $\pm 10\%$
 - (ii) Variation in supply frequency $\pm 5\%$
 - (iii) Combined voltage and frequency variation $\pm 10\%$
- (b) Motors shall be suitable for full voltage direct-on-line starting.
- (c) The power rating of the motor shall be the larger of the following :
 - (i) 115% of the power input to the pump at duty point.
 - (ii) Maximum power input while operating within maximum and minimum system resistance.

4.3 Insulations

- (a) Any joints in the motor insulation such as at coil connections or between slot and winding sections, shall have strength equivalent to that of slot sections of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The motors shall be provided with class F insulation with temperature rise limited to that of class B insulation.
- (b) Motors shall be given power house treatment. This comprises an additional treatment to the winding over and above the normal specified treatment. After the coils are placed in slots and all connections have been made, the entire motor assembly shall be impregnated by completely submerging in suitable insulating compound or

varnish followed by proper baking. At least three such submersions and bakings shall be applied to the assembly.

4.4 Constructions Features

- (a) The motor construction shall be suitable for easy disassembly and reassembly. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.
- (b) Motors weighing more than 25 kg. Shall be provided with eyebolts, lugs or other means to facilitate safe lifting.
- (c) The rotor bars shall not be insulated in the slot portion between the iron core laminations for squirrel cage motors.

4.5 Terminal Box

- (a) Terminal boxes shall be of weather proof construction designed for outdoor service. To eliminate entry to dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be capable of being turned through 360 degrees in steps of 90 degrees.
- (b) The terminals shall be of the stud type with necessary plain washers, spring washers and check-nuts. They shall be designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearances. Suitable cable glands and cable lugs shall be supplied to match specified cables.

4.6 Accessories

Two independent earthing points shall be provided on opposite sides of the motor, for bolted connections. These earthing points shall be in addition to earthing stud provided in the terminal box.

4.7 H.V. Motors

- a) Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 80% of the rated voltage.
- b) Motors shall be capable of satisfactory operation at full load at a supply voltage of 80% of the rated voltage for 5 minutes, commencing from hot condition.
- c) The locked rotor withstand time under hot conditions at 110% rated voltage shall be more than starting time at minimum permissible voltage by at least two seconds or 15% of the accelerating time whichever is greater. The locked rotor current of motors shall not exceed 600% of full load current of motors which is inclusive of 20% tolerance.
- d) Motors when started with the drive imposing its full starting torque under the specified supply voltage variations shall be capable of withstanding at least two successive starts from cold condition and one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.
- e) The three phases shall be segregated by metal barriers within both line and neutral terminal box.
- f) The earthing pads shall be of non-corrodible metal, welded / brazed at two locations on opposite sides. The pad size shall be 75 x 65 x 25 mm. With two holes drilled at 40 mm. centers, tapped and provided with suitable bolts and washers for connecting the earthing strip.
- g) At least six resistance type temperature detectors for the stator winding each having D.C. resistance of 100 ohms at 0 degrees Celsius, embedded in the stator winding at locations where highest temperatures may be expected, shall be provided. The material of the RTD's shall be platinum.
- h) Motors shall have space heaters suitable for 240 V single phase 50 Hz AC supply. These shall be placed in easily accessible position in the lower part of motor frame.

Provision shall be made to measure temperature of bearing by inserting hand held temperature measuring device.

- i) Motors shall have drain plugs so located that they will drain water, resulting from condensation or other causes from all pockets in the motor casing.

4.8 L.V. Motors

- (a) Motors shall be suitable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 85% of the rated motor voltage.
- (b) The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerance as per the applicable standard).
- (c) Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.
- (d) Stator leads shall be brought to the terminal box as insulated cable through a suitable barrier and terminated in clamp type terminals.

5. Valves

5.1 General

- (a) Valves shall be as per internationally recognised standards. Flanges shall be machined on faces and edges and conform to ISO 7005, IS 6392 or BS 4504.
- (b) Valves shall be double flanged type and the face shall be parallel to each other and flange face should be at right angles to the valve centreline. Back side of valve flanges shall be machined or spot faced for proper seating of the head and nut.
- (c) Valve buried or installed in underground chamber, where access to a handwheel would be impractical shall be operated by means of extension spindle and / or keys.
- (d) Valve of diameter 450 mm. and above shall be provided with lifting eyes and shall have detachable bolted covers for inspection, cleaning and servicing.

- (e) Valve shall be suitable for frequent operation as well as operation after long periods of idleness in either open or closed position.
- (f) The valve stem, thrust washers, screws, nuts and all other components exposed to the water shall be of a corrosion resistant grade of stainless steel.
- (g) Valves shall be free from sharp projections.

5.2 Butterfly Valve

- (a) Butterfly valve shall be as per IS 13095 / BS 5155. Valve shall suitable for mounting in any position.
- (b) The valve seat shall be secured to the valve body. When the valve is fully closed, a seal shall seat firmly so as to prevent leakage. The seat surfaces shall be machined smooth to provide a long life for the seal.
- (c) The valve seal shall be replaceable and securely clamped to the edge of the disc by stainless steel seal retention members, or equivalent so as to prevent leakage and to hold the seal securely during operation. The seal retention member shall be securely clamped with stainless steel fasteners. All fasteners shall be set flush so as to offer the least resistance possible to the flow through the valve.
- (d) Valve shall be suitable for throttling purpose.
- (e) All valve spindles & handwheels shall be positioned to give good access for operational personnel.
- (f) Valve of diameter 450 mm. and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.
- (g) All handwheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the handwheels.

5.3 Sluice Valves

- (a) Sluice valve shall conform to IS 780 and IS 2906 or relevant internationally recognised standards.
- (b) They shall be of rising or non-rising spindle type depending on application. The valve shall be furnished with a bushing arrangement for replacement of packing without leakage. They shall also have renewable channel and shoe linings. The gap between the shoe and channel shall be limited to 1.5 mm.
- (c) The gate face rings shall be screwed into the gate or alternatively securely pegged over the full circumference.
- (d) Valves of 450 mm. and above shall be provided with thrust bearing arrangement for ease of operation.
- (e) Valves of diameter 450 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.
- (f) All valves, spindles and handwheels shall be positioned to give good access for operational personnel.
- (g) All handwheels shall be arranged to turn in a clockwise direction to close the valve, the direction to close the valve, the direction of rotation for opening and closing being indicated on the handwheels.

5.4 Non-Return Valve

- (a) The valve shall be suitable for mounting on a horizontal pipeline and flow direction shall be clearly embossed on the valve body.
- (b) The valves shall possess high speed closing characteristics and be designed for minimum slam condition when closing.

- (c) In case of multidoor swing type check valve, the non-slam characteristic shall be achieved by providing suitable combination of door and hydraulic passages without any external damping arrangements or passages. The angle of sealing and door weight shall be designed to provide the most efficient working with least restriction to flow.
- (d) Valve of diameter greater than 450 mm. shall be provided, in addition to others, feet and jacking screws. Hinge pins / shaft shall preferably be square in section to ensure positive location of flaps and provide for secure fixing.

5.5 Air Valve

- (a) The valve shall be capable of exhausting air from pipework automatically when being filled. The air being released at a sufficiently high rate to prevent the restriction of the inflow rate. Similarly the valve shall be capable of ventilating pipework automatically when being emptied, the air inflow rate being sufficiently high to prevent the development of a vacuum in the pipelines. The valve shall also automatically release air accumulating in pipework during normal working conditions.
- (b) Air valve shall be of the double orifice type with a large orifice for ventilation or exhaust of the pipeline and smaller orifice for automatic release of air under normal working pressure.
- (c) Air valve shall be designed to prevent premature closure prior to all air having been discharged from the line. The orifice shall be positively sealed in the closed position but the float (ball) shall only be raised by the liquid and not by a mixture of air and liquid spray. The seatings shall be designed to prevent the floats sticking after long periods in the closed position.

5.6 Pressure Relief Valve

- (a) Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurised in excess of a preset maximum allowable pressure. The valves shall be drop tight under normal operating conditions.

- (b) The valve operation shall be achieved by the interaction of the inlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valves.
- (c) The pilot valve or relay system shall be actuated by a diaphragm connected to the inlet pressure on its underside and a constant pressure on its upper side derived either from weight or from a spring.

6. Electric Actuator

- (a) All local controls shall be protected by a lockable cover.
- (b) Each actuator shall be adequately sized to suit the application and be continuously rated to suit the modulating control required. The gearbox shall be oil or grease filled, and capable of installation in any position. All operating spindles, gears and headstocks shall be provided with adequate points for lubrication.
- (c) The actuator shall be capable of producing not less than 1½ times the required valve torque and shall be suitable for at least 15 minutes continuous operation.
- (d) The actuator starters shall be integrally housed with the actuator in robustly constructed and totally enclosed weatherproof housing. The motor starter shall be capable of starting the motor under the most severe conditions.
- (e) The starter housing shall be fitted with contacts and terminals for power supply, remote control and remote positional indication, and shall also be fitted with internal heaters so as to provide protection against damage due to condensation. Heaters shall be suitable for single phase operation. The heaters shall be switched “ON” when the starters are “OFF” and shall be switched “OFF” when the starters are “ON”.
- (f) Each starter shall be equipped as follows :
 - (i) 2 Nos. - Three phase magnetically operated line contactors with no-volt release and electrical and mechanical interlock.
 - (ii) 1 No. - Three phase terminal cut-out device.

- (iii) 1 No. - Control circuit transformer fully protected by fuses on primary and secondary circuit.
 - (iv) 1 No. - Set of “Open”, “Close” and “Stop” buttons.
 - (v) 1 No. - Local - Off-remote switch with padlocking facilities.
 - (vi) 1 No. - Set of torque and limit switches for “Open” and “Close” positions.
 - (vii) Valve position indicator and handwheel for manual operation.
 - (ix) Reduction gear unit.
- (g) Gearbox shall have a life of 1,00,000 hours, and be selected in accordance with AGMA recommendation.

7. Pipe Work

All pipes, fittings, bolts, nuts, jointing materials and appurtenances for piping required for execution of the Works shall be manufactured and erected in accordance with the erection plans, specifications and directives of the Engineer. All pipework and fittings shall be to a class in excess of the maximum pressure attained in service including any surge pressure.

The pipework installation shall be so arranged to offer ease of dismantling and removal of pumps or other major items of equipment. Flanged adapter shall be included in the suction and delivery pipe work of all pumps as well as on delivery header for easy dismantling, and provision shall be made for a flexible joint arrangement to building structures. All loose flanges shall be secured to fixed flanges by suitable tie-bolts. All pipe work shall be adequately supported with purpose-made fittings. When passing through walls, pipe work shall incorporate a puddle flange or other suitable sealing device. Flange adapters and unions shall be supplied and fitted in pipe work runs, wherever necessary, to permit the simple disconnection of flanges, valves and equipment. The final outlet connection of the pipe work shall match the connecting point of the transmission main.

Flanged joints shall be made with minimum 3 mm thick full face, fabric reinforced rubber gaskets, pierced to take the bolts, and the face of all flanges shall be machined to give a true angle of 90° to the centre line of the pipe or fittings. All necessary supports, saddles,

slings, fixing bolts and foundation bolts shall be supplied to support the pipe work and its associated equipment in an approved manner. Valves, meters and other devices mounted in the pipe work shall be supported independently of the pipes to which they are connected.

The whole of the jointing work and materials necessary to fix and connect the pipes, including adequate and efficient pipe support shall be included in the Contract. The Concessionaire shall be responsible for ensuring that the internal surface of all pipe work is thoroughly clean before and during erection and before commissioning. Cleaning shall include removal of all dirt, rust, scale and welding slag due to site welding. Before despatch from the manufacturer's works, the ends of the pipes, branch pipes, etc., shall be suitably capped and covered to prevent any accumulation of dirt or damage. This protection shall not be removed until immediately prior to connecting adjacent pipes, valves or pumps. All small bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Engineer.

Material of steel pipes and fittings shall conform to IS:2062. Fabrication and testing shall be in accordance with IS:3589 for pipes and IS:6392, ISO 7005 or P.S. 4804 for flanges.

All the underground buried mild steel piping shall be protected by the application of hot coal tar enamel and fibre glass wrapping. The coating shall consist of one coaltar primer coat, one coaltar enamel coat, wrapping of fibre glass and one more coat of enamel and then final wrap of enamel impregnated fibre glass.

8. Hand operated travelling cranes

Hand operated travelling cranes shall be manufactured in accordance with medium duty class 2.

The term crane shall be deemed to include also hoists, gantry, rails end stops, holding down bolts and all other items required for complete installation.

Sufficient slings, ropes, shackles, lifting beams and all other necessary equipment shall be supplied to handle all items of plant served by the crane. They shall be labelled or marked with their safe working load in accordance with the safety code and with the purpose, for which they are intended.

9. Sluice Gate

9.1 Design Requirements and Construction Features

- (a) The construction of sluice gates shall be in accordance with the Specification and generally as per AWWA C 501 or IS:13349.
- (b) The sluice gates shall be capable of performing the duties set in this Specification without undue wear or deterioration. They shall be constructed so that maintenance is kept to a minimum. All parts of sluice gate, including lifting mechanism components shall be designed for the heads specified with a minimum safety factor of five.
- (c) All sluice gates shall be of the rising spindle type.

9.2 Frame

The frame shall be of ample section and cast in one piece. All surface forming joints and bearings shall be machined. The frame shall be of the flange back type and shall be machined on the rear face to bolt directly to the machined face of the wall thimble.

9.3 Guide

- (a) Guide shall be bolted to the frame or cast integrally with it and shall be machined on all bearing and contact faces.
- (b) The length of guide shall be such that it should support the gate upto the horizontal line of stem nut pocket.
- (c) Arrangement shall be made to prevent lateral movement of bolted on guides. They shall be capable of taking the entire thrust produced by water pressure and wedging action. Wedges shall be attached securely to the guides at points where, in the closed position, they will make full contact with the wedging surfaces on the slides.

9.4 Seating Faces

- (a) Seating faces shall be made of full width, solid section. They shall be secured firmly by means of counter sunk fixings in finished grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in place, free from distortion and loosening during the life of the sluice gates.
- (b) The faces shall be of ample section and finished smooth. The maximum clearance between the seating surfaces, with the slide in the closed position shall not exceed 0.10 mm.

9.5 Wedging Devices

Sluice gates shall be equipped with adjustable side, top and bottom wedging devices as required to provide contact between the slide and frame facing when the gate is in closed position. All faces shall be machined accurately to give maximum contact and wedging action. Wedges shall be fully adjustable with suitable adjusting screws and locknuts and so designed that they will remain in the fixed position after adjustment.

9.6 Gate Slides

- (a) The slide shall be with strengthening ribs where required and a reinforced section to receive the seating faces.
- (b) The slide shall have tongues on each side extending its full length, and the tongues shall be machined accurately on contact surfaces. Surfaces of the slide that come in contact with the seat facing and wedges shall be machined accurately. The maximum allowable clearances between the slide and the slide guide shall be 1.6 mm.
- (c) An integrally cast stem nut pocket with reinforced ribs shall be provided above the horizontal centre line of the slide. The stem nut pocket shall be provided with drain.

9.7 Stem Nut and Lift Nut

Gate shall be provided with a lower fixed stem nut for connecting the stem to the slide and a revolving lift nut located in the lifting mechanism in the head stock. They shall be of ample design to endure the thrust developed during gate operation under maximum gate operating condition loads in opening and closing direction. The stem nut and slide shall

be constructed to prevent turning of the stem nut in the pocket in the slide. The stem be threaded and keyed or threaded and pinned to the stem.

9.8 Stem

The threads of the stem shall be machined cut or rolled and of the square or acme type. The number of threads per inch shall be such as to work most effectively with the lift mechanism used. The top of the stem be provided with a stop collar.

9.9 Stem Coupling

The coupling shall be threaded and keyed or threaded and bolted, and shall be of greater strength than the stem.

9.10 Stem Guides

Stem guides shall be cast, with bushings and mounted on cast brackets. Guides shall be adjustable in two directions and shall be so constructed that when properly spaced they shall hold the stem in alignment. Number of stem guides shall be such that unsupported length of stem shall not exceed one hundred times its diameter.

9.11 Lifting Mechanism

- (a) Sluice gate shall be operated through suitable lifting mechanism which shall incorporate suitable gearing, if required.
- (b) Lifting mechanism shall be suitable for operation by one man under all conditions. Lifting mechanism shall incorporate a strong locking device suitable for use with a padlock or padlock and chain.
- (c) The manual operation shall be of the handwheel or crank operated type and shall have a lift nut threaded to fit the operating stem. Crank shall be removable. Ball or roller thrust bearings shall be provided above and below the flange on the lift nut to take the load developed in opening and closing the gate with a torque of 14 kg-m. on the crank. Fittings shall be provided to lubricate gears and bearing.

- (d) The design of the lift mechanism of the hand operated gates shall be such that the slide can be operated with a torque of not more than 7 kg-m. on the operator after the slide is unseated from wedges based on the operating head. The maximum crank radius shall be 380 mm.
- (e) All gears and bearings shall be enclosed in a cast iron housing with labyrinth seals. The lifting mechanism shall be with a cast iron pedestal, machined and drilled to receive the gear housing and suitable for bolting to the operating floor. The gates shall close with clockwise rotation of the crank. The direction of rotation to close the gates shall be indicated on the lift mechanism.
- (f) A suitable means shall be provided for lubricating the stem threads directly adjacent to the lift nut. An inspection cover shall be provided to access the lift nut and gearing.
- (g) Stem shall be provided with a GI pipe cover shall be fixed to the head stock.

9.12 Fasteners

All anchor bolts, assembly bolts, screw, nuts, etc. shall be of ample section to safely withstand the forces created by operation of the gate.

9.13 Wall Thimbles

- (a) Wall thimbles shall be made of cast iron and shall be supplied along with the gate. The wall thimbles shall provide a rigid mounting, designed to prevent warping of the gate frame during installation.
- (b) The cross section of the thimble shall have the shape of the letter 'F'. The front, or mounting flange, shall be machined and shall be drilled and tapped to the same template used for its particular gate frame. The frame shall be attached to the thimble with bolts of studs. The depth of the wall thimbles shall not be less than 300 mm.
- (c) To permit entrapped air to escape as the thimble is being encased in concrete, holes not lesser than 35 mm. diameter at more than 600 mm. span, shall be cast or drilled in each entrapment zone formed by the reinforcing ribs or the flange and water stop.

9.14 Lifting Lugs

Lifting lugs shall be provided for all gates.

Section - G5.1
General electrical specifications

Section G5.1: General electrical specifications

1. Scope of works and responsibility of the concessionaire

The concessionaire is advised to peruse the document in full and understand the scope of work as detailed elsewhere in this document. He is / they are also advised to make himself / themselves aware of the site requirements and conditions before submission of his / their bid. Clarification, if any, required shall be made with the consultant before submission of bid.

However, nothing shall absolve the concessionaire to carry out and complete the entire works including those minor / incidental works required for the completion of the work whether it is explicitly brought out in this document or not.

The Concessionaire shall make appropriate arrangement for power supply provisions during Construction Period. All power and lighting circuits shall be constructed with due regard for personnel safety and shall comply with recognized codes of practice and local regulations. All circuits shall be fitted with earth leakage systems.

This specification is a general specification and the applicability of various component requirements shall be as per actual requirements from site to site basis

2. Interpretation

All the technical terms referred in this document shall have the interpretation as per the relevant Indian standard code / Indian Electricity Rules / Indian Electricity Act etc., In case on any doubt in any of the meanings / interpretations, the tenderer shall get the same clarified from the owner prior to submission of bid.

3. Electrical 's license

The electrical works shall be carried out by persons holding valid competency certificate issued / recognised by the Licensing Board of the locality / State in which the works is to be done. The Concessionaire holding valid Licence / Authorisation from the Licensing Board of the locality / State for carrying out the installation work of such nature and voltage grade.

4. Design philosophy

All equipment offered by the Concessionaire shall offer the following features:-

- Safety to personnel and equipment during operation and maintenance.
- Reliability of Services.
- Ease of maintenance.
- Facility for ready addition of future loads.
- Convenience of operation.
- Maximum Inter-changeability of equipment.
- Minimum fire risk.

5. Codes and Standards

Whether explicitly mentioned in this specification document or not, all the engineering, systems, equipment, materials and works being provided by the Concessionaire for this project shall conform to the requirements of the respective latest editions / amendments of the Indian Standards Specifications. In particular cases where relevant Indian Standards are not available, other International Codes and Standards may be accepted, subject to Executing Agency's specific approval.

The design and the installation shall be in accordance with established and sound engineering practices, standard specifications and must conform to the statutory regulations applicable.

The equipment and installation shall conform to (but not be limited to) the following (Latest versions/editions).

- Indian Electricity Act, 1910
- Indian Electricity Rules, 1956
- The Factory Act, 1948

In case of conflict between various documents, specifications and codes / standards etc. the following order of procedure shall govern:

- Job specification
- Codes and Standards.

6. Electrical system

Unless and until specified, otherwise the complete electrical system shall be suitable to work satisfactorily with the following system parameters

System Voltage (High Voltage)	:	11 kV (E) 3 wire 50 Hz AC system of supply and subject to permissible variations as per IE Rules
System Voltage (Medium Voltage)	:	415 Volts, 3 phase, 4 Wire AC system of supply subject to permissible variations as per IE rules
System Voltage (Low Voltage)	:	240 Volts Single phase 3 wire AC system of supply subject to permissible variations as per IE rules
Frequency	:	50 Hz and subject to permissible variations as per IE rules
Neutral Earthing	:	Solidly earthed
Fault Level	:	50 kA at Main / Incomer level
Control Voltage	:	110 Volts AC

7. Service conditions

All equipment to be supplied against this specification shall be suitable for satisfactory continuous operation under the following tropical conditions.

Maximum ambient temperature (deg C)	:	50
Maximum temperature in shade (deg C)	:	45
Average temperature in air (deg C) in shade	:	35
Relative Humidity (%)	:	60 to 80
Maximum altitude above mean sea level (Meters)	:	1000
Operating Environment	:	Moderately hot and humid tropical climate conducive to rust & fungus growth.

8. Drawings and data

The concessionaire shall furnish the following drawings and data as part of the work:

- i. General arrangement showing plan, elevation and typical section views.

- ii. Foundation plan showing location of fixing channels, floor openings etc.
- iii. Schematic wiring drawings for each breaker.
- iv. Technical literature on the equipment offered.
- v. Make/ Model No. of various major electrical equipment

The Concessionaire shall also furnish the following drawings for each major equipment such as HV panels, Transformers, MV panels, APFCR Panel, Street lighting Poles etc., after the award of contract.

- (i) Overall outline dimensions and general arrangement including plan, front elevations, clearances required in front and back etc.,.
- (ii) Schematic control diagrams to cover controls, protection, interlocks, switch instruments, space heaters, etc., for each type of module.
- (iii) Itemized bill of material for each module, listing all devices mounted and cable glands, indicating all type, rating quantity and special notes, if any.
- (iv) Detailed internal wiring diagram of each type of module, including terminal block number, ferrule numbers and the external cable connection designations.
- (v) Inter panel interconnection wiring diagram including terminal numbers and ferrule numbers.

9. Acceptable makes / Brands of electrical equipment / items

The list of preferred brands / makes of various electrical equipment / items is furnished vide **Clause 11 of this section** The tenderer are free to choose any one of the make / brand listed therein and have to clearly bring out the same in their tender. However, the owner reserves the right to insist for any specific / particular brand from the list without any additional financial implication.

10. Specific project requirements for electrical equipment

10.1. 11 KV Ring Main Unit (RMU)

❖ Scope

This specification describes the minimum requirement for design, manufacture, inspection and testing before despatch, packing and delivery F.O.R. (Destination) of SF6 insulated

RMUs as per BOQ complete with other accessories and auxiliaries equipments and mandatory spares, described herein and required for their satisfactory operation.

The objective of the RMUs is for extremely small construction width, compact, maintenance free, independent of climate, easy installation, operational reliability, safe and easy to operate, minimum construction cost, minimum site work and minimum space requirement.

The RMUs shall conform in all respects to high standards of Engineering design, workmanship and latest revisions of relevant standards at the time of offer.

The type of the 11 KV circuit breaker shall be VCB. Insulating medium for load break isolators, Earth switch, 11 KV Buses and other associated equipment's should be SF6 gas.

❖ **General**

The insulation / dielectric media inside the stainless steel welded tank should be SF6 gas. The RMU should be of extensible type on both sides with provision of attaching /connecting with SNAP FIT arrangement without external bus bars additional load break switches and circuit breakers in future whenever required.

The RMU shall be for a nominal voltage of 12 KV for 11 kV RMU using SF6 gas as insulating and Vacuum as arc quenching medium. The RMU and combination shall be tropicalized and outdoor metal enclosed type. The RMU metal parts shall be of high thickness, high tensile steel which must be grit /short blasted, thermally sprayed with Zinc alloy, phosphate or should follow the 7 tank pre-treatment process and be subsequently painted with polyurethane based powder paint. The overall paint layer thickness shall be not less than **80 microns**.

Relevant IE rules for clearances, safety and operation inside the enclosure shall be applicable. The enclosure shall be **IP54** and type tested from recognized laboratories by National Accreditation Board of Laboratories (NABL). All live parts except for the cable connections in the cable compartments shall be insulated with SF6 gas.

The SF6 gas tank shall be made of **TIG** welded **stainless steel**, to have the best weld quality. The gas cubicle shall be metal enclosed with stainless steel of minimum 2 mm thickness and should be provided with a pressure relief arrangement away from operator.

The gas tank shall be of completely welded construction. The connection of different welded sections of gas tank by gasket and bolts, to form a RMU chamber is not acceptable.

Both the load break switches and the tee off circuit breaker shall be suitable for **motorization in future**. The cable box of isolators and circuit breakers both should be of front access type. The side and rear access cable box are not preferred as they require greater space for cable connection and maintenance at site. Any accidental over pressure inside the sealed chamber shall be limited by the opening of a pressure-limiting device in the rear-bottom part of the enclosure. Gas will be release to the rear of the switchboard away from the operator and should be directed towards the bottom, into the trench to ensure safety of the operating personnel and the pedestrians / civilians. All the manual operations should be carried out on the front of the switchboard.

The entire units of RMU shall be enclosed in a single compact metal clad, outdoor enclosure suitable for all weather conditions. The switchgear/steel gas tank shall be filled with SF6 as per IEC/IS Standards relative pressure to ensure the insulation and breaking functions. The steel gas tank must be sealed for life and shall meet the “Sealed pressure system” criteria in accordance with the IEC 298 standard. The RMU must be a system for which no handling of gas is required throughout the 20 years of service life.

The RMU shall have a design such that in the event of an internal arc fault, the operator shall be safe. This should be in accordance with IEC 298 and relevant Test certificates shall be submitted with the Tender.

❖ **The RMU shall be tested for an minimum internal arc rating of 20 kA for 1 Sec.**

Suitable temperature rise test on the RMU shall be carried out & test reports shall be submitted with tender for technical bid evaluation. Each switchboard shall be identified by an appropriately sized label, which clearly indicates the functional units and their electrical characteristics devices is visible to the operator on the front of the switchboard and operations are visible as well.

The entire system shall be totally encapsulated. There shall be no access to exposed conductors. In accordance with the standards in effect, the switchboards shall be designed so as to prevent access to all live parts during operation without the use of tools.

The entire 11 KV RMU are insulated by inert gas (SF6) suitable for operating voltage up to 12 KV respectively. The 11 KV circuit breakers must be VCB breaker. **It is necessary to fit an absorption material in the tank to absorb the moisture from the SF6 gas.** The SF6 insulating medium shall be constantly monitored via a temperature compensating gas pressure indicator offering a indication at different temperature ranges, like -25, 0, 20, 40, 60 deg centigrade, having distinctive RED and GREEN zones for safe operation.

- **Sulphur Hex fluoride Gas (SF6 GAS)**

The SF6 gas shall comply with IEC 376, 376A and 376B and shall be suitable in all respects for use in 11 KV and 22 kV RMUs under the operating conditions. The SF6 shall be tested for purity, dew point air hydrolysable fluorides and water content as per IEC 376, 376A and 376B.

- **Standards**

Unless otherwise specified elsewhere in this Specification, the RMU, Switchboard (Switchgear), Load break isolators, Instrument Transformers and other associated accessories shall conform to the latest revisions and amendments thereof to the following standards.

- IEC 60 298/IEC 62 271-200/IS 12729:1988 - General requirement for Metal enclosed switchgear
- IEC60129/IEC62271-102/IS 9921 - Alternating current disconnectors (Load break isolators) and earthing switch
- IEC 62 271-100/IEC 60 056/IS 13118:1991 - Specification for alternating current circuit breakers.
- IEC 62 271-1/IEC 60694 - Panel design, SF6/Vacuum Circuit Breakers
- IEC 60044-1/IEC 60185/IS 2705:1992 - Current Transformer
- IEC 60265/IS 9920:1981 - High voltage switches.
- IEC 376 - Filling of SF6 gas in RMU.
- IEC 60273/IS :2099- Dimension of Indoor & Outdoor post insulators with voltage > 1000 Volts.
- IEC 60529/IS 13947(Part-1) - Degree of protection provided by enclosures for low voltage switchgear and control gear.
- Indian Electricity Rules/Bills

Equipment meeting with the requirements of any other authoritative standards, which ensures equal or better quality than the standard mentioned above shall also be acceptable. If the equipment's, offered by the Bidder conform to other standards, salient points of difference between the standards adopted and the specific standards shall be clearly brought out in relevant schedule. In case of any difference between provisions of these standards and provisions of this specification, the provisions contained in this specification shall prevail. One copy of such standards with authentic English Translations shall be furnished along with the offer.(Hard copy)

- **Specific requirements in RMU**

The RMUs going to be installed in the field network, will be hooked with **SCADA** through RTUs and hence, RMUs used shall be compatible with SCADA **RMU outdoor metal clad enclosure.**

The RMU enclosure must be a metallic, it shall follows an industrialized process of manufacturing. The RMU and combination shall be tropicalized and outdoor metal enclosed type. The RMU metal parts shall be of high thickness, high tensile steel which must be grit/short blasted, thermally sprayed with Zinc alloy, phosphate or should follow the 7 tank pre-treatment process and be subsequently painted with polyurethane based powder paint. The overall paint layer thickness shall be not less than 80 microns.

The rating of enclosure shall be suitable for operation on three phase, three wire, 11 KV, 50 cycles, A.C. System with short-time current rating of 20 kA for 3 seconds with RMU Panels. The enclosure should have two access doors one for the operation and relay monitoring and other for the cable access. Both the doors should have the locking facility.

- **Take OFF terminal units for future automation:**

The RMU should be provided with necessary take off terminal units for future automations, located in the front recesses / LV cubical of the RMU.

- **Isolators (Load Break Type)**

The load break isolators for Incoming and Outgoing supply must be provided. These should be fully insulated by SF6 gas. The load break isolators shall consist of 630 Amp fault making/load breaking spring assisted ring switches, each with integral fault making earth switches. The switch shall be naturally interlocked to prevent the main and earth switch

being switched 'ON' at the same time. The selection of the main and earth switch is made by a lever on the facia, which is allowed to move only if the main or earth switch is in the off position. The load break isolators should have the facility for future remote operation. Each load break switch shall be of the triple pole, integral earthing arrangement.

The isolating distance between the OFF and the ON position in the isolator should be more than **80 mm**, so as to have enough isolating distance for ensuring safety during DC injection for Cable testing.

- **Earthing of Isolators and breakers (earth switch)**

Necessary arrangements are provided at Load break isolators / Distribution Transformer Breaker for selecting Earth position. Mechanical interlocking systems shall prevent the RMU function from being operated from the 'ON' to 'Earth' on position without going through the 'OFF' position.

- **Tee Off breaker (Vacuum)**

The VCB breaker for the controlling of DT must be provided inside welded stainless steel SF6 gas tank with the outdoor metal clad enclosure. The VCB circuit breaker must be a spring assisted three positions with integral fault making earth switch. The selection of the main/earth switch lever on the facia, which is allowed to move only if the main or earth switches is in the off position.

The manual operation of the circuit breaker shall not have an effect on the trip spring. This should only be discharged under a fault (electrical) trip; the following manual reset operation should recharge the trip spring and reset the circuit breaker mechanism in the main off position.

The circuit breaker shall be fitted with a mechanical flag, which shall operate in the event of a fault (electrical) trip occurring. The 'tripped' flag should be an unambiguous colour differing from any other flag or mimic. Both the circuit breaker and ring switches are operated by the same unidirectional handle.

The protection on the circuit breaker shall comprise of the following components:-

- 3 class X protection CT's,

- a low burden trip coil and
- a **self-powered (No external DC or AC source required) IDMT protection relays (Numeric/Microprocessor based)** 3 x over current and earth fault element shall be Definite Time type relay. The protection system should be suitable for protecting transformers of rated power from 250 KVA onwards. The relay should be housed within a pilot cable box accessible.

- **Bushings**

The units are fitted with the standardized bushings that comply with IEC standards. All the bushings are the same height from the ground and are protected by a cable cover.

- **Cable boxes**

All the cable boxes shall be air insulated suitable for dry type cable terminations and should have front access only. Side and rear cable entry / access should be avoided, so not to have extra space at site for cable connection and cable testing. The cable boxes at each of the two ring switches should be suitable for accepting HV cables of sizes 3C x 240 sq.mm and circuit breaker cable suitable up to 3C x 300 sq.mm.

The cable boxes for an isolator in it's standard design should have sufficient space for connecting two cables per phase.

- **Cable testing facility**

It shall be possible to test the cable after opening the cable boxes. The cable boxes should open only after operation of the earth switch. Thus ensuring the earthing of the cables prior to performing the cable testing with DC injection.

- **Voltage indicator lamps and phase comparators**

The RMU shall be equipped with a voltage indication to indicate whether or not there is voltage on the cable. There should be a facility to check the synchronization of phases with the use of external device. It shall be possible for the each of the function of the RMU to be equipped with a permanent voltage indication as per IEC 601958 to indicate whether or not there is voltage on the cables.

- **Extensible**

Each RMU shall have the provision for extension by load break isolators / breakers in future, with suitable accessories and necessary Bus Bar. The equipment shall be well designed to avoid any kind of extension / trunking chamber for connecting and housing extensible Busbars. Extensible isolators and circuit breakers shall be individually housed in separate SF6 gas enclosures. Multiple devices inside single gas tank / enclosure will not be acceptable. In case of extensible circuit breakers, the Breaker should be capable of necessary short circuit operations as per IEC at 20 KA, and the Breaker should have a rated current carrying capacity of 200 A.

- **Wiring & Terminals**

The wiring should be of high standard and should be able to withstand the tropical weather conditions. All the wiring and terminals (including take off terminals for future automation, DC, Control wiring), Spare terminals shall be provided by the Concessionaire. The wiring cable must be standard single-core non-sheathed, Core marking (ferrules), stripped with non-notching tools and fitted with end sleeves, marked in accordance with the circuit diagram with printed adhesive marking strips. The wiring should be of high standard and should be able to withstand the tropical weather conditions. All wiring shall be provided with single core multi strand copper conductor wires with PVC insulation.

The wiring shall be carried out using multi-strand copper conductor super flexible PVC insulated wires of 650/1100 V Grade for AC Power, DC Control and CT circuits. Suitable colored wires shall be used for phase identification and interlocking type ferrules shall be provided at both ends of the wires for wire identification. Terminal should be suitably protected to eliminate sulphating. Connections and terminal should be able to withstand vibrations. The terminal blocks should be stud type for controls and disconnecting link type terminals for CT leads with suitable spring washer and lock nuts.

Flexible wires shall be used for wiring of devices on moving parts such as swinging Panels (Switch Gear) or panel doors. Panel wiring shall be securely supported, neatly arranged readily accessible and connected to equipment terminals, terminal blocks and wiring gutters. The cables shall be uniformly bunched and tied by means of PVC belts and carried in a PVC carrying trough. The position of PVC carrying trough and wires should not give any hindrance for fixing or removing relay casing, switches etc., Wire termination shall be made with solder less crimping type of tinned copper lugs. Core identification plastic

ferrules marked to correspond with panel wiring diagram shall be fitted with both ends of each wire.

Ferrules shall fit tightly on the wire when disconnected. The wire number shown on the wiring shall be in accordance with the IS. 375. All wires directly connected to trip circuits of breaker or devices shall be distinguished by addition of a red color unlettered ferrule. Inter-connections to adjacent Panels (Switch Gear) shall be brought out to a separate set of Terminal blocks located near the slots or holes to be provided at the top portion of the panel. Arrangements shall be made for easy connections to adjacent Panels (Switch Gear) at site and wires for this purpose shall be provided and bunched inside the panel. The bus wire shall run at the top of the panel. Terminal block with isolating links should be provided for bus wire. At least 10% of total terminals shall be provided as spare for further connections. Wiring shall be done for all the contacts available in the relay and other equipment and brought out to the terminal blocks for spare contacts. Color code for wiring is preferable in the following colours.

- (a) Voltage supply Red, Yellow, Blue for phase and Black for Neutral
- (b) CT circuits similar to the above
- (c) DC circuits Grey for both positive and negative
- (d) 250 V AC circuits Black for both phase and neutral
- (e) Earthing Green

The wiring shall be in accordance to the wiring diagram for proper functioning of the connected equipment. Terminal blocks shall not be less than 650 V grade and shall be piece-molded type with insulation barriers. The terminal shall hold the wires in the tight position by bolts and nuts with lock washers. The terminal blocks shall be arranged in vertical formation at an inclined angle with sufficient space between terminal blocks for easy wiring. The terminals are to be marked with the terminal number in accordance with the circuit diagram and terminal diagram. The terminals should not have any function designation and are of the tension spring and plug-in type.

▪ **Earthing**

The RMU outdoor metal clad, Switch Gear, Load break isolators, Vacuum circuit breakers shall be equipped with an earth bus securely fixed along the base of the RMU. The size of the earth bus shall be made as per IEC/IS standards Necessary terminal clamps and connectors shall be included in the scope of supply.

All metal parts of the switchgear which do not belong to main circuit and which can collect electric charges causing dangerous effect shall be connected to the earthing conductor made of **copper** having CS area of minimum 75 sq.mm. Each end of conductor shall be terminated by M12/equivalent quality and type of terminal for connection to earth system installation. Earth conductor location shall not obstruct access to cable terminations.

The following items are to be connected to the main earth conductor by rigid or **copper** conductors having a minimum cross section of 75 sq.mm

- (a) Earthing switches
- (b) Cable sheath or screen
- (c) Capacitors used in voltage control devices, if any.

The metallic cases of the relays, instruments and other panel mounted Equipment shall be connected to the earth bus by independent copper wires of size shall be made of IEC/IS standards. The colour code of earthing wire shall be green.

Earthing wires shall be connected on the terminals with suitable clamp connectors and soldering shall not be permitted.

▪ **Accessories**

The following spares and accessories shall be supplied along with the main equipment's at free of costs. This shall not be included in the price schedule.

- 1) Charging lever for operating load break isolators & circuit breaker of each RMU.
- 2) The pressure gauges indications – 1 numbers
- 3) Provision shall be made for padlocking the load break switches/ Circuit breaker, and the earthing switches in either open or closed position with lock & master key.

▪ **Testing of equipment & Accessories**

Provision for testing CTs, Relays, Breakers and Cables shall be made available. The supplier shall provide procedure and schedule for Periodical & Annual testing of equipments, relays, etc.

- **Tests:**

Type test

The Tenderer should, along with the tender documents, submit copies of all Type test certificate of their make in full shape as confirming to relevant ISI/IEC of latest issue obtained from a International/National Govt. Lab/Recognized laboratory. After Award of Contract, Quality Plan and inspection plan shall be mutually discussed and finalized as per applicable Indian standards as per Schedule 11 128.

The above type test certificates should accompany the drawings for the materials duly signed by the institution who has type test certificate.

- **Acceptance and Routine tests**

All acceptance and routine tests as stipulated in the latest IEC/ IS shall be carried out by the supplier in the presence of owner's representative. The supplier shall give at least 7 days advance intimation to the owner to enable them to depute their representative for witnessing the tests. The partial discharge shall be carried out as routine test on each completely assembled RMU gas tank and not on a sample basis. As this test checks and guarantees for the high insulation level and thus the complete life of switchgear.

- **Additional tests**

The client reserves the right for carrying out any other tests of a reasonable nature at the works of the supplier/laboratory or at any other recognized laboratory/research institute in addition to the above mentioned type, acceptance and routine tests at the cost of the client to satisfy that the material complies with the intent of this specification.

- **Pre-commissioning tests**

All the pre-commissioning tests will be carried out in the presence of the client's engineer and necessary drawing manual and periodical test tools shall be arranged to be supplied. During the above tests the Concessionaire's representative should be present till the RMUs are put in to service.

- **Inspection:**

The owner may carry out the inspection at any stage of manufacture. The supplier shall grant free access to owner representative at a reasonable time when the work is in progress. Inspection and acceptance of any equipment under this specification by the owner shall not relieve the supplier of his obligation of furnishing equipment in accordance with the specification and shall not prevent subsequent rejection if the equipment is found to be defective.

The supplier shall keep the owner in advance, about the manufacturing programme so that arrangement can be made for inspection. The owner reserves the right to insist for witnessing the acceptance/routine testing of the bought out items. The owner has rights to inspect the supplier's premises for each consignment for type & routine test. No material shall be dispatched from its point of manufacture unless the material has been satisfactorily inspected and tested / unless the same is waived by the owner in writing.

▪ **Quality Assurance Plan:**

The bidder shall invariably furnish following information along with his offer / in case of event of order.

(i) Statement giving list of important raw materials including but not limited to:

- (a) Contact material
- (b) Insulation
- (c) Sealing material
- (d) Contactor, limit switches, etc. in control cabinet.

Name of sub-suppliers for the raw materials, list of standards according to which the raw materials are tested, list of test normally carried out on raw materials in presence of Bidder's representative, copies of test certificates.

(ii) Information and copies of test certificates as in (i) above in respect of bought out accessories

(iii) List of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspections.

- (iv) Special features provided in the equipment to make it maintenance free.
- (v) List of testing equipment available with the Bidder for final testing of RMUs and associated combinations vis-à-vis, the type, special, acceptance and routine tests specified in the relevant standards. These limitations shall be very clearly brought out in the relevant schedule i.e. schedule of deviations from specified test requirements. The supplier shall, within 15 days from the date of receipt of Purchase Order submit following information to the owner.
- (vi) List of raw materials as well bought out accessories and the names of sub-suppliers selected from those furnished along with offer.
- (vii) Necessary test certificates of the raw material and bought out accessories.
- (viii) Quality Assurance Plan (QAP) withhold points for owner inspection. The quality assurance plan and hold points shall be discussed between the owner and supplier before the QAP is finalized.

The supplier shall submit the routine test certificates of bought out items and raw material, at the time of routine testing of the fully assembled breaker.

- **Training**

The supplier shall give rigorous training to the engineers & staff at the site for 2 days in attending trouble shooting and maintenance.

SCADA Connectivity: Specific requirement for SCADA connectivity following requirement shall be fulfilled:

1. FPI shall be provided per isolator
2. **DC control supply system should be 24 V DC.**
3. Battery charger to cater load of minimum 10 motorized operation cycles (CLOSE / OPEN) in absence of battery.
4. Battery to cater load of minimum 10 motorized operation cycles (CLOSE-OPEN) in absence of battery charger. **The battery backup should be minimum of 2Hrs**
5. Availability of MCB's for battery charger supply, RMU Motor supply & FRTU supply (Minimum 2 Amp circuit for future use of FRTU).

6. Individual control circuit of isolator/CB/BC to have point of isolation/protection.
7. Individual motor circuit of isolator/CB/BC to have point of isolation/protection.
8. RMU shall have minimum protection of IP 54 with gland plate & knock outs. Provision for control cable entry should preferably be from Right/ Left top through LV cable box & shall be independent of HV isolator/CB/BC status. It should be vermin proof.
9. Control cable gland plate shall be independent of power cable gland plate.
10. A point of earthing for control cables shall be electrically isolated from power cable earthing.
11. Ambient temperature of 50 degree C max. Allowable temperature rise of battery & battery charger above ambient 40 degree C.
12. Local / Remote switch shall be provided on all the isolator & breaker panels for selection of controls
13. CT & PT terminals for all the circuit breakers only.

Following is the list of I/O requirements for RMU modules. Please note that all DI & DO should be potential free contacts.

- a) List of potential free contacts for Isolator (Terminals shall be provided):

Digital Indications

1. Isolator ON
2. Isolator OFF
3. Isolator Earth switch Status (ON/OFF)
4. FPI Operated
5. LOCAL/REMOTE switch position

List of commands

1. Isolator Close
2. Isolator Open
3. FPI reset

- b) List of potential free contacts for Circuit Breaker / Bus coupler (Terminals shall be provided):

Digital Indications

1. Circuit Breaker ON
2. Circuit Breaker OFF
3. Auto trip
4. LOCAL/REMOTE switch position

List of commands

1. CB Close
2. CB Open

Requirement for Multifunction Meters (MFMs):

1. Terminals shall be provided for CT and PT connections.
2. Space may be provided for MFM mounting inside control panel.

- c) List of potential free signals for AUXILIARY:

Digital indications

1. RMU Battery charger fail
2. Battery Low indication
3. SF6 low

Documentation and drawings

All drawings shall conform to relevant International Standards Organization (ISO) Specification.

The tenderer shall submit along with his tender dimensional general arrangement drawings of the equipment's, illustrative and descriptive literature in triplicate for various items in the RMUs, which are all essentially required for future automation.

- i) Schematic diagram of the RMU panel
- ii) Instruction manuals
- iii) Catalogues of spares recommended with drawing to indicate each items of spares
- iv) List of spares and special tools recommended by the supplier.
- v) Copies of Type Test Certificates as per latest IS/IEC.

- vi) Drawings of equipment's, relays, control wiring circuit, etc.
- vii) Foundation drawings of RMU.
- viii) Dimensional drawings of each material used for item Vii.
- ix) Actual single line diagram of RMU/RMUs with or without Extra combinations shall be made displayed on the front portion of the RMU so as to carry out the operations easily.

The following should be supplied to along with the initial supply of the equipment's ordered.

Two copies of printed and bound volumes of operation, maintenance and erection manuals in English along with the copies of approved drawings and type test reports etc.

▪ **Nameplate**

Each RMU and its associated equipment's shall be provided with a nameplate legible and indelibly marked with at least the following information.

- (a) Name of manufacturer
- (b) Type, design and serial number
- (c) Rated voltage and current
- (d) Rated frequency
- (e) Rated symmetrical breaking capacity
- (f) Rated making capacity
- (g) Rated short time current and its duration
- (h) Purchase Order number and date
- (i) Month and Year of supply
- (j) Rated lightning impulse withstand voltage
- (k) Feeder name (Incoming and Outgoing), DTs Structure name, 11000 Volts Dangers etc.

Note: Recognized abbreviations may be used to express the above and auxiliary supply shall be stated either on the circuit breaker name plate or any other acceptable position.

▪ **Fault Passage Indicators (FPI):**

These shall facilitate quick detection of faulty section of line. The fault indication may be based on monitoring fault current flow through the device. The unit should be self-contained requiring no auxiliary power supply. The FPI shall be integral part of RMU. The FPI shall have *LCD/LED display*, automatic reset facility. The sensors to be bushing mounted. **FPI shall be provided per Isolator**

▪ **Tropicalisation**

Due regard should be given to the climatic conditions under which the equipment is to work. Ambient temperature normally varies between 20 °C and 32 °C, although direct sun temperature may reach 50 °C. The climate is humid and rapid variations occur, relative humidity between 60% and 90% being frequently recorded, but these values generally correspond to the lower ambient temperatures. The equipment should also be designed to prevent ingress of vermin, accidental contact with live parts and to minimize the ingress of dust and dirt. The use of materials, which may be liable to attack by termites and other insects, should be avoided.

▪ **Motorization**

All the functions within the RMU i.e. Isolators / Breakers should be suitable for motor drive mechanism and closing coil making it suitable to make it ON from remote.

Control Supply and Auxiliaries : Following Auxiliaries has to considered

- (i) Shunt trip coil – 24VDC for Isolators and Breakers
- (ii) Closing Coil – 24VDC
- (iii) 6NO+6NC – Potential free auxiliary contacts for breakers / isolator
- (iv) Auxiliary supply should be – 24 V DC
- (v) Local / Remote switch for breaker and Isolators

▪ **Metering**

Separate Metering Module consisting of bus connected PT's and metering CT's to be provided for VCB function along with Provision of installing Multifunction meter to be provided. The PT's and CT's provided shall made up of epoxy cast resin with an Accuracy class of 0.5. The CT ratio shall be as per transformer Rating. The metering is required only in breaker functions.

10.1.1. Guaranteed Technical particulars for RMU

The tenderer shall fill-in the following schedules, which is part of the tender specification and offer. If the schedules are not submitted duly filled-in with the offer, the offer shall be liable for rejection.

Sl. No.	Description	Parameter / value	parameters / values as offered by the concessionaire
I	Tag No. of Panel		
	Quantity		
	Location		
	Service		
	Combination type	2 LBS + 1 VCB	
	Functional Requirement	Service entrance “metering & control”	
	Make / Model		
II	11 KV Bus Bar		
	Current carrying capacity	630 Amps.	
	Short time rating current for 3 secs	20 KA	
	Insulation of bus bar	SF6	
	Bus bar connections	Anti-oxide grease	
III	Parameters for VCB and load break isolators		
	Type	Metal enclosed	
	No of Phases	3	
	No. of poles	3	
	Rated voltage	12 KV	
	Operating voltage	11 KV	
	Rated lightning impulse withstand voltage	75 KV	
	Rated power frequency withstand voltage	28 KV	

	Insulating gas	SF6	
	Rated filling level for insulation	As per IEC	
	Isolating distance between ON and OFF position in isolator	80 mm (min).	
	Rated short time current	20 KA	
	Rated short time	3 s	
	Rated peak withstand current	50 KA.	
	No of operations in Short circuit	15 Nos (minimum)	
	Operating mechanism	Circuit breaker with spring assisted anti reflex / trip free mechanism.	
	Rated current (Bus)	630 A	
	Rated current (breaker)	200 A	
	Circuit Breaker interrupter	VCB	
	Rated frequency	50 Hz	
	Rated operating sequence	O-3 min - CO	

10.2. 11 kV Metal enclosed switchgear

Applicable standards

The switchgear and its components shall conform to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern.

IS : 13118	Circuit Breakers
IS : 3427	Metal enclosed switchgear
IS : 2705	Current Transformers
IS : 3156	Voltage Transformers
IS : 5576, 11353	Arrangement for switchgear, bus bars, main connections and auxiliary wiring
IS : 2544	Bus bar support insulators
IS:13947 (Part I)	Degree of Protection
IS:3231, 3842	Electrical relays for power system protection
IS:1248	Electrical indicating instruments
IS:9385	High voltage fuses
IS:722, 8530	AC Electricity Meters
IS : 613	Specification for copper rods and bars for electrical purposes
IS : 6005	Code of practice for phosphating iron & steel
IS : 9920	Alternating current switches for voltages above 1000 V
IS : 13703	Low voltage fuses
IS : 3452	Toggle switches
IS : 10118	Code of Practice for selection, installation and maintenance of switchgear and control gear
IS : 6875	Control switches

■ Features of construction

- (a) The switchgear shall be outdoor, metal enclosed with separate compartments for
 - (i) Circuit breaker
 - (ii) Control, metering and relaying devices
 - (iii) Busbars
 - (iv) Instrument transformers
 - (vi) Power cable terminations

- (a) Adjacent switchgear cubicles shall be provided with side sheets on either side to ensure complete isolation. The bottom of the switchgear shall be fully covered by sheet steel.
- (b) Separate removable gland plates shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material.
- (c) All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt, and sward by pickling, emulsion, cleaning etc. The sheet steel shall be phosphated and then painted with two coats of zinc rich primer paint. After application of the primer, two coats of finishing synthetic enamel paint over baked / stoved shall be applied.
- (d) The circuit breaker shall be fully draw out type. The circuit breaker shall have distinct service and test positions. In the test position, the circuit breakers shall be capable of being tested for operation without energising the power circuits. Four normally open auxiliary contacts shall be provided for each of the service and test limit position switches.
- (e) The test position should preferably be obtained without the need to disconnect normal control connections and use of extension cords for testing.
- (f) The switchgear shall fully house the breaker both in the service position as well as in the test position.
- (g) The current transformers shall be mounted on the fixed portion of the switchgear and not on the breaker truck.
- (h) The cable compartment shall house all power cable connections along with associated cable terminations. Wherever zero sequence current transformers are provided for earth fault protection, these shall also be located inside the cable compartment.
- (i) Each switchgear cubicle shall be fitted with a label in the front and rear of the cubicle. Each switchgear shall also be fitted with label indicating the switchgear designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.

- **Safety interlocks and features**

- (a) Withdrawal or engagement of circuit breakers or disconnecting switch shall not be possible unless it is in the open position.
- (b) Operation of circuit breaker or disconnecting switch shall not be possible unless it is fully in service position, or in test position or in fully drawn-out.
- (c) Operation of a disconnecting switch shall not be possible unless the associated circuit breaker is open.
- (d) Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the exposed live parts when the breaker is withdrawn.
- (e) Caution name plate with inscription 'Caution- Live Terminals' shall be provided at all points, where the terminals are likely to remain live and isolation is possible only at remote end, e.g. incoming terminals of main disconnecting switch.
- (f) A draw-out with breaker of given rating shall be prevented from engaging with stationery element of higher rating.

- **Main Bus Bars**

- (a) Busbars shall be fully insulated by encapsulation in epoxy resin, with mould caps protecting all joints.
- (b) Busbars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit.
- (c) Busbars shall be of electrolytic aluminium conductor of hard drawn and high conductivity.

- **Circuit Breakers:**

- (a) **Auxiliary contacts:**
Auxiliary switch mounted on the fix portion of the breaker and directly operated from the breaker operating mechanism shall be provided and shall have minimum 6 'NO' and 6 'NC' potential free contracts for Purchaser's use. Any auxiliary relays

required for contact multiplication for other requirements shall be provided. The contacts shall be rated for 10 amps, 240 V A.C and 1 Amp. (Inductive breaking), 110 V D.C. The above auxiliary switches shall not operate when the breaker is withdrawn to test position and operated.

(b) **Spring operated mechanism:**

The operating mechanism shall be complete with motor, opening and closing springs, limit switches for automatic charging and all necessary accessories. Facility for manual charging of the closing spring shall be provided. The operating mechanism shall be trip-free and non-pumping electrically. An anti-pumping relay to achieve electrical anti-pumping feature shall be provided even if the breaker has provision for anti-pumping by mechanical arrangement.

▪ **Earthing:**

- (a) An earthing bus shall be provided at the bottom and extend throughout the length of the switchgear. It shall be bolted / welded to the framework of each unit and each breaker earthing bus.
- (b) All non-current carrying metalwork of the switchgear shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid.
- (c) Positive earthing of the circuit breaker frame shall be maintained both in service and test position.

▪ **Annunciators:**

- (a) Facia annunciators, suitable for operation on 24 V DC shall be provided. Facia annunciators shall be:
 - i. Equipped with 'Sound Cancel', 'Acknowledge' and 'Reset' push buttons common to annunciators on all switchgear aligned together and a 'Lamp Test' push button for each annunciator on individual panels;
 - ii. Provided with two lamps connected in parallel on each facia window with series resistors;
 - iii. Suitable for normally open indicating contacts of either 'hand' or 'self' reset type;
 - iv. Suitable for annunciating subsequent faults with the specified sequence, immediately after acknowledging the previous fault;

- v. Facia window of minimum size of 35 mm. x 50 mm;
- vi. Designed for an operating sequence indicated below :

Alarm condition	Fault contact	Audible alarm	Visual alarm
Normal	Open	Off	Off
Abnormal	Closed	On	Flashing
Sound Cancel	Closed or Open	Off	Flashing
Acknowledge	Closed or Open	Off	Steady on
Back to Normal	Open	Off	Steady on
Reset	Open	Off	Off
Lamp Test	Open	Off	Steady on

▪ **Switchgear accessories and wiring**

- (a) Switchgear shall be supplied completely wired internally upto equipment and terminal blocks and ready for external cable connections at the terminal blocks. Inner panel wiring between cubicles of same switchgear shall be provided.
- (b) All auxiliary wiring shall be carried out with 650 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall not be less than 1.5 sq.mm.
- (c) Terminal blocks shall be of stud type, 650 volts, 10 amps, rated complete with insulated barriers.
- (d) All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks.
- (e) Accuracy class for indicating instruments shall be 1.0. Instruments shall be 110 mm. Square with 240° scale for flush mounting with only flanges projecting.
- (f) Ammeters, voltmeters, shall be of moving iron type. The accuracy class shall be 1.0. The range shall be indicated on the drawing / data sheets. Digital microprocessor based power monitor shall be provided to monitor all electrical parameters, such as KVA, KW with resettable maximum demand recorder and indicator, KVAR, KWH, KVARH, Power Factor PF, Frequency, Voltage current

etc. The power monitor shall operate off a PT secondary of 110 volts, suitable for operation on 3-phase, 3-wire system and to measure unbalanced loads.

- (g) Relays shall be suitable for flush mounting with only flanges projecting.
- (h) All protective relays shall be in draw-out cases with built-in test facilities. Necessary test plugs shall be supplied loose. All auxiliary relays and timers shall be supplied loose. All auxiliary relays & timers shall be supplied in non-draw-out cases. Externally operated hand reset flow indicators shall be provided on all relays and timers. Timers shall be of electromagnetic or electronic type only.
- (i) Control and instrument switches shall be rotary type provided with inscription plates clearly marked to show operating position and suitable for semi-flush mounting with only switch front plate and operating handle projecting out.
- (j) Breaker control switches shall be pistol grip black and selector switches shall be oval or knob and black. Breaker control switches shall be three-position spring return to neutral type. Instrument selector switches shall be of the maintained stay-put type. Contacts of the switches shall be spring assisted and contact faces shall be with rivets of pure silver. The contact ratings shall be adequate to meet the requirements of circuit capacity in which they are used.
- (k) All push buttons shall have two normally open and two normally closed contacts unless specified otherwise. The contacts shall be able to make and carry 5 A at 110V DC and shall be capable of breaking 1 A inductive load at 110V DC. They shall be provided with inscription plates engraved with their functions.
- (l) Indicating lamps shall be panel mounting type with series resistors. The wattage of lamps shall be 5 to 10 watts.
- (m) Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for 240V, 1 pH, 50 Hz supply. They shall be complete with HRC fuses, isolating switches and thermostat to cut off heater at 45° C.
- (n) Each switchgear panel shall be provided with 240 Volts, 1 phase, 50 Hz, 5 amps, 3 pin receptacle with switch located in a convenient position.

- (o) An interior illuminating lamp together with operating door switch and protective fuse shall be provided.
- (p) Provision shall be made for receiving, distribution, isolating and fusing of auxiliary D.C. and A.C. supplies for controls, space heating, etc. The fuse ratings shall be so chosen as to ensure selective clearance of sub circuit faults.
- (q) Fuses shall be HRC cartridge type mounted on plug in type fuse base.
- (r) The D.C. and A.C. auxiliary supply shall be distributed inside the switchgear with necessary isolating arrangements at the point of entry and with sub-circuit fuses as required.

▪ **Instrument transformers**

- (a) The CTS shall withstand momentary and short time current ratings of the associated switchgear. CTS and PTS shall be of the cast resin type and completely encapsulated.
- (b) The core balance CTS shall be suitable for the respective outgoing feeders and shall be suitably supported.
- (c) PTS shall be single phase, draw out type. PTS shall be provided with fuses on both primary and secondary sides, except those terminals that are required to be connected to earth. These shall have an isolating link. Fuses on primary side shall have rupturing capacity equal to the switchgear rating.

▪ **Cable termination**

- (a) Necessary number of cable glands shall be supplied for terminating auxiliary power and control cables. Glands shall be of heavy-duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring.
- (b) Cable lugs for all power and control cable connections shall be supplied. The lugs shall be tinned copper / aluminium depending on cable conductor and of solder less crimping type.

- (c) All necessary materials required for terminating the power cables such as tapes, filters, binding wires, armour clamps, brass glands etc., shall be supplied.

- **Drawings and data**

- (a) **The Tenderer shall furnish the following drawings & data as part of the Tender:**

- General arrangement showing plan, elevation and typical section views.
- Foundation plan showing location of fixing channels, floor openings etc.
- Schematic wiring drawings for each breaker.
- Technical literature on the breakers offered.
- Bill of material listing equipment designation, make type, rating etc., of various equipment mounted on switchgear panel.

- (b) **The Concessionaire shall furnish the following drawings for each panel & switchgear after the award of contract.**

- Overall outline dimensions & general arrangement including plan, front elevations, clearances required in front and back, details of bus duct connections, if any.
- Overall outline dimensions & general arrangement including plan, front elevations, clearances required in front and back, details of bus duct connections, if any.
- Schematic control diagrams to cover controls, protection, interlocks, instruments, space heaters, etc., for each type of module.
- Itemized bill of material for each module, listing all devices mounted and cable glands, indicating all type, rating quantity and special notes, if any.
- Detailed internal wiring diagram of each type of module, including terminal block number, ferrule numbers and the external cable connection designations.
- Inter panel interconnection wiring diagram including terminal numbers and ferrule numbers.

10.2.1. Guaranteed Technical particulars for 11 kV panel

Sl. No.	Description	Parameter / value	Offered parameter / value (to be filled in by the tenderer)
I	Tag No. of Panel		
	Quantity		
	Location	Near STP and pump house	
	Service	Outdoor	
	Functional Requirement	Transformer primary control	
	Type	ICOG	
II	11 KV Bus Bar		
	Current Carrying Capacity	630 Amps.	
	Short time rating current for 3 secs	20 KA	
	Insulation of bus bar	Air	
III	Parameters for VCB		
	Type	Metal enclosed	
	No of Phases	3	
	No. of poles	3	
	Rated voltage	12 KV	
	Operating voltage	11 KV	
	Rated lightning impulse withstand voltage	75 KV	
	Rated power frequency withstand voltage	28 KV	
	Insulating gas	Air	
	Rated filling level for insulation	As per governing IS	
	Isolating distance between ON and OFF position in isolator	80 mm (min).	
	Rated short time current	20 KA	
	Rated short time	3s	

Sl. No.	Description	Parameter / value	Offered parameter / value (to be filled in by the tenderer)
	Rated peak withstand current	50 KA.	
	No of operations in Short circuit	15 Nos (minimum)	
	Operating mechanism	Circuit breaker with spring assisted anti reflex / trip free mechanism.	
	Rated current (Bus)	630 A	
	Rated current (breaker)	200 A	
	Circuit Breaker interrupter	VCB	
	Rated frequency	50 Hz	
	Rated operating sequence	O-3min- CO	

10.3. 11 kV XLPE Power cables

10.3.1. Scope

The specification covers design, manufacture, shop testing, packing and delivery of 11 kV multi core, cross-linked polyethylene insulated power cables suitable for effectively earthed neutral system.

10.3.2. Standards

Unless otherwise specified elsewhere in this specification, the rating as well as performance and testing of the HT XLPE power cables shall conform to the latest revisions available at the time of placement of order of all the relevant standards as listed in, but not limited to table below

IS: 8130 – 1984	Conductors for insulated electric cables and flexible cords.
IS :7098 (Part 2) – 1985	XLPE PVC sheathed cable for working voltages from 3.3 kV up to and including 33 kV.
IS: 5831 – 1984	PVC insulation and sheath of electric cables.

IS: 3975 – 1988	Mild steel wires , formed wires and Tapes for armouring of cables
IS :10462 (Part I) –1983	Fictitious calculation method for determination of dimensions of protective coverings of cables.

10.3.3. General constructional requirements

The HT multi core power cables shall normally be with stranded compacted H2/H4 grade aluminium conductor as per IS: 8130 - 1984, provided with conductor screening (of extruded semi-conducting cross link material) and shall be insulated with XLPE of natural colour. Identification of cores shall be by colour, as per provision of clause 13.1 of IS: 7098 (Part 2) - 1985. The insulation (XLPE) screening shall be provided consisting of extruded semi-conducting cross link material in combination with a metallic layer of copper tapes. Three such screened cores shall be laid up together with fillers and/or binder tapes where necessary and provided with extruded inner sheathing of heat resistant PVC conforming to type ST-2 of IS: 5831- 1984. Maximum continuous operating temperature shall be 90 deg C under normal operation and 250 deg C under short circuit condition Armouring shall be provided consisting of single galvanized round steel wires (In case of Single core cable armouring shall be of Non-magnetic material) conforming to IS:3975 - 1988 (amended upto date) and over the armouring a tough outer sheath of PVC compound shall be extruded. The PVC compound for the outer sheath shall conform to type ST-2 of IS: 5831 - 1984 (amended upto date). The colour of the outer sheath shall be black. The cable shall be manufactured strictly conforming to IS:7098 (Part 2) – 1985 amended upto date and shall bear ISI mark.

10.3.4. Sequential marking of length of cable

Non-erasable Sequential Marking of length shall be provided by embossing on outer sheath of the cable for each meter length. The quality of insulation should be good and insulation should not be deteriorated when exposed to the climatic conditions.

10.3.5. Discharge free construction:

Inner conductor shielding, XLPE insulation and outer core shielding shall be extruded in one operation by special process (viz. Triple Extrusion Process) to ensure that the insulation is free from contamination and voids and perfect bonding of inner and outer shielding with insulation is achieved. The bidders are requested to elaborate the manufacturing technique adopted by their manufacturers to achieve this motive. The

Company will order the verification of triple extrusion process at manufacturer's works as a pre-qualification if it is technically accepting the bid. During verification if it is found that the firm is not manufacturing the cable with triple extrusion process the offer shall be rejected.

10.3.6. Continuous A.C. Current carrying capacity:

Continuous a.c. current capacity shall be as per Table given below.

Conductor sizes in sq.mm.	Continuous a.c. current capacity in Amps. at maximum conductor temp. of 90 deg .C.	
	When laid direct in the ground 30 deg. C	When laid in air 40 deg. C
70 sq mm	160	165
95 sq mm	190	200
120 sq mm	215	230
150 sq mm	240	265
185 sq mm	270	310
240 sq mm	315	345
300 sq mm	355	396
400 sq mm	405	460
500 sq mm	450	590

10.3.7. Short circuit current

Short circuit current of 11 kV XLPE cable shall be as per Table given below.

Duration of Short Circuit in sec	Area of Al. Conductor	Short circuit current in kA
t	A	$I=0.094 \times A/\text{sq.rt} (t)$
1	70 sq.mm	6.58
1	95 sq.mm	8.93
1	120 sq.mm	11.28
1	150 sq.mm	14.10
1	185 sq.mm	17.39
1	240 sq.mm	22.56
1	300 sq.mm.	28.20

Duration of Short Circuit in sec	Area of Al. Conductor	Short circuit current in kA
1	400 sq.mm.	37.60
1	500 sq.mm	47.00
1	630 sq.mm	59.20

10.3.8. Routine tests

All the Routine tests as per IS: 7098 (Part 2) - 1985 amended upto date shall be carried out on each delivery length of cable. The result should be given in test report. Partial discharge test must be carried out in a fully screened test cell. It is, therefore, essential that the manufacturer should have the appropriate type of facility to conduct this test, which is routine test.

10.3.9. Acceptance tests

All Acceptance tests as per IS: 7098 (Part 2) - 1985 as modified upto date including the optional test as per clause no 18.4 and Flammability Test shall be carried out on sample taken from the delivery lot.

10.3.10. Packing and marking:

- **Identification marks on cable:**

The following particulars shall be properly legible embossed on the cable sheath at the intervals of not exceeding one meter throughout the length of the cable. The cables with poor and illegible embossing shall be liable for rejection.

- a) Manufactures name and/or Trade name.
- b) Voltage grade.
- c) Year of manufacture.
- d) Successive Length.
- e) Size of cable
- f) ISI mark

The cable shall be supplied in continuous standard length of 250 running meters with plus or minus 5% tolerance wound on non-returnable wooden drum of good quality and non-standard lengths not less than 100 meters upto 5% of the ordered quantity shall be

accepted. Alternately, cable can be supplied wound on non-returnable steel drum without any extra cost to the purchaser. Packing and marking shall be as per Clause No. 21 of IS: 7098 (Part 2) - 1985 amended up to date.

10.4. Transformers

10.4.1. Applicable standards

The power and auxiliary transformers shall conform to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern.

IS : 2026	Power Transformer
IS : 3639	Fittings and Accessories
IS : 1180	Auxiliary Transformer
IS : 6600	Loading of oil immersed transformer
IS : 335	Insulating oil
IS : 2099	Bushings for > 1000 V, AC
IS : 7421	Bushings for \leq 1000 V, AC
IS : 13947 (Part I)	Degree of Protection
IS : 1271	Electrical insulation classified by thermal stability

10.4.2. Features of construction

- (a) The transformer tank shall be made from high-grade plate steel, suitably reinforced by means of stiffeners made of structural steel sections. All seams, flanges, lifting lugs, braces and other parts attached to the tank shall be welded. The interior of the tank shall be cleaned by shot blasting and painted with two coats of heat resistant and oil insoluble paint. Adequately sized manholes shall be provided for easy inspection and maintenance. All joints which may have to be opened from time to time in the course of operation shall be of a design to permit them to be made easily oil tight in reassembly. Steel bolts and nuts exposed to atmosphere, shall be galvanised. The tank cover shall be suitably sloped so that it does not retain rainwater.
- (b) Lifting lugs and eyebolts shall be so located that a safe clearance is obtained between sling and transformer bushings, without the use of a spreader.

- (c) Transformer of rating above 500 KVA shall be equipped with detachable or separately mounted radiator banks. Transformers of rating 500 KVA and below shall be provided with fixed type radiators.
- (d) When transformers are provided with separately mounted radiators, flexible joints shall be provided on the main oil pipes connecting the transformer tank to the radiator banks to reduce vibration and facilitate erection and dismantling. The interconnecting pipes shall be provided with drain plug and air release vents.
- (e) The transformer tank, radiators and conservator shall be designed taking into account the loss of thickness due to shot blasting.
- (f) The transformer core shall be constructed from high grade, non-ageing, cold rolled, grain oriented, silicon steel laminations coated with insulation varnish. The steel laminations shall be of “core” type.
- (g) Each lamination shall be coated with insulation, which is unaffected by the temperature attained by the transformer during service.
- (h) Core lamination shall be annealed and burrs removed after cutting. Cut edges shall be insulated.
- (i) The frame work and clamping arrangements of core and coil shall be securely earthed inside the tank by copper strap connection to the tank.
- (j) Windings shall be of suitably insulated copper wire or copper strip. The windings shall be fully shrunk under vacuum before assembly.
- (k) High voltage end windings shall be suitably braced to withstand short circuit stresses and stresses set up by surges.
- (l) All taps shall be provided on the HV winding.
- (m) The core and coil assembly shall be dried out and impregnated under vacuum.

- (n) Cable boxes shall have sufficient space for segregating the cable cores and to give adequate clearance in air between bare conductors at the terminals. Cable boxes shall be complete with necessary cable lugs and armour grips.
- (o) All auxiliary wiring from current transformers, winding temperature indicators, etc., shall be marshalled to a separate weatherproof and vermin proof marshalling box with an independent access cover.
- (p) The marshalling box shall be complete with necessary cable glands and cable lugs. The marshalling box and components shall comply with the requirements specified for control cabinets indicated elsewhere in this specification.

10.4.3. Performance requirements:

- (a) Transformers shall operate without injurious heating at the rated KVA at any voltage within ± 10 percent of the rated voltage of that particular tap.
- (b) Transformers shall be capable of delivering the rated current at a voltage equal to 105 percent of the rated voltage without exceeding the limiting temperature rise.
- (c) Transformer for two or more limits of voltage or frequency or both shall deliver its rated KVA under all the rated conditions of voltage or frequency or both; provided an increase in voltage is not accompanied by a decrease in frequency.
- (d) Transformers shall operate below the knee of the saturation curve at 110 percent voltage to preclude ferro-resonance and non-linear oscillations.
- (e) Transformers shall be capable of operation continuously, in accordance with the applicable standard loading guide at their rated KVA and at any of the specified voltage ratios. Under these conditions, no limitations by terminal bushings, on-load tap changers or other auxiliary equipment shall apply.
- (f) The neutral terminal of windings with star connection shall be designed for the highest over current that can flow through this winding.
- (g) The transformers shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth, so as to eliminate wave form

distortion and any possibility of high frequency disturbances reaching a magnitude as to cause interference with communication circuits.

- (h) The Engineer's Representative reserves the right to reject the transformer if the same does not meet the specification requirement subject to tolerances as per IS: 2062. The rejected transformers shall be replaced by transformers complying with the requirements to this specification at the Concessionaire's cost.
- (i) If the commissioning of the project is likely to be delayed by the rejection of a transformer, as mentioned under h) above, the Engineer's Representative reserves the right to accept the rejected transformer until the replacement transformer is made available. Transporting the rejected and replacement transformers as well as installation and commissioning of both the transformers shall be at Concessionaire's cost.

10.4.4. On Load Tap Changing Gear for transformer:

- (a) The OLTC gear shall be designed to complete successfully tap changes for the maximum current to which transformer can be loaded, i.e. 150% of the rated current. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault currents without injury.
- (b) When a tap change has been commenced it shall be completed independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency, which may result in the tap changer movement not being completed once it is commenced.
- (c) Oil in compartments, which contain the making and breaking contacts of the OLTC shall not mix with oil in other compartments of the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. A Buchholz relay shall be installed in the above pipe. The conservator shall be provided with a prismatic oil level gauge.
- (d) Oil, in compartments of OLTC which do not contain the make and break contracts, shall be maintained under conservator head by valved pipe connections. Any gas

leaving these compartments shall pass through the Buchholz relay before entering the conservator.

- (e) Oil filled compartments shall be provided with filling plug, drain valve with plug, air release vent, oil sampling device, inspection opening with gasketed and bolted cover with lifting handles.

- (f) OLTC driving mechanism and its associated control equipment (Local) shall be mounted in an outdoor, weatherproof cabinet with IP 55 protection, which shall include:
 - Driving motor (415V, 3-phase, 50 Hz, AC squirrel cage).
 - Motor starting contactor with thermal overload relays, isolating switch and HRC fuses.
 - Control switch: Raise / off / lower (spring return to normal type).
 - Remote / local selector switch (maintained contact type).
 - Mechanical tap position indicator showing rated tap voltage against each position and resettable maximum and minimum indicators.
 - Limit switches to prevent motor over-travel in either direction and final mechanical stops.
 - Brake or clutch to permit only one tap change at a time on manual operation.
 - Emergency manual operating device (hand crank or head wheel).
 - A five-digit operation counter.
 - Electricity interlocked reversing contactors (preferably also mechanically interlocked).
 - 240V, 50 Hz, AC space heater with switch and HRC fuses.
 - Interior lighting fixture with lamp door switch and HRC fuses.
 - Gasketed and hinged door with locking arrangement.
 - Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.
 - Necessary relays, contactors, current transformers etc.

- (g) Control Requirements for OLTC:

The following electrical control features shall be provided:

- Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.
- Only one tap change from each tap change impulse even if the control switches or push button is maintained in the operated position.
- Cut-off of electrical control when manual control is resorted to cut-off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.
- Cut-off of electrical control when it tends to operate the tap beyond its extreme position.

(h) Automatic Control of OLTC:

Automatic OLTC control shall include the following items:

- Voltage setting device
- Voltage sensing and voltage regulating devices
- Line drop compensator with adjustable R and X elements
- Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation
- Adjustable dead band for voltage variation

(i) **OLTC panel:**

The OLTC remote control equipment shall be suitable for 24 V DC supply and shall be housed in an indoor sheet steel cubicle to be located in a remote control room. The OLTC control panel shall comprise of rigid welded structural frames made of structural steel section or of pressed and formed cold rolled steel and frame enclosures, doors and partitions shall be of cold rolled steel of thickness 2 mm. Stiffeners shall be provided wherever necessary. All doors, removable covers and plate shall be gasketed all around with neoprene gaskets. Panel shall be dust, weather and vermin proof providing degree of protection of IP 54, colour of finish shade for interior and exterior shall be glassy white and light grey semi glossy shade 631 of IS-5 respectively. Earthing bus shall be of 25 x 6 mm copper.

The panel shall consist of:

- (i) Control Switch : Raise / Off / Lower
(spring return to normal type)
- (ii) Auto / manual selector switch (maintained contact type)
- (iii) Tap position indicator
- (iv) Facia type alarm annunciators with “accept” and “lamp test” facilities
 - Supply failure
 - Drive motor auto tripped
 - Tap change delayed
- (v) Necessary auxiliary relays
- (vi) Lamp indications for:
 - Tap change in progress
 - Lower limit reached
 - Upper limit reached
- (vii) Cable glands for power and control cables
- (viii) 240 V rated panel space heater with ON-OFF switch
- (ix) Fluorescent type interior lighting fixture with lamp and door switch
- (x) HRC fuses
- (xi) Terminal blocks
- (xii) Internal wiring
- (xiii) Earthing terminal

10.4.5. Fittings and accessories:

The following fittings and accessories shall be provided with transformer:

- (a) Inspection manhole in the cover
- (b) Lifting lugs for both the transformer and the core
- (c) Two earthing terminals on opposite ends of the transformer tank
- (d) Name plate, rating plate and diagram plate
- (e) Detachable radiator banks, complete with top and bottom shut-off valves, air release plug, drain valve and lifting lugs, suitably located thermometer pockets for measuring inlet and outlet oil temperature and one grounding terminal for connection of grounding conductor. Fins of the radiators shall not have sharp edges but shall be rounded shape.
- (f) Conservator, complete with filling plug, sump and drain valve, and a shut-off valve on the pipe connection between transformer tank and conservator, to permit removal of the conservator. The conservator shall be designed to maintain an oil seal through a temperature range of 100 degree C.
- (g) Oil level indicator with minimum marking.
- (h) Weather proof dehydrating breather with activated alumina or silicagel as the dehydrating agent.
- (i) Magnetic type oil level gauge with low oil level alarm contact, mounted on the conservators with waterproof and dustproof terminal box.
- (j) Gas detector relays with separate alarm and trip contacts complete with shut-off valves.
- (k) Separate drain valve, oil sampling valve with plug and top filter valve shall be provided on the tank.

- (l) Explosion vent with diaphragm for relieving pressure inside the transformer. The device shall be rain proof after operation. For transformers of 500 KVA and above an equaliser pipe connecting the pressure relief device to the conservator shall be supplied.
- (m) Separately mounted, water proof and dustproof marshalling box housing the oil temperature indicator and winding temperature indicator with alarm and trip contacts and marshalling facilities for electrical devices mounted on transformer.
- (n) For transformers rated 500 KVA and above, adequate number of air vents for relieving trapped air during oil filling and during maintenance.
- (o) Thermometer pockets and sensing element mounted on the transformer tank cover for measuring top oil temperature.
- (p) Four jacking pads for lifting the transformer with jacks.
- (q) Pulling eyes and skids for the movement of the transformers.
- (r) Bi-directional wheels for movement of the transformers.
- (s) Accessories for clamping the wheel mounted transformer to the foundation in order to withstand earthquake forces with a seismic acceleration of 0.2 g.
- (t) Noise level of transformers shall be less than 80 dB.
- (u) Transformer shall be supplied complete with insulating oil required for first filling plus 10% excess oil.

10.4.6. Drawings and data

The following drawings shall be submitted for the Employer's approval:

- (a) General outline drawing as submitted at the tendering stage but with binding dimensions and weights within 2 months of award of contract.

(b) General outline drawings showing plan, front elevation, and side elevation, with all fittings and accessories, locating dimensions of cable entries, earthing terminals, foundation / floor fixing details, jacking pads and weights of the following. :

- OLTC (Local and Remote) cabinets
- Marshalling box
- Cable boxes
- Disconnecting chambers

(c) Cable junction box details, mounting details, make and type number, current and voltage rating, creep age distances and principal characteristics.

(d) Rating and diagram plates

(e) OLTC cabinets: schematic circuit diagram and actual detailed wiring diagram giving terminal numbers within 5 months of award of Contract.

(f) Marshalling box terminal connections wiring diagram.

10.4.7. Guaranteed Technical particulars for Transformer

Sl. No.	Description	Owner's requirement	As offered Particulars (to be filled in by the tenderer)
1	Make		
2	Service	Outdoor	
3	Rating	As per requirement of individual facility in KVA	
4	Rated Voltage		
a	HV winding	11,000 V	
b	LV winding	433 V	
5	Number of Phases	3 phase	
6	Rated Frequency	50 Hz	
7	Vector group	DYn 11	
8	Type of cooling	ONAN	
9	Tapings :	on 11 kV side	

Sl. No.	Description	Owner's requirement	As offered Particulars (to be filled in by the tenderer)
a	Range	+ 5%, to – 15%	
b	Number of steps	8 steps 9 position	
c	Losses at 75° C & Principal tapping	As per IS 1180	
10	No load loss at rated voltage and frequency	As per IS 1180	
11	Load losses at rated current	As per IS 1180	
12	Total loss at maximum rated power	As per IS 1180	
13	Impedance voltage at 75° C		
A	At principle tapping		
B	At Maximum tapping		
C	At minimum tapping		
14	Hottest spot temperature in winding limit		
15	Efficiency at 75° C and 0.9 PF		
A	At full load	As per IS 1180	
B	At 75 % load	As per IS 1180	
C	At 50 % load	As per IS 1180	
16	Maximum efficiency	As per IS 1180	
17	Maximum current density at rated power		
A	HV winding		
B	LV winding		
18	Maximum flux density in iron at rated voltage & Frequency		
A	At 100 % rated voltage		
B	At 110 % rated voltage		
19	Maximum clearances in air		
A	Between phases (HV / LV)		
B	Between phases & earth		
20	Insulation level		
A	Impulse		
B	HV		

Sl. No.	Description	Owner's requirement	As offered Particulars (to be filled in by the tenderer)
C	LV		
21	Power frequency		
A	HV		
B	LV		
22	Winding type		
A	HV winding		
B	LV winding		
23	Details of core		
A	Core lamination material		
B	Insulation of lamination		
C	Thickness of lamination		
D	Type		
E	Specific loss of core steel at 1.5 tesla		
24	Details of tank		
A	Material		
B	Thickness of side		
C	Thickness of bottom		
D	Thickness of cover		
E	Thickness of tube		
F	Maximum internal pressure withstanding capacity of the tank		
G	Details of Radiator		
H	No. of Radiator tanks		
I	Thickness of radiator plate		
J	Weight of each radiator tank		
K	Cooling surface area		
L	Volume of conservator		
M	Total oil required		
N	Whether first filling of oil with 10% excess furnished	Required	
25	Details of bushing		
A	Type		
b	Voltage class		

Sl. No.	Description	Owner's requirement	As offered Particulars (to be filled in by the tenderer)
c	Creep age distance		
d	Weight of bushing		
e	Current rating		
f	Insulation level		
g	Impulse		
h	Power frequency dry KV		
i	Power frequency wet		
j	Length of insulator		
k	loss angle at working voltage		
26	Explosion vent material		
A	Thickness		
B	Maximum rupturing pressure of the diaphragm		
27	Tank pressure test		
A	Pressure		
B	Duration		
C	Tank vacuum test		
D	Pressure		
E	Duration		
28	Maximum noise level		
29	Overall dimensions including coolers & fittings		
A	Height		
B	Breadth		
C	Length		
C	Crane lift for dismantling core and coil assembly		
D	Weight of core & winding		
E	Tank & Fittings weight		
F	Oil weight		
G	Total weight including radiator, OLTC, and oil		

10.5. MV Panel Board / Switch Board construction

All MV and LV panel boards / switch boards, unless and mentioned otherwise, shall meet the following requirements. For particular requirements and data sheets as applicable to the subject project, refer section 9.9 of this tender document.

Type	:	Floor mounting, free standing, single front, fully compartmentalized, totally enclosed, dust & vermin proof, modular in construction & fully extensible on either sides
Conforming to	:	IEC 60439
Construction	:	<ul style="list-style-type: none"> ➤ 2.00 mm thick for frames and other load bearing members ➤ 1.6 mm thick for doors and partitions ➤ 3.0 mm for gland plates & of non-metallic construction for termination of single core armoured cables
Form of separation	:	Form 3 B
Bus bar configuration, MOC, busbar supports, busbar insulation, busbar compartments, cable alley and feeder compartments	:	<ul style="list-style-type: none"> ➤ TPN bus bars with 50% neutral for all applications not involving harmonic loads and with 100 % neutral for loads with harmonics. ➤ Risers (vertical busbars) shall have a continuous current rating at least 125% of combined feeder ratings of the particular vertical section. ➤ Completely enclosed busbar compartment running horizontally at the top / bottom as per actual panel configuration ➤ Completely enclosed compartments for vertical busbars. ➤ Individual feeder modules in multi-tier modular formation. ➤ Vertical cable alleys with removable gland plates at the bottom/ top ➤ Busbar supports- Non-hygroscopic / SMC/ DMC supports with anti-tracking design and strength to withstand the dynamic forces during short circuit current of appropriate value ➤ Busbar insulation – 1.1 kV grade Heat shrinkable colour coded ➤ Busbar connections- by using cadmium plated high tensile hardware

Bus bar MOC and sizing	<p>: ➤ MOC – High conductivity, high strength Aluminium alloy complying to requirements of Grade E 91E of IS 5082 (or) E.C grade copper</p> <p>➤ All bus bars to be dimensioned considering the maximum permissible rise in temperature of 50 Degrees over ambient temperature under normal operating conditions.</p>
Earth bus	<p>: ➤ Continuous Aluminium strip of adequate cross section to carry the fault current to be run inside each shipping section.</p> <p>➤ All compartment doors to be provided with insulated earth continuity conductors / jumper wires</p>
Panel height, door and shipping sections	<p>➤ Panel height shall generally not exceed 2100 mm including the bottom mounting channel.</p> <p>➤ The operating handle of the switchgear at the top most tier shall be not more than 1800 mm from FFL.</p> <p>➤ The operating handle of the switchgear at the lower most tier shall be not less than 300 mm from FFL</p> <p>➤ Panel doors (Front) – Hinged</p> <p>➤ Panel doors (rear) – Bolted</p> <p>➤ Bus bar chamber and cable chamber doors – Bolted</p> <p>➤ Gaskets – Continuous type of neoprene</p> <p>➤ Locks – Each compartment shall be with interlock to ensure that the doors do not open with switch ON. Interlock defeat also required to be provided</p> <p>➤ All switchgear compartments to be suitable for LOTO arrangement.</p> <p>➤ The panel shall generally be made in sections not exceeding 2.50 mtrs long for ease of handling and movement inside panel rooms.</p>
Degree of protection	<p>➤ IP 42 for indoor panels</p> <p>➤ IP 54 for panels meant for use in dusty and humid operating environment</p> <p>➤ IP 65 for outdoor panels</p>
Finish	<p>➤ Powder coat finished as per IS 3618.</p>
Cable termination	<p>➤ From top / bottom as per data sheet.</p> <p>➤ Shall be suitable for terminating the number of cable runs and the type of cable as per SLD / data sheet.</p>

Wiring	<ul style="list-style-type: none"> ➤ All control wiring (Other than CT circuit) to be done using 1.5 Sq.mm PVC insulated wires ➤ All CT wiring shall be not less than 2.5 Sq.mm PVC insulated wires
Meters	<ul style="list-style-type: none"> ➤ All MFMs / Ammeters / Voltmeters and other meters as called for in the SLD shall be suitable for flush mounting type on panel compartment doors and shall be digital versions with RS 485 communication feature.
Relays	<ul style="list-style-type: none"> ➤ Shall be as per SLD /data sheet
Control Supply	<ul style="list-style-type: none"> ➤ Shall be derived using 415 / 110 V AC control transformer and with MCB protection on both primary and secondary side of the control transformer.
Space Heaters	<ul style="list-style-type: none"> ➤ All bus bar compartments shall be provided with space heater to prevent moisture condensation and maintain cubicle temperature 5 degree C above the ambient. The space heaters shall be located suitably and shall be controlled through thermostats with suitable setting with MCB.
Indication lamps	<ul style="list-style-type: none"> ➤ LED cluster type. The lamps shall have red, green, amber, Blue and white caps as applicable made out of temperature resistant prismatic glass. The lamp holders and caps shall be guaranteed for continuous operation of lamps without any damage.
Control switches / Push button actuators	<ul style="list-style-type: none"> ➤ Control and instrument selector switches shall be rotary type provided with escutcheon plates clearly marked to show operating position and suitable for semi-flush mounting with only the switch joint plate and operating handle projecting out. The connection shall be from the back.
Legend plates / name plates / warning boards	<ul style="list-style-type: none"> ➤ Each compartment of the PANEL / MDB / PDB / MCC/ PMCC shall be provided with a nameplate engraved with its designation. The nameplates shall be rear engraved perspex with white letters on black background. The name plate shall also indicate the rating of the switchgear, the equipment fed and its rated power (in kw or hp) ➤ Metallic nameplate shall be provided on any one side of the panel / switch board duly indicating as a minimum the name

		of the panel vendor, the P.O No. & date, the month & year of installation, ➤ Warning stickers with danger signage & text in trilingual (English / Hindi and Local language) red letters on white background shall be provided at appropriate locations.
Mimic display		➤ The panel front facia shall be provided with mimic key SLD (either red painted or with red sticker)

10.5.1. Control and switchgear specifications

- All control gear and switchgear shall be ROHS compliant
- All control and switchgear, unless and mentioned otherwise, shall meet the following requirements.

ACB	:	EDO type
Pole configuration	:	As per equipment requirement
Breaking Capacity	:	As per system requirements
Protection type	:	O/L, S/C and E/F
Accessories	:	UV, Earth Fault and Shunt release (two of the accessories as per data sheet)
Auxiliary contacts	:	2 NO and 2 NC minimum

MCCB	:	Panel internal mounted with door mounted rotary handle operated type
Pole configuration	:	As per equipment requirement
Breaking Capacity	:	As per system requirements
Protection type	:	Thermal magnetic up to 250 Amps Microprocessor based for ratings 250 Amps and above
Cable termination	:	All MCCBs for terminating cables above 35 Sq.mm shall be with spreader links
Accessories	:	UV, Earth Fault & Shunt release (two of the accessories as per data sheet)
Auxiliary contacts	:	2 NO and 2 NC minimum

MCB	:	DIN rail mounted with dolly handle operated type
Pole configuration	:	As per requirement at individual facility

Breaking Capacity	:	As per requirement at individual facility
Protection	:	O/L & S/C
Cable termination	:	All MCBs for terminating cables above 16 Sq.mm shall be with spreader links
Fault Level	:	10 kA for MCBs rated more than 25 Amps

Motor Starter component rating	:	Based on Type -2 co-ordination charts
Motor starter type	:	Upto and including 10 HP– DOL Above 10 HP and upto and including 30 HP – Star Delta starting Above 30 HP and upto and including 50 HP – Soft start Above 50 HP – VFD
Additional protection	:	Current sensing type single phase and phase reversal protection
Metering and CT	:	For motors upto 10 HP CT shall be provided in the centre phase complete with ammeter. For motors above 10 HP CT shall be provided in all three phases complete with ammeter and ammeter selector switch
Cable termination	:	All terminations for cables above 16 Sq.mm shall be with spreader links

10.5.2. Soft starters for LV motors

The soft starters shall comply with the requirements of IEC 60034, 60947 and IS 325 including those standards referred to therein.

Constructional and performance features

Motor soft starters shall be switched or electronic type.

Soft starter panel shall be indoor, metal clad with separate metal enclosed compartments for

- a) control, metering and current transformers for differential protection, if specified
- b) shorting (bypass) arrangement
- c) bus bars
- d) power cable terminations
- e) push buttons with indicating lamps.

Soft starter shall achieve smooth starting by torque control for gradual acceleration of the drive thus preventing jerks and extending the life of equipment.

Starting current shall be limited to 2.5 to 3 times the rated current of the motor. The soft starter manufacturer shall co-ordinate with motor manufacturer for this purpose.

Separate removable gland plates shall be provided for power and control cables.

Each cubicle shall be fitted with a label in the front and rear of the cubicle, indicating the panel designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.

Necessary wiring diagram shall be provided considering starting interlock, trip circuit, starting and running mode signal.

It shall be possible to manually start the motor locally from the starter panel or in Auto mode through PLC.

10.5.3. Variable Frequency Drives (VFD)

AC induction motor in clear water pumping station for rural distribution shall be coupled with a Frequency drive of rating commensurate with the rated motor.

The Frequency drives shall be of Current Source Inverter Pulse Width Modulated (CSIPWM) with GTO/IGBT/IGCT/SGCT/DTC technologies or later version, which performs precise speed and torque control of standard squirrel cage motors with optimum efficiency. Each drive must have a soft starting feature and a by pass arrangement for DOL starting of motors. All frequency drives shall be suitable for data connectivity with PLC/SCADA system and shall have Ethernet TCP/IP suitable communication 99 port and protocol. The drives must be easily programmable. The drives shall be provided with surge protection, programmable lockable code. The Frequency drive shall have following characteristics:

- Accurate open loop torque control
- Torque step rise time typically less than 5 ms
- Speed control inaccuracy typically 0.1% to 0.5% of nominal speed

- 150% overload capacity for 60 second
- Total Harmonic distortion shall comply with the provisions of IEEE 519. Necessary metering, self-diagnostic arrangement (including display and alarm facilities) shall be provided for local/ remote monitoring.

❖ Technical Parameters

- Main connection
 - Voltage : 3 phase, 415 +/- 10 % permitted tolerance
 - Frequency : 45 to 65 Hz, maximum rate of change 17%/s
 - Imbalance : Max. +/- 3% of nominal phase to phase input voltage
 - Fundamental Power factor : 0.97 (at nominal load)
- Motor connection
 - Voltage : 3 phase, from 0 to applied incoming supply voltage, 3-phase
 - symmetrical
 - Output Frequency : 0 to 250 Hz
 - Frequency Resolution : 0.01 Hz
- Continuous Current : $1.0 * I_{2N}$ (normal use)
- Short Term Overload
- Capacity (1min./10min)
- : $I_{2max} = 1.1 * I_{2N}$
- Field Weakening point : 8 to 300 Hz
- Acceleration Time : 0 to 1800 sec
- Deceleration Time : 0 to 1800 sec
- Efficiency : Min. 97% at nominal power level
- Environment limits
- Ambient temperature : 0 to 45 deg. Cent.
- General Standard Control Connections or as per Process Requirement
- 3 programmable differential analogue inputs (1 voltage signal, 2 current signals)
- 7 programmable digital inputs
- 2 programmables analogues outputs (current signal)
- 3 programmable digital outputs (from C relays)
- Power Torque Speed value must be configurable to the ethernet tcp/ip port for their remote data acquisition in PLC/ SCADA. Optional analogue and digital extension modules can be added as well as a wide range of field bus adapters.
- Protection
 - Over current

- Short circuit at start-up
- Input phase loss
- Output phase loss
- Motor overload
- Earth fault
- Overvoltage
- Undervoltage
- Over temperature
- Motor stall
- Application macros

The features a selection of built-in, pre-programmed application macros for configuration of inputs, outputs, signal processing and other parameters. It shall have interfacing facilities to communicate data to SCADA system. These include:

- FACTORY SETTING for basic industrial applications
- HAND/AUTO CONTROL for local and remote operation
- PID CONTROL for closed loop processes
- TORQUE CONTROL for process where torque control is required.
- SEQUENTIAL CONTROL for processes where torque control is required.
- USER MACRO 1 and 2 for user's own parameter setting
- Comprehensive testing and diagnostic function
- Tests
 - Each unit of Variable frequency drive shall be tested at the manufacturer's work with the motor they have been assigned to work for at the STP
 - Test result must satisfy the efficiencies on various loads and at different frequency levels against their quoted values.

Contactor	:	Air break
Pole configuration	:	Three pole / Four Pole as per data sheet
Auxiliary contacts	:	2 NO + 2 NC
Utilisation category	:	As per data sheet

CT	:	Cast resin type
Ratio, class & Burden	:	As per SLD / Data sheet

Insulation class	:	1.1 kV
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Control Transformer	:	Cast resin type
Voltage Ration	:	415 / 110 V AC
Insulation class	:	1.1 kV
Rating	:	1000 VA

Capacitor		
Type	:	Dry type, Mixed Di-electric versions with self-healing capacity conforming to IS 13340.
Voltage	:	220 Volts to 575 Volts based on application

Push button Actuators		
Type	:	Panel door mounted – shrouded type for START and Mushroom type for STOP / RESET
Contact ratings	:	6 Amps

10.6. 1.1 kV XLPE cable

10.6.1. Scope

This part of the specification covers the requirements of design, manufacture, inspection, testing and supply at site of 1.1 kV grade XLPE power and control cables.

10.6.2. Standards

The 1.1 kV grade Power & Control Cables conform to the requirements of the latest Indian Standard Specifications including but not limited to the following:

IS 7098	:	Cross-linked polyethylene insulated PVC sheathed cables
IS 3975	:	Mild steel wires, strips and tapes for armouring of cables
IS 10418: 1982	:	Drums for electric cables.
IS 10810	:	Methods of test for cables
IS 1554 (Part I)	:	PVC Cables for voltage up to and including 1100 volts
IS 8130	:	Conductors for insulated electric cables
IS 5831	:	PVC insulation and sheath of electric cables

IS 3975	:	Mild steel wires, strips and tapes for armouring of cables
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10.6.3. General construction

The cables shall be suitable for laying in trays, trenches, ducts, conduits and buried underground installation with uncontrolled backfill and possibility of flooding by water. These shall have following constructional features.

All power and control cables for use on low voltage system shall be heavy of 1100 V grade with aluminium / copper conductor, XLPE insulated, PVC inner sheathed, armoured and overall PVC sheathed.

The construction of the conductors shall be SOLID for aluminium conductor cables up to 10 mm sq. and for copper conductor cables up to 2.5 mm sq. For cables above 10 mm sq. and for copper cables above 2.5 mm sq. the conductor shall be STRANDED. Conductors of nominal cross sectional area less than 10 sq.mm shall be circular only. Conductors of nominal cross section area 16 sq.mm and above may be circular or sector shaped.

The core insulation shall be with XLPE applied over the conductor by extrusion and shall conform to the IS 7098. Control cables having 6 cores & above shall be identified with prominent & indelible numerals on the outer surface of the insulation. Colour of the numbers shall be white with a spacing of maximum 500 mm between two consecutive numbers.

The inner sheath shall be applied over the laid-up cores by extrusion and shall be of PVC conforming to the requirements of type ST2 PVC compound per IS 5831. The extruded inner sheath shall be of uniform thickness of size not less than 0.5 mm up to 16 sq.mm, 0.8 mm from 25 sq.mm upto 120 sq.mm and 1.0 mm above 120 sq.mm conductor size. Taped inner sheath shall also be acceptable.

For multi core cables, the armouring shall be by single round galvanized steel wires where the calculated diameter below armouring does not exceed 13 mm and galvanized steel strips where this dimension is greater than 13 mm. Requirement and methods of tests for armour material and uniformity of galvanization shall be as per IS 3975 and IS 2611.

The outer sheath for the cables shall be applied by extrusion and shall be of PVC compound and conforming to the requirements of type ST 2 compound per IS 5831. To

protect the cables against rodent and termite attack, suitable chemicals shall be added into the PVC compound of the outer sheath.

The dimensions of the insulation, armour and outer sheath materials shall be governed by values given in IS 1554 (Part I).

10.6.4. Packing

The cables shall be supplied in standard drum lengths duly wound on non-returnable wooden drums.

Vendor shall ensure that the bending radii of cables are not less than 12 times their overall diameters when wound on drums. Both ends of the cables shall be sealed.

Following information shall be printed on the flange of each cable drum.

- a) Type
- b) Size
- c) Voltage grade
- d) Length in meters
- e) ISI Mark
- f) Gross weight
- g) Direction of rolling

10.7. Specification for power / lighting distribution boards

10.7.1. Scope

This part of the specification covers the requirements of design, manufacture, assembly, inspection, testing and delivery at site of Power/ Lighting Distribution Boards / Panels.

10.7.2. Standards

The Power / Lighting Distribution Boards shall conform to the requirements of the latest Indian Standard Specifications including but not limited to the following:

IS 13947	:	Low Voltage Switchgear and Control gear
IS 11353	:	Guide for Uniform System of marking and identification of conductors and apparatus
IS 2705	:	Current Transformers
IS 8623	:	Low voltage switchgear and control gear assemblies
IS 4237	:	General requirements for switchgear and Control gear for voltages not exceeding 1000 V
IS 13032	:	Miniature air-break circuit breakers for voltages not exceeding 1000 V
IS 13947	:	Switches, disconnectors, air break Switch (Part 3) disconnectors and fuse combination units
IS 13703	:	LV Fuses for voltages not exceeding 1000 V ac or 1500 V dc Part 1 General requirements
IS 1248	:	Direct acting electrical instruments
IS 722	:	AC Electricity Meters

10.7.3. Construction & component specification

The boards shall be sheet steel enclosed on all sides and shall be dust and vermin proof, providing a degree of protection equivalent to IP 54. The sheet steel used shall be 14/16 Gauge CRCA.

The distribution boards shall be provided with hinged doors for access to components. Doors shall be provided with gasket all around with neoprene gaskets.

The Power Distribution Boards (PDBs) / Lighting DB, shall be suitable for wall mounting. Cable entries to these boards for incoming as well as outgoing cables shall be from the Top. The bus bars of Power Distribution Boards (PDBs) / Lighting DB shall be of electrical grade Copper of adequate size. These shall be supported on SMC/ DMC/ Epoxy non-hygroscopic supports at suitable intervals to withstand the thermal and dynamic stresses developed due to short circuit current of 10KA for Power DBs & Lighting DB.

Internal Earth bus of adequate size of copper flat shall be provided extending through the entire length of the boards

10.7.4. Earth Leakage Circuit Breakers (ELCBs)

The ELCBs shall be designed to operate within 30 milliseconds to provide effective protection against electrocution risks and fires caused by earth leakage faults of 30 mA and above. All parts of the switching mechanism shall be of non-corroding self-lubricating material thus providing consistent and trouble free services. These shall have short circuit withstand capacity of 10 KA.

10.7.5. Miniature Circuit Breakers

These shall be hand operated type. The miniature circuit breaker shall incorporate thermal overload and magnetic short circuit tripping devices. These shall have short circuit withstand capacity of 10 KA.

Provide positive 'ON' locking devices for miniature circuit breakers supplying power to corridor lights, night lights and other circuits requiring continuous supply.

Provide a neatly typed directory on each panel, listing the locations of devices and equipment served by each circuit, mounted on the inside of the front cover in a frame with hard transparent shield.

10.7.6. Internal wiring

The boards/ panels shall be supplied completely wired, ready for the external connections at the terminal blocks. Wiring shall be carried out with 1100V grade PVC insulated, stranded copper conductor of adequate size (min. 2.5 mm sq.) Identification ferrules shall be provided to correspond with wiring diagrams. All wiring shall be terminated on terminal block. Terminals of Power Distribution Boards / Lighting DB shall covered terminals.

10.7.7. Painting

Sheet metal work of the Boards / Panels shall undergo a thorough surface treatment comprising rust removal, degreasing, pickling and phosphating prior to painting. The pre-treated boards/ panels shall be painted / Powder coated with two coats of suitable primer and finished with two coats of Power coated of approved shade as per IS-5.

10.8. Specification for cable carrier / cable containment system and accessories

10.8.1. Scope

This part of the specification covers the requirements of design, manufacture, assembly, inspection, testing and delivery at site of cable carrier / cable containment system with accessories.

10.8.2. Standards

The Cable carrier system with accessories shall conform to the requirements of the latest Indian Standard Specifications including but not limited to the following:

IS 513	:	Cold rolled low carbon steel and strips
IS 1079	:	Hot rolled carbon steel and strips.
IS 2629	:	Recommended practice for hot dip galvanizing
IS 2611	:	Methods for testing uniformity of coating of Zinc coated articles
IS 1367	:	Technical supply conditions for threaded steel fasteners.
IS 1663	:	Method for tensile testing of steel sheet & strip of thickness 0.5 mm to 3 mm

10.8.3. Construction

Cable carries, fittings and accessories shall be fabricated out of rolled Mild Steel sheets free from flaws such as laminations, rolling marks, pitting etc. conforming relevant codes.

Minimum thickness of Mild Steel sheets used for fabrication of cable carries and fittings shall be 1.60 mm up to 450 mm wide trays and 2.0 mm above 450 mm wide trays. The thickness of side coupler plates shall be minimum 3 mm.

All accessories like bends, reducers, tees, crosses coupler plates, etc., shall be pre-fabricated and not fabricated at site.

Structural supports shall be made out of Mild steel with hot dip galvanized of adequate size and load carrying capacity.

Structural supports shall be located appropriately and the distance between any two supports shall not be more than 1500 mm.

In RCC trenches, the cable carriers shall be of cantilever construction and erected with anchor fasteners / insert plate with adequate load carrying capacity. Fittings like bends, reducers, tees, crosses, etc. accessories like side coupler plates etc. and hardware GI bolts, nuts, springs, washers as may be required shall be treated as part of the supply item.

In masonry brick work the cable carrier support shall be grouted adequately with appropriate supports using cement mortar.

In vertical sections the cable carriers shall be of ladder / perforated construction with one or multi tiers complete with matching fittings like bends, reducers, tees, crosses etc., accessories like side coupler plat etc. and hardware GI bolts, nuts, springs, washers, etc. as may be required.

The standard length of each size and type of cable tray / ladder shall be not more than 2.5 metre.

10.8.4. Support system for cable carriers

The support system shall be fabricated from standard structural steel members. The cable carriers and support system shall be hot dip galvanised

10.8.5. Galvanizing

Galvanising of steel components and accessories shall conform to relevant code The galvanising shall be uniform, clean, smooth, continuous and free from spots. Should the galvanizing of the samples be found defective, the entire batch steel shall have to be re-galvanised at Concessionaire's cost after pickling.

The amount of zinc deposit over threaded portion of bolts, nuts, screws a washers shall be as per relevant codes. The removal of extra zinc on threaded portion of components shall be carefully done to ensure that the threads have the required zinc coating on them.

The hot dip galvanized thickness shall not be less than 80 micron thickness.

Section – G5.2
Technical specification for Diesel generator set

Section G5.2: Technical specification for Diesel generator set

1. General

1.1 Scope of work

This specification covers the technical requirements and essential particulars for the Design, manufacture, supply, inspection, testing and commissioning of adequate size of Diesel Generator systems as covered in the specification documents and drawings. The Concessionaire shall demonstrate that the DG set satisfies the requirements of the specification and applicable codes

2. Diesel Generator

2.1 Applicable codes and standards

2.1.1 The DG set shall conform to the latest editions of the codes and standards listed under Clause 2.1.2 below & other applicable standards. Nothing in this specification shall be construed to relieve the Concessionaire of this responsibility.

2.1.2 The applicable Indian standards and codes shall be followed wherever applicable for the DG set. In all cases, the latest revision of the standards shall be referred to. If requirements of this specification conflict with the requirements of the standards, this specification shall govern. The following standards, unless otherwise specified herein, shall be referred to.

IEC 34	Rotating electrical machines
BS 5000	Part 3 Reciprocating IC engines: Performance
IS 10002	Performance requirements of Diesel Engines
IS 10000 (OR) Equivalent BS code	Method of tests for IC engines
BS 5514 / (ISP 3046)	Reciprocating internal combustion engines performance standard reference conditions, declarations of power, fuel and lubricating oil consumptions and test methods
IS : 2147	Degree of protection provided by enclosure for low voltage switchgear and control gear
IS : 4722	Rotating Electrical Machines
IS : 3043	Code of practice for earthing

IS 8623	Low voltage switchgear & control gear assemblies
IS 5578	Marking of insulated conductors
IS 11353	Uniform system of marking & identification of conductors and apparatus
IS 2705	Current Transformers
IS 7098	Cross linked polyethylene insulated (XLPE) PVC sheathed cables, Part 1: For working voltage up to and including 1100 V
IS 3156	Voltage transformers
IS 5082	Material data for aluminium bus bar
IS 1248	Direct acting electrical indicating instruments
IS 9224	Fuses with high breaking capacity
IS 13947	Low voltage switchgear & control gear
IS 13364	Specification for ac generators driven by Part 2, reciprocating internal combustion engine rated above 20 kVA and up to 1250 kVA
IS 3231	Specification for electrical relays for power system protection
IS 8686	Specification for static protective relays
IS/ IEC 60947	Low-voltage switchgear and control gear

3. Construction & component specification

3.1 Diesel Engine

- 3.1.1 The diesel engines shall be approved make, suitable for Prime power rating, direct injection, four stroke, multi cylinder, water cooled through base mounted radiator, turbo charged, water cooled type operating, acoustic enclosure & capable of developing requisite BHP rating to drive the Alternator
- 3.1.2 The engine shall be designed to operate at 50° C ambient temperature without any de-rating factor
- 3.1.3 The engine & the governing system shall conform to class-A1 governing as per BS 5514 and shall be suitable for Prime power rating generating application. The unit

shall be suitable for operation on High Speed Diesel Oil without any modifications.

- 3.1.4 The governing system of the engine shall be of the microprocessor based electronic type suitable to control frequency variation within +/-4% for a sudden load change up to 70% The governor shall ensure that the speed of the set is regulated within 1% of the nominal speed under normal operating conditions
- 3.1.5 The engine shall be electric start and shall be suitable for battery assisted manual / auto / SCADA system starting. The design shall ensure that the starter will be automatically released when the engine picks up speed beyond 60% of the rated speed.
- 3.1.6 All moving parts of the engine and other associated equipment shall be provided with guards to prevent accidental contact. The guard shall be designed to facilitate easy removal and reinstallation
- 3.1.7 The engine fitments shall include but not be limited to the following:-
- i) Flexible coupling and flywheel with guard
 - ii) Air inlet system with Dry type air filter with clogged condition indicator & turbo charger
 - iii) Fuel system complete with Fuel Pump, flexible hoses, primary & secondary fuel filters with service indicator and manual priming pump.
 - iv) Exhaust system with dry manifold and residential silencer.
 - v) Lube oil system with gear type oil pump, oil cooler, filter and crank case heater.
 - vi) Cooling system with engine coolant belt, fan, guard, radiator & low coolant level switch.
 - vii) 24V D.C. Starter and battery charging alternator with auto cut off.
 - viii) Acoustic enclosure suitable for outdoor operation

4. Alternator

- 4.1 The Alternator shall be industrial type, 1500 RPM, 415V, 3 Phase, neutral, 50Hz, adequate size of DG set in KVA, 0.8PF, star connected, IP-23, horizontal foot mounted, continuous duty suitable for prime power alternator, double bearing, self-excited, self-regulated, brushless excitation machine with exciter and automatic voltage regulator (AVR). The exciter shall be rotating diode type and Class 'H' insulated. The exciter shall be capable of forcing the field for 3 seconds

(or duration as specified in the data sheet) in the event of short circuit fault at generator terminal. The exciter should be capable of building up voltage from residual magnetism, protection against low speed operation & high motor starting capability. The rectifier shall have in built protection for over voltage and rate of rise of voltage. The generator shall have on line greasing facility with grease nipple & relief device. All other parameters shall be as specified in the data sheet and conforming to codes and standards specified in the data sheet or relevant standards.

- 4.2 Continuous damper winding fitted on each pole.
- 4.3 Thermistor for Hot spot detection with control unit for mounting in the control panel.
- 4.4 Terminal box with separately mounted adopter box having bus bars and flexible wiring between Alternator terminals and adopter box drawn in PVC covered metallic flexible conduit. The adopter box shall be suitable for terminating adequate size of 2 runs x 3½ core XLPE armoured Aluminium cable.
- 4.5 The Alternator shall further meet the following specification.
- 4.6 The alternator shall conform to IS 4722 / BS standards.
- 4.7 The alternator shall be suitable for 20% over speed for two minutes.
- 4.8 The alternator terminal volt age for any load variation should be maintained within +/-2%.
- 4.9 The transient and steady state frequency variation should be limited to +/-4% for sudden load variation upto 70%. The generator TVD for sudden load variation of 100% shall not be more than 15%.
- 4.10 Both ends of each phase winding shall be brought to the terminal box.
- 4.11 The alternator shall be capable of carrying 50% overload for a duration of one minute and 10% overload for one hour in 12 hours operation.
- 4.12 The alternator shall withstand a 3 phase short circuit at the terminals for a period

of 3 seconds

- 4.13 The total harmonic distortion shall not exceed 3% and the design shall permit up to 30% unbalance between phases while in operation
- 4.14 The efficiency shall preferably not be less than 93% in the normal operating range of 50% to 100% loading

Driven equipment	-	adequate size as required
Output	-	adequate size as required
Terminal voltage	-	415 volts under full load conditions
Frequency	-	50 Hz
No. of Phases	-	Three
Power Factor	-	0.8 lag
Stator Connection	-	Star
Excitation	-	Brushless
Coupling	-	Direct
Operating duty	-	Continuous
Place of Installation	-	Outdoor
Class of Insulation	-	Class 'F'
Impedance	-	Confirming to IS
Voltage Regulation	-	+ / - 2.5% voltage regulation for a load variation of full load to no load at 0.80 lag power factor with AVR
Over Speed	-	All rotating part of alternator suitable for 120% over speed for two minutes
Excitation	-	AC Brushless static exciter of suitable voltage and of adequate capacity to meet the excitation current of the alternator at full load at 0.80 power factor

5. Acoustic enclosure

- 5.1 The acoustic enclosure shall be of free standing, floor-mounting type integral with the DG set.
- 5.2 The enclosure shall be provided with rugged heavy-duty structural steel base frame

with chequered plate flooring on which the DG set is to be mounted. The enclosure shall be prefabricated factory-built and modular in construction.

- 5.3 The enclosure shall consist of acoustically treated panels housed in rugged steel frames, which shall be bolted together to form the body of the enclosure.
- 5.4 Hinged doors shall be provided, on either side, which shall also be acoustically treated, thereby providing easy access to the DG set while minimizing the operating space requirements.
- 5.5 The construction of the acoustic enclosure shall be such that with both the acoustic doors open on the either side, full access is available to the engine and alternator.
- 5.6 Fresh air inlet into the system a parallel baffle air inlet silencer shall be provided. Additionally, to augment the fresh air inlet requirements, a forced air ventilation duct with associated silencer shall be provided above the alternator.
- 5.7 For hot air discharge, an acoustic discharge plenum shall be provided in front of the engine radiator, for discharge of hot air into the surroundings through a parallel baffle air outlet silencer. The enclosure shall have suitable openings in the roof module for exhaust piping.
- 5.8 The acoustic panels shall be filled with a special grade high-density mineral wool retained on the inside by perforated GI sheets specially designed for optimum sound attenuation.
- 5.9 The outer surface of the Acoustic Panels shall be fabricated of perforated 16 G corrugated CRCA sheet steel.
- 5.10 All structural members such as angles / channels used in the construction of the enclosure frame.
- 5.11 All materials used for Acoustic Enclosure shall be fire resistant / fire retardant grade.
- 5.12 The sheet steel treatment shall consist of degreasing, de-rusting and phosphating followed by two coats of zinc chromate primer, followed by two coats of

- Zinpholite surface for superior corrosion resistance and two coats of finish paint.
- 5.13 For effective Acoustic sealing, necessary gasket material shall be provided.
- 5.14 All hardware and fittings used shall be passivated with zinc.
- 5.15 With the above Enclosure, the sound pressure levels when measured at a distance of 1 meter outside the Acoustic Enclosure shall be confirming to the CPCB / Tamilnadu state Pollution control Board regulation.
- 5.16 It shall be ensured that at least 1000 mm (min.) clear space is available all around the Acoustic Enclosure to ensure free airflow for the Gen-set as required and to facilitate accessibility for generator operation and routine maintenance.
- 5.17 The enclosure shall be provided with suction fans to ensure that the adequate cooling and combustion air is made available to the engine and the temperature within the enclosure is limited to 5° C above ambient.
- 5.18 The fan shall be designed with sufficient static to draw the requisite quality of air from the duct provided for this purpose. Calculations shall be furnished to prove the adequacy of the ventilation system offered. The suction fans shall start automatically when the temperature in the enclosure reaches 40°C and shall continue to run for 5 to 10 minutes after the load is disconnected. A temperature controller shall be provided for this purpose housed in sheet steel enclosure.
- 5.19 Two light points controlled by a switch complete with 36W fluorescent Luminaries and lamps shall be provided. Provision shall also be made for fixing a heat detector inside the acoustic enclosure, which will be connected to the central fire alarm panel.
- 5.20 Necessary openings shall be made for the entry of power cable and control cables, fuel piping, exhaust piping, air inlet pipe etc.
- 5.21 With the installation of the acoustic enclosure, there shall not be any de-rating of the DG set. The maximum temperature of oil and water shall not exceed the limits prescribed by the manufacturer of the engine. The DG set shall give rated output

continuously.

- 5.22 The ventilation system shall be designed to provide an adequate air volume whenever the DG set is in operation.
- 5.23 The ventilation fan shall be of the axial flow type designed to handle the static pressure estimated based on the inlet air duct size and length.

6. Instrument / Control Panel

6.1 Instrument / Control Panel shall have the Equipment's / Instruments but not limited to the following

- a) Auto Start / Stop control
- b) Local / Remote / SCADA control
- c) MCCB / ACB for power control
- d) MCB for Control wiring
- e) Lube oil pressure
- f) Coolant temperature
- g) Low Coolant Level
- h) High Coolant Temperature
- i) Over Speed
- j) Engine start / stop key switch.
- k) D.C Voltage.
- l) Engine RPM
- m) Operating Hours Meter
- n) Over / Under Voltage
- o) Over Current
- p) Safety cutouts for low lube oil pressure high coolant temperature, over speed, emergency stop, low coolant level and fail to start
- q) Indications for the above safety cutouts
- r) Alternator Voltage and Amperage of all 3 phases
- s) Wiring harness using temperature resistant insulation and flexible copper conductor wires. The wiring should be clamped at regular intervals and terminated using lugs.
- t) Stainless steel flexible for engine exhaust
- u) Stop solenoid.
- v) Panel illuminating lights

- w) Emergency stop
- x) DG set controller with RS 485 Communication / Equivalent port to communicate to SCADA system (supplied by others) to control / monitor critical and essential system.

7. Accessories

7.1 The following accessories shall be supplied with the DG set

- a) Common base frame for the Engine and Alternator
- b) Anti-vibration mounts of reputed make in requisite quantity
- c) Protective guards for all rotating parts
- d) 18 G galvanized sheet steel trays beneath the engine, day tank and overflow collection tank to collect the oil leakage

8. Batteries

- 8.1 The batteries shall be of heavy duty, high performance & rated for continuous duty.
- 8.2 Each battery shall be rated 24 V. The number and AH capacity shall be selected to suit the engine requirements.
- 8.3 Battery shall be suitable for six successive starting attempts each of 10 seconds duration with a gap of 5 seconds between successive starts.
- 8.4 The battery shall be supplied complete with electrolyte and accessories. The accessories shall include battery stand, battery leads with terminal ends, acrylic top cover and inter battery connectors. First charging of the batteries shall be included.

9. Control cabling

- 9.1 The cables shall comply with all currently applicable Indian Standards & IEC standards and the following specific standards and codes:
- 9.2 Copper/Aluminium control cables - PVC / XLPE insulated, PVC sheathed 650/1100V grade as per IS: 1554-I & IS: 7098 - I. Overall shielding if required with Aluminium Mylar tape with 100% coverage & 25% overlap on laid up cores for static noise reduction.
- 9.3 Flexible, chord cables and wiring cables - PVC insulated & sheathed upto 1100V as per IS: 694, single and multi core.
- 9.4 Coaxial cables - RG and UR series as specified and as per MIL-C-17 / Bs: 2316 / IS 5068/ Is 11967 and suitable for 50/75/100/125 ohms
- 9.5 Signal cables as per BS:5308, DIN VDE 0815 & 816, IS: 1554, IEC: 189
- 9.6 Conductor shall be stranded / solid, circular / shaped - electrical grade aluminium / copper as per IS: 8130 and IEC: 60228 / BS: 6360.
- 9.7 Cable Insulation as per IS: 5831 / IS: 7098 and BS: 6746 / BS: 5467 / IEC: 60502
- 9.8 Inner sheath & outer sheath shall be PVC / HR PVC / PVC FRLS / PVC FR as per ST 1 / ST 2 / IEC 754 Part1 / IEC 60332 Part I & III / IEEE-383 / ASTM 2843 & 2863, EIL Specs etc.
- 9.9 Armouring shall be G.S round wire / Flat strip or Aluminium wire / Flat strip over the inner sheath as per IS 3975

10. Receipt of material at site

All material loading, unloading, transportation, (shifting and storage, safe keeping) etc., is under the scope of DG vendor.

11. Testing, commissioning, training and approvals

Testing and commissioning shall be carried out based on the specifications, data sheets, BOQ and the latest requirements of the various statutory authorities.

After installation as per the final approved drawing, the site testing shall be carried out by the vendor as specified before commissioning the DG set system. After testing the entire system to the satisfaction of the client and their representatives it shall be handed over to the client after completing the testing and commissioning formalities.

A thorough training of the operation and maintenance procedures etc as required or necessary shall be given by the vendor to the Client's representatives with appropriate write-ups and manuals / catalogues as reference for a minimum period of three months after handing over.

The documents / drawings required for obtaining the approval / sanction from the Electrical inspector, State Electricity board, State regulatory authority, Factory inspector, Pollution control board, Regulatory authority, and any other statutory agency appointed for the purpose by the state / central / municipal / local bodies shall be prepared by the DG set supplier.

12. Guarantee

The performance figures specified shall be guaranteed within the tolerance specified or as permitted by relevant standards. In case of failure of equipment to meet the guaranteed performance, the client reserves the right to reject the equipment. However, the Client also reserves the right to use the rejected equipment until new equipment meeting the guaranteed performance requirements is supplied by the vendor at no extra cost. If any equipment supplied by the vendor fails at site during erection, commissioning or service (within guarantee period), the vendor shall repair and put back into successful operation the failed equipment within the time frame and procedure of repair agreed with the client depending on nature of failure at no extra cost to the purchaser. The guarantee period shall be as specified in the commercial terms and conditions.

13. Bar chart / Network

The bidder to indicate following schedules:

- Manufacturing, Inspection & Testing at works
- Shipping

- Pre - commissioning / testing
- Commissioning
- Service kits with all filters and other consumables
- List of recommended spares for three years satisfactory operation.

14. Documentation and drawing requirements:

The following documents, drawings etc shall be submitted along with the offer:

Data sheet / Compliance and guaranteed particulars statement.

DG layout plan showing all dimensions, including operational and maintenance clearances with sections as required. The plan should also indicate ventilation requirement, civil foundations, loading data, wall openings, etc. & generator earthing requirement

Schematic diagram of control panel with accessories like AVR, AMF, and auxiliary power distribution details etc., along with cable schedule.

Terminal box drawing, literature, write-ups, description of DG set excitation system, voltage regulator, governor, & other auxiliaries, catalogues / brochures etc.

Component list with rating & ranges of all items

Single line diagram for the whole system - control and power

Technical specification sheet with brochures / catalogues and operational details for:

- DG sets
- Acoustic enclosure or Room sound proofing
- Detailed specification sheet for all auxiliary components giving material specifications, make/model, capacity, ratings etc.

15. Testing

The following tests shall be carried out at the manufacturer's works and the test results submitted to the client. The Client reserves the right to inspect the above tests or waive the inspection.

- **Tests on engine**

- Engine starting time
- 4 hour running at full load followed by 1 hour running at 110 % of load
- Fuel consumption test:
- One hour running at 100% load
- One hour running at 75% load
- One hour running at 50% load

- **Testing arrangement**

- Arrangement for loading DG by: Vendor
- Fuel charges for site testing by: Vendor

- **Shop tests**

- All the tests required by the manufactures practice or by applicable standard during the manufacture stage.
- Performance tests on the assembled diesel generator set. (With Voltage regulator)
- Check of fuel consumption at different loads.
- Measurement of Generator Winding Temperature after stabilized condition at 10 % overload.
- Measurement of cooling water temperature of engine at 10% overload as above
- Measurement of vibration
- Measurement of sound level at 1 Meter Level and 10 Meter distance
- Functional tests on fuel transfer pump.
- Dielectric and insulation tests
- Routine test on voltage regulator
- Hydrostatic Pressure test on both fuel tanks (at 2 Bars)
- Simulation of all protection
- Simulation of mains failure and mains return
- **Load tests at 0.8 Power Factor**
 - 2 Hour at 100 % rated load

- 1 Hour at 110 % rated load
- 1 Hour at 75 % rated load.
- 1 Hour at 50 % rated load.
- o Starting tests to show time of starting and load acceptance

16. Inspection, operation, maintenance Manuals

The supplier shall submit along with the delivery and/or on commissioning - as applicable, the Type & Routine test certificates / Guarantee certificates, etc.

17. Make of DG set

The concessionaire to decide and get approval from the executing agency

18. Guaranteed technical particulars for DG SET

Sl. No.	Description	Clients requirement	Vendor's confirmation
1	<u>DG Sets</u>		
	Rating of sets	adequate size as required	
	Manufacturer:		Vendor to specify
	Model No. & Type:		Vendor to specify
	Quantity	1 Nos.	
	Application:	Standby power generation - suitable for continuous full / part load operation	
	Anti-vibration mounting	Required	Vendor to specify
	Sound proofing	Acoustic enclosure	
	Total static weight with enclosure		Vendor to specify
	Total Dynamic weight with enclosure		Vendor to specify
	Exhaust line with silencer & chimney	Required	Vendor to specify
2	<u>Engine</u>		
	Make		
	Model no.:		Vendor to specify
	Name plate rating:		Vendor to specify
	BHP:		Vendor to specify

Sl. No.	Description	Clients requirement	Vendor's confirmation
	Engine speed:		Vendor to specify
	Method of starting:	Electric	
	Aspiration:	Water cooled Turbo charged	Vendor to specify
	Emission:	EURO III air emission norms or CPCB norms.	Vendor to specify
	Lube oil heater:	Required	
	Lube oil consumption:		Vendor to specify
	Cylinder jacket heating (cooling water heating) with thermostat:	Required	
	Lube oil priming facility:	Required	
	Lube oil pump:	Engine driven only	
	Engine noise level	Specify in db	
	Minimum operating time without cooling water at full load	Specify in minutes	Vendor to specify
	Combustion air flow	Meter cube / hour:	Vendor to specify
	De rating under site conditions:	Specify - if any	Vendor to specify
	No. of cylinders:	Specify	Vendor to specify
	Turbo charger	Inter / after	Vendor to specify
	Maximum time to start from cold & attain rated speed & ready to take load	Specify in seconds	
	Short time overload capacity	110% for 1 hr in 24 hrs of operation	Vendor to specify
3	<u>Cooling system</u>		
	Method of Jacket cooling:		Vendor to specify
	Heat Removal:		Vendor to specify
	Radiator fan:	Engine driven	
	Total radiated heat:		Vendor to specify
4	<u>Fuel oil system:</u>		
	Fuel oil:	High speed Diesel	
	Fuel tank level indication	Required	
	Fuel tank gauge glass	Required	
	Fuel flow meter	Specify	

Sl. No.	Description	Clients requirement	Vendor's confirmation
	Fuel transfer pump drive	If required: Engine driven	
	Fuel consumption at		
	a) Full load:	Specify in Litres/kWh	Vendor to specify
	b) 75% load:	Specify in Litres/kWh	Vendor to specify
	c) 50% load:	Specify in Litres/kWh	Vendor to specify
	d) 25% load:	Specify in Litres/kWh	Vendor to specify
5	<u>Exhaust</u>		
	Exhaust silencer type	Heavy duty Residential / hospital type	Vendor to specify
	Exhaust noise level (with silencer)	Confirming to CPCB / TNPCB norms	Vendor to specify
	Heat rejection to exhaust system	Specify in deg C over ambient	Vendor to specify
	Max. Permissible back pressure	Specify in exhaust in kg /cm sq:	Vendor to specify
	Exhaust gas flow:		Vendor to specify
	Exhaust gas temperature:		Vendor to specify
	Chimney height	Specify as required, building height is around 4.50 M	
	Emission Limits (g/KW-hr)		
	NOX + HC	Confirming to CPCB / TNPCB norms	
	CO	Confirming to CPCB / TNPCB norms	
	IPM	Confirming to CPCB / TNPCB norms	
	Smoke Limit absorption coefficient, WI (at full load)		
6	<u>Governor data:</u>		
	Make:	Specify	Vendor to specify
	Model No:	Specify	Vendor to specify
	Type:	Electronic only, give details	
	Adjustable droop provided:	Required	

Sl. No.	Description	Clients requirement	Vendor's confirmation
	Speed raise / lower from panel	Required	
7	<u>Alternator:</u>		
	Make:		Vendor to specify
	Model No:		Vendor to specify
	No. of phases:	3 phase and neutral	
	Enclosure:	IP 23	
	Terminal voltage & freq.:	415 V AC & 50 Hz	
	Time permitted to build up rated voltage	3 seconds max.	Vendor to specify
	Permissible voltage dip	10% for sudden loading of 50 %	
	Rating of biggest motor that can be started on DOL with permissible voltage dip of 10% when the generator is		
	a) unloaded:		Vendor to specify
	b) 80 % loaded:		Vendor to specify
	c) 50 % loaded:		Vendor to specify
	Power transfer:	Cable adopter box	
	Rating:	adequate size of DG set as required at 0.8 P.F	
	Insulation class-Armature:		Vendor to specify
	Field:		Vendor to specify
	Inertia time constant:	Specify kW-Sec / kVA	
	Bearing type:		Vendor to specify
	RFI suppression	Required	
	Short circuit withstand time:	Specify	
	Overload withstand capacity	Min. 150% for 15 Sec.	
	Neutral earthing:	Solidly Earthed	
	Type of Cooling:		
	Efficiency of Alternator		
	a) At 100% MCR & rated p.f.:		Vendor to specify
	b) At 75 % MCR & rated p.f.:		Vendor to specify

Sl. No.	Description	Clients requirement	Vendor's confirmation
	c) At 50 % MCR & rated p.f.:		Vendor to specify
	Max continuous & momentary unbalanced load capacity:		
	Asymmetrical short circuit withstand capability & duration:	Specify	Vendor to specify
	Open circuit transient time constant:	Specify	Vendor to specify
	Short circuit ratio:	Specify	Vendor to specify
8	<u>Exciter</u>		
	Type of excitation	Brushless	
	Capacity		Vendor to specify
	Operating voltage & current:		Vendor to specify
	Duration of field forcing:		Vendor to specify
	Class of insulation:		Vendor to specify
9	<u>AVR</u>		
	Type of A V R:	Self-regulated	
	Mounting of AVR:		Vendor to specify
	Dead band: %		Vendor to specify
	Response time:		Vendor to specify
	Voltage of operation:		Vendor to specify
	Line drop compensator provided to maintain bus voltage constant:	Required	
	Range of voltage adjustment:	Specify	Vendor to specify
	Fine tuning adjustment:	Specify	Vendor to specify
10	<u>Set mounted panel</u>		
	The following analogue type indicators with 4 -20 mA output ports to be provided:		
	Lube oil Temperature indicator:	Required	
	Make:	Specify	Vendor to specify
	Type:	Specify	Vendor to specify
	Accuracy:	Specify	Vendor to specify

Sl. No.	Description	Clients requirement	Vendor's confirmation
	Fuel oil Pressure Indicator:		
	Make:	Required	
	Type:	Specify	Vendor to specify
	Accuracy:	Specify	Vendor to specify
	Lube oil Pressure Indicator:	Required	
	Make:	Specify	Vendor to specify
	Type:	Specify	Vendor to specify
	Accuracy:	Specify	Vendor to specify
	Engine Speed Indicator:	Required	
	Make:	Specify	Vendor to specify
	Type:	Specify	Vendor to specify
	Accuracy:	Specify	Vendor to specify
	Any other indicator required for the engine protection to be recommended by the vendor.	Specify	Vendor to specify
11	<u>Painting:</u>		
	Surface Pre-treatment:	Sand blasting / Chemical cleaning	
	Primer:	Two coats of primer	
	Final Paint Shade:	Siemens grey as per IS 5 or as approved	
	Minimum Paint Thickness:	100 microns	
12	<u>Acoustic enclosure</u>	-	
	Make:		Vendor to specify
	Model No:		Vendor to specify
	Type:		Vendor to specify
	Application	Outdoor / IP54 rating	
	Sound Level	Confirming to CPCB / TNPCB norms	
13	<u>Control & power panel</u>	-	
	Cabinet Construction:	Mounted inside the enclosure	

Sl. No.	Description	Clients requirement	Vendor's confirmation
	Degree of protection:	IP54	
	Access:	Front / Back	
	Cable entry:	TOP / BOTTOM and as per site requirements	
	Controller:	Integrated Microprocessor:	
	Make:		Vendor to specify
	Model No:		Vendor to specify
	Type:		Vendor to specify
	No. of starting commands in single attempt in Auto position: min.	3 minimum	
	Time gap between commands:	Specify in seconds	
	Auto stop on resumption of main supply:	Required with inbuilt time delay.	
	Note		
	DG control & On, Off status to be communication port with SCADA system		
14	<u>Miscellaneous</u>		
	Guaranteed output in KWH unit generated per litre of HSD		
	Alternator to care of 3 RD , 5 TH , 7 TH Harmonic distortion.		

19. Earthing and lightning protection

19.1 General

The metallic body / enclosure of all electrical equipment shall be earthed with a minimum of 2 distinct earth connections of adequate size earth conductors.

Earthing shall be in conformation with IS 3043

19.2 Earth station

○ Pipe electrode earthing

Earth electrode shall be of minimum 40 mm dia class “B” GI Pipe 3.0 m long with tapered bottom and with 12 mm dia holes at 75 mm c/c on all sides for bottom 2.0 m with top watering arrangement.

○ Plate electrode

600 x 600 x 6 mm GI plates with 25 mm dia watering pipe with funnel buried at a depth of 2.5 m forms earth electrode. Earthing strip is directly brought to chamber/disconnecting link in protective pipe.

Earth electrode shall be back filled with alternate layers of charcoal and salt are provided through out height of electrode with overall 300 mm cover

19.3 Inspection chamber

Brick masonry chamber of size 450 x 450 x 450 mm with heavy duty cast iron cover and frame with top at ground level are provided for watering arrangement.

19.4 Soil treatment

In case of rocky soil or hard murrum, soil resistance is very high. Hence, for getting lower resistivity values, the Concessionaire shall carryout artificial soil treatment to achieve the required level of lower resistance as per IS.

The earth resistance shall not exceed 1.0 ohms in any case. The Concessionaire shall provide additional earth pits to get the desired earth resistance value of 1.0 ohm.

19.5 Lightning protection

Lightning protection shall be in confirmation with IS/IEC : 62305.

The lightning protection to the buildings shall be effected by use of conventional vertical lightning air termination or horizontal faraday cage or by a combination of both. G.I tapes

/ strips or aluminium circular conductor shall be laid on all parapet walls and as down conductors.

Conventional spike type lightning arrestor shall be mounted at the highest point of the building and a supporting pole shall be used to achieve the desired height and angle of coverage.

The down conductors shall be brought down from parapet / terrace level to ground level duly ensuring that adequate side flashing distance is maintained between the down conductor and other metallic pipes, if any, running parallel from terrace to ground.

A Test and disconnecting link box shall be provided at a height of 1.0 mtr from G and the down conductor shall be terminated onto this link. Beyond this link 25 x 6 mm GI strip shall be run up to earth station.

Earth station for lightning protection system shall of 600 x 600 x 6 mm GI plate earthing.

19.6 Inspection and testing

The consultant and the representative of the Owner shall have free access to vendor's works to inspect, expedite and witness shop tests. Any materials or works found to be defective or which does not meet the requirements of this specification will be rejected and shall be replaced at supplier's cost. Purchaser reserves the right to carryout stage wise inspection.

All routine tests shall be carried out on the electrical equipment as per relevant Indian Standard Specifications. The delivery of the electrical equipment / electrical items shall be accompanied with copies of such routine test certificates clearly mentioning reference to the P.O No., Line item No. of P.O, quantity as per P.O, quantity inspected and passed, Governing IS for testing, test results and details of test equipment with their calibration details.

Section - G5.3
Erection, testing and commissioning

Section G5.3: Erection, testing and commissioning

1. Equipment installation, testing and commissioning

1.1 Installation of equipment

- a) In accordance with the specific installation instructions, as shown in the Concessionaire's drawings or as directed by the Executing Agency, the Concessionaire shall unload, erect, install, wire, test and place into use of all electrical equipment included in the contract. Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square and properly aligned and oriented.
- b) The Concessionaire shall furnish all supervision, labour, tools, equipment, rigging materials and incidental materials such as bolts, wedges, anchors, concrete inserts etc. required to completely install, test and adjust the equipment.
- c) Drawings, instructions and recommendations shall be correctly followed in handling, settling, testing and commissioning of all equipment and care shall be exercised in handling to avoid distortion to stationary structures, the marring of finish, or damaging of delicate instruments or other electrical parts.
- d) The Concessionaire shall erect and commission the equipment as per the instructions of the Executing Agency and shall extend all co-operation to him.
- e) In case of any doubt / query as to correct interpretation of drawings or instructions, necessary clarification shall be obtained from the Executing Agency. The Concessionaire shall be held responsible for any damage to the equipment consequent to not following instructions correctly.
- f) The Concessionaire shall move all equipment into the respective buildings through regular doors or floors openings provided specifically for the equipment. The Concessionaire shall make his own arrangement for lifting of equipment.
- g) Where assemblies are supplied in more than one section, the Concessionaire shall make all necessary mechanical and electrical connections between sections including the connections between bus bars / wires. The Concessionaire shall also carry out the

adjustments/alignments necessary for proper operation of the circuit breakers. All insulators and bushings shall be protected against damage during installation. Insulators or business chipped, cracked or damaged due to negligence or carelessness shall be replaced by the Concessionaire at his own expenses.

- h) The Concessionaire shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments or relays are supplied separately, they shall be mounted only after the associated control panels have been erected and aligned. The blocking material/mechanism employed for the safe transit of the instruments and relays shall be removed after ensuring that the panels have been completely installed and no further movement of the same would be necessary. Any damage to relays and instruments shall be immediately reported to the Executing Agency.
- i) Care shall be taken during handling on insulating oil to prevent ingress of moisture or foreign matter. In the testing, circulation, filtering, or otherwise handling of oil, rubber hose shall not be used. Circulation and filtering of oil, the heating of oil by regulated short-circuit current during drying runs and sampling and testing of oil shall be in accordance with the latest Code of Practice IS:10028 (Part II) shall be carried out.
- j) Inspection, storage, installation, testing and commissioning of transformers shall be in accordance with the latest Indian Standard Code of Practice IS:10028. All commissioning tests as applicable, vide Appendix B of IS:10028 (Part II) shall be carried out.
- k) Switchgear, relay and control panels shall be installed in accordance with the latest Indian Standard Code of Practice IS:10118. The switchgear panels shall be installed on finished surface or concrete or steel sills. The Concessionaire shall be required to install and align any channel sills which form part of the foundations. Tape or compound shall be applied where called for. The base of outdoor type units shall be sealed in approved manner to prevent ingress of moisture.
- l) After installation of all power and control wiring, the Concessionaire shall perform operating tests on all switchgear and panels to verify the proper operation of switchgear/panels and the correctness of the interconnections between various items of equipment. This shall be done by applying normal AC or DC voltage to the circuits

and operating the equipment. Megger tests for insulation, polarity installation tests shall be carried out by the Concessionaire who shall also make all necessary for proper functioning of the equipment.

- m) Installation and testing of the battery and battery chargers shall be done in strict compliance with the applicable standards. Each cell shall be inspected for breakage and condition of cover seals as soon as received at site. The battery shall be set up on racks as soon as possible after receipt, utilizing lifting devices. The cells shall not be lifted by terminals. Contact surface of the battery terminals and inter cell connectors shall be cleaned, coated with protective grease and assembled. Each connection shall be properly tightened. Each cell shall be tested with an hydrometer and thermometer and the results logged. A freshening charge, if required, shall be added. When handed over to the Executing Agency, the battery shall be fully charged and the electrolyte shall be at the full level of the specified specific gravity.
- n) Equipment furnished with finished coats of paint shall be touched up by the Concessionaire if their surface is spoiled or marred while handling.
- o) Foundation work and grouting-in of fixing bolts or channels for all transformer, switchgear, motors and control panels will be carried out by the Concessionaire.

1.1.1 Installation work for earthing and lightning protection system.

- o The Concessionaire shall install aluminium / copper / steel conductors, braids, etc. required for the system and individual equipment earthing. All work such as cutting, bending, supporting, painting/coating, drilling, brazing/soldering/welding, clamping, bolting and connecting onto structures, equipment frames, terminals, rails or other devices shall be in the Concessionaire's scope of work. All incidental hardware and consumables such as fixing cleats/clamps, anchor fasteners, lugs, bolts, nuts, washing, bituminous.
- o The quantities, sizes, materials of earthing conductors and electrodes to be installed as per requirement. Routes of the conductors and locations of electrodes shall be as shown on the project drawings.
- o The work of embedment of earthing conductor in RCC floors / walls along with provision of earth plate inserts / pads / earth risers shall be done by the Concessionaire

when the floors are cast or during construction of walls. The Concessionaire's scope of installation shall include laying the conductors in position with 50 mm concrete cover, making welded connections to inserts/pad/risers above the floor near the equipment. The embedded conductors shall be connected to reinforcing rods wherever necessary.

- If the tap connections (earthing leads) from the floor embedded main earthing grid to the equipment are more than 500 mm long then the same shall be embedded in floor by the Concessionaire where required, together with associated civil work such as excavation / chasing, concreting and surfacing, if not already done in the civil work. The concrete cover over the conductor shall not be less than 50 mm.
- Installation of earth conductors in outdoor areas, buried in ground, shall include excavation of earth upto 600 mm deep 450 mm wide, laying of conductors at 600 mm depth, brazing / welding as required, of main grid conductor joints as well as risers of length 500 mm above ground at required locations and then backfilling material to be placed over buried conductor shall be free from stones and other harmful mixtures. Backfill shall be placed in layers of 150 mm, uniformly spread along the ditch and tampered utilizing pneumatic tampers or other approved means. If the excavated soil is found unsuitable for backfilling, the Concessionaire shall arrange for suitable material from outside.
- Installation of earth connection leads to equipment and risers on steel structures / walls shall include laying the conductors, welding / cleating at specified intervals, welding / brazing to the main earth grid risers, bolting at equipment terminals and coating welded / brazed joints by bitumen paint. Galvanized conductors shall be touched up with zinc rich paint where holes are drilled at site for bolting to equipment / structure.
- Electrodes shall be installed (a) directly in earth, or (b) in constructed earth pits and connected to main buried earth grid. The scope of work shall include excavation, construction of the earth pits including all materials required for construction of earth pits, placing the rod and fixing test links on those pipe / rod / plate electrodes in test pits and connecting to main earth conductors.
- Installation of lightning conductors on the roofs of buildings shall include laying, anchoring, fastening and cleating of horizontal conductors, grouting of vertical rods

wherever necessary, laying fastening / cleating / welding of the down comers on the walls / columns of the building and connection to the test links to be provided above ground level.

- Installation of the test links shall include mounting of the same at specified height on wall / column by suitable brackets and connections of the test link to the earth electrode.
- Whenever main earthing conductor crosses cable trenches, they shall be buried below the trench floor.
- Suitable earth risers shall be provided above finished floor/ground level. If the equipment is not available at the time of laying of the main earth conductors, the minimum length of such riser inside the building shall be 200 mm and outdoors shall be 500 mm above ground level. The risers to be provided will be marked in project drawings.
- Earth leads and risers between equipment earthing terminal and the earthing grid shall follow as direct and short a path as possible.
- Wherever earthing conductors passes through walls galvanized iron sleeves shall be provided for the passage of earthing conductor. The pipe ends shall be sealed by the Concessionaire by suitable water proof compound.

1.1.2 Earthing connections

- All connections in the main earth conductors buried in earth/concrete and connection between main earthing conductor and earth leads shall be of welded type.
- Connection between earth leads and earthing terminal provided on the equipment shall be bolted type.
- All bimetallic connections shall be treated with suitable compound to prevent moisture ingress.
- Metallic conduits and pipes shall be connected to the earthing system.
- Lightning protection system down conductors shall not be connected to other earthing conductors above ground level. Also no intermediate earthing connection shall be made to lightning arrestor and transformer earthing leads which shall be directly connected to plate electrode.

1.1.3 Earth electrodes

- Electrodes shall as far practicable, be embedded below permanent moisture level.
- Test pits with concrete covers shall be provided for periodic testing of earth resistance. Installation of plate electrodes in test pits shall be suitable for watering. The necessary materials required for installation work shall also include civil work such as excavation and connection to main earth grid.
- Earth pits shall be treated with salt and charcoal.
- Soil, salt and charcoal placed around the electrode shall be finely graded, free from stones and other harmful mixtures. Backfill shall be placed in layers of 250 mm thick uniformly spread and compacted. If excavated soil is found unsuitable for backfilling, the Concessionaire shall arrange for a suitable soil from outside.

1.1.4 Lightning protection system

- The lightning protection of air termination rods and/or horizontal air termination conductors shall be fixed in such a way that they remain in their installed position even during severe weather conditions. The necessary accessories such as cleats, clamps, welding materials, bolts, nuts shall be supplied by the Concessionaire.
- Air termination system shall be connected to earthing system by down conductors. The down conductors shall follow a direct path to earth. There shall not be any sharp bends, turns and kinks in the down conductors.
- All joints in the down conductors shall be of welded type. All metallic structures within 2 metres of down conductors shall be bonded to lightning protection system.
- Every down conductor shall be provided with a 'test link' at about 1000 mm above ground level housed in a suitable G.I. enclosure made of adequate thickness steel sheet and hot-dip galvanised. The test joint shall be directly connected to the earthing system electrode.
- The lightning protection system shall not be in direct contact with underground metallic service ducts, cables, cable conduits and metal enclosures of electrical equipment. However, all metal projections, railings, vents, tanks, etc. above the roof shall be bonded together to form a part of roof grid.

1.2 Installation of cable racks and trays

- a) Lines and grade for trays may be measured from building steel and finished floor elevations. Changes in line or grade, or the addition of offsets by means of cutting standard tray sections and inserting additional tray fittings to match with the existing arrangement shall be considered as a normal part of the work.
- b) Where embedded steel inserts in concrete floors/walls for welding the supports for cable racks/trays are not available, Concessionaire shall provide suitable anchor fasteners at no extra cost.
- c) Cable shall be clamped to the cable trays at regular intervals.
- d) Flexible metallic conduits shall be used for termination of connection to equipment such as motors, limit switches and other apparatus.

1.3 Installation of cables

- a) The Concessionaire shall install, test and commission the cables specified in the specification in accordance with drawings & instructions issued by the Executing agency representative. Cables shall be laid directly buried in earth, on cable racks, in built-up trenches, on cable trays and supports, in conduits and ducts or bare on walls, ceiling etc. as per drawings. Concessionaire's scope of work includes unloading, laying, fixing, jointing, bending and termination of the cables. The Concessionaire shall also supply the necessary materials and equipment required for jointing and termination of the cables.
- b) All apparatus, connections and cable work shall be designed and arranged to minimise risk of fire and any damage which might be caused in the event of fire. Wherever cables pass through floor or wall openings or other partitions, suitable bushes of an approved type shall be supplied and put into position by the Concessionaire.
- c) Standard cable grips and reels shall be utilised for cable pulling. If unduly difficult pulling occurs, the Concessionaire shall check the pull required and suspend pulling until further procedure has been approved by the Executing Agency. The maximum pull tension shall not exceed the recommended value for the cable measured by the tension dynamometer. In general, any lubricant that does not injure the overall covering and does not set up undesirable conditions of

electrostatic stress or electrostatic charge may be used to assist in the pulling of insulated cables in conduits and ducts.

- d) After pulling the cable, the Concessionaire shall record cable identification with date pulled neatly with waterproof ink in linen tags. Identification tags shall be attached securely to each end of cable with non-corrosive wire. The said wire must be non-ferrous material on single conductor power cable. Tags shall further be attached at intervals on long runs of cables on cable trays and in pull boxes. Cables and joint markers and RCC warning covers shall be provided wherever required. All cables shall be allocated a unique number which shall be fixed to each end of the cable using corrosion resistant label. Cable of different categories shall be tagged with the following subscripts and three digit number.

- HV power HV-P _____
- LV power P _____
- Control C _____
- Instrumentation I _____
- Protection PR _____
- Telecommunication T _____

- e) Sharp bending and kinking of cables shall be avoided. The bending radii for various types of cables shall not be less than those specified below :

- KV XLPE multicore armoured cables: 15 times the overall dia of the cable
- 650 / 1100 V PVC insulated armoured cables: 12 times the overall dia of the cable

If shorter radius appears necessary, no bend shall be made until clearance and instructions have been received from the Executing Agency.

- f) Power, control and instrumentation cables shall be laid in separate cable racks / trays.
- g) Where groups of HV, LV and control cables are to be laid along the same route, suitable barriers to segregate them physically shall be provided.

- h) Cables of different categories shall be installed so as to maintain satisfactory clearances for safety and in order to reduce the possibility of electrical interference. The following table gives the distances in mm that shall be maintained between the different categories / voltage grade of cable.

Cable category	HV Power	LV Power	C&I Protection	Telecommunication / data network
HV Power	-	275	550	550
LV Power	275	-	275	275
C&I Protection	550	275	-	275
Telecommunication	550	275	275	-

- i) Where cables cross roads and water, oil, gas or sewage pipes, the cables shall be laid in reinforced spun concrete or steel pipes. For road crossings the pipe for the cables shall be buried at not less than one metre depth.
- j) Cables laid in ground shall be laid on a 50 mm riddled earth bed. The cables shall then be covered on top and at their sides with riddled earth of depth of about 150 mm. This is then gently filled up to a depth of about 100 mm above the top of uppermost cable to provide bedding for the protective cable covers which are placed centrally over the cables. The protective cable covers for LV cables may be of earthenware and for HV cables of reinforced concrete. The RCC covers shall have one hole at each end, to tie them to each other with GI wires to prevent displacement. The trench is then backfilled with the excavated soil and well rammed in successive layer of not more than 300 mm depth, with the trenches being watered to improve consolidation wherever necessary. To allow for subsidence, it is advisable to allow a crown of earth not less than 50 mm in the centre and tapering towards the sides of the trench.
- k) In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints to be made, should the cable develop a fault at a latter date.
- l) Cables on cable racks, on cable trays and conduits shall be formed to avoid bearing against edges of trays, racks, conduits or their supports upon entering or leaving trays, racks or conduits. Cables shall be racked or laid directly into cantilevered cable trays where practicable, but in some cases it may be necessary that cables

are pulled or threaded into trays. To facilitate visual tracing, cables in tray shall be laid only in single layers and unnecessary crossing of cables shall be avoided. Cables on trays shall finally be clamped in an approved manner.

- m) Cable splices will not be permitted except where permitted by the Executing Agency. Splices shall be made by Concessionaire for each type of wire or cable in accordance with the instructions issued by cable manufacturer's and the Executing Agency. Before splicing, insulated cables shall have conductor insulation stepped and bound or pencilled for recommended distance back from splices to provide a long leakage path. After splicing, insulation equal to that on the spliced conductors shall be applied at each splice.
- n) Jointing of cables shall be in accordance with relevant Indian Standard Code of Practice. Materials and tools required for cable jointing work, including cold setting bituminous compound shall be supplied by the Concessionaire. Cables shall be firmly clamped on either side of a straight through joint at a distance of not more than 300 mm away from the joints. Identification tags shall be provided at each joint at all cable terminations.
- o) At cable terminal points where the conductor and cable insulation will be terminated, termination shall be made in neat, workmanlike and approved manner by men specialised in this class of work.
- p) Control cable termination shall be made in accordance with wiring diagrams, using colour codes established by the Executing Agency for the various control circuit, by code marked wiring diagram.
- q) When control cables are to be fanned out and cabled together with cord, the Concessionaire shall make connections to terminal blocks, and test the equipment for proper operation before cables are corded together. If there is any question as to the proper connection, the Concessionaire shall make a temporary connection with sufficient length of cables so that the cable can be switched to another terminal without splicing. After correct connections are established through operating the equipment, cables shall be cut to their correct lengths, connected to terminals in the specified manner, and corded together where necessary to hold them in place in a workmanlike manner.

- r) Cable seals shall be examined to ascertain if they are intact and that cable ends are not damaged. If the seals are found to be broken the cable ends shall not be jointed until after due examination and testing by the Executing Agency. Before jointing is commenced, insulation resistance of both sections of cables to be jointed shall be checked by megger.
- s) After installation and alignment of motors, the Concessionaire shall complete the conduit installation, including a section of flexible conduit between motor terminal box and trench/tray. The Concessionaire shall install and connect the power, control and heater supply cables as per equipment manufacturer's drawings, if any.
- t) For directly buried underground cables, Concessionaire shall install galvanised cast iron cable markers over ground, at all bends, loops, joints, crossing points and at every 25 meters interval on straight runs. The cable markers shall be anchored in the ground to a depth of minimum 500 mm. The cable markers for L.T. cables & HT cables shall be distinctly different in shape and marked as L.T. Cables and HT Cables as the case may be by 30 mm size letters.

1.4 Lighting system installation

This covers the requirements of installation of the following :-

- a) Lighting fixtures complete with lamps and accessories
- b) Main Lighting distribution board
- c) Lighting panels
- d) Receptacles and lighting control switches
- e) Point wiring
- f) Street lighting poles and flood light towers
- g) Multicore cables for street and boundary lighting
- h) Maintaining equipment/materials during storage and being responsible for the equipment/material until they are handed over to the Executing Agency.
- i) Installation, testing and commissioning shall be carried out in accordance with the drawings and as stipulated in this specification.

1.4.1 Applicable standards

Electrical wiring installations : IS:732

(system voltage exceeding 650 V)

Code of practice for interior illumination (Part-1)	:	IS:3646/BS:8206
Code of practice for street lighting installation	:	IS:1944
Code of practice for industrial lighting	:	IS:6666
Code of practice for fire safety of building	:	IS:1646
Boxes for enclosure of electrical accessories	:	IS:5133 (Part I)
Guide for safety procedures and practices in electrical work	:	IS:5216
Ceiling roses	:	IS:371

1.4.2 **Lighting fixtures**

- a) The installation of lighting fixtures shall be based on the mounting arrangement shown in the drawings enclosed. Installation shall include all materials required to mount the fixtures in the manner as shown in the drawings. Installation of lighting fixtures shall include installation of control gear box wherever applicable.
- b) Installation of receptacles and switches shall be carried out suitably as per the lighting layout drawings prepared by Concessionaire and approved by Executing Agency. Switch shall be mounted in flush with the front cover plate. Supply and installation of necessary hardware shall be included in the scope for installation of receptacles/switches.
- c) Lighting distribution boards shall be installed at the location indicated in the layout drawings prepared by Concessionaire and approved by Executing Agency. Installation rates quoted for installation of lighting distribution boards shall include supply and installation of base channels, foundation bolts, etc.
- d) Outdoor lighting distribution boards shall be installed on a concrete plinth. The top of plinth shall be 100 mm (min.) above the ground level. Construction of concrete

plinth shall be included in the installation of outdoor lighting distribution board. Installation cost of lighting distribution board shall include installation of earthing conductor from LDB to the nearest earthing grid.

1.4.3 Point wiring

➤ **Supply and installation of conduit point wiring**

- The point wiring shall include supply of necessary materials for the conduit wiring such as galvanised rigid steel conduit, galvanised M.S. fixing saddles with spacer plates, nylon/fibre plugs, galvanised M.S. fixing screws, 12 SWG galvanised steel earthing wire, PVC insulated copper or aluminium conductor wires, control switches and pulling, termination of the earthing/PVC insulated wires as required, installation of control switches, drilling holes in brick walls/RCC roof slabs for taking the wiring conduits and refinishing any other works/material necessary for making point wiring complete in all respects.
- Wires used for conduit point wiring of lighting fixtures/ceiling fans and receptacles shall be 1100 V grade, PVC insulated, single core, stranded copper conductor wires of sizes not less than 1.5 sq.mm and 2.5 sq.mm respectively. Wires shall conform to IS:694 and shall bear the ISI mark.
- Bidder shall take into consideration necessary galvanised MS fixing clamps when the wiring conduits are to be supported from steel roof truss/structural members.

➤ **Point wiring shall also include/hold good for the following:**

- Supply and installation of lighting control switches and switchboxes complete with fixing accessories.
- Drilling holes in brick/RCC wall & roof for taking cable or conduit, sealing and refinishing with cement plaster.
- Testing, commissioning and handing over the lighting system in commercial working condition.

➤ **Outdoor Lighting (Street and Flood Lighting)**

The following shall be deemed to be included as part of the installation work for outdoor lighting point wiring.

- Installation of multicore/single core cables between LDB and junction box mounted on street light pole/flood lighting tower, from junction box to metal enclosed control gear box.
- Supply and installation of crimping type cable lugs, double compression type cable glands at each junction box and fixture, termination and testing and commissioning of cables.
- Concessionaire's scope shall also include excavation and preparation for buried cables. Supply and installation of route markers, supply and installation of HDPE pipes for road crossing shall also be included.
- Supply and installation of necessary cleating arrangement for cabling on flood light poles.
- Concessionaire shall provide necessary foundation for erecting street light pole/flood light tower and install the same. Concessionaire shall prepare foundation drawings with necessary details to Executing Agency for approval.
- Concessionaire shall plan and cut the cables in such a way that there is no wastage and no cable jointing is required in any run. However, should any joint become necessary, the same shall be provided by the Concessionaire and joint marker shall also be provided at no extra cost.
- Earthing of street light pole/flood light tower, lighting fixtures, control gear boxes, junction boxes, etc. are also included in the scope of installation. Concessionaire shall earth street light pole/flood light poles and junction box with 25 x 3 mm G.S. flat tap off from the 25 x 3 mm M.S. flat earthing grid along the street lighting included in the scope. The Concessionaire shall interconnect earthing grid to plant main earthing grid at first and last pole of each feeder circuit and at one intermediate pole.

➤ **Installation of lighting poles & towers for outdoor lighting (Street and flood lighting)**

- Work includes supply and installation of street light poles and flood light towers including associated junction boxes with fuses, links and terminals for junction boxes and junction boxes near each flood light fixtures.
- All street light poles and towers shall be painted with two coats of red oxide oil primer followed by two coats of aluminium alkyd paint.

➤ **Installation of Lighting Distribution Board, Lighting Panels (AC & DC), 240 V, AC 1-Phase Distribution Boards**

Installation of above items shall include necessary foundation channels, bolts/nuts, etc. for grouting lighting distribution boards, iron brackets/grouting brackets, bolts/nuts for wall/column mounted panels and associated civil works.

1.5 Point wiring

1.5.1 Wiring

- a) Wiring shall be carried out strictly as per project drawings and technical specification. All exposed conduit wiring shall have provision for easy inspection. Exposed wiring when run along wall shall be as near the ceiling as possible. Where cable wiring is specified cable shall be cleated on to the wall as close to the ceiling as possible. In all types of wiring due consideration shall be given for neatness and appearance.
- b) Wherever DC emergency lighting is provided, emergency lighting wires shall run in a separate conduit. Colour of the wires used shall be as follows; white for positive, black for negative.
- c) Wherever lighting system has three phase distribution, separate conduits shall be used for different phases. For easy identification of phases and neutral wires, the following colour wires shall be used.

- | | | | |
|-------|-----------|---|--------|
| (i) | R - Phase | - | Red |
| (ii) | Y - Phase | - | Yellow |
| (iii) | B - Phase | - | Blue |

(iv) Neutral - Black

- d) There shall be a circuit breaker or a linked switch on each live conductor of supply mains at the point of entry. The wiring throughout the installation shall be such that there is no break in neutral wire in the form of switch or fuse unit.
- e) Conductors not arranged for connection to the same system or supply different phases of the same supply, shall be kept apart throughout their entire run.
- f) Receptacles and lighting fittings in general shall be fed from different circuits. Five amps receptacles for toilet or small rooms can be fed from the lighting circuit with proper isolating arrangement.
- g) Each final sub-circuit from a lighting panel shall be controlled by a single pole switch connected to the live conductor.
- h) For long conduit wiring runs, inspection/pull boxes shall be provided at intervals not exceeding 10 m. Such facilities shall also be provided at conduit bends.

1.5.2 General practices

- a) All receptacles and switches to be installed in offices and control rooms shall be flush mounted within the wall and those in other areas shall be wall or column mounted.
- b) Ceiling roses shall not embody fuse terminals as an integral part. For voltages exceeding 250 volts, a ceiling rose or any similar attachment shall not be used.
- c) A socket outlet shall not embody fuse terminals as an integral part of it. The switch controlling the socket outlet shall be on the live side of the line.
- d) All exposed metal parts of the plug, when the plug is in complete engagement with the socket outlet, shall be in effective electrical connection with the earthing pin.

1.5.3 Earthing

- a) Exposed conduits and fittings shall be earthed by 12 SWG GI wires run along the length of the conduit and secured by means of suitable clamps efficiently fastened to conduit tip. To achieve perfect electrical continuity, the conduits shall be bonded effectively on either end of a coupling and other joints. In case of concealed wiring 1.5 / 2.5 sq.mm PVC insulated wire inside the conduit shall be used for earthing.
- b) Conduits shall be earthed at the ends adjacent to switch boards at which they originate or otherwise at the earth clip, clamp or gland, in effective electrical contact with the conduit.
- c) For outdoor lighting poles the earthing conductor shall be terminated upto the junction box on the pole and 12 SWG wire shall be taken up to the pole fitting.

1.6 Pre-Commissioning checks and commissioning

All checks and tests shall be as per the Manufacturer's drawing manuals, relevant codes of installation and commissioning check lists as given below :-

- a) Among other commissioning tests, the following shall be carried out at site after completion of installation. Concessionaire shall ensure to use calibrated test equipment having valid calibration test certificates from standard laboratories

traceable to National Standards / International Standards. All tests to be carried out in the presence of Executing Agency.

(i) For Transformers

Dielectric strength of transformer oil. Operation of all protective equipment, voltage/turns ratio at all taps, winding resistance at all taps, vector group test, phase sequence test, buchholz relay operation (alarm and trip), OLTC control indicating and alarm circuits, lightning arrestor installation, test the bushing oil for dielectric strength.

(ii) For Switchgear

Power frequency high voltage test, operation tests.

(iii) For Relays

Check internal wiring, relay settings.

Satisfactory operation over their whole operating range by secondary injection. Check the minimum pick up voltage of D.C. coils, megger all terminals to body and AC to DC terminals.

(iv) Relay and Control Panel

Switch development, check on relays, check on metres, functional checking of all control circuit, e.g. closing, tripping, control, interlock, supervision, and alarm circuits including proper functioning of the component equipment.

(v) Circuit breakers

Manual operation of breakers, power closing/opening operation manually and electrically, breaker closing and tripping time, trip free and anti pumping operation, control wiring for correctness of connections, continuity and IR value, electrical and mechanical interlocks, all functional checks on CTS, checks on spring charging motor.

(vi) Battery

Special gravity test, cell voltage check, capacity test as per IS, Initial charging cycle.

(vii) Battery charger & D.C. Distribution Board

Functional check of auxiliary devices such as alarms, indicating etc., measurement of voltage regulation.

(viii) Voltage transformers

Polarity test, ratio test on all cores, oil level and leakages, 'Insulation resistance test', earthing connection.

(ix) Current Transformer

Megger between windings and winding terminal to body, polarity test, capacitance and tan delta test.

(x) Cables

- All new cables shall be tested for its insulation strength before terminating / jointing. After terminating / jointing is completed of all L.V. (i.e. 650/1100V) cable shall be tested by 1000V megger. All H.T. Cables (i.e. 11 KV) shall be tested by 2500 V motor operated megger.
- Cable core shall be tested for
 - Continuity
 - Absence of cross phasing
 - Insulation resistance to earth
 - Insulation resistance between conductors

(xi) Earthing and Lightning Protection System

The Concessionaire shall ensure the continuity of all conductors and joints. The Executing Agency may ask for earth continuity tests earth resistance measurements and other tests which in his opinion are necessary to prove that the system is in accordance with design, specification, code of practice and electricity rules. Earth resistance value should be not greater than one (1) ohm,

(xii) Lighting System

Before putting complete system into service, commissioning tests stipulated in applicable standards and code of practice shall be carried out by the Concessionaire in the presence of the Executing Agency covering all lighting system equipment.

(xiii) The Concessionaire shall carry out insulation resistance tests by megger of following rating:

- Control circuits upto 220 V : 500 V megger
- Power circuits upto 1.1 KV : 1000 V megger

1.7 Safety procedure and practice

Following safety procedure and practice should be provided by concessionaire in switchgear room/sub-station as per latest edition of I.S. 5216.

a) Rubber matting

- (i) In front of 11 KV switchgear.
- (ii) In front of 415 V switchgear and other panel in switchgear room.

b) Shock treatment charts

- (i) One chart near 11 KV switchgear room
- (ii) One chart near 415 V switchgear room

c) Caution/Danger Board

- (i) 11 KV switchgear
- (ii) 11 KV capacitor panel
- (iii) 415 V switchgear
- (iv) Transformer near H.T. cable box
- (v) All power Distribution Board

d) Fire Safety

The requirement of hand appliance in switchgear room, electrical equipment room shall be provided as per Clause 4.0 of Fire Protection Manual by Regional Traffic Committee, 10th edition 1988.

Section - G5.4
Instrumentation Works

Section G5.4: Instrumentation Works

1. General

The Concessionaire is required to adopt the latest technology with compatible automation system having fully automatic process control, The “Plant Control Configuration” attached to the Scope of Works gives basic and minimum requirement of Instrumentation and Control Automation with electrical interface. ON LINE to monitor and control the plant from a single location. The plant data collected through online monitoring of water quality and flow shall be made available via the internet to various statutory bodies.

2. General requirements

This part covers the general requirements for the design, supply, installation, inspection and testing of the instrumentation and automation solution proposed for flow measurement, monitoring of water quality and control of plant.

3. Reference Standards

Unless otherwise approved, instrumentation shall comply with relevant quality standards test procedures and codes of practice collectively referred to as Reference Standards including those listed below in accordance with the requirements detailed elsewhere in this specification.

IEC 60381-1:1982 Analogue signals for process control systems.

4. Specification for direct current signals:

- IEC 60947-4-1:2000 Specification for low-voltage switchgear and Control Gear. Contactors and motor-starters. Electromechanical contactors and motor-starters.
- IS 15953 : 2011
- ISA-5.1-2009
- IEC 62443
- IEC 61346
- IEC 60870-6- all parts
- IEC 61131-3 industrial control programming standard advancements
- IEC 61850 all parts ranging from 1 - 10

- IEC 61850-10:2012 - Conformance testing 118
- IEC TR 61850-90-3:2016 - Using IEC 61850 for condition monitoring diagnosis and analysis + IEC TR 61850-90 all parts
- IEC 60947-4-2:1999 Specification for low-voltage switchgear and Control Gear. Contactors and motor-starters. A.C. semiconductor motor controllers and starters.
- IEC 60947-4-3:1999 Specification for low-voltage switchgear and Control Gear. Contactors and motor-starters. Contactors and motor-starters. AC semiconductor controllers and contactors for non-motor loads.
- IEC 60770-1:1999 Transmitters for use in industrial-process control systems. Methods for performance evaluation.
- BS ISO 1217:1996 Displacement compressors. Acceptance tests.
- ISO 2112:1990 Specification for aminoplastic moulding materials.
- ISO 6817:1997 Measurement of conductive liquid flow in closed conduits. Method using electromagnetic flow meters.
- BS EN 837-1:1998 Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing.
- BS EN 1057:1996 Copper and copper alloys. Seamless, round copper tubes for water and gas in sanitary and heating applications.
- BS EN 1092-1:2002 Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Steel flanges.
- BS EN 1563:1997 Founding. Spheroidal graphite cast iron.
- BS EN 60529:1992 Specification for degrees of protection provided by enclosures (IP code).
- BS EN 60534-1:1993 Industrial-process control valves. Industrial-process control valves. Control valve terminology and general considerations.
- BS EN 60546-1:1993 Controllers with analogue signals for use in industrial-process control systems. Controllers with analogue signals for use in industrial-process control systems.

5. Methods for evaluating performance

- BS EN 60584-2:1993 Thermocouples.

6. Tolerances

- BS EN 60654:1998 Operating conditions for industrial-process measurement and control equipment. All relevant parts.

- BS EN 60751:1996 Industrial platinum resistance thermometer sensors.
- BS EN 60873:1993 Methods of evaluating the performance of electrical and pneumatic analogue chart recorders for use in industrial-process control systems.
- BS EN 61000-6:2001 Electromagnetic compatibility (EMC). Generic standards. Emission standard for industrial environments.
- BS 89:1990 Direct acting indicating analogue electrical measuring instruments and their accessories. All parts.
- BS 90:1975 Specification for direct-acting electrical recording instruments and their accessories.
- BS 476 Fire tests on building materials and structures. All parts.
- BS 1042-1.4:1992 Measurement of fluid flow in closed conduits. Pressure differential devices. Guide to the use of devices specified in Sections 1.1 and 1.2.
- BS 1041-2.1:1985 Code for temperature measurement. Expansion thermometers. Guide to selection and use of liquid-in-glass thermometers.
- BS 1041-2.2:1989 Code for temperature measurement. Expansion thermometers. Guide to 119 selection and use of dial-type expansion thermometers.
- BS 1041-3:1989 Temperature measurement. Guide to selection and use of industrial resistance thermometers.
- BS 1041-4:1992 Temperature measurement. Guide to the selection and use of thermocouples
- BS 1042-1.4:1992 Measurement of fluid flow in closed conduits. Pressure differential devices. Guide to the use of devices specified in Sections 1.1 and 1.2.
- BS 1123-1:1987 Safety valves, gauges and fusible plugs for compressed air or inert gas installations. Code of practice for installation.
- BS 1203:2001 Hot-setting phenolic and aminoplastic wood adhesives. Classification and test method.
- BS 1553-1:1977 Specification for graphical symbols for general engineering. Piping systems and plant.
- BS 1571-2:1975 Specification for testing of positive displacement compressors and exhausters. Methods for simplified acceptance testing for air compressors and exhausters.
- BS 1646-1:1979 Symbolic representation for process measurement control functions and instrumentation.

7. Basic requirements

- BS 1646-2:1983 Symbolic representation for process measurement control functions and instrumentation. Specification for additional basic requirements.
- BS 1646-3:1984 Symbolic representation for process measurement control functions and instrumentation. Specification for detailed symbols for instrument interconnection diagrams.
- BS 1646-4:1984 Symbolic representation for process measurement control functions and instrumentation. Specification for basic symbols for process computer, interface and shared display/control functions.
- BS 1794:1952 Specification for chart ranges for temperature recording instruments.
- BS 2765:1969 Specification for dimensions of temperature detecting elements and corresponding pockets.
- BS 3680 Measurement of liquid flow in open channels. All relevant parts.
- BS 3693:1992 Recommendations for design of scales and indexes on analogue indicating instruments.
- BS 4675-2:1978 Mechanical vibration in rotating machinery. Requirements for instruments for measuring vibration severity.
- BS 4999-142:1987 General requirements for rotating electrical machines. Specification for mechanical performance: vibration.
- BS 5169:1992 Specification for fusion welded steel air receivers.
- BS 5728-3:1997 Measurement of flow of cold potable water in closed conduits. Methods for determining principal characteristics of single mechanical water meters (including test equipment).
- BS 6004:2000 Electric cables. PVC insulated, non-armoured cables for voltages up to and including 450/750 V, for electric power, lighting and internal wiring.
- BS 6739:1986 Code of practice for instrumentation in process control systems: installation design and practice.
- BS 7671:2001 Requirements for electrical installations. IEE Wiring Regulations. Sixteenth edition. Instrument Society of American Standards and Recommended Practices:
 - S 5.1 Instrumentation symbols and identification
 - S 5.4 Instrument loop diagrams
 - S 7.3 Quality standard for instrument air
- RP 16.1 Terminology, dimensions and safety practices for indicating variable 2, 3 area meters

- RP 16.4 Nomenclature and terminology for extension-type variable-area meters (rotameters)
- RP 16.5 Installation, operation, maintenance instructions for glass tube variable area meters (rotameters)
- RP 16.6 Methods and equipment for calibration of variable area meters (rotameters)
- RP 18.1 Specifications and guides for the use of general purpose enunciators
- S 26 Dynamic response testing of process control instrumentation
- RP 31.1 Specification, installation and calibration of turbine flow meters
- S 37.1 Electrical transducer nomenclature and terminology
- S 37.3 Specifications and tests for strain gauge pressure transducers
- S 50.1 Compatibility of analog signals for electronic industrial process instruments
- S 51.1 Process instrumentation terminology
- RP 60.08 Electrical Guide for Control Centers
- Installation works shall comply with all relevant local Indian Regulations including the Code of Practice for Electrical Wiring Installations – IS 732.

8. Basic Features

Each instrumentation system shall be designed, manufactured and installed to achieve the following basic requirements:

- To maintain the highest standards of availability, reliability and accuracy and to give clear warnings of any deterioration in performance
- To suit the abilities of the staff who will:
 - (i) Use the systems
 - (ii) Service the systems
- To measure, indicate, process, store and control the relevant parameters, as specified
- To give clear warnings of dangerous and other abnormal conditions and to initiate plant safety procedures, shutdowns and corrective measures as specified to assure the safety of ‘operations and maintenance’ personnel and that of the plant and to store and collate the data, as required
- To derive, present and utilize, as required, such additional data to facilitate:
 - (i) The most efficient operation of the plant
 - (ii) The routine maintenance of the plant

9. Design requirements for instrumentation and control systems (I&C)

The instrumentation, control and automation installations shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification. The instrumentation control and automation systems shall comply with the relevant Indian Standards being practiced as per the industry norms. All consumable items and spare parts shall be readily available within India.

All equipment and materials incorporated in the system shall be selected, designed and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability. The instrumentation control and monitoring system equipment and materials shall have an operational life of not less than 15 years.

Unless otherwise specified, all functions shall be transmitted electrically and all analogue signal transmission systems shall be in accordance with IEC 60381-1:1982 or equivalent and shall use a signal of 4mA to 20mA dc. Where possible, measuring systems shall be designed so that any necessary power supply is taken from the appropriate instrument panel. Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter, and shall be capable of meeting the requirements specified in the appropriate part of IEC 60770-1:1999 or equivalent. Equipment mounted in enclosures shall be suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated heat and heat dissipated by other plant. All components shall be rated adequately and circuits shall be designed so that change of component characteristics within the manufacturers' tolerances shall not affect the performance of plant. All equipment shall be designed to operate without forced (or fan) cooling.

All measuring instruments shall have zero and span adjustment. Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steelwork and weatherproof enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection at all times including periods of servicing, adjustment, calibration and maintenance. The installation arrangements for meters measuring conductivity, pH, dissolved oxygen, chlorine residual and ionic concentration shall include a sample bench and other facilities for operating portable test meters. Each installation shall incorporate a valve and pipework for obtaining a sample representative of the fluid at the position of the permanent meter, tundish and drain. If the measuring and sampling points are remote from each other, the test and sample facilities

shall be provided at both points. Sample transport times shall be minimized by provision of a bypass and drain with control and isolating valves and a local flow meter to enable the correct sample flow to be adjusted. An automatic portable sampler shall be provided for collecting and transporting the samples from the sampling locations to the laboratory.

10. Instrument Design Criteria

The design criteria to be applied to instrumentation system shall be as follows:

- Instrumentation & Control (I&C) systems shall be selected, designed, manufactured, installed, tested and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability. Instruments mounted in field and on panels shall be suitable for continuous real time operation. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect the plant operation. All I&C equipment shall be new, of proven design, reputed make and have data logging facility. Unless otherwise specified, all instruments shall be tropicalized. The outdoor equipment shall be designed to withstand tropical rain and shall be suitable for the worst environmental operating conditions. Wherever necessary space heaters, heat dissipaters, dust and weather proof cabinets shall be provided. Instruments offered shall be complete with all the necessary mounting accessories & safety features.
- No custom made hybrid type integrated circuits shall be used in any circuit in instrumentation and control equipment.
- Instruments and loggers provided shall be able to carry out continuous real time monitoring and logging of selected water quality parameters.
- All instrumentation shall be suitable for continuous real time operation and be powered through the UPS.
- As far as possible and depending upon the location and availability of wireless services, all transmitting instruments and data loggers shall be of wireless type (GPRS / GSM based). In case of non-feasibility, the output of the transmitting instruments shall be 4-20 mA / 0-10V DC linear having two wire system.
- After a power failure, when power supply resumes, the instruments and associated equipment shall start working automatically.
- Unless otherwise specified, the normal working range of all indicating instruments shall be between 25% and 80% of the full scale range.

- The field instruments i.e. the instruments mounted outside the control panel shall be
- mounted at a convenient height of approximately 1.2 m above grade platform.
- Unless otherwise stated, field mounted electrical and electronic instruments shall be weatherproof to IP-65 or better.
- The instruments shall be designed to work at the ambient conditions of temperature, humidity, and contamination that may prevail at site. The instruments shall be given enough protection against corrosion. All wetted parts of instrument sensors shall be non – corrosive and suitable for use within sewerage environment.
- The performance of all instruments shall be unaffected for the $\pm 10\%$ variation in supply voltage and $\pm 5\%$ variation in frequency simultaneously.
- Unless otherwise specified, double compression glands shall be used for glanding the cable in field instruments and instrument control panel.
- All digital outputs shall be volt free.
- All probe type analyzers should be IP68 rated.
- All displays shall be of the digital type with no moving parts and should utilize back lit liquid crystal diode LCD/ LED technology.
- Instrumentation shall utilize solid state electronic technology and avoid the use where practical of any moving parts.
- Minimum maintenance requirements. The instruments selected shall be rugged and not require any consumables / filling solutions. Systems should be able to work with minimum power requirements.
- Lockable enclosure shall be provided for all the field mounted instruments.
- All the instruments and cabinets shall have tag plates / name plates permanently attached to them.
- All instruments to be used or installed within a corrosive sewerage environment shall be explosion proof and intrinsically safe.
- The data obtained from the online quality monitoring system shall be conveyed back via suitable communications protocol, to web servers hosted by a service provider. The service provider shall have the data storage capacity for next 15 years.
- Unless otherwise specified, all continuous online monitoring instruments shall be plug and play type.
- Instrumentation system shall be provided to monitor the following parameters

11. Online Continuous Dissolved Oxygen Measuring System

- Ultrasonic Level Measurement
 - Ultrasonic Differential Level Measurement

- Flow Measurement Instrument at Parshall Flume
 - Gas Flowmeter (Thermal Mass Flow Measurement System)
- Pressure Transmitter
- Continuous Online Total Suspended Solids Analyzer
- Continuous Online pH Measuring System
- Online Residual Chlorine Measuring System
- Conductivity Meter
- Ammonia Analyzer
- Alkalinity Analyzer
- Indicative BOD Analyzer
- Indicative COD Analyzer
- Indicative TOC Analyzer
- Measurement of CO₂, CH₄ and H₂S Gas Concentration
- Electro-Magnetic Flow Meter
- Online Gas Calorific Value Measurement
- Instrumentation

12. Online Instruments

The online measurement at Inlet and outlet for continuous monitoring of the raw and treated sewage characteristics are specified below.

- At the Inlet Point and the Outlet Point –
 - Electro-Magnetic Flow Meter/ Ultrasonic Open Channel Flow Measurement
 - Conductivity Meter
 - Continuous Online pH Measuring System
 - Continuous Online Total Suspended Solids Analyzer 1 to 4
 - Indicative BOD Analyzer
 - Indicative COD Analyzer
 - Online Residual Chlorine Measuring System

Online instrument system shall have the ranges in accordance with CPCB “Guidelines for continuous monitoring for Effluents” and CPHEEO.

13. Laboratory – Laboratory instruments and sampling system

The laboratory shall be housed within the administrative building and shall be equipped with instruments, equipment, chemicals and other infrastructure that is necessary to perform the routine analysis for the parameters as detailed in “Table 2”. The equipment shall be supplied with all the accessories that are necessary to make the equipment functional for analyzing parameters and generating daily reports. In addition to these, Concessionaire shall also provide necessary chemicals, glassware and reagents required for sample testing in the laboratory along with calibration standards / solutions for calibrating the instruments.

The quality of the sewage entering, passing and leaving the treatment plant shall be monitored via online monitoring equipment as well as manual sampling systems and tested daily, at least from the following parameters:

Table 2 – Parameters to be monitored

Sl. No	Parameter
1	BOD
2	pH
3	SS
4	Temp.
5	COD
6	TOC
9	Acidity, Alkalinity
12	MLSS/MLVSS
13	Dissolved Oxygen
14	SVI
15	Total Hardness, Calcium Hardness
16	Gas Analysis
17	Calorific Value Monitoring
18	Volatile Suspended Solids
19	Total Solids
20	Specific Gravity
21	Moisture Content
22	Total Coliform
23	Faecal Coliform
24	Total Dissolved Solids

Sl. No	Parameter
25	Bacteria, Escherichia Coli, Salmonella, Viruses and Helminth Eggs

Two portable samplers shall be provided to collect composite samples for monitoring from Inlet chamber for raw Sewage

The laboratory shall have the equipment, storage space and chemicals for all the chemical and bacteriological routine analyses. The area of laboratory shall be sufficient with sufficient length of working platforms and adequate no. of sinks. Area of laboratory shall be defined by Concessionaire as per the requirement of the Concession Agreement. At least the following equipment and all required laboratory chemicals / reagents given in Table 3 are to be provided by the Concessionaire within the scope of work and have to be replenished by him till the end of the O&M Period.

All lab based test instruments results shall be stored automatically and transferred to the PLC as well as web servers on real time basis for control and report applications.

Table 3: Lab Instruments

Sl. No.	Parameter
1	Comparator test set for residual chlorine or chloroscope
2	Single / Multi parameter meter for pH, Conductivity, DO, Ammonia
3	Mains operated pH meter completed with one calomel electrode and glass electrode
4	Turbidity meter - Bench Model
5	Turbidity meter - Hand held (Portable)
6	UV / VIS Spectrophotometer
7	Water bath with 6 to 8 concentric holes and discs, electrically heated
8	Hot plates – 25cm
9	Ultrapure Water Plant
10	Conductivity with TDS meter
11	Refrigerator (280 litres capacity) double door / cooling cabinet for sample preservation
12	Muffle furnace
13	Electronic Burettes and Dispensers
14	Magnetic stirrer

Sl. No.	Parameter
15	Analytical balance (Electronic) with weight box – Resolution up to 4 decimal places
16	Jar-Test apparatus – 6 Stirrers
17	Centrifuge
18	Flame photometer with gas cylinder
19	Fume cupboard
20	Field Test kit for cations and anions
21	Depth Sampler
22	Total Organic Carbon Analyser
23	Sieve shaker with standard sieves and two pan balance weighing up to 200gm samples
24	Hot Air Oven
25	Autoclave
26	Binocular microscope
27	Automatic Portable Sampler
28	Pipette Box (Stainless Steel)
29	Wooden Racks/Aluminium Racks
30	Wire Baskets
31	Cotton/ Aluminium Foils
32	Burners (Bunsen) With Pilot Lamp
33	Suction Flask (1 Litre Cap)
34	Suction Pump
35	Sampling Bottles
36	Measuring Cylinders (1000 ML, 500 ML, 200 ML, 100 ML, 50 ML, 25 ML)
37	Vacuum pump
38	Soxhlet extraction unit
39	Kjeldhal digestion unit
40	Weighing Balance (max 10kg)
41	Laminar Air Flow chamber
42	M. Endo Broth (dehydrated)
43	Lactose or Lauryl Tryptose broth
44	Mac Conkey broth
45	Brilliant Green Bile Lactose Broth
46	Total Plate Count Agar
47	Peptone / Tryptone Water
48	BOD Analysis: Incubator, Reagents, etc

Sl. No.	Parameter
50	COD Analysis: COD Reactor – 15 Vials, Reagents, etc
51	Filtration assembly for suspended solids
52	Incubator 44°C (Water/Air-Jacketed)

14. Online Instruments Specifications

14.1. Flow measuring system

A. Electromagnetic flowmeter

Flow meters shall operate on the electromagnetic induction principle and shall consist of a measuring sensor and measuring transmitter complying with ISO 6817:1997. Measuring sensors shall have a full bore stainless steel metering tube and non-conductive, abrasion-resistant lining to suit the fluid being metered. The lining of material can be of polyurethane. No rubber lining will be allowed. The flow meter shall have flanged connection. Measuring sensors shall have factory sealed power and signal cables. Unless otherwise specified, the cable lengths shall be sufficient to permit termination external to the chamber, either at a junction box or at the measuring transmitter. Remote flow indicator cum integrator shall be provided on the control panel.

Measuring sensors installed within a chamber shall be suitable for indefinite submersion under a head of water equal to the chamber depth or 3 meters whichever is the greater. Measuring sensors shall be installed on a steel cradle or concrete plinth with upstream and downstream straight pipe lengths not less than those recommended by the manufacturer. When fitted in lined non-metallic or internally-coated pipe work, measuring sensors shall have an earthing electrode or corrosion resistant earthing rings. To ensure full electromagnetic compatibility the flow tube flanges and transmitter housing shall be connected earth.

Measuring sensors shall be bonded by tinned copper braid links at each end to the adjacent pipe work to ensure a good connection between the body and the metered liquid. Measuring sensors installed in a cathodic protected pipeline shall have isolation and bonding in accordance with the recommendations of the manufacturer. The measuring transmitter shall provide a precise current input to the field winding of the measuring sensor and shall convert the resultant signal from the electrodes to

analogue and pulse outputs in accordance with IEC 60381-1:1982. The signal processing facilities of the converter shall ensure that the output signals are unaffected by interfering voltages, stratified flow, changes in fluid electrical conductivity within the limit stated, non-homogeneity of the fluid and the presence of ferrous particles. The zero and output signals shall be unaffected by partly-fouled electrodes.

The following measuring transmitter features shall be provided as a minimum:

- Measuring transmitter features:
 - Pulsed D.C. field excitation
 - Scaled pulse output for integration counter drive
 - Capability of bi-directional measurement with differing forward and reverse ranges and with local and remote indication of flow reversal
 - Contact operation at a programmable measured value
 - Integral display of flow and integrated quantity
 - Galvanic isolation between each output circuit and between the electrode circuit and output circuit
 - Output circuit isolation from earth within the instrument but suitable for earthing at any point in the external circuit

- Key entry for basic parameters
 - Commissioning and re-scaling to require no special programming knowledge
 - Adjustable low flow cut-off
 - Self-diagnosis
 - Continuously adjustable velocity and flow range settings 1 to 8
 - Terminals accommodated in a compartment separate from electronic components
 - Outputs including: analogue - 4-20mA
 - Pulse - two programmable outputs
 - Alarms - two outputs programmable for high/low
 - Flow, polarity, forward/reverse, instrument fault, liquid sensing fault condition including partially empty pipe

❖ **Technical specifications**

- Measuring Principal : Electromagnetic
- Type : Pulsed DC
- Application : H₂S laden atmosphere and other poisonous gases,
- Corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe
- Metering Tube : SS 304
- Sensor Housing : SS 304 fully welded
- Connection / Junction Box : SS 304
- Lining Material : PTFE/Polyurethane
- Range : As per site requirement
- Accuracy : $\pm 0.5\%$ of flow rate at maximum mean velocity of
- 1.5 to 3.0 m/sec
- Electrode Type : Flush or bullet nose as recommended by the manufacturer
- Earthing Ring/Electrode Material: Type 316 stainless steel
- Protection Category
 - a.) Sensor : IP-68
 - b.) Transmitter / Controller : IP-65
- Transmitter / Controller Type : Microprocessor Based
- Display : Indicating and totalizing
 - a.) Indicator : Digital 16-character display
 - b.) Totalizer : Digital 16-character display
- Mounting : Pipe, wall, panel
- Diagnostic : Inbuilt
- Power Supply : 230 V AC $\pm 10\%$, 50 Hz
- Analog Output : Isolated 4 – 20mA / 0-10VDC output based on the flow rate
- Zero & Span : Field Adjustable
- Turndown Ratio : Minimum of 10 to 1 when flow velocity at minimum flow is at least 0.3 metres per second
- Zero Stability Feature : Required to eliminate the need to stop flow to check zero alignment
- Pressure Loss : Very Low
- Removable Electrodes : Required
- Flange Material : Carbon steel, Epoxy Coated
- Empty Pipe Detection : Inbuilt
- Operating Temperature : 0 to 50°C

- Temperature Compensation: Inbuilt temperature sensors for automatic compensation for changes in air temperature
- Communication Protocol : Open Protocol like MODBUS, PROFIBUS, etc.

14.2. Level measuring system

14.2.1. Ultrasonic level meters

Ultrasonic level measuring devices applied for liquid level measurement shall comprise of level sensor / transducer, level transmitter, digital level indicator / remote indicator, control unit and any other items required to complete the level measuring system.

The transducer shall be suitable for flange or bracket mounting as required. To reduce the effect of sewage turbulence in wet wells / tanks, averaging facility should be provided in the transmitter unit for providing steady readings.

The design and application of the ultrasonic level measuring system shall take into account the vessel / sump / wet well / channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

In case of ultrasonic level sensor, the installation shall avoid any degradation of instrument performance due to spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection. If turbulence exists, shielding, stilling tubes or other measures shall be provided to avoid effects on the measurement.

❖ Technical specifications

- Measuring Principal : Ultrasonic
- Application : H₂S laden atmosphere and other poisonous gases, corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe
- Range : As required at site
- Accuracy : $\pm 0.25\%$ of measured value or better
- Resolution : 2mm or 0.2 percent of range, whichever is greater
- Blanking Distance : As short as 0.3 meters

- Beam Angle : 12 degrees or less
- Temperature compensation : Integral
- Mounting
 - a.) Sensor : Flange or bracket
 - b.) Transmitter / Controller : Wall, Panel, Pole
- Protection Category
 - a.) Sensor : IP-68
 - b.) Transmitter / Controller : IP-66 (NEMA 4X)
- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting 130
- Power Supply : 230 V AC \pm 10%, 50 Hz
- Analog Output : Isolated 4 – 20mA
- Relay Contacts : Minimum of 3 SPDT contacts
- Zero & Span : Field Adjustable
- Operating Temperature : 0 to 50°C
- Communication Protocol : Open Protocol like MODBUS, PROFIBUS, etc.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement

14.2.2. Ultrasonic differential level measurement

The ultrasonic type differential level measuring system shall consist of ultrasonic type level sensors on upstream and downstream of screens, differential level computer / transmitter and indicator. The flow computer / transmitter shall be microprocessor based and shall have facility for programming (i.e. adjustment of set points) while the sensor shall be capable of adjustable datum setting facilities.

The differential level control shall be done by two ultrasonic sensors, one before and one after the screen to sense the differential level through the screen and give a signal to the control to start the screens operation as soon as a preset differential level is reached. After receiving the level signal the control shall start and operate the screen as long as the preset level difference appears.

❖ Technical specifications

- Measuring Principal : Ultrasonic
- Application : H₂S laden atmosphere and other poisonous gases,
- Corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe
- Range : As required at site
- Accuracy : $\pm 0.25\%$ of measured value or better
- Resolution : 2mm or 0.2 percent of range, whichever is greater
- Blanking Distance : As short as 0.3 meters
- Beam Angle : 12 degrees or less
- Temperature compensation : Inbuilt
- Mounting
 - a.) Sensor : Flange or bracket
 - b.) Transmitter / Controller : Wall, Panel, Pole
- Protection Category
 - a.) Sensor : IP-68
 - b.) Transmitter / Controller : IP-66 (NEMA 4X)
- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC $\pm 10\%$, 50 Hz
- Analog Output : Isolated 4 – 20mA
- Relay Contacts : Minimum of 3 SPDT contacts
- Zero & Span : Field Adjustable
- Operating Temperature : 0 to 50°C 131
- Communication Protocol : Open Protocol like MODBUS, PROFIBUS, etc.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement

14.3. Pressure measuring system – pressure transmitter

Pressure measuring system shall measure pressure and transmit signal proportional to pressure.

The system shall consist of a combined pressure transducer and transmitter, digital panel indicator, connecting pipe work, diaphragm seal and valves. Pressure measuring system shall be rugged in construction and shall be capable for with standing surge pressures likely to occur in the monitored system. Pressure transmitters shall have over range protection up

to 1.5 times the maximum line pressure and shall be capable of withstanding full line pressure on any side with the other side vented to atmosphere without damage or effect on the calibration. No plastic material shall be used in their construction. Internal parts shall be of stainless steel, bronze or approved corrosion-resistant material. Where necessary, a special diaphragm shall be used to segregate the corrosive fluid media. In ammonia applications, the diaphragm shall be in stainless steel. In chlorine applications, the diaphragm shall be in silver or tantalum. In Sulphur dioxide applications, the diaphragm shall be in tantalum.

The zero and span of a pressure transmitter shall not change by more than $\pm 0.1\%$ of the span per $^{\circ}\text{C}$ change in ambient temperature. After application for 10 minutes of pressure at 130% of maximum pressure, the change in zero and span shall not exceed $\pm 0.1\%$ of the span. Pressure transmitters shall be protected to BS EN 60529:1992, IP 65 standard or higher. For transmitters installed in locations liable to flooding or underwater applications, they shall be to IP 68 standard and shall operate up to a maximum submergence of 20 meters of water.

❖ **Technical specifications**

- Parts : Transmitter and communicator
- Type : Electronic variable capacitance; two-wire transmitter
- Application : H₂S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe
- Range : As required at site
- Accuracy : $\pm 0.25\%$ of span or better
- Humidity : 0 to 100% relative humidity
- Damping : Fluid or electronic type with adjustment
- Indicator : LCD with LED backlighting
- Materials : Wetted parts including process flanges and drain / vent valves, Type 316 stainless steel otherwise specified
- Wetted O-Rings : Glass filled TFE, graphite filled PTFE, or Viton, unless otherwise specified
- Fill Fluid : Silicone
- Output : 4 – 20mA DC output proportional to the pressure range
- Mounting : Pipe or wall as specified. Provide stainless steel brackets with stainless steel bolts

- Housing : Modular with separate compartments for
- electronics and field wiring termination. Epoxy coated aluminium, unless otherwise specified
- Power Supply : 230 V AC \pm 10%, 50 Hz
- Operating Temperature : 0 to 50°C
- Communication Protocol : Open Protocol like MODBUS, PROFIBUS, etc.

14.4. Dissolved oxygen measuring system - DO analyzer

DO analyzers shall be installed to continually record the dissolved oxygen level at every grid within each aeration basin. The primary sensing device used for the dissolved oxygen level measurement, shall be a sensing probe mounted within the aeration basin and connected to a controller for displaying and transmitting the results

❖ Technical specifications

- Measuring Principal : Optical
- Application : H₂S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe
- Range : 0 to 20.0 ppm, 0 to 20.0 mg/L
- Accuracy : \pm 0.5% or better
- Repeatability : \pm 0.5% of span
- Sensitivity : \pm 0.5% of span
- Pressure Limit : 4 - 6 bar
- Temperature Indication : Inbuilt
- Calibration Method : Air Calibration: One point, 100% water saturated air;
- Sample Calibration: Comparison to standard instrument, or comparison to Winkler Titration method
- Cleaning : Air Blast Unit. Probe should be able to function with cleaning unit attached to it
- Mounting
 - a.) Sensor : Inside aeration basin at each grid
 - b.) Transmitter / Controller : Wall, Panel, Pole
- Protection Category
 - a.) Sensor : IP-68 for Sensor
 - b.) Transmitter / Controller : IP-66 (NEMA 4X)

- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC \pm 10%, 50 Hz
- Analog Output : Isolated 4 – 20mA
- Relay Contacts : Minimum of 2 SPDT contacts 133
- Operating Temperature : 0 to 50°C
- Communication Protocol : Open Protocol like MODBUS, PROFIBUS, etc.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement

14.5. Total Suspended Solids Measuring System - TSS Analyzer

❖ Technical specifications

- Measuring Principal : Optical
- Application : H₂S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe
- Range : 0 – 50 mg/l, 0 - 1000 mg/l, 0 – 5000 mg/l
- Accuracy : <5% of reading or better
- Pressure Limit : 6 bar
- Flow Rate : Maximum 3m per second
- Temperature Indication : Inbuilt
- Calibration Method : Single point or two point
- Cleaning : Inbuilt
- Mounting
 - a.) Sensor : Inside pipe / channel / tank
 - b.) Transmitter / Controller : Wall, Panel, Pole
- Protection Category
 - a.) Sensor : IP-68 for Sensor
 - b.) Transmitter / Controller : IP-66 (NEMA 4X)
- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC \pm 10%, 50 Hz
- Analog Output : Isolated 4 – 20mA

- Relay Contacts : Minimum of 2 SPDT contacts
- Operating Temperature : 0 to 50°C
- Communication Protocol : Open Protocol like MODBUS, PROFIBUS, etc.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement
- pH Measuring System – pH Analyzer

14.6. pH measuring system- pH Analyzer

❖ Technical specifications

- Measuring Principal : Combination / Differential Electrode
- Application : H₂S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe 134
- Range : 0 - 12 pH
- Accuracy : ±0.02 pH or better
- Repeatability : ±0.05 pH
- Sensitivity : ±0.01 pH
- Pressure Limit : 4 - 6 bar
- Flow Rate : Maximum 3m per second
- Temperature Indication : Inbuilt
- Temperature Compensation : Inbuilt automatic temperature compensation
- Temperature Accuracy : ±0.5 °C
- Calibration Method : Two point automatic, one point automatic, two point manual, one point manual
- Mounting
 - a.) Sensor : Inside pipe / channel / tank
 - b.) Transmitter / Controller : Wall, Panel, Pole
- Protection Category
- For Transmitter / Controller : IP-66 (NEMA 4X)
- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC ± 10%, 50 Hz
- Analog Output : Isolated 4 – 20mA
- Relay Contacts : Minimum of 2 SPDT contacts

- Operating Temperature : 0 to 50°C
- Communication Protocol : Open Protocol like MODBUS, PROFIBUS, etc.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement

14.7. Residual Chlorine Measuring System – Residual Chlorine Analyzer

❖ Technical specifications

- Measuring Principal : Amperometric or DPD Colorimetric
- Application : H₂S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe
- Range : 0 – 10 ppm
- Accuracy : ±3% of the reference test or better
- Resolution : 0.001 ppm
- Repeatability : 30 ppb or 3%, whichever is greater
- pH : Automatic
- Temperature Compensation : Inbuilt temperature sensor
- Temperature Indication : Inbuilt
- Pressure Limit : 0.5 bar
- Flow Rate : Maximum 50 L/hour
- Calibration Method : 1-point or 2-point calibration
- Mounting : Wall, Panel 135
- Protection Category
 - a.) Sensor : IP-65
 - b.) Transmitter / Controller : IP-66 (NEMA 4X)
- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC ± 10%, 50 Hz
- Analog Output : Isolated 4 – 20 mA
- Relay Contacts : Minimum of 2 SPDT contacts
- Operating Temperature : 0 to 50°C
- Communication Protocol : Open Protocol like MODBUS, PROFIBUS, etc.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement

14.8. Conductivity Measurement – Conductivity Analyzer

❖ Technical specifications

- Application : H₂S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe
- Range : 0 - 1000 μ S/cm
- Accuracy : $\pm 0.5\%$ or better
- Temperature Compensation : Inbuilt
- Temperature Indication : Inbuilt
- Pressure Limit : 6.9 bar
- Flow Rate : Maximum 3m per second
- Mounting
 - a.) Sensor : Inside pipe / channel / tank
 - b.) Transmitter / Controller : Wall, Panel, Pole
- Protection Category
- For Transmitter / Controller : IP-66 (NEMA 4X)
- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC $\pm 10\%$, 50 Hz
- Analog Output : Isolated 4 – 20mA
- Relay Contacts : Minimum of 2 SPDT contacts
- Operating Temperature : 0 to 50°C
- Communication Protocol : Open Protocol like MODBUS, PROFIBUS, etc.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement 136

14.9. Ammonia Measurement - Ammonia Analyzer

❖ Technical specifications

- Application : H₂S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe

- Range : 0 – 5 mg/l, 0 - 50 mg/l
- Accuracy : 3% ±1mg/l or better
- Repeatability : 2% ±1mg/l or better
- Flow Rate : Maximum 20 L/h
- Cleaning : Automatic
- Mounting
 - a.) Analyzer : Wall, Panel
 - b.) Transmitter / Controller : Wall, Panel, Pole
- Protection Category
 - a.) Analyzer : IP-55 or better
 - b.) Transmitter / Controller : IP-66 or better
- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC ± 10%, 50 Hz
- Analog Output : Isolated 4 – 20mA
- Relay Contacts : Minimum of 2 SPDT contacts
- Operating Temperature : 0 to 50°C
- Communication Protocol : Open Protocol like MODBUS, PROFIBUS, etc.
- Cable Length : As per site requirement

14.10. Alkalinity Measurement – Alkalinity Analyzer

❖ Technical specifications

- Application : H₂S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe
- Range : 0 – 500 mg/l
- Accuracy : ±5% of reading or ±1.0 mg/L, whichever is greater
- Repeatability : ±3% of reading or ±0.6 mg/L, whichever is greater
- Pressure Limit : 2 bar
- Flow Rate : Maximum 2 L/m
- Mounting : Wall, Panel
- Protection Category : IP-66 (NEMA 4X)
- Power Supply : 230 V AC ± 10%, 50 Hz
- Analog Output : Isolated 4 – 20mA

- Relay Contacts : Minimum of 2 SPDT contacts
- Operating Temperature : 0 to 50°C
- Communication Protocol : Open Protocol like MODBUS, PROFIBUS, etc.

14.11. Total Nitrogen Measurement – Total Nitrogen Analyzer

❖ Technical specifications

- Measuring Principle : UV Absorption
- Application : H₂S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe
- Range : 0 – 30 mg/l, 0 - 80 mg/l
- Accuracy : ± 3% of mean + 0.5 mg/l
- Resolution : 0.1 mg/L
- Pressure Limit : 0.5 bar
- Cleaning : Automatic
- Mounting
 - a.) Sensor : Inside pipe / channel / tank
 - b.) Transmitter / Controller : Wall, Panel, Pole
- Protection Category
 - a.) Sensor : IP-68
 - b.) Transmitter / Controller : IP-66 (NEMA 4X)
- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC ± 10%, 50 Hz
- Analog Output : Isolated 4 – 20 mA
- Relay Contacts : Minimum of 2 SPDT contacts
- Operating Temperature : 0 to 50°C
- Communication Protocol : Open Protocol like MODBUS, PROFIBUS, etc.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement

14.12. BOD Measurement – Indicative BOD Analyzer

❖ Technical specifications

- Measuring Principle : UV Absorption
- Application : H₂S laden atmosphere and other poisonous gases,
- Corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe
- Range : 0 – 50 mg/l, 0 - 500 mg/l
- Accuracy : ± 5% or better
- Compensation : 550 nm
- Sample pH : 4.5 to 9 pH
- Pressure Limit : 0.5 bar
- Cleaning : Automatic 138
- Mounting
 - a.) Sensor : Inside pipe / channel / tank
 - b.) Transmitter / Controller : Wall, Panel, Pole
- Protection Category
 - a.) Sensor : IP-68
 - b.) Transmitter / Controller : IP-66 (NEMA 4X)
- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC ± 10%, 50 Hz
- Analog Output : Isolated 4 – 20mA
- Relay Contacts : Minimum of 2 SPDT contacts
- Operating Temperature : 0 to 50°C
- Communication Protocol : Open Protocol like MODBUS, PROFIBUS, etc.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement

14.13. COD Measurement – Indicative COD Analyzer

❖ Technical specifications

- Measuring Principle : UV Absorption
- Application : H₂S laden atmosphere and other poisonous gases,
- Corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe
- Range : 0 – 250 mg/l, 0 - 1000 mg/l

- Accuracy : $\pm 5\%$ or better
- Compensation : 550 nm
- Sample pH : 4.5 to 9 pH
- Pressure Limit : 0.5 bar
- Cleaning : Automatic
- Mounting
 - a.) Sensor : Inside pipe / channel / tank
 - b.) Transmitter / Controller : Wall, Panel, Pole
- Protection Category
 - a.) Sensor : IP-55 or better
 - b.) Transmitter / Controller : IP-55 or better
- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC $\pm 10\%$, 50 Hz
- Analog Output : Isolated 4 – 20mA
- Relay Contacts : Minimum of 2 SPDT contacts
- Operating Temperature : 0 to 50°C
- Communication Protocol : Open Protocol like MODBUS, PROFIBUS, etc.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement

14.14. TOC Measurement – Indicative TOC Analyzer

❖ Technical specifications

- Measuring Principle : UV Absorption / UV Persulphate
- Application : H₂S laden atmosphere and other poisonous gases,
- Corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe
- Range : 0 - 1000 mg/l
- Accuracy : $\pm 5\%$ or better
- Compensation : 550 nm
- Sample pH : 4.5 to 9 pH
- Pressure Limit : 0.5 bar
- Mounting
 - a.) Sensor : Inside pipe / channel / tank
 - b.) Transmitter / Controller : Wall, Panel, Pole

- Protection Category
 - a.) Sensor : IP-55 or better
 - b.) Transmitter / Controller : IP-55 or better
- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC \pm 10%, 50 Hz
- Analog Output : Isolated 4 – 20mA
- Relay Contacts : Minimum of 2 SPDT contacts
- Operating Temperature : 0 to 50°C
- Communication Protocol : Open Protocol like MODBUS, PROFIBUS, etc.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement

15. Surge Protection Devices

Surge protection devices (SPDs) shall be suitable for withstanding the surge arising out of high energy static discharge / lightning strikes and protect the instrument to which it is connected against damage. SPDs shall provide protection through the use of quick acting semiconductors like Tranzorb, zener diodes, varistors and an automatic disconnect and reset circuit. SPDs shall be passive and shall require negligible power for operation. During the occurrence of a surge it shall clamp on the allowable voltage and pass the excess voltage to the ground. The SPD shall be self resetting to minimize the down time of the measurement loop.

SPDs shall be provided to protect devices transmitting and receiving analogue and digital signals derived from field devices located outdoors.

The surge protection device shall be rated for surge rating of 10kA.

16. Cabinets for field instruments

Wall mounted cabinets shall be provided for enclosing transducer unit and associated accessories which are mounted outside the main control panel. The cabinet shall be of die-cast aluminium; field provided not less than IP-65 protection and shall be lockable. The

cabinet shall have facilities for earthing. A steel plate shall be provided inside the cabinet for mounting instrument and accessories.

17. Panel Details

17.1. Cabinet / Enclosure for Instruments

Enclosures shall be any form of board, cabinet, panel, desk, box or case used to protect, contain or group instrumentation, telemetry or control equipment. Cabinets shall be fabricated from cold rolled steel with powder coating sheet of minimum 2 mm thick and shall be suitable for wall mounting or pedestal mounting as required. A steel plate/pipe, as per the requirement, shall be provided in the cabinet for mounting the instrument and accessories. The cabinet shall be properly painted from inside and outside and shall have built in locking facility. The cabinet shall also be earthed properly. All equipment in or on enclosures shall be arranged logically and, as far as possible, symmetrically, with projections kept to a minimum. Each enclosure shall be designed on ergonomic principles and shall permit in-situ and safe access for any normal adjustment, maintenance and servicing. The tops of plant-mounted enclosures shall be sloped downwards from front to rear.

The minimum degree of protection shall be IP 54 for indoor locations and enclosures for use outside buildings or in places where splashing may occur shall have a minimum rating of protection to BS EN 60529:1992, IP 65 and have tops which project sufficiently to protect the vertical faces of the enclosure and any component mounted thereon from splashing, inclement weather and direct sunlight. Also, when enclosures for use outside buildings are located where exposure to direct sunlight will give rise to high top-panel surface temperatures such that the internal temperature rises above the manufacturer's recommendation (normally 40°C), the enclosure shall include a sun shield fitted to the top of the enclosure and should have sufficient air ventilation for heat dissipation.

Fixing arrangements for surface-mounting enclosures shall be external to the enclosure and shall ensure that the rear face of the enclosure is not in contact with the surface to which it is fixed.

Enclosures shall have hinged access doors, fitted with recessed lockable handles. Doors shall be of rigid construction and provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Hinges shall be of the lift-off

pattern and one hinge shall engage before the other for ease of fitting. Wherever necessary, removable access covers secured by quick-release fasteners shall be provided to ensure ease of maintenance for all installed apparatus. Mounting plates, brackets and racks shall be provided for all other internal equipment which shall be hinged or otherwise arranged with quick-release fasteners or captive screws to give quick and easy access to equipment, securing screws, terminals and wiring.

Enclosures for two or more devices with electrical circuits shall have gland plates and terminal blocks as specified elsewhere. Each enclosure shall be designed for the safe testing and servicing of equipment with the power on. Each part which may be live under any circumstances shall be so covered or shielded as to prevent inadvertent contact.

17.2. Panel Design and Construction

Unless otherwise specified, all instrument panels, instrument cubicles, control panels, control consoles and desks, associated equipment and terminal racks, telemetry and electronic equipment racks and the like shall be free-standing, floor-mounted units and shall conform to the requirements of this part and will hereafter be referred to as panels. The design and dimensions of control consoles and desks shall be determined according to their intended function but shall be in accordance with the requirements of the Specification drawings. The height shall not exceed 1400mm above the finished floor level.

Unless otherwise specified as per the approved Design and Drawings, the height of panels shall be not greater than 2130mm overall (excluding lifting devices) above finished floor level. Front of-panel instruments and controls shall be mounted so that the height of their centers above the floor shall be generally between 1800mm and 900mm for indicators, 1400mm and 900mm for recorders and process controllers, 2000mm and 750mm for alarm facias and signal lamps and 1500mm and 750mm for manual controls. Controls, switches and push-buttons shall be positioned below or adjacent to any associated reading instrument. Panels for use in locations such as pumping stations and machinery rooms shall have anti-vibration mountings. The clearance between the extremities of apparatus mounted on the internal walls shall allow safe and unobstructed access to all terminals and to parts requiring maintenance. Panel layout drawings shall normally include a list of all instruments, accessories and components contained therein. If the drawings have insufficient space for the list, a separate schedule of instruments, accessories and components shall be provided and the panel drawing shall contain a cross reference to the contents list and an indication of the panel location of each item on the list.

17.3. Panels - major

Panels shall be constructed generally as specified in the preceding clause and as shown in the Specification drawings. Panel material shall be prime-quality, cold-rolled and annealed mild steel or zinc-coated mild steel sheet, suitably braced and stiffened as necessary with flat bar or angle to form a rigid structure.

Panel fronts shall be flat and free from bow or ripple. Exterior corners and edges shall be rounded or welded and ground to give a smooth overall appearance. Flanged edges shall be straight and smooth. Materials shall be chosen with due regard to the panel size, number of cut-outs, instrument weight and position of centre of gravity and method of fabrication, with the following:

- minimum thicknesses
 - Instrument bearing surfaces, gland plates and pneumatic distribution plates: 3mm
 - Internal mounting plates: 3mm
 - Doors, covers and filler panels: 2mm

No design involving the use of externally-visible assembly or fixing bolts and screws nor any design resulting in dust or water-collecting crevices will be accepted. Stiffeners and supporting frameworks shall be provided where necessary inside panels. Framework shall be hinged or fixed, suitable for the installation of instruments, components and internal equipment for which it is provided and located to give easy access to adjacent equipment.

When a panel is constructed in sections, the sections shall be designed for ease of assembly during installation and, in any case, shall not exceed 2 m in length. All necessary nuts, bolts, washers and the like shall be supplied and included in the same shipment as the relevant sections. Sections exceeding 1 m in length shall be provided with double doors. Unless otherwise shown in the Specification drawings, each panel shall be mounted on a self-draining base frame fabricated from 150 mm deep, steel channel section which shall be drilled or provided with clamps for bolting to the floor. The base frame shall be set back from the panel front face to give a toe space of not less than 25mm. The outside of the base frame shall be covered with an approved kicking strip.

Ceiling and other filler panels shall be fabricated from sheet steel and adequately stiffened. Each section shall have 50 mm returned edges along all four sides and shall be braced to the main steelwork of the panel. A chequered plate floor shall be provided inside and above the level of the base frame, having openings suitable for the bottom entry of cables when applicable. Sufficient removable undrilled gland plates, in sections convenient for handling, shall be fitted close to the appropriate terminal blocks and not less than 230 mm above the panel floor or not less than 230 mm below the panel top. The gland plates shall have removable side covers giving access to both sides of the gland plate and ensuring vermin-proof and dust-proof construction. Gland plates of a surface-mounted enclosure may form a part of the base or top. Panels containing pneumatic or other instruments using a fluid as the transmission medium shall have distribution plates with bulkhead unions for the termination of internal and external pipework.

All doors shall open outwards and all doors in one panel assembly shall use the same lock and key combination. Panel design shall ensure adequate ventilation and air circulation without permitting the entry of vermin or dust. Panels installed in control rooms or other clean condition areas shall have louvres to allow air circulation. Temporary closures shall be provided to prevent the entry of dust and vermin during transit and installation. After commissioning has been completed, all entries except air-circulation louvres shall be sealed.

No equipment other than front-of-panel items shall be mounted on panel wall surfaces. If electrical and non-electrical instruments are mounted in the same panel, the panel shall be subdivided internally to separate the electrical and non-electrical sections. All connections shall be arranged to ensure that no accidental damage to cabling or electrical components can occur in the event of failure of any non-electrical component or connection. Provision shall be made for safe and easy handling during transit and installation. If lifting eyes are provided, they shall be reversible and panel tops shall be reinforced where necessary.

Where equipment is specified to be installed at a future date, space shall be allocated, and cutouts with removable masking plates, brackets, supports, wiring, terminals and piping and the like shall be provided. Panels shall be finish-coated at the place of manufacture before commencing the installation of apparatus and other fittings.

17.4. Panels - Minor

Panels for installation on the Plant which contain relatively few items of equipment, or where so specified elsewhere, shall be provided as minor panels and shall be constructed

generally as specified in the preceding clause and comply with this Clause. Panels shall be fabricated from sheet steel or other approved material less than 2.5mm thick suitably braced to form a robust and rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance and assembly bolts, screws or rivets shall not be visible on the front face.

The design shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Openings for cables shall be made vermin-proof. Doors shall be hinged and shall be provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Unless otherwise specified, panels shall be suitable for floor mounting and shall not exceed 2130mm in height. Where surface mounted panels are provided, the fixing shall prevent the ingress of moisture and the rear of the enclosure shall be not less than 10mm from the wall.

Lifting eyebolts shall be removed and replaced with bolts after installation. Panels shall be extensible, and symmetrically arranged as far as possible with projections kept to a minimum. Where two or more panels are fitted together, they shall form a flush-fronted continuous panel of uniform height. Front door and top cover dimensions shall match. Instruments, relays, and control devices shall be mounted at a height not more than 2000mm and not less than 300mm from floor level.

The arrangement of equipment within each enclosure shall be such as to permit easy access for installation and maintenance. No instruments, relays or other components shall be mounted on rear access doors or removable covers.

17.5. Panels - composite

In situations where space limitations preclude the use of separate instrumentation, control and automation (ICA) and switchgear panels and with prior approval of the consultant ICA equipment may be combined within a single enclosure subject to the following conditions:

17.6. Enclosure

- The observance of all other clauses herein relating to enclosures, mounting boards and minor panels.

- The written assurance of each supplier of ICA equipment that the proximity of the switchgear will have no detrimental effect on the life or performance of any ICA component
- The total segregation of ICA equipment and switchgear including the glanding and termination facilities.
- The absence of any voltage exceeding 250V ac or 50V dc from any compartment containing ICA equipment.
- The use of the full height of the panel (excluding the busbar chamber and cable space) for any ICA equipment compartment.

17.7. Panels - Glass Reinforced Plastic (GRP)

Any panel required to be installed outside buildings shall be manufactured from double-skin, resin-bonded fibreglass, with a totally encapsulated infill of rigid weatherproof and 'boil proof' plywood to BS 1203:2001 between the two skins to provide a rigid and vandal-proof enclosure.

The environmental rating shall be IP 65 or better.

For any application in a non-temperate climate or where so specified elsewhere, the roof section shall be sloping and have a totally-encapsulated infill of end-grain balsa instead of plywood. Box section steel shall be encapsulated into door edges and door frames. Door locks, handles and hinges shall be of a high tensile strength, non-corroding alloy with stainless steel pins and through fixing bolts. Large plane surfaces shall have adequate reinforcing to ensure rigidity.

The doors shall be complete with latching handles and locks. All door catches and locks shall latch onto steel-reinforced surfaces. Threaded studs shall be incorporated into the design of the panel for the mounting of sub frames within the panel. Any panel drilled to provide fixings for internal equipment will not be accepted. Each cubicle shall be provided with a floor or deck with a removable gland plate for cable entry.

The laminate material shall have flame-retardant characteristics in compliance with BS 476 Class 2, and shall retain 'stability, integrity and insulation' for 30 minutes. Colour-impregnated gel coats backed by coloured resin shall be used to ensure maintenance free and 'colour-fast' finishes. The internal finish colour shall be white. The fronts of externally-visible instruments and windows shall be of glass. An air-gap of 100mm shall

be provided between the top surface of the panel and its protective canopy. All internal equipment shall be mounted on supports built into the fiberglass structure. Fixing bolts through the skin will not be accepted.

17.8. Panel protection

Adequate facilities for isolation and protection by miniature circuit breaker or fuse for each instrumentation and control circuit and sub-circuit shall be provided and shall be so arranged that any interruption causes minimum disruption of plant, operates the appropriate alarm and cannot result in any unsafe operating condition. All fuses shall be of the cartridge pattern and main fuses shall be of the high rupturing capacity type. Fuse and solid-link carriers and bases shall be of plastic-moulded insulating material as per best industry practices. Ceramic materials will not be accepted. Live connections shall be efficiently shrouded and it shall be possible to change fuses with power on without danger of contact with live metal. The fuses shall be rated to give maximum protection to the equipment in circuit and the rating shall be permanently inscribed on the fuse label and on the fuse carrier.

Unless necessary for the protection of particular equipment, miniature circuit breakers used for individual circuits in a panel or control desk shall not trip on over-voltage or under-voltage. Bases for solid links shall not be interchangeable with those for fuses. Fuses and links in the same circuit shall be mounted opposite each other in separate adjacent rows and shall not alternate in the same row. At least 10% and not less than two unallocated miniature circuit breakers or fuses and links shall be provided in each panel distribution board. Miniature circuit breakers and fuses of similar size and rating shall be of the same make and type. At least 10%, and not less than two, spare fuses and links of each rating shall be provided and fitted in clips inside the panel.

Each instrument requiring a power supply shall be individually wired and protected so that, in the event of a failure in one circuit, the remainder is unaffected. Power supply circuits shall be of sufficient rating that any protective device may operate without reducing the voltage at the terminals of any other component to an unacceptable level. Remote alarms shall be operated on failure of the electrical supply to a panel or to any internal sub-circuit. Clearly identifiable, switched socket outlets of 15A minimum rating to comply with IS 4615, supplied at the main cabinet operating voltages shall be fitted within the panel at the rate of one for each operating voltage per meter of panel length; for a panel whose length is less than one meter, one switched socket outlet for each main operating voltage shall be

provided. Suitable socket outlets for portable tools and hand lamps shall be provided as specified elsewhere.

17.9. Panel isolation

Clearly-labelled isolating circuit breakers shall be provided for each incoming power supply. Switches shall be of the quick make-and-break type with spring-loaded contacts that close fully without requiring full operation of the handle. The handle and cover shall be interlocked so that the handle cannot be operated when the cover is open and the cover cannot be opened unless the switch is in the 'off' position. The 'on' and 'off' positions of each switch shall be indicated clearly.

Circuit breakers for panel power supplies shall be mounted near an access point and in positions where they may be operated easily from a standing position. Plug-in isolating links or devices of an approved type shall be provided in any circuit that may still be alive when the power supply isolators are in the 'off' position, as, for example, in circuits controlling equipment whose power supply is independent of the panel. Such links or devices shall be properly screened and, if not incorporated in or adjacent to their associated outgoing terminals, shall be labelled with suitable warning notices. Any item of panel equipment to which panel internal wiring is connected with a plug and socket instead of terminals shall be wired in flexible cable of adequate rating between the 'free' plug and a socket mounted adjacent to the device. The power supply connector shall be a socket.

17.10. Panel terminal blocks

External wiring for panel power supplies shall be terminated on the appropriate isolator. Signal cables from strain gauges, analyzers, resistance thermometers, re-transmitting slide wires and thermocouples may be terminated at their appropriate instruments. A terminal block shall be provided as the interface between the corresponding conductors of each internal and external wire and each internal and external connection except those listed above. The terminal blocks shall be mounted vertically where possible and not nearer than 230mm to the floor or less than 230mm from an incoming cable gland.

Terminal block rows shall be spaced apart by not less than 150mm and arranged to permit convenient access to wires and terminals and to enable ferrule numbers to be read without difficulty. Other circuits shall be grouped on the terminal blocks according to the classification given in the clause for 'Panel internal wiring' which shall be clearly marked

along the corresponding section of each terminal board. Groups of different voltages on the same board shall be separated by insulated barriers.

All connections shall be made from the front of terminal blocks and no live metal shall be exposed at the back. All terminal blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw and which permits removal of any terminal without disturbance to adjacent terminals. Pinch-screw type terminal blocks will not be accepted. Terminal mouldings shall be in melamine to ISO 2112:1990, polyamide or equivalent. Terminal rails shall be hot-dip galvanized. Current bars between the two connection points of each terminal block shall be of copper or brass with tin/lead alloy plating. All steel parts shall be zinc-plated and passivated with a yellow chromate layer.

Terminal blocks for input and output analogue signals and for circuits containing volt-free contacts internal or external to the cabinet shall be of the Klippon type SAKC or equivalent which permit the connection of a test millimeter or continuity meter without disconnecting any wiring.

Terminal blocks for power supplies for equipment external to the panel shall permit the isolation of the item of external equipment without affecting the operation of any other circuit within or outside the panel.

No more than one core of external cables or one internal wire shall be connected to any terminal. If terminal blocks are used as common points for two or more circuits, individual terminals with the appropriate number of permanent cross-connections shall be provided. The lengths of exposed cable cores shall be sufficient to reach any terminal in the appropriate row or rows. The cores shall be formed into a neat loom and a separate loom shall be provided for each cable.

Identification ferrules as specified in the clause for 'Panel wiring identification and termination' shall be fitted on each core of all external cables and on each internal wire. The size of the terminals shall be appropriate to the size and rating of the cable cores which will be connected to them but shall not be smaller than Klippon type SAK2.5 or equivalent.

Each row of terminal blocks shall contain at least 25% spare terminals over the number required for terminating all cores of external cables in that row. Unless otherwise specified or shown in the Specification drawings, each external cable shall contain at least 20% spare

circuits, with a minimum of one spare circuit. Terminal blocks shall be numbered consecutively in a sequence different from that used for identifying wiring. The terminal numbers, voltage grouping and terminal board layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring can be made. All the terminal boards shall be provided with covers of transparent insulating material that does not sustain combustion and shall be sectionalized where possible to give access to groups of terminals without uncovering all boards. Terminals which may be live when the panel is isolated from its main supplies shall be suitably labelled to minimize the risk of accidental contact.

17.11. Panel internal wiring

Panel circuits shall be segregated into the following categories:

- Group 1: Power control and very-high-level signal wiring (above 50V):
 - AC power supplies
 - DC power supplies
 - DC current signals above 50mA (such as CT circuits)
 - AC voltage and control signals above 50V (such as PT circuits)

- Group 2: High-level signal wiring (6V to 50V dc):
 - Signals from conventional electronic transmitters and controllers (such as 4mA to 20mA)
 - Circuits to alarm enunciators and other solid-state devices (excluding those in categories 2.1, 2.5, 3.1, 3.2 and 3.3)
 - Digital signals
 - Emergency shut-down and tripping circuits
 - On / Off control circuits
 - Intrinsically safe circuits
 - Speech-frequency circuits

- Group 3: Low-level signal wiring (5V dc and below):
 - Signals from thermocouples
 - Signals from resistance thermometers and re-transmitting slide-wires
 - Signals from analytical equipment and strain gauges

For Group 3 wiring, internal connections to the instruments shall be made by one of the following methods:

- The twisted, screened conductors of the external cable shall be led direct to their appropriate instruments via ducting systems installed for this purpose during construction of the panel.
- The conductors of the external cables shall be terminated on terminals segregated from all other categories and the connections to the appropriate instruments shall be made using twisted pairs with individual screening installed for this purpose during construction of the panel.

Internal wiring for all circuits in Group 2 except those sharing a common connection shall be multi-stranded, twisted pair, 0.75mm² minimum copper conductors with HPDE or PVC insulated cable of adequate grade and rating in accordance with BS 6004:2000. Wiring for circuits in other Groups or sharing a common connection shall be run in stranded, 1.0mm² minimum copper conductors with 250V grade, PVC-insulated cable of adequate grade and rating. Wiring sheath colours shall be black for AC circuits, and grey for DC circuits (excluding thermocouple circuits) and blue for Group 2.6 circuits. Circuits supplied at 240V, between 240V and 110V dc shall also be physically segregated from each other and from other circuits. Access to wiring and components of circuits having voltages exceeding 240V shall not be possible unless and until the circuit has been isolated.

Separate ducts, trunking, cable looms, tray work and the like shall be provided within the panel for each category with at least 150mm between parallel paths of Group 1 and those of any other Group. Intrinsically-safe circuits and their terminals shall be segregated from other circuits and terminals. All wiring shall be neatly and securely fixed by insulated cleats, bunched and secured by approved plastic strapping or run in approved insulated wiring trunking or non-corrodible flexible tubing. Not more than 75% of the capacity of trunking, ducts, looming, or tubing shall be used. Insulated earth wiring shall be so arranged that access to any equipment or connection point or the removal of any item of equipment is unimpeded. Wiring for future equipment shall be secured and terminated on terminal blocks. Lacing for wiring looms shall be of rot-proof cord or plastic strips. Inter-section wiring in multi-section cabinets shall be via a terminal block in each section.

17.12. Panel wiring identification and termination

Identification ferrules shall be fitted at both ends of each wire. The numbers or letters used shall correspond with the appropriate wiring diagram. The ferrules shall be of plastic

insulating material with permanent black characters on a colour-coded background for numbers and on a white background for letters, unaffected by oil or water. They shall be so arranged that they can be read logically from left to right when viewed normally. The system of wire identification shall be such that wires in the same circuit on opposite sides of a terminal shall have the same reference, and this system shall be continued through all external cabling. Terminal ferrules (spade, tongue, crimped connections) shall be provided on each conductor.

17.13. Panel earthing

A continuous copper earth bar of not less than 25mm x 6mm cross section shall run the full length of each panel and shall be securely fixed and bonded electrically to the main frame. The cable gland-plates and the earth bar shall be provided with suitable brass terminals of not less than 6mm diameter for connecting the metal cladding or armouring of all incoming and outgoing cables to the station earthing system.

A second continuous copper earth bar of not less than 25mm x 6mm cross section, electrically isolated from the steelwork of the panel and metal cladding and armouring of cables, shall be provided for earthing the signal earth connection of each instrumentation and control device and the screen(s) of each instrument cable not earthed elsewhere to the station instrumentation earth plate. The earth bar shall have sufficient brass terminals as specified above for each instrumentation and control device and the screen of every shielded cable plus 25% spare terminals. In multi-section panels, each earth bar shall be electrically bonded to the corresponding bars in the adjacent section(s). Instrumentation and instrument cable screen earthing shall comply with BS 6739: 1986, Section 10, unless otherwise stated in this clause.

17.14. Panel Heating

Each panel shall have one or more thermostatically-controlled tubular or ribbed panel heaters to prevent condensation and assist ventilation and which shall be adequate for ambient temperatures down to 5°C. The heater rating shall not exceed 0.2W/Sq.mm and the surface temperature of any part which could be contacted accidentally shall not exceed 60°C. Heaters shall be so situated that no deterioration can be caused to any equipment or wiring in the panel. The heating circuits shall be switched and fused independently of the instrumentation and control equipment and manually controlled by an enclosed switch mounted in an accessible position within the panel. Thermostats shall be mounted remote from the heaters and other sources of heat and shall be fully adjustable over a range of not

less than 0°C to 50°C. Thermostats shall cut out each heater when the internal temperature of the panel exceeds a preset value; differential thermostats shall be used to maintain the panel internal temperature at a pre-set value above the external ambient temperature. If the permanent power supply is not available at the time of installation of the panel and condensation is detected, a temporary power supply shall be connected to the panel of sufficient rating to operate the heaters.

17.15. Panel lighting

Each panel shall be adequately illuminated internally, as evenly and as free from dazzle as possible, by fixed fluorescent lighting controlled from totally-enclosed light switches and by totally-enclosed door-operated switches positioned so as not to interfere with access. There shall also be one installed inspection lamp per three meters of panel length or part thereof with adequate flexible connection cable to reach any point in the panel. The control switch for an inspection lamp shall form part of the lamp assembly. Lighting circuits shall be fused independently of any instrumentation and control circuit and designed to allow lamps to be replaced safely and shall be fed from a distribution board and circuit breaker connected on the live side of the main panel ac supply circuit breaker.

17.16. Panel ventilation

Each panel shall be provided with ventilation fans as required to ensure that equipment within the panel is maintained within manufacturer's recommendations, with due regard to the environment in which the panel will be mounted. Fans shall be controlled by a suitably labeled enclosed switch mounted internally in an accessible position. Fans shall be mounted with their axes horizontal and shall be arranged to draw clean air into the panel. Air entries shall have filters which can be renewed from outside the panel and shall be designed to prevent the entry of rain, spray, injurious fluids, sand or dust.

17.17. Panel piping and tubing

Panels containing equipment using a supply of compressed air shall have a common air pressure reducing station with duplicate pressure-reducing valves and filters. The pressure reducing station shall also include isolating valves upstream and downstream of each filter/reducing-valve set, pressure-relief valve, pressure indicator and low-pressure alarm unit for the low-pressure header and a pressure indicator for the high-pressure pipework. The pressure-reducing station components shall be mounted in a clear space inside the

panel, supported on a suitable framework between the lower horizontal row of instruments and the main low-pressure header. All piping, fittings and valves downstream of the pressure-reducing station shall be of brass, copper or plastic. PTFE tape shall not be used downstream of the main filters. The low-pressure header shall be brass and shall be near the panel floor with drain valves and tundishes piped to a drain. Branch air headers shall be of brass (15mm diameter minimum) and shall run vertically from the header to the instrument. The low pressure header and each branch shall have a 6mm minimum, non-ferrous shut-off valve for each instrument requiring an air supply and a compression coupling for each air-purge connection. At least 10% spare connections for possible future instruments shall be provided in each panel section. Any header dismantled before shipment shall have brass unions or flanges at each panel-section junction. Panel-mounted instruments shall be piped to bulkhead fittings on a gland plate during assembly at the manufacturer's works. Piping shall be colour-coded in accordance with Recommended Practice ISA-RP 7.2 issued by the Instrument Society of America and shall be segregated from wiring so that any leakage is harmless. Each panel-mounted pressure gauge shall have a stainless steel flush-mounted shut-off and fine-regulating valve mounted vertically below. A drip tray shall be provided below each row of gauges. Exhaust and depressurizing pipework shall be routed out of the panel.

17.18. Panel labels

Labels shall be provided for every panel to describe the duty or otherwise identify the panel and its sections and every instrument, component and item of equipment mounted internally and externally. Where applicable, front-of-panel labels shall be as shown in the Specification drawings. Each label shall be permanently secured to the surface near the item to which it refers.

Externally-fitted labels shall be of perspex or other approved transparent plastic, with letters and numbers rear-engraved and filled with black. The rear surface of each perspex label shall be finished with a coat of paint of the same colour as the panel external finish. Instrument duty labels fitted externally shall be below the item to which they refer. Embossed tape or similar adhesive labels will not be approved.

Laminated materials or rear-engraved and filled plastic shall be used for internally-fitted labels, which shall be white with engraved black letters. Labels conforming to the requirements of the preceding paragraphs or other approved means shall be provided:

- Labels

- To describe or identify circuits or circuit components
- To identify DC polarity
- To warn or remind about dangerous or potentially-dangerous circumstances
- Wherever elsewhere specified

Unless otherwise specified, all engraving shall be in plain block letters, 4mm high. The minimum practicable number of different sizes shall be used. Manufacturers' nameplates shall not be fitted on panel external surfaces.

17.19. Panel finish

For control and instrument panels, desks and cubicles a hard, smooth, durable finish, free of blemishes, shall be provided. Before painting, all external welds and any rough areas shall be smoothed, and all surfaces shall be thoroughly cleaned and free from scale, contaminates corrosion or grease. If rust-proof or Zintec steel has not been used in the construction, the panel shall be treated with a passivating agent such as phosphoric acid. All internal surfaces shall have a minimum of three coats of paint of which the first shall be an approved antirusting priming coat and the final coat shall be opaque gloss white enamel. All external surfaces shall have not less than five coats of paint of which the first shall be an approved etch priming coat, and the second and third suitable undercoats, all of which shall be rubbed smooth when dry before application of the next coat. The undercoats shall be easily distinguished in shade or colour from the priming and finishing coats. The two final coats shall be of stove enamel paint, gloss or semi-matt finish, to a colour and finish. Stoving shall be carried out in accordance with the recommendation of the paint manufacturer. The overall dry film thickness (DFT) shall be between 85 and 120 microns. Nuts, bolts, washers and other fixing devices which may have to be removed for transit or maintenance purposes shall be galvanized or otherwise finished to an approved standard. A 500ml tin of matching touch-up paint shall be provided and packed with each panel.

18. Electrical Indicators and Integrators

Indicators for use with analogue signal-transmission systems shall comply with BS 89:1990 or equivalent and have an accuracy class index of 1.0. Indicator movements shall be critically damped (dead-beat). Indicators for use on more than one circuit shall have rotary switches to select the circuit, with engraved plates to show the circuit selected. Indicators shall have circular scales or shall be of the vertical edgewise type and shall be designed to avoid parallax error.

Scales shall be clearly marked in SI units and shall comply with BS 3693:1992 or equivalent. All instruments mounted on one panel or board, or in adjacent groupings, shall have similar styles of figures and letters. Dials shall be white with black scales and lettering not subject to fading.

The material for scales shall be such that no peeling or discolouration will take place with age under any environmental conditions. Major scale marks and numerals shall be of the same size and thickness and shall be separated by not more than twenty-five minor marks. Pointers shall taper to the width of the scale marks. Integrators shall be of the multi-digit cyclometer type. Integrators operating in conjunction with an electromagnetic or ultrasonic flow meter shall use the pulse output from the flow transmitter. Any integrator operating from a device without a pulse output shall have an integral or separate current-to-pulse converter with sufficient adjustment of the pulse rate to avoid the use of any multiplying factor except in integer power of 10. Each integrator shall incorporate an adjustable limiter whereby any input below a pre-set value is inoperative. Unless otherwise specified, integrators shall have a minimum of eight digits with a decimal point where applicable.

18.1. Alarm System

Alarms shall be initiated by the opening or closing of volt-free contacts which shall remain unchanged throughout the periods in which the alarm conditions exist. Alarm circuits shall be capable of conversion from open-healthy to open-alarm or vice versa by a simple modification after installation requiring no additional parts or special equipment.

Each alarm shall initiate the operation of both visual and audible devices. The sound intensity of each audible device shall be suitable for the maximum sound level of its environment.

Audible devices in the same room or area shall have distinguishable sounds and adjustable sound levels.

19. Matrix Type Alarm Annunciators

The alarm annunciator shall be microprocessor based, modular, split type unit with alarm windows mounted on the front door and electronic modules inside the panel. The weather protection class for alarm annunciator shall be IP-54 of IS 13947, Part-I. Each alarm shall initiate a visible and audible indication of the specified condition. Unless otherwise

specified, alarm indicators shall be grouped together in annunciator units each having at least 20% spare ways. Alarm indicator lamps (Cluster LED type) shall have transparent screens engraved with appropriate legends as approved in the Designs and Drawings. The legend area of each indication shall not exceed 40mm high and 75mm wide. When any alarm condition occurs, a condition device common to an alarm annunciator system shall sound and the appropriate indicator shall flash on an off. The flashing rate shall not be less than 2 Hz and shall not exceed 5 Hz. On pressing an accept pushbutton, the audible device shall be silenced and the flashing light shall become steady. The alarm indicator shall remain illuminated until the alarm condition ceases and a reset pushbutton has been operated.

The operation or acceptance of one alarm shall not inhibit the operation of the audible device or the flashing of the appropriate alarm indicator if a further alarm condition occurs.

At unmanned locations alarms operated on two or more annunciators shall require acceptance at each annunciator. Alarms shall be accepted automatically and the appropriate audible device silenced after an adjustable period of 1 to 5 minutes.

An integral 'test' pushbutton shall be provided to illuminate each lamp in the appropriate group and to operate the audible device but shall not cause a spurious alarm condition on any other annunciator.

Alarm circuitry shall be arranged so that spurious or transient alarm states persisting for less than 0.5 seconds do not initiate any action.

Alarm annunciator / indicator legends or labels shall be arranged with three lines of text as follows:

- Top Line: Location; example: sludge blanket level
- Middle line: parameter; Level
- Bottom line: status. High

20. Push-Buttons and Indicator Lights

Push-buttons in control circuits shall have shrouds, guards or other suitable means for preventing inadvertent operation. Status-indicator lights shall be of the high-intensity LED type. Indicator lights shall be of a design which allows easy LED replacement from the

front. Indicator lights shall be easily visible above the ambient light level when viewed from within an included angle of 120 degrees. LEDs shall be chosen to ensure clear discrimination between the energized and de-energized states and to ensure an average working life of not less than 3000 hours. A 'lamp test' push-button shall be provided for each group of indicator lights. The colours of push-buttons and indicator lights on instrument panels shall be as follows:

o INDICATOR LIGHTS ON INSTRUMENT PANELS

- o Start or on (energize) - Green
- o Stop or off (de-energize) - Red
- o Open valve - Black*
- o Close valve - Black*
- o Accept - Black
- o Lamp test - Black
- o Reset - Black
- o Motor running (energized) - Red
- o Motor stopped (de-energized) - Green
- o Valve open - Red
- o Valve closed - Green
- o Urgent alarm - Red
- o Non-urgent alarm - Yellow
- o Plant healthy or ready for use - White

*Panel-mounted push-buttons for valve operation shall be coloured black, or as per the approved Design and Drawings, with the duty clearly defined by legend on an associated label.

21. Analogue Signal Transmission

Unless otherwise specified, analogue signal-transmission systems shall be in accordance with BS EN 60546-1:1993 and shall use a signal of 4mA to 20mA DC. Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter. Transmitters shall be capable of meeting the requirements laid down in the appropriate part of IEC 60770-1:1999.

22. Analogue Process Controllers

Analogue controllers shall use solid-state components and shall have outputs containing three terms with negligible interaction. The controller fascia shall have measured value, set

value and output indication, manual set-value and output controls, auto/manual switch for control mode and remote-local transfer switch for set-value control. Manual control stations shall have measured value and set-value indication, local/remote switch and control available lamp indicator. Each controller shall have the means to restrict its output signal to a predetermined, fully adjustable band so that the regulating device is not moved to unsafe positions. The adjustment of these safe operating limits shall be by means of accessible, clearly marked, internal components. A continuously adjustable proportional band of not less than 5 to 500% shall be provided. Integral and derivative action times shall be adjustable over ranges which shall not be narrower than 6 seconds to 25 minutes and 0- to 10 minutes respectively. If the integral or derivative action times' adjustments are in steps, the ratio of successive steps shall not exceed 2. The controls used to set the P, I and D values may be at the front of the instrument or mounted internally in an accessible position.

Each controller shall be designed so that in the event of failure, it shall be possible to plug a portable manual station into the controller case and to control the regulating device manually.

Controller design shall ensure automatic procedure-less, bump less transfer whenever the instrument is switched from "auto" to "manual" or vice versa. Controller action shall be adjustable from direct to reverse and vice versa by the operation of an internal switch. Analogue process controllers shall be capable of meeting the requirements laid down in the appropriate part of BS EN 60546-1:1993.

Section G5.5
SCADA (Online Monitoring System)
for STP and LS/ PS

Section G5.5: SCADA (Online Monitoring System) for STP and LS/ PS

1. General

One of the key requirements forming part of Operation and Maintenance requirement of STPs and LS/PS, is REAL TIME ONLINE MONITORING of various data & details by authorities & officials in ULB, NMCG and in other stake holder departments of the project.

In order to facilitate this requirement, the concessionaire shall design and implement an SCADA concept based ONLINE MONITORING SYSTEM for real time monitoring of various parameters of the STP and LS/ PS including mechanical equipment (pumps, motors, valves, etc.), process instruments and power network. **However, NO ON SITE / REMOTE CONTROL OF ANY EQUIPMENT is envisaged in this system.**

The SCADA based REAL TIME ON LINE MONITORING SYSTEM (hereinafter referred to as RTOLMS) should be such that it has feature as per generic requirements to enable transmission of real time data of all the monitored parameters over Internet networks, leased and phone lines, wireless communication etc., or a mix of these as appropriate and as feasible at the respective site(s). The indicative list of such parameters which are to be logged and monitored / communicated on line are given in the table below.

Table 1: Typical parameter and relayed to control monitoring station

Parameters	Description of soft signal	Lifting station/ Pumping station / Main pumping station (Typical)		STP & septage treatment plant			Bio gas generation	Bio gas DG set
		Sump / collection well	Pumps	Sump / collection well	Pumps	Other equipment's		
Date & Time	Real time	✓	✓	✓	✓	✓	✓	✓
Liquid Level	High	✓		✓				
	Low	✓		✓				
Liquid flow	Inlet flow measurement	✓	✓	✓	✓			

Parameters	Description of soft signal	Lifting station/ Pumping station / Main pumping station (Typical)		STP & septage treatment plant			Bio gas generation	Bio gas DG set
		Sump / collection well	Pumps	Sump / collection well	Pumps	Other equipment's		
Sewage quality	pH, BOD, COD, TDS, TSS, and colour			✓				
Pump status for individual pumps	On, OFF, Trip		✓		✓	✓		
Flow rate in common header	Flow rate, head		✓		✓			
Electrical parameter for individual pumps & main switch board	Voltage, Current, KWH, PF, KVA		✓		✓	✓		
No of operating personnel			✓		✓	✓	✓	
Temperature - Ambient, liquid		✓	✓					
Bio gas monitoring	Online status for various activity						✓	
Gas generation	Cum / day, cumulative gas generation, gas quality						✓	

Parameters	Description of soft signal	Lifting station/ Pumping station / Main pumping station (Typical)		STP & septage treatment plant			Bio gas generation	Bio gas DG set
		Sump / collection well	Pumps	Sump / collection well	Pumps	Other equipment's		
DG set running hours								✓
Electrical parameter for individual Bio gas based engine generator,DG set pumps & main switch board	Voltage, Current, KWH, PF, KVA							✓

2. System architecture

The schematic representation of the required RTOLMS architecture to be provided by the bidder as part of Basic engineering package to meet the KPI requirements as per schedule 1 and 11.

Figure 1: Proposed SCADA

3. Scope of work

The scope of work, as a minimum shall include.

- Supply, installation, testing and commissioning of all necessary Hardware and Software for RTOLMS System including LAN switches, Modems, UPS, central work station, HMIs, data / fibre cabling between various sensing devices to the PLCs in the respective STPs, septage treatment plant, LS / PS

- Supply, installation, testing and commissioning at STPs, septage treatment plant, LS & PS of all necessary isolating and interface modules and RTUs, potential free auxiliary NO/NC contacts etc., required for making the existing / new Electrical power system components compatible for monitoring the voltage, current, PF, kVA, KWh, KVAh, pump ON/OFF status etc., besides interfacing of data on levels, pressure, flow rate and various other parameters of raw water and treated water.
- Supply, installation, testing and commissioning of all Networking Equipments (Router, firewall etc.) for the central unit at STP(s) and septage treatment plant
- Interface / Integration of PLC & RTU of STP, septage treatment plant, LS & PS with RTOLMS System.
- Integration of Field Instruments Hardware with RTOLMS System.
- Testing, Erection & Commissioning of supplied system.

4. Features Required in RTOLMS System

RTOLMS system will have many extra features and the proposed system should support multiple PLC/ RTU Protocol like Modbus, Profibus, DNP (Serial/TCPIP), OPC etc.

4.1. System components

The system shall consist of a modular controller (including control, I/O, and communications functions) and software modules that facilitate open systems connections.

The system shall include a full complement of modular supporting equipment (including mounting racks, power supplies, termination strips, equipment enclosures, prefabricated cables, furniture, etc.), all of which shall be designed to simplify construction.

4.2. Open Communications

The control system shall be open to enable easy integration with OPC (OLE for Process Control) [where OLE stands for Object Linking and Embedding (OLE)] server so as to collect the data from the remote housing station.

4.3. Reliability and redundancy

The system must be designed for maximum reliability and minimal downtime and work satisfactorily under harsh and dusty ambient conditions. This should be achieved through

a fault-tolerant design with minimal common cause failures and state-of-the-art redundancy schemes. The main system should offer 100 % redundancy for both hardware and software. The offered system shall offer highest possible MTBF within the service period of 15 + years.

4.4. Hardware Details

❖ SCADA CUM COMMUNICATION SERVER, WEB SERVER, ISR SERVER

Qty	Hardware Component	Remarks
1	RTOLMS SCADA cum Communication Server	○ The interfaces for each server are connected to Ethernet networks to collect data from field.
1	WEB server	○ Interface with Internet to remote client
1	ISR server	○ Databases server with Oracle/SQL for Alarm and MIS Report

❖ USER INTERFACE SUBSYSTEM

Qty	Hardware Component	Remarks
2	Workstation Console	○ The console is provided with TFT Monitor ○ The interface is connected to the Ethernet networks.
1	Remote access terminal	○ LAPTOP connected through a serial link and a modem.

❖ LOCAL AREA NETWORK SUBSYSTEM

Qty	Hardware Component	Remarks
1	LAN Switch	Ethernet switch 14 ports (10/100 Base TX) + 2 Fibre Port
6	Remote Location LAN switch	Ethernet switch 14 ports (10/100 Base TX) + 2 Fibre Port
1	Router	Port 2 LAN+2 WAN, all are 10/100 with 2 V.35

2	Firewall	4LAN+2 WAN, all Wan are 10/100Mbps and LAN are 10/100/1000 Mbps
Lot	12C Single armored cable Mode Fibre	For Connectivity

4.5. Peripheral Subsystem

❖ PRINTERS

Qty	Hardware Component	Remarks
1	Laser Printer(Colour)	Each laser printer is connected to Ethernet network.

❖ UPS

Qty	Hardware Component	Remarks
1	UPS of appropriate kVA rating for STP and septage treatment plant	The UPS shall be with two hours battery autonomy.
2	UPS of appropriate kVA rating for LS & PS	The UPS shall be with 2 hours battery autonomy

Note : This UPS shall be independent of that to be provided for the PLC system at STP , septage treatment plantand LS/PS locations

4.6. Hardware Components Description

This section describes the common hardware components.

❖ Communication cum SCADA Server, Web Server, ISR Server* Characteristics *

Intel® Xeon® Quad-Core Processor E5606 2.13 GHz, 8MB L3 Cache	1
Integrated Two Broadcom dual-port Gigabit Ethernet with TOE enabled	1
8GB Memory (4x2GB), 1333MHz, DDR3 RAM	1
2nd Intel® Xeon® Quad-Core Processor E5606 2.13 GHz, 8MB L3 Cache	1
300GB 15K RPM,6Gbps SAS 3.5 Hot Plug Hard Drive " With RAID5	3
DVD+/-RW ROM, SATA, Internal for Ms 2008 R2	1
High Output Power Supply, Redundant, 460W	1
Power Cord, GType, 230V (Nepal, Sri Lanka, India)	2
2U Cable Management Arm	1
2U Sliding Rail	1
Windows Server	1

* The system (hardware, software, accessories, etc.) being provided during installation would be of latest configuration.

❖ Workstation Console Monitor*

Motherboard	Intel® Xeon® Dual-Core Processor W3503 (2.40 GHz, 4 MB cache, 1066 MHz memory)
Video Card	ATI FirePro 2270 (512 MB)
RAM Memory	4GB (2x2GB) DDR3 SDRAM Memory, 1333MHz, ECC 1
HDD	500 GB SATA (7200 RPM) HDD
Input Power Supply	220 to 240 VAC (+/- 10%), 50 Hz (+/- 2 Hz)
Power Cord	Indian Style
CD Drive	16X DVD +/-RW Combo Drive
Keyboard	USB Entry Keyboard
Mouse	USB Optical Scroll Mouse (2 buttons) with Mouse Mat
LAN (Ethernet port)	Dual Broadcom RJ45 10/100/1000 BASE on board Ethernet NIC
I/O Cards	One serial RS-232 port, 4 USB port and one parallel port
Indicator & Switch	Power on/off x 1, HDD x 1. Power on/off x 1, System reset x 1

*The system (hardware, software, accessories, etc.) being provided during installation would be of latest configuration.

❖ LAN Switch*

Specification		Managed Industrial Ethernet switch			
Ethernet Standards		IEEE 802.3 IEEE 802.3u for IEEE 802.3x for Flow Control	for 100BaseT(X)	and	10BaseT 100BaseFX
Design Standard		FCC Part 15, CISPR (EN55022) class A, Shock- IEC60068-2-27, Vibration-IEC60068-2-6, EN61000-4-2 (ESD), EN61000-4-3 (RS), EN61000-4-4 (EFT), EN61000-4-5 (Surge), EN61000-4-6 (CS), EN61000-4-8, EN61000-4-11 standards			
Input Voltage		9.6-60 VDC			
Operating temperature:		0 to 60°C			
Ambient Humidity:	Relative	5% to 95% Non-condensing			
Overload Protection	Current	Present			
Mounting		DIN Rail Mounting			
No. of Ports		12 Nos. (10 CU + 2 FO)			
Interface					

Ethernet ports	10 no. RJ45 Ports with 10/100BaseT(X) auto negotiation speed, Full/Half duplex mode, and auto MDI/MDI-X connection
Fiber Port	Two 10/ 100BaseFX port SC Type Single-Mode, 1310 nm Supports Ring, and Self-Healing

The system (hardware, software, accessories, etc.) being provided during installation would be of latest configuration.

❖ **Router ***

Memory	RISC @ 533 MHz
	Flash Memory:256M Bytes
	SDRAM: 256M Bytes
Interface	2 x 10/100/1000 Mbps Ethernet Port
	2 Serial Ports (V.35)
	2 X 10/100 Mbps WAN Interface
	1 Console port
	1 Auxiliary port
Performance	
Throughput	300 Kpps (64-byte packets)
Routing table size	30000 entries
Network Management	IMC - Intelligent Management Center; command-line interface; Web browser; SNMP Manager; Telnet; RMON1; FTP; IEEE 802.3 Ethernet MIB
Operating Temperature	0° to 40° C (32° to 104° F) (Relative Humidity: 5% to 90% non-condensing)
Non-Operating Temperature	-40° to 70° C (Relative Humidity: 5% to 90% non-condensing)
Power	100-120/200-240 VAC

*The system (hardware, software, accessories, etc.) being provided during installation would be of latest configuration.

❖ **12C Single Mode Fibre Cable***

Configuration	Multitube double sheath armoured cable
Nos. of Core	12

Maximum Tensile Loading	1361 x 1021
Installation	2700N
Long Term Installed	900N
Operating Temperature	-30°C to +60°C
Normal Dia	14.8 mm
Nominal weight	200 KG/KM
Mode	Single Mode
Single mode Fiber:	(G.652.B)

4.7. Server Panel

The equipment can be of any Standard make which can comply with the following standards:

Type	SERVER RACK 42U/600W/1000D
Specification	Captive Front Panel Hardware, Pkt of 20
	Castors (Plain)
	Server Rack, 19"/42U
	consisting of High quality extruded Aluminium vertical profiles 4 Nos. Top and Bottom steel end
	frames with bottom Panel having gland plate for cable entry, Top cover with FHU provision, Side
	Panels with latches and venting slots at bottom 1/3 area and 2 pairs of 19" Mounting Angles
	Dimension: 2150 x 600W x 1000D Powder Coated BLACK
	Front CRCA steel single door with Perforation
	Rear CRCA steel single door with Perforation
	Component Shelf, Universal, 19"W/575mmD, Load cc 50 kg.
	Top Mounting, Fan Housing Unit with 4 fans 230 V / 90CFM
	Rotary Keyboard Tray with slides
	Castors (with brake)
	Earth Continuity straps (kit)

4.8. Power Supply

Redundant power supplies shall be available for card rack mounting to form as an integral part of the system. The module rack must provide two individual power supply buses that to be driven by two independent power sources for high availability placed in the rack in

current sharing mode. Each module shall be capable of using power from any of the two buses.

4.9. Enclosures

The racks shall be mounted in an industrial enclosure with a front & rear -access design, with all frequently accessed items (such as modules, connectors, status indicators, switches, and termination assemblies) located in the front of the enclosure. For maximum flexibility, the enclosures shall be modular, with the ability to be stacked, joined side to side, or joined back to back. To provide the degree of environmental security required, enclosures shall be available in sealed and vented versions.

Enclosure shall be i) for Indoor IP 44 and ii) for Outdoor IP 65

4.10. Input / Output Devices

Input/output Modules shall be intelligent I/O modules. Each module should be able to communicate with the CPU in a dedicated fashion without requirement of any additional interfacing hardware so as to reduce the common cause of the Failure. Each module should have its own microprocessor to execute its input/output function, maintain its configured data, and perform module diagnostics.

All process I/O shall be electrically isolated from both computer common and communications common. Isolation shall meet be min 1500 VAC requirements. Modules shall automatically determine their physical address and report this information to the controller. No range jumpers or user- configurable physical address jumpers should be necessary.

All configurable data shall be set via software, with no hardware jumpers used. Configurable data should include channel tag.

All the I/O modules shall have max 8 channels for the Analog and 16 channels for the Digital modules. Special modules like Counter inputs shall monitor dry contact pulses with an input resolution of one HZ minimum. More numbers per channel may be accepted if the overall reliability factor of MTBF within the service period of 15 + years is achieved.

4.11. Field Termination for I/O Modules

Each I/O module's field signals shall be wired into the system such that an I/O module can be removed at any time without disturbing the field wiring.

The field wiring should be separate from the I/O module(s). The extension from the module(s) shall be accomplished via a marshalled I/O cable assembly. This assembly should be a multi-conductor cable that attaches to the module rack (and the back of the I/O module) on one end and a finished termination end.

The marshalled termination assemblies shall be DIN rail-mounted PCB-based fixtures that include terminal blocks and two receptacles for accepting the interconnect cable plug. These receptacles must be female to eliminate the possibility of power from the terminal block being exposed on pins.

5. Detailed functional Specification of RTOLMS System Components

5.1. Data Acquisition

The RTOLMS system shall perform data acquisition from PLC of pre-treatment plant, STPs, LS / PS and field equipment. PLC is to be located at each location of the plant. PLC communications with central system shall utilize the Open protocol like Modbus, Profibus and Ethernet TCP/IP.

5.2. Data Exchange

The RTOLMS systems shall be able to exchange various types of data with the other application software using ActiveX Data Objects (ADO) or Dynamic Data Exchange (DDE).

5.3. Data Processing

a) Analog data

Analog data processing shall be performed according to the requirements listed below.

- Conversion to measurable Units as required by ULB / NMCG

- Reasonability limits checking
- Limit monitoring

b) Digital/Status Input Data

The following status input data types shall be accommodated as a minimum: Two-state points: The following pairs of state names shall be provided:

- (1) Open/Closed
- (2) Tripped/Closed
- (3) Alarm/Normal
- (4) On/Off
- (5) Auto/Manual
- (6) Remote/Local

c) Calculated Data

It shall be possible to define the calculations on real-time data and historical data, periodically and on request. The results shall be incorporated into the database as calculated data available for display & report generation.

The user shall be able to define calculated analog values using database points as the arguments and mathematical functions as the operations. Functions such as addition, subtraction, multiplication, division, maximum value, minimum value, average, count, square root, exponentiation, trigonometric functions, logarithms and other statistical functions shall be provided.

The RTOLMS system shall be capable of analyzing the open/closed status of switching devices, such as Motor, PUMP etc. The configuration shall be updated whenever a switching device status change is detected.

5.4. *Sequence-Of-Events Recording*

The Sequence-of-events (SOE) data shall be collected by the RTOLMS system from PLCs. The description of each event shall include the database description name, device state, the date, and the time (to the nearest millisecond) of each event.

5.5. *Information Storage and Retrieval*

Information Storage and Retrieval (ISR) system shall collect and store analog data (telemetered and calculated) periodically at every 5 minute (configurable) and status data by exception. Associated quality codes shall be included. It shall be possible to perform calculations on the stored data, and the results of these calculations shall be collected and stored. Other information such as alarms, events, SOE and reports shall also be stored. The data shall be stored on hard disc with date tag on daily basis for easy retrieval. Subsequently, the data shall be retrieved for analysis, display, trending, and report generation.

5.6. *Extensive Use of Standard*

The RTOLMS Software should be such that it uses an extensive use of standards, achieved by a corporate commitment to comply with all standards that are recognized on the RTOLMS market, and in particular:

- Intel (or compatible) based hardware;
- Operating system options of WNT 4.0, Windows 2000 or Windows 2003;
- Uses Microsoft Foundation Class (MFC) Object Oriented Database;
- Developed with Microsoft Developer's Studio;
- Installed using Microsoft Install Shield utilities;
- Component Based Architecture;
- Interfaced using Active X controls (OCX);
- TCP/IP for Local and Wide Area Networks (LAN & WAN);
- Web-enabled Operator Consoles;
- Control Center Application Programming Interface (CCAPI) Initiatives

5.7. *System Sizing & Extensibility*

The hardware and software openness of RTOLMS allows the client / concessionaire to smoothly upgrade the proposed system with great facilities. Common upgrading needs include (but not limited to) the following items:

- Additional measurement points (analog and digital);
- Additional protocol-compliant IEDs;
- Additional protocol-compliant PLCs;
- Additional operator consoles;

- Additional printers;

5.8. *Graphical User Interface (GUI)*

The GUI shall operate within a window environment, the system shall use displays which mimic the existing control panels so that the operators working in conventional control room environment are comfortable while working on the new system. Concessionaire shall develop control panel display generally similar to the one existing in conventional control room.

The GUI shall allow the personnel to monitor and control the equipment through the control panel displays and Tabular displays. The control panel displays shall be dynamically updated for measurands, device positions, annunciations. To have better visibility of control panels, it shall be possible to iconise each control panel separately. Operator shall select that icon to zoom/view that panel display & carry out operations such as alarm annunciation accept/reset, device close/open operations etc.

5.9. *Trending*

Trend displays shall enable the user to select real-time and historical data for trending on graphical displays and for tabular displays. It shall be possible to take print of these trends.

5.10. *Alarms*

Alarms are conditions that require user notification when detected. Audio, visual alarm shall be generated for all such conditions. It shall be possible to accept & reset all trip & non-trip alarm annunciation appearing on control panel facia from control panel display itself. Alarm annunciation on control panel shall have following characteristics:

Condition	Facia	Sound
Alarm initiation by relay contact	Flashing Glow	On
Accept PB pressed	Steady Glow	Off
Reset	Off (if relay contact is reset) Steady Glow (if relay contact is not reset)	Off

Other alarm conditions shall be acknowledged from respective alarm list displays. Other alarm conditions shall include, but not be limited to the following:

- (a) Telemetered or calculated value limit violations
- (b) Un-commanded changes of a power system device state
- (c) Data source communication errors resulting in loss of data
- (d) SCADA hardware and software element failures.

The standard products for advanced alarm management shall also be provided. Regardless of the alarm management technique used, all alarm messages shall be recorded with time & date tag on auxiliary memory for review and printing on demand by the user.

Displays shall highlight alarm condition using a combination of colour, intensity, inverse video and blinking. Alarm messages shall be a single line of text describing the alarm that has occurred with date & time of occurrence.

5.11. Events

Events are conditions or actions that shall be recorded by the SCADA system but do not require user action. Events shall be recorded in the form of an event message. The event message format shall be similar to the alarm message format. Events shall include but not be limited to the following:

Values returning to normal from a limit violation State Device status change on manual operation.

5.12. Hardcopy Printing of Display

A means shall be provided to produce a copy of a display. The display printout shall be initiated from user friendly push buttons/pull down menus. The options for printing mode shall include at least selection for orientation, background colour, page size, colour or black & white print and print preview. It shall also be possible to print selected portions of display and direct printing on any of the connected printer.

5.13. Report Generation

The user shall be able to schedule periodic reports generation, direct a report to a display, print a report, and archive a report. Hardcopy report formats shall be handed over to

Concessionaire for generation of report formats in the system. It shall also be possible to define and generate the additional user configurable reports. The generation and printing of any report shall not effect normal scanning of data from PLC. The report scheduling display shall enable entry of the following parameters, with default values provided where appropriate:

- (a) Report name
- (b) Report destination (printer or archiving device)
- (c) Time the system should produce the report.

5.14. RTOLMS System Access Security

A mechanism for defining and controlling user access to the SCADA system shall be provided.

5.15. Alarm Summary Displays

Displays that list or summarize all unacknowledged and acknowledged alarms shall be provided. The user shall be able to select between viewing alarms in chronological and reverse chronological order. The default shall be most recent alarms. The summary shall separate acknowledged and unacknowledged alarms. To facilitate identification of unacknowledged messages the time field shall blink or entire row shall blink. It shall be possible to sort alarms by user defined text, date, time.

5.16. Event Summary Displays

Event summary displays shall list the most recent events. The user shall be able to select between viewing events in chronological and reverse chronological order. The user shall be provided with a convenient and efficient means of selecting an event summary display. It shall be possible to sort events by user defined text, date, time.

5.17. Operating Information Summaries

The operating information summaries defined below shall be provided. Summary items will be listed in reverse chronological order with the most recent item shown on the first page. The user shall have the ability to sort summary items by device.

5.18. *Abnormal Summary*

The summary display shall list devices and values that are found to be abnormal, i.e., are not in their normal state. Telemetered, calculated, and manually entered status and data values shall be included.

5.19. *Out-Of-Scan Summary*

The out-of-scan summary display shall list device status and data values that are not currently being processed by the system.

5.20. *Alarm Inhibit Summary*

This display shall list devices and data values for which the user has suspended alarm processing.

5.21. *Tag Summary*

This display shall list and describe all active device tags.

5.22. *Help Displays*

Help displays shall be provided to aid the user in interpreting displayed information and to guide the user through a data entry or control procedure.

5.23. *Alarm Beeper Services*

The Alarm Beeper service audibly notifies the operator of recent alarms by playing a wave file. Wave files can be used to distinguish between Alarm priorities. All the Windows' .wav files or customized wav files can be used.

5.24. *Alarm Pager Services*

The Alarm Pager service allows the user to configure the system to issue various pages in response to specified alarms.

Section G5.6
Inspection and testing at manufacturer's works

Section G5.6 : Inspection and testing at manufacturer's works

All inspection and testing shall be carried out in accordance with the Specification and in absence of Specification relevant Indian Standard or internationally approved equivalent standard. After award of contract, Bidder shall furnish QA plan, which will be mutually discussed with the Executing Agency and finalized QA plan shall include test, and incoming supply of raw materials and bought out items, stage inspections and tests on finished products at manufacturer's works / appropriate testing station. QA plan shall clearly indicate tests which are intended to be witnessed by the Bidder alone and those by both Bidder and Executing Agency.

The Concessionaire shall carry out wherever practical, at the place of manufacture tests of the Plant / Equipment.

The Executing Agency shall be entitled to attend the aforesaid inspection and / or tests by his own duly authorized and designated representatives.

The Executing Agency and his duly authorized representative shall have access to the Concessionaire's premises at all suitable times to inspect and examine the material and workmanship of the mechanical and electrical plant and equipment during its manufacture there. If part of the plant and equipment is being manufactured on other premises, the Concessionaire shall obtain permission for the Executing Agency or his duly authorized representative, to inspect as if the plant and equipment was manufactured on the Concessionaire's own premises. Testing (including testing for chemical analysis and physical properties) shall be carried out by the Concessionaire and certificates submitted to the Executing Agency who will have the right to witness or inspect the above mentioned inspection / testing at any stage desired by him. Where inspection or testing is to be carried out at a subConcessionaire's works, a representative of the Concessionaire shall be present.

The procedure for the testing and inspection to be carried out during or following the manufacture of the materials to ensure the quality and workmanship of the materials and to further ensure that they conform to the Contract is whatever place they are specified shall be as described below.

The Concessionaire shall give the Executing Agency at least 21 clear days' notice in writing of the date and the place at which any plant or equipment will be ready for inspection/testing as provided in the Contract. The Executing Agency or his duly

authorized representative shall thereupon at his discretion notify the Concessionaire of his intention either to release such part of the plant and equipment upon receipt of works test certificates or of his intention to inspect. The Executing Agency shall then give notice in writing to the Concessionaire, and attend at the place so named the said plant and equipment which will be ready for inspection and/or testing. As and when any plant shall have passed the tests referred to in this section, the Executing Agency shall issue to the Concessionaire a notification to that effect.

The Concessionaire shall forward to the Executing Agency duly certified copies of the test certificates and characteristics performance curves for all equipment.

If the Executing Agency fails to attend the inspection and/or test, or if it is agreed between the parties that the Executing Agency shall not do so, then the Concessionaire may proceed with the inspection and/or test in the absence of the Executing Agency and provide the Executing Agency with a certified report of the results thereof as per (b) above.

If any materials or any part of the works fails to pass any inspection / test, the Concessionaire shall either rectify or replace such materials or part of the works and shall repeat the inspection and/or test upon giving a notice as per (a) above. Any fault or shortcoming found during any inspection or test shall be rectified to the satisfaction of the Executing Agency before proceeding with further inspection.

Where the plant and equipment is a composite unit of several individual pieces manufactured in different places, it shall be assembled and tested as one complete working unit, at the maker's works or at site as mutually agreed by the Executing Agency and Concessionaire.

Neither the execution of an inspection test of materials or any part of the works, nor the attendance by the Executing Agency, nor the issue of any test certificate pursuant to (c) above shall release the Concessionaire from any other responsibilities under the Contract.

The test equipment, meters, instruments etc., used for testing shall be calibrated at recognized test laboratories at regular intervals and valid certificates shall be made available to the Executing Agency's at the time of testing. The calibrating instrument used as standards shall be traceable to National / International standards. Calibration certificates or test instruments shall be produced from a recognized Laboratory for the Executing

Agency's consent in advance of testing and if necessary instruments shall be recalibrated or substituted before the commencement of the test.

Items of plant or control systems not covered by standards shall be tested in accordance with the details and program agreed between the Executing Agency and Concessionaire.

Tests shall also be carried out such that due consideration is given to the Site conditions under which the equipment is required to function. The test certificates shall give all details of such tests.

The Concessionaire shall establish and submit a detailed procedure for the Inspection of materials or any part of the works to the Executing Agency for approval within the date indicated in the Programme Details. The detailed procedure shall indicate or specify, without limitation, the following:

- i) Applicable code, standard and regulations
- ii) Fabrication sequence flow chart indicating tests and inspection points
- iii) Detailed tests and inspection method, indicating tests and inspection points
- iv) Acceptance criteria
- v) Test report forms and required code certificates and data records
- vi) Method of sampling, if any sampling test to be conducted
- vii) Concessionaire's or Executing Agency's witness points.

The Concessionaire shall not pack for shipment any part of the Plant until he has obtained from the Executing Agency or his authorized representative his written approval to the release of such part for shipment after any tests required by the Contract have been completed to the Executing Agency's satisfaction.

Part-C
Testing and Commissioning

Part C
Testing and Commissioning
Requirements Inspection and Testing During Construction

1.1 General

Inspection and testing of all Facilities shall be carried out in accordance with the relevant Indian Standard or internationally approved equivalent standard. QA plan shall clearly indicate tests which are intended to be witnessed by the Concessionaire alone and those by Concessionaire and Project Engineer.

Inspection and tests schedule shall be as follows;

- (i) Manufacturer tests
- (ii) Acceptance Inspection / Quantity checking
- (iii) Install /Site Inspection
- (iv) Site Acceptance Test
- (v) Tests on Completion
- (vi) Process Wet Tests (by Raw Sewage)
- (vii) Operation Test (Tests After Installation)

The Concessionaire shall establish and submit a detailed procedure for the inspection of materials or any part of the Facilities to the Engineer for approval within the date indicated in the Programme Details. The detailed procedure shall indicate or specify, without limitation, the following:

- Applicable code, standard, and regulations.
- Fabrication sequence flow chart indicating tests and inspection points.
- Detailed tests and inspection method, indicating the measuring apparatus to be used, items to be measured, calculation formula, etc.
- Acceptance criteria.
- Test report forms and required code certificates and data records.
- Method of sampling, if any sampling test to be conducted.
- Concessionaire's or Project Engineer's witnesspoints.

The witness testing shall be carried out for all the Mechanical, Electrical, Instrumentation, PLC, SCADA and Associated Equipment.

1.2 Testing on Construction Completion

For all the Bhagalpur facilities, prior to the commencement of Trial Operations on respective Construction Completion the Concessionaire shall submit the following to the BUIDCO:

- (1) As-Built Drawings
- (2) Operation and Maintenance Manuals
- (3) Site test results

The initial charges of oil, grease, generator fuel / oil, chemical, disposal of cake, etc. necessary for Trial Operation shall be borne by the Concessionaire.

a) Manual Commissioning Tests

Manual commissioning tests shall be such preliminary trials, tests and retests on Bhagalpur facilities prior to Bhagalpur facilities COD respectively, in order to demonstrate that the Bhagalpur facilities as a whole are ready to undergo the manual operation tests and that these will take place with a minimum of interruption.

b) Manual Operation Tests

When the manual commissioning tests have been completed so that the Bhagalpur facilities have been demonstrated to the satisfaction of the BUIDCO, the Concessionaire shall commence the manual operation tests.

These tests shall demonstrate the correct operation of the Bhagalpur facilities whilst using the minimum quantity of automatic control and monitoring equipment. Such equipment shall be at least that required for the maintenance of safety and for the normal mode of operation of such Facilities.

The Bhagalpur facilities will be required to demonstrate satisfactory operation at all design flow rates.

c) Automatic Commissioning Tests

The Automatic Commissioning Tests shall be such preliminary trials, tests and retests on Bhagalpur facilities in order to demonstrate that the Bhagalpur facilities as a whole are ready to undergo the tests of completion and that these will take place with a minimum of interruption.

1.3 Dry Test Requirements

As a minimum requirement the following dry tests shall be carried out as a general requirement:

- (1) A general inspection to check for correct assembly and quality of workmanship
- (2) A check on the presence of lubricant, cooling medium, electrolyte, etc.
- (3) A check on adequacy and security of Facilities fixing arrangements.
- (4) A general check to ensure that all covers, access ladders, water proofing, guard railings etc. are in place.
- (5) A check on damp-proofing, rust-proofing and vermin-proofing and particularly the sealing of apertures between building structures, chambers etc. and the outside.

a) Civil and Building Works

As a minimum requirement, check for the presence of foreign bodies in pipe work and structures shall be carried out on the civil and building works.

b) Mechanical Works

As a minimum requirement, preliminary running checks as far is permitted by circumstances in order to ensure smooth operation of Facilities shall be carried out on the mechanical systems.

c) Electrical Works

As a minimum requirement the following dry tests shall be carried out on the electrical systems:

- a. Check phasing and polarity.
- b. Carry out point to point check on cables.

- c. Check on security of cable terminations.
- d. Check on completeness and adequacy of earthing systems.
- e. Check setting on protection relays, sizes of fuses and motor overload settings.
- f. Carry out checks on cabling systems in accordance with the requirements of the relevant standards.
- g. Check operation of main circuit breakers by secondary injection methods.
- h. Check rotational direction of Plant.
- i. Check instrument loop integrity, functionality and calibration.
- j. Check operation of standby generator installation and mains / generator changeover procedures; a 4 hour load test (using the normal load of the Works) shall be carried out on the generator when the load is available.
- k. Check plant functionality.
- l. Check functionality of the central MMI and its power supply.

1.4 Process plant item / equipment

All process plant items / equipment shall be tested to ensure they meet the requirements for quality of workmanship, construction and performance as laid down in the Concession Agreement.

1.4.1 Hydraulic Wet Test Requirements

Hydraulic wet tests shall be carried out on completion of dry tests.

Clear water shall be used for hydraulic wet tests. The purpose of the tests is to prove the hydraulic performance of the Works. In order to demonstrate this, the Concessionaire shall ensure that each part of the Works is hydraulically loaded to its rated throughput for a period of at least four hours.

In order to ensure a sufficient supply of water to carry out these tests the Concessionaire shall provide all required facilities, including but not limited to any temporary facilities that may be required for storage and recycle of clear water or facilities for the disposal of the water off Site in an approved manner.

The following tests inter alia shall be carried out:

- (i) Pressure testing of all piped systems laid direct in ground in accordance with the relevant standards.
- (ii) Fill all structures and check for leaks.
- (iii) Filling of all storage vessels to check for leaks and distortion.
- (iv) Running of all pumped systems in order to check for.
- (v) Correct functionality.
- (vi) Absence of leaks.
- (vii) Correct running temperatures.
- (viii) Smoothness of running and the absence of undue vibration or stress.
- (ix) Check drive running currents.
- (x) Carry out calibration of instruments where appropriate.
- (xi) Carry out valve operation, diversions etc. to fully hydraulically load each process element (or where there is a requirement to withstand an over load), overload each process element.
- (xii) Demonstrate correct functionality of electrical, control and instrumentation systems.

1.4.2 Process Wet Tests (with Raw Sewage)

On approval by the Project Engineer the Concessionaire shall carry out process wet tests.

Raw Sewage shall be used as the primary feed stock for process wet tests. These tests shall be carried out to demonstrate the process performance of the Works. In order to demonstrate this, the Concessionaire shall ensure that each part of the Works is loaded to its rated throughput (including a period of overload if required in order to demonstrate compliance with the Project Engineer's Requirements) for a continuous stable operating period of not less than 48 hours.

The Concessionaire shall provide all required facilities for the disposal off Site in an approved manner. The following tests inter alia shall be carried out:

- (i) Check for leaks on vessels, structures, pumps and pipe work.
- (ii) Running of all pumped systems in order to check for.
 - Correct functionality.
 - Absence of leaks.
 - Correct running temperatures.
 - Smoothness of running and the absence of undue vibration or stress.

- Check drive running currents where the solution pumped is different from that pumped during hydraulic wet tests.
- (iii) Carry out calibration of instruments.
- (iv) Carry out valve operation, diversions etc. to fully hydraulically load each process element (or where there is a requirement to withstand an over load), overload each process element.
- (v) Demonstrate correct functionality of electrical, control and instrumentation systems not checked during dry or hydraulic wet tests or which may have changed as a result of the different operating conditions now prevailing.

On completion of the tests on the various parts of the works the Concessionaire shall run all Bhagalpur facilities as a whole in order to demonstrate the full functionality and performance of the Bhagalpur facilities at various throughput rates for a continuous period as specified in Concession Agreement.

1.5 Trial Operations

The Trial Operations shall be used to prove the operation of the Bhagalpur facilities are in compliance with the KPIs at varying flows and with varying Influent Standards.

- 1) The quality of Treated Effluent produced
- 2) Guaranteed Energy Consumption
- 3) Quality of Digested Sludge
- 4) The quality of Treated Water produced

Raw Sewage shall be used as the main feed stock for Trial Operations. These tests shall be carried out to demonstrate the process performance of the Facilities. In order to demonstrate this, the Concessionaire shall ensure that each part of the Facilities are loaded to rated throughput.

The following tests, inter alia, shall be carried out:

- (1) Check for leaks on vessels, structures, pumps and pipe work.
- (2) Running of all pumped systems in order to check for.
 - ✓ Correct functionality.
 - ✓ Absence of leaks.
 - ✓ Smoothness of running and the absence of undue vibration or stress.
 - ✓ Check drive running currents where the solution pumped is different from that pumped during hydraulic wet tests.

- (3) Carry out calibration of instruments.
- (4) Carry out valve operation, diversions etc. to fully hydraulically load each process element (or where there is a requirement to withstand an over load), overload each process element.
- (5) Demonstrate correct functionality of electrical, control and instrumentation systems not checked during dry or hydraulic wet tests or which may have changed as a result of the different operating conditions now prevailing.

1.6 Trial Operation & minimum performance standards test record

The Concessionaire shall maintain two copies of Trial Operation test reports for documentation of the following information on daily basis.

- Print outs of data logs from SCADA system.
- Samples collected for assessment the quality of Treated Effluent
- Samples collected for assessment the quality of Treated Water
- Electricity consumption.
- Stabilized Digested Sludge characteristics
- Log sheets required for noting down readings / results of various tests shall be prepared.

PART D
Specifications for Operation and Maintenance

Part D : Specifications for Operation and Maintenance

1.1. General

The Facilities and Associated Infrastructure shall run 24 hours every day and 365 days each year continuously under normal operation.

1.2. The O&M manual

The Concessionaire shall submit an O&M Manual as per the Concession Agreement before COD. The O&M of the Facilities and Associated Infrastructure shall be done as per the approved O&M Manual, any approved updations to it as agreed by the Executing Agency and the EHS Plan.

1.3. Guidelines of operations

1.3.1. Inventory control

Throughout the O&M Period, the Concessionaire shall provide and maintain tools and spare parts in accordance with the Concession Agreement.

The current stock levels shall be updated on-line by monitoring signals of the SCADA system (e.g. level of chemical tanks). All delivery of spare parts and consumables shall be recorded as appropriate.

The Concessionaire shall carry out inventory checks every six months. The inventory checks shall be scheduled to avoid disturbance to the O&M.

1.3.2. Chemicals, Dangerous Goods and Hazardous Materials

The Concessionaire shall provide and maintain storage of chemicals, dangerous goods and hazardous materials required for the O&M. Dangerous goods include any of the goods or substances to which the Dangerous Goods Ordinance applies.

1.4. Guidelines for Maintenance

The Concessionaire shall carry out corrective and preventive maintenance of the Facilities and Associated Infrastructure in accordance with the Design and Drawings, O&M Manual, Scheduled Maintenance Programme and EHS Plan to ensure the facilities and equipment perform to the specific standards.

The maintenance of all civil structures shall be done for a period of 15 years as per the frequency as per CPWD maintenance manual 2012 as approved by Executing Agency.

1.5. Maintenance Management

A Computerized Maintenance Management System (CMMS) shall include functions for the creation and upkeep of work orders and maintenance records. The database shall include the following information:

- Preventive maintenance programmes of systems, equipment, building and infrastructure of the Facility, which are used to generate work orders for preventive maintenance automatically;
- Logs of system or equipment fault / breakdown and automatic generation of work orders for corrective maintenance;
- Date of inspection / maintenance (preventive or corrective) carried out;
- Names and positions of Concessionaire's staff carried out the inspection / maintenance; Logs of manual alterations of any operations records, etc;
- Details of inspection / maintenance carried out including:
 - Causes of maintenance Maintenance procedures
 - Special gears / equipment used Spare parts used
 - Equipment / parts replaced
 - Any follow-up actions / recommendations (e.g. change of operational procedures, etc.)

The CMMS shall have functions to organise, sort and filter the maintenance records in the database as required and perform statistical analysis and generate reports for performance monitoring. The CMMS database shall be archived on a monthly basis. One electronic copy of the entire database shall be stored on the Site for retrieval as necessary.

1.5.1. Calibration of Instruments and Measuring Equipment

The Concessionaire shall maintain accuracy and reliability of all measurement facilities throughout the O&M Period to enable correct and effective monitoring and control of the Facilities and Associated Infrastructure.

The Concessionaire shall be responsible for the calibration and re-calibration as necessary of all measurement facilities. All calibration work shall be carried out so as not to delay or disrupt the O&M. Calibration frequency shall not be less than that recommended by the manufacturers of the instruments or measuring equipment and in any case no longer than 12-month intervals.

1.5.2. Tools and Spare Parts

During the O&M Period, the Concessionaire shall provide and maintain tools and spare parts in accordance with the Concession Agreement.

The storage of special tools and inventory of spare parts shall be recorded and monitored.

At the expiry of the O&M Period, the Concessionaire shall handover to the Executing Agency all special tools and spare parts in accordance with the Concession Agreement. The stock level of spare parts shall be sufficient for 1 year operation from the end of the Concession Term.

1.6. Records and Reporting

1.6.1. Archiving of SCADA and CMMS Data

The Concessionaire shall maintain all operation and maintenance records, including SCADA, throughout the O&M Period in a safe and secure manner. Any amendment to the records shall only be made in accordance with proper checking and authorization procedures, which shall be included as part of the O&M Manual.

The Project Engineer shall be allowed to check the above mentioned data and records described at any time.

As far as possible, all records shall be kept electronically utilizing the Concessionaire's computer facilities with backup security. If the computer facilities fail, then appropriate paper records shall be produced and filed.

1.6.2. Site Diary

The Concessionaire shall maintain a Site Diary which shall include, as a minimum, the following information on a daily basis:

- Date and weather; Operation hours; Labour on the Site;
- Flow and quality records of influent and effluent; Disposal records of treatment by-products;
- Accidents and incidents;
- Instructions to the Concessionaire; Comments by the Concessionaire;
- Complaints received and action taken; Authorized visitors to the Site; and

The Site Diary shall be checked and signed by authorized personnel of the Concessionaire in accordance with the O&M Manual.

The Concessionaire shall keep appropriate records of all personnel employed at the Site. These records shall be available for inspection by the Project Engineer at any time.

1.6.3. Safety and Health Records

The Concessionaire shall keep records on all safety and health matters as per the requirements of the Concession Agreement, O&M Plan and the EHS Plan and update such records daily for inspection by the Project Engineer.

1.6.4. Daily report

The Concessionaire shall provide details in the form of daily reports, of operational data and information in relation to the O&M of the Facilities to the Executing Agency in a systematic and concise manner, which shall include the following. The frequency of testing must as per the Table: Testing Methodology and Frequency

- Availability of the Facilities and the Associated Infrastructure

- Characteristics of the Treated Effluent and deviations from the KPIs, if any
- Characteristics of the Digested Sludge and deviations from the KPIs, if any

1.6.5. Monthly Report

The Concessionaire shall provide details in the form of monthly reports, of operational data and information in relation to the O&M of the Facilities to the Executing Agency in a systematic and concise manner. Monthly reports shall be submitted to the Executing Agency by the 7th day of the subsequent month and shall include the following:

- Availability of the Facilities and the Associated Infrastructure
- Characteristics of the Treated Effluent and deviations from the KPIs, if any
- Characteristics of the Digested Sludge and deviations from the KPIs, if any
- Summary of energy consumption (fuel and electricity) of the Facility;
- Quantities of chemicals, reagents, fuel and spare parts consumed; Stock level of chemicals, reagents, fuel and spare parts;
- Programme showing the scheduled maintenance (including planned and ongoing) work in the following month.

1.6.6. Quarterly Report

The Concessionaire shall provide details in the form of quarterly reports, of operational data and information in relation to the O&M of the Facilities to the Executing Agency in a systematic and concise manner. Quarterly reports shall be submitted to the Executing Agency within 7 days of end of a quarter and shall include the following:

- Availability of the Facilities and the Associated Infrastructure
- Characteristics of the Treated Effluent and deviations from the KPIs, if any
- Characteristics of the Digested Sludge and deviations from the KPIs, if any
- Summary of energy consumption (fuel and electricity) of the Facility;
- Quantities of chemicals, reagents, fuel and spare parts consumed; Stock level of chemicals, reagents, fuel and spare parts;
- Programme showing the scheduled maintenance (including planned and ongoing) work in the following quarter.

1.6.7. Annual Report

The Concessionaire shall submit Annual Reports to the Executing Agency within 30 days of end of the year and the report shall include the following:

- summaries of quantities and characteristics of Sewage received and treated at the STP during the reporting year;
- overall performance of the STP with highlights on non-compliance with KPIs as reported in each quarter;
- summary of expiry dates for licences, permits and certificates for the O&M;
- summary of major equipment breakdown, repair, overhaul, renewal, replacement, modification, performance tests, condition surveys carried out;
- summary of incidents related to safety and health, environmental issues, security and complaints;
- scheduled maintenance, overhaul, renewal, replacement, modification of major plant and equipment, Performance Tests and Condition Surveys in the forthcoming 12 months;
- list of Changes ordered by the Executing Agency, with details and status;

1.6.8. Monthly Environmental Monitoring Report

The Concessionaire shall submit Monthly Environmental Monitoring Reports to the Executing Agency providing overview of compliance with EHS Plan.

1.6.9. Testing Methodology and Frequency

The raw sewage and treated effluent shall be tested and checked for compliance with KPIs as defined below.

Parameters to be measured	Frequency	Methodology
Treated Effluent (pH ,BOD, TSS, COD, TDS, and colour)	It should be every 2 hours	Analysing the average of periodical values at every 5 minutes (configurable) and status data by exception of respective online instruments/analyzers
Treated Effluent (pH ,BOD, COD, TSS, TDS,Fecal Coliform,and colour)	One composite sample a day	24-hour composite be collected and analysed. These samples shall be stored in a refrigerator at a temperature between 1°C and 4°C. The sample shall not be allowed to freeze.

Parameters to be measured	Frequency	Methodology
Treated Effluent (pH ,BOD, TSS, COD,TDS, Fecal Coliform and colour)	One Composite sample of a day every month	The sample shall be tested in National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited laboratory recognised by CPCB and SPCB.
Digested Sludge		
Outlet Concentration of dewatered sludge ,volatile suspended solids, Salmonella, Viruses and Helminth Eggs.	At time of disposal	Seven samples of sludge shall be collected at the time of disposal and analyzed for Outlet concentration of dewatered sludge , volatile suspended solids, Salmonella, Viruses and Helminth Eggs. The geometric mean of the Outlet concentration of dewatered sludge, volatile suspended solids, Salmonella, Viruses and Helminth Eggs of these seven samples shall not exceed the prescribed standards/ limits as mentioned in the KPI.
Fecal coliform limit	At time of disposal	Seven samples of sludge shall be collected at the time of disposal and analyzed for faecal coliforms. The geometric mean of the these seven samples shall not exceed the fecal coliform limits.
Outlet Concentration of dewatered sludge, Fecal coliform limit , volatile suspended solids, Salmonella, Viruses and Helminth Eggs.	Once in month	The Outlet Concentration of dewatered sludge, volatile suspended solids, fecal coliform, Salmonella, Viruses and Helminth Eggs of any one sample every month shall be tested in National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited laboratory recognised by CPCB and SPCB

PART E
Electrical Load List

Part E : Electrical Load List

List of Electrical Drives

This information requested for each proposed STPs, septage treatment plant, PS and LS is to consider the Bidders load calculations for Transformer Sizing Calculation and for communication to the Electricity Board and for assessment of Emergency Load requirement. The Bidders shall include any particular additional equipment anticipated for the running of the facilities. The bidders shall fill in the requisite information as per the technology considered.

SL No.	DESCRIPTION	QTY.	W	S	$q = \text{flow capacity (m}^3/\text{h)}$	$h = \text{differenti at head (m)}$	$Ph = q \rho g h / (3.6 \times 10^6)$ $g = \text{gravity (9.81 m/s}^2)$ $\rho = \text{density of fluid (kg/m}^3)$	$\eta = \text{pump efficiency}$	$P_s = \frac{Ph}{\eta}$ $P_s = \text{shaft power (kW)}$	Motor efficiency	motor KW	KW of the Motor with relevant margin in case of raw sewage pumps with 25% over shaft power)	KW of Motor / Unit selected (each)	Type of feeder	V	DUTY HOURS	Total KW	Total energy consumption per day, kWh	LOAD FACTOR	corrected P.F.	KW ABSRBE D	KVA INPUT	
	STP																						
1.	Fine Screens																						
2.	Conveyor System																						
3.	Vortex Mechanism																						
4.	Primary Clarifier Mechanism																						
5.	Primary Sludge Pumps																						
6.	Scum pumps																						
7.	Mixers in Anoxic Tank																						
8.	Air Blowers																						
9.	EOT for Blowers																						
10.	Secondary Clarifier Mechanism																						
11.	Return Activated Sludge Pumps																						
12.	Waste Activated Sludge																						
13.	Decanters (IF SBR provided)																						
14.	Motorized Gates																						
15.	Thickened Sludge Pumps																						
16.	Dilution Water Pumps																						
17.	Digester Feed Pumps																						
18.	Digester Mixers																						
19.	Air Compressor																						
20.	Bogas Scrubber																						
21.	Dewatering																						

Sl. No.	DESCRIPTION	QTY.	W	S	$q = \text{flow capacity (m}^3/\text{h)}$	$h = \text{differential head (m)}$	$Ph = q \rho g h / (3.6 \times 10^6)$ $g = \text{gravity (9.81 m/s}^2)$ $\rho = \text{density of fluid (kg/m}^3)$	$\eta = \text{pump efficiency}$	$\frac{Ps}{Ph} / \eta$ $Ps = \text{shaft power (kW)}$	Motor efficiency	motor KW	KW of the Motor with relevant margin in case of raw sewage pumps with 25% over shaft power)	KW of Motor / Unit selected (each)	Type of Feeder	V	DUTY HOURS	Total KW	Total energy consumption per day, kWh	LOAD FACTOR	corrected P.F.	KW ABSORBED	KVA INPUT
	equipment Feed Pumps																					
22.	Dewatering equipment																					
23.	Poly dosing Agitator																					
24.	Poly dosing Pumps																					
25.	Centrifugal Pumps																					
26.	Plant Water Pumps																					
27.	Analytical Instruments																					
28.	Lighting and Miscellaneous Works																					
29.	Any other equipment anticipated by bidders																					

Schedule-11 SITE LAYOUT

Existing STP Layout at Bhagalpur (25°14'55.41"N, 86°57'13.01"E)

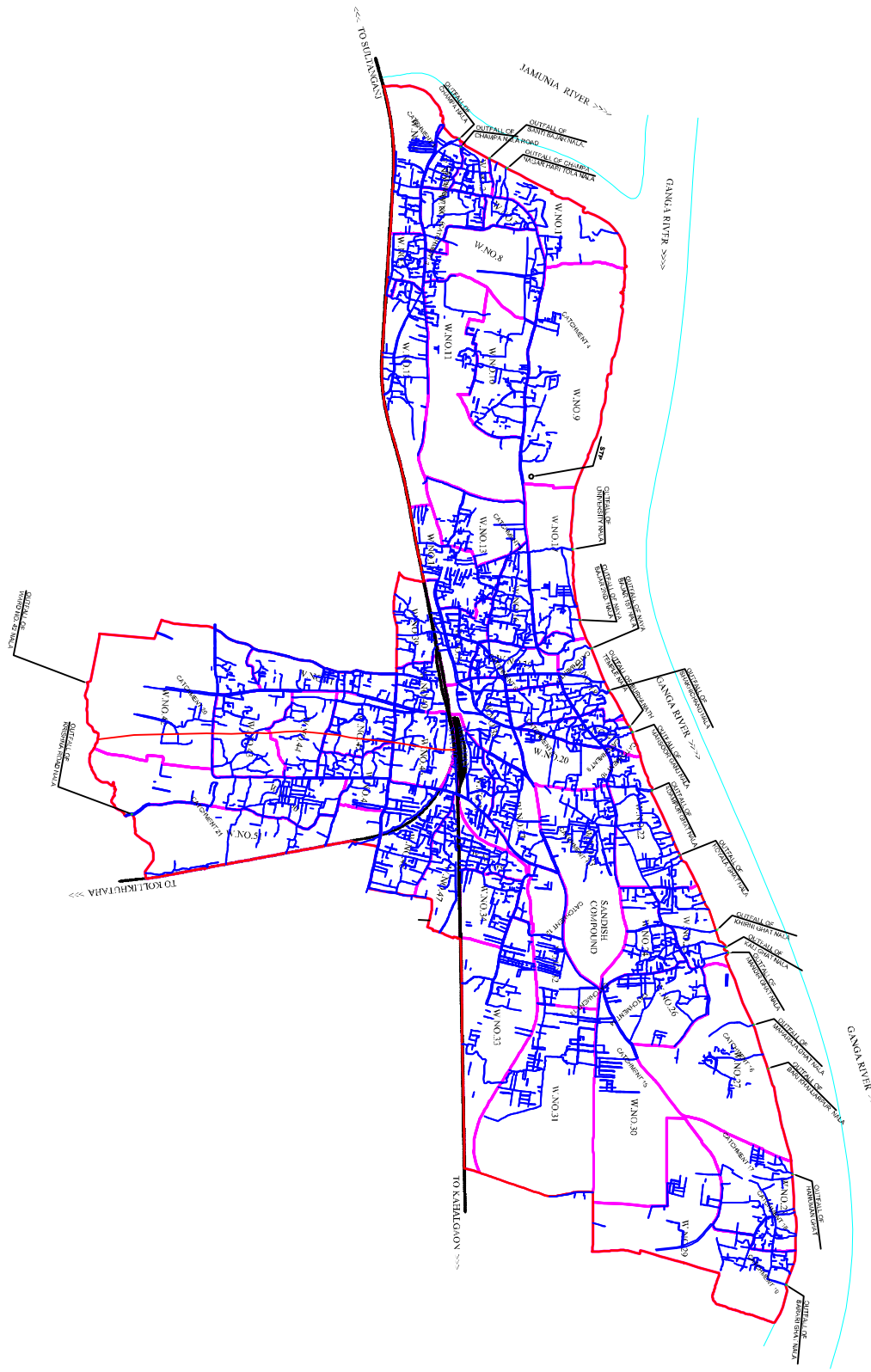


Schedule 13
LIST OF DRAWINGS

Schedule 13 – List of drawings

1. Map showing Location of Drains and Outfall
2. Map showing contour of Town
3. Typical Outfall structure
4. Map showing existing condition of outfall in Bhagalpur
5. Map showing location of IPS and STP & Sewer network in Bhagalpur
6. Map showing catchment in Bhagalpur

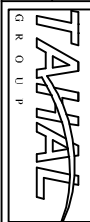
(Note: all drawing provided is for indicative purpose only)



LEGEND	
	ROAD
	BOUNDARY
	WATERFALL
	RIVER
	OPEN FIELD
	BUILDING
	POND
	DRAINAGE
	WATER BODY

	NORTH N S E W
SCALE 1:8000 DRG. NO. TAMIL/SPP/BLD/01/05	DATE 15/03/2018 SHEET NO. 01/01

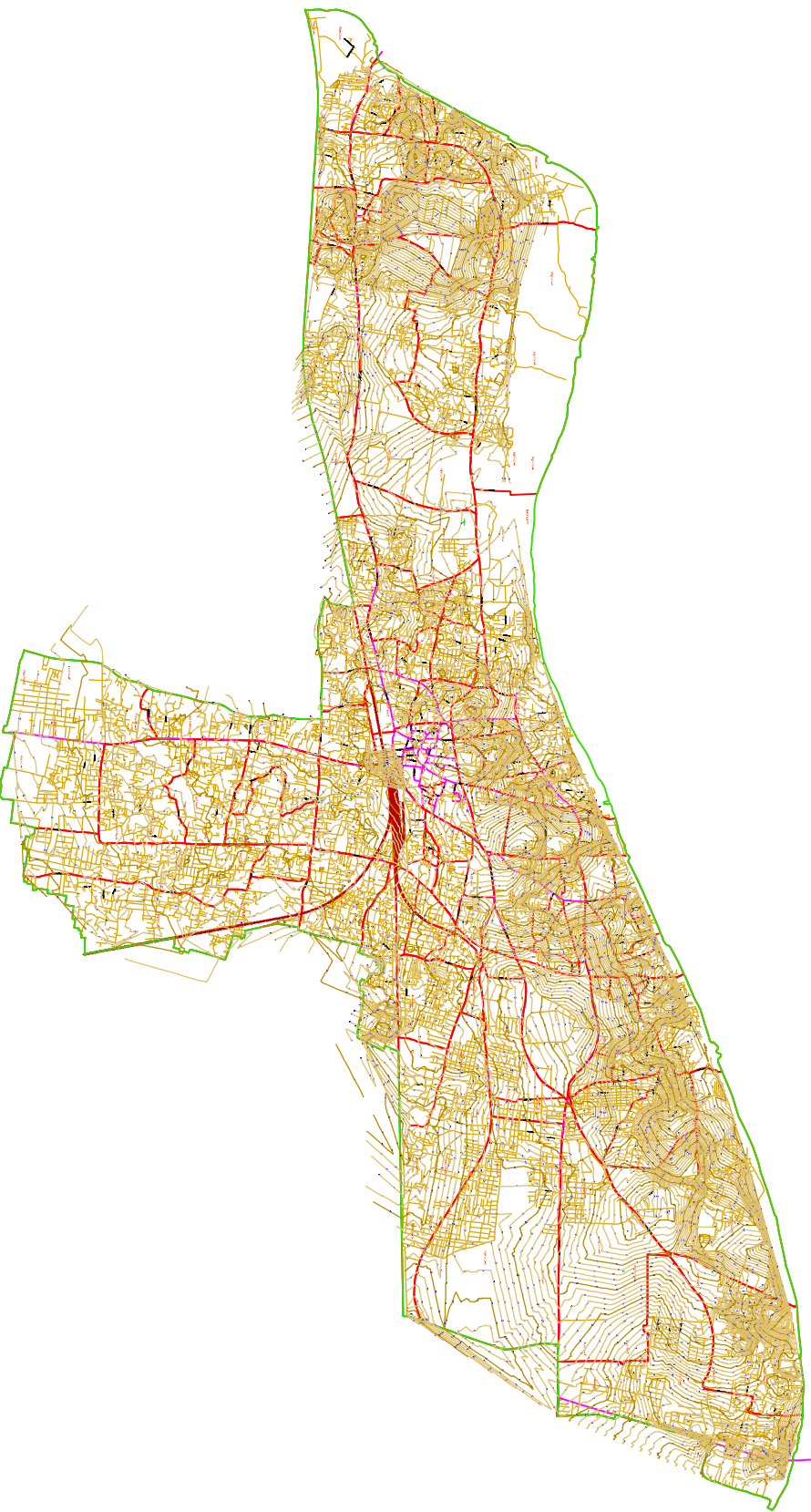
TAMIL CONSULTING ENGINEERS LTD. H/O: NO. 48, RAJASIKHAI, 2 FLOOR, SECTOR 44, INDUSTRIAL AREA, KAGAZIPET, CHENNAI 600 028	Prepared by SANDEEP KUMAR	Checked by CHANDRAN KUMAR	Drawn by SATHI BHANUJI	Approved by DEEPAK SHANKAR
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TITLE MAP SHOWING GRADING AND DRAINAGE TASK DPR ON I&D SCHEME FOR BHAAGPUR TOWN

PROJECT PREPARATION OF DPR ON UNBUILT PORTION AND DIVERSION
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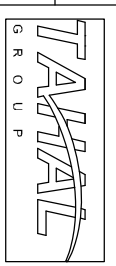
CLIENT SUPERIOR PROJECTS FOR URBAN DEVELOPMENT U.D.E.H.D. GOVERNMENT OF BIHAR



CLIENT
 SUPPORT PROGRAMME FOR
 URBAN REFORM (SPUR),
 U.D. & H.D.,
 GOVERNMENT OF BIHAR

PROJECT
 PREPARATION OF CITY SANITATION PLANS, FEASIBILITY
 STUDY REPORTS AND DETAILED PROJECT REPORTS FOR
 INTEGRATED MUNICIPAL SOLID WASTE MANAGEMENT,
 COMPREHENSIVE WASTE WATER MANAGEMENT,
 KEMANSUKAN AND RECREATION LEVEL OPEN SPACES
 IN 14 URBAN LOCAL BODIES OF BIHAR - GROUP 3.

TITLE
 MAP SHOWING CONTOUR OF
 BHAGALPUR TOWN
TASK
 DPR ON I&D
 SCHEME FOR BHAGALPUR TOWN



TAHAL CONSULTING ENGINEERS LTD.
 FLAT NO. A-2 DEVERGAMA APARTMENT, TILAK MARG, NORTH S.K. PUR, BOHING
 ROAD, PATNA-800001
 Prepared by: RISHAD MUSTAFA
 Designed by: ASLAMI PARVEZ
 Checked by: DIHANESHI PRASAD
 Approved by:

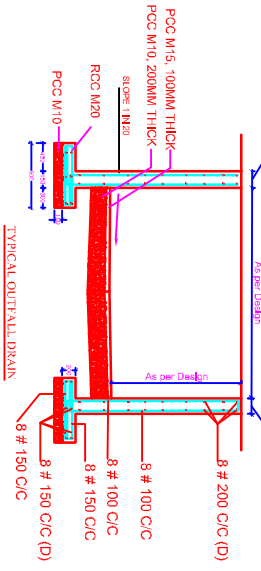
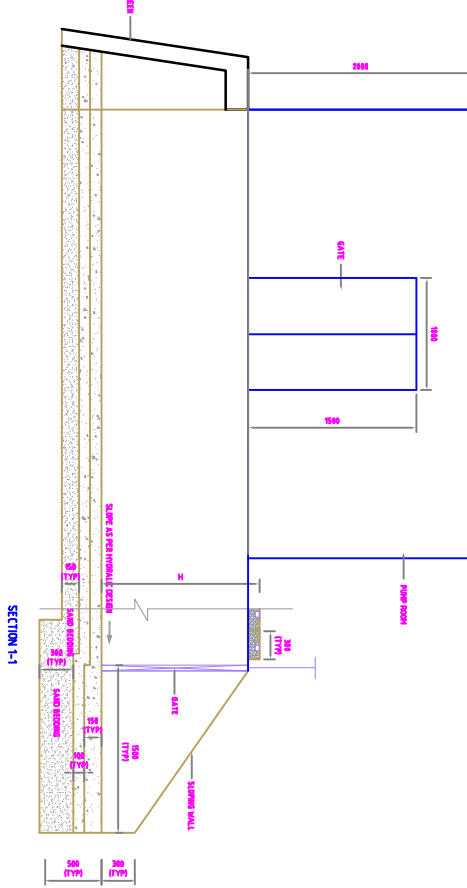
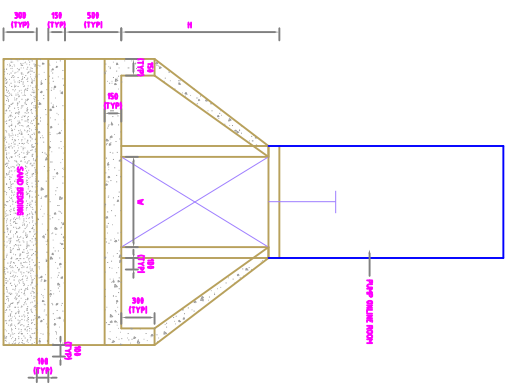
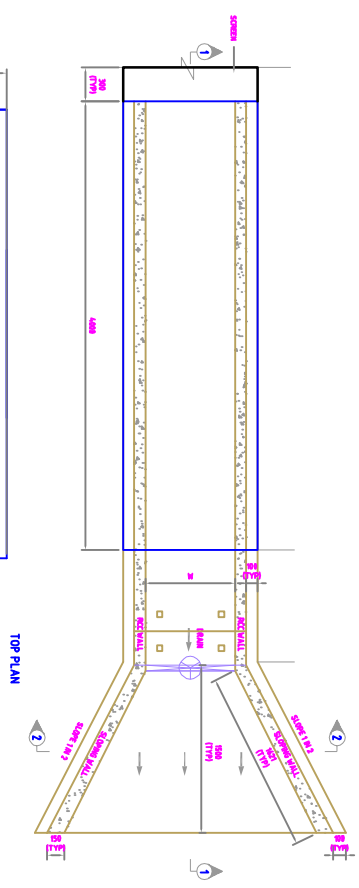
Revisions	Date	Description	Checked by

LEGEND

WARD BOUNDARY	
MUNICIPAL BOUNDARY	
CONTOUR	

NORTH

 SCALE
 N.T.S (A0)
 DRG. NO. TAHAL/SPUR/MD/DRM/06
 DATE
 OCTOBER-2015
 SHEET NO.
 BHP-01

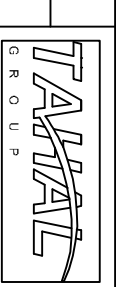


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CLIENT
SUPPORT PROGRAMME FOR
URBAN INFRASTRUCTURE
AND HIGHWAY
DEVELOPMENT OF BIHAR
GOVERNMENT OF BIHAR

PROJECT
PREPARATION OF DPR ON INTERCEPTION AND DIVERSION

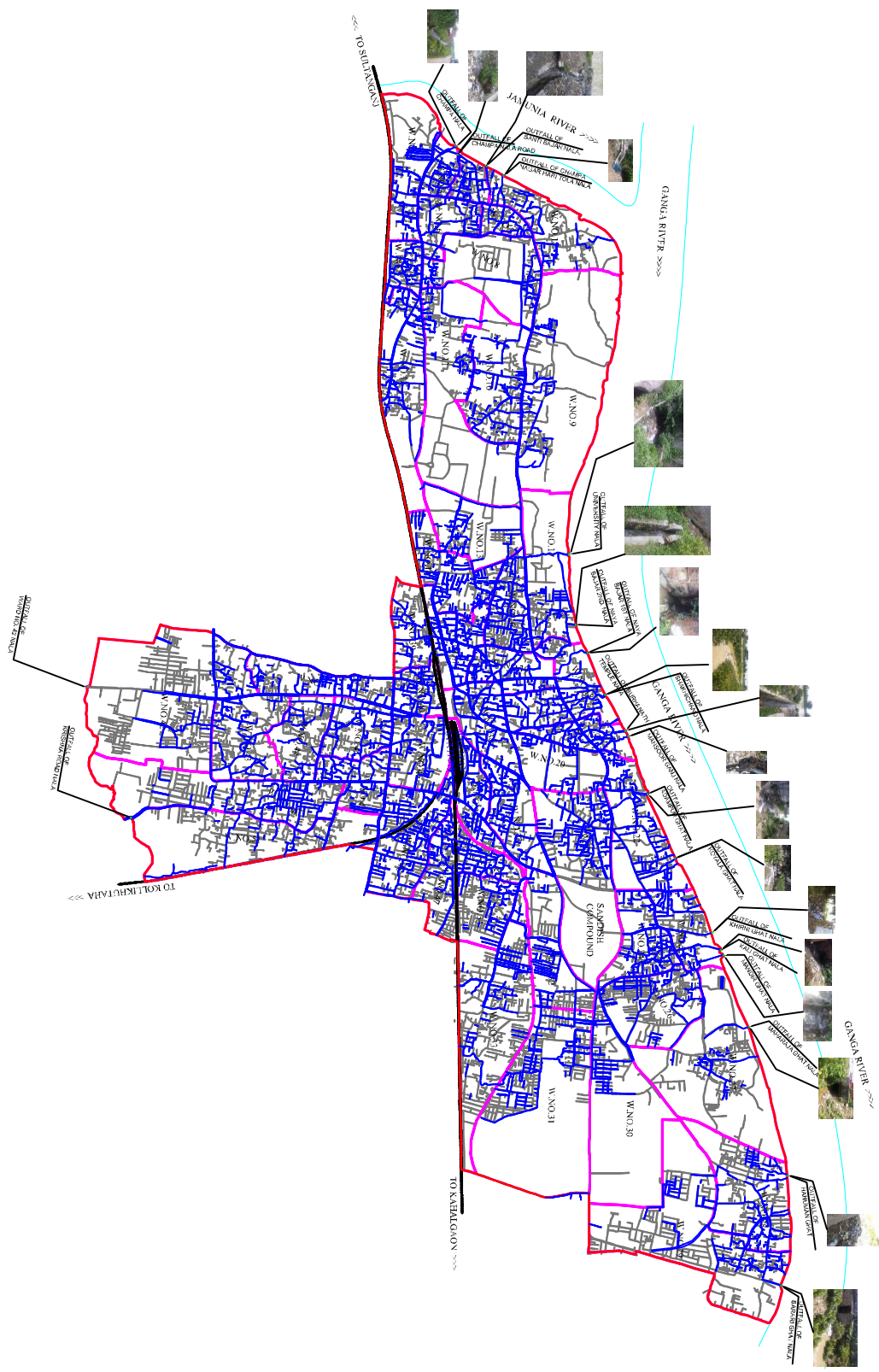
TITLE
TYPICAL OUTFALL STRUCTURE



TAVAZI CONSULTING ENGINEERS LTD.
FLAT NO. A-2, DEVERAMA APARTMENT, TILAK MARG, NORTH S.K. PURI, BOHARING
ROAD, PATNA-800001
SANDEEP KUMAR
CHANDAN KUMAR
SATYABHAI ANBERASH
DEEPAK SHARVA
Prepared by
Designed by
Checked by
Approved by

NORTH
SCALE
1:10 (A1)
DRG. NO.
TAVAZI/SPUR/IBD/08
DATE
AUG/2018
SHEET NO.
BHR/01

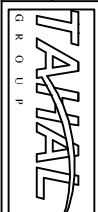
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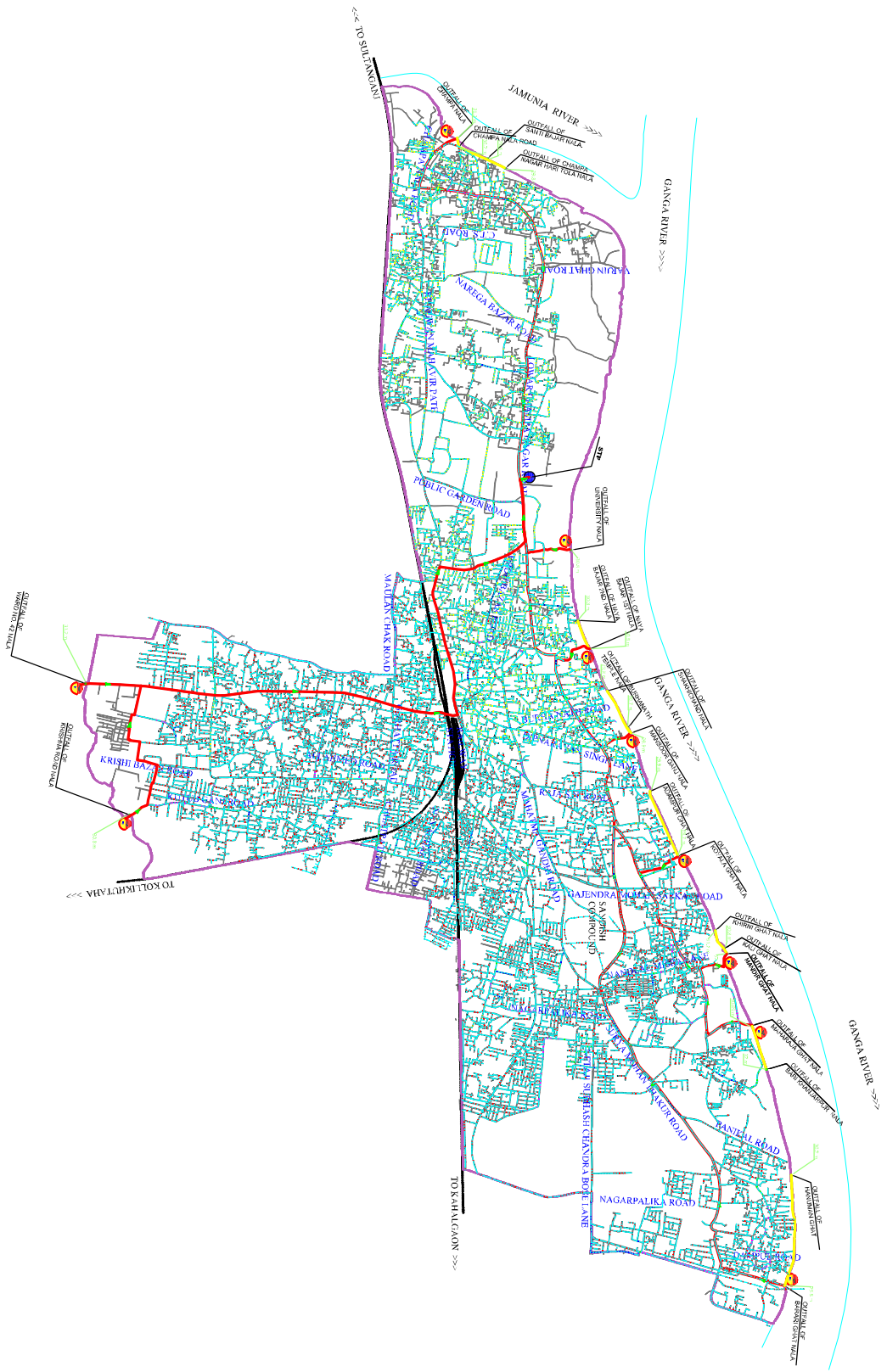
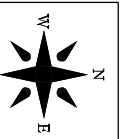
LEGEND

ROAD	
RAILWAY TRACK	
WATER BOUNDARY	
WATER	
OFFICIAL BOUNDARY	
Settlement	
Zone	
Topographic	
Vegetation	

CLIENT SUPERIOR PROJECTS FOR SPECIAL INVESTMENT AND DEVELOPMENT CORPORATION OF BIHAR	PROJECT PREPARATION OF THE CONSTRUCTION AND DIVISION SCHEME FOR BHAGALPUR TOWN	DATE 11.11.2019	TASK DPR ON ROAD SCHEME FOR BHAGALPUR TOWN	TAHALI CONSULTING ENGINEERS LTD. H/O:100, ANAPASARI, 2 FLOOR, SECTOR 44, INDUSTRIAL AREA, KATKI, BHAGALPUR-812009	Prepared by SANTOSH SINGH	Checked by CHANDAN SINGH	Drawn by SUDHAKAR SINGH	Approved by DEEPAK SINGH	SCALE 1:10000	DATE 11.11.2019	DATE 11.11.2019
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LEGEND	
[Symbol]	ROAD
[Symbol]	RAILWAY TRACE
[Symbol]	WARD BOUNDARY
[Symbol]	MUNICIPAL BOUNDARY
[Symbol]	RIVER
[Symbol]	OPTICAL POINT
[Symbol]	KLING MAIN
[Symbol]	GRAVITY MAIN
[Symbol]	IPS
[Symbol]	SIP
[Symbol]	SIGNAL NETWORK



NORTH	
[Symbol]	SCALE
[Symbol]	1:10,000
[Symbol]	DWG. NO.
[Symbol]	TAMU/SP/IB/IBD/BN/11
[Symbol]	DATE
[Symbol]	10/11/2015
[Symbol]	SHEET NO.
[Symbol]	05/01

DESIGNED BY	SAITABHAKTI ANDHAKSHI	CHECKED BY	DEEPAK SHAMMA
DRAWN BY	SAITABHAKTI ANDHAKSHI	APPROVED BY	
DATE	10/11/2015		
PROJECT NO.	13/01/2015		

TITLE	MAP SHOWING LOCATION OF IPS AND SIP
DATE	10/11/2015
DR. ON LEAD	SCHHEM FOR IPR

PROJECT	PREPARATION OF IPR ON INTERSECTION AND DIVERSION
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CLIENT
 STATE ROAD AGENCY
 URBAN DEVELOPMENT
 GOVERNMENT OF BIHAR

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT



TAMU CONSULTING ENGINEERS LTD.
 PLOT NO. 48/1, SECTOR 3, ECTOR SECTOR 4 INSTITUTIONAL AREA, GOREGAON (WEST), MUMBAI - 400 033