14.0 CURING

14.1 Concrete shall be cured by keeping it continuously moist wet for the specified period of time to ensure complete hydration of cement and its hardening. Curing shall be started after 8 hours of placement of concrete in normal weather, and in hot weather after 4 hours. The water used for curing shall be of the same quality as that used for making of concrete.

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances such as hose, sprinklers etc. A layer of sacking, canvas, hessian, or other approved material, which will hold moisture for long periods and prevent loss of moisture from the concrete, shall be used as covering. Type of covering which would stain, disfigure or damage the concrete, during and after the curing period, shall not be used. Only approved covering shall be used for curing.

Exposed surfaces of concrete shall be maintained continuously in a damp or wet condition for at least the first 7 days after placing of concrete.

The Contractor shall have all equipment and materials required for curing on hand and ready to use before concrete is placed.

For curing the concrete in pavements, floors, flat roofs or other level surfaces, the ponding method of curing shall be used. For the first 24 hours after concreting, the concrete shall be cured by use of wet sacking, canvas, hessian etc. The minimum water depth of 25 mm for ponding shall be maintained. The method of containing the ponded water shall be approved by the Engineer-in-Charge. The ponded areas shall be kept continuously filled with water, and leaks, if any, shall be promptly repaired. Areas cured by ponding method shall be cleared of all debris and foreign materials after curing period is over.

Alternatively, membrane curing may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compounds shall be applied to all exposed surfaces of the concrete by spraying or brushing as soon as possible after the concrete has set. Minimum film thickness of such curing compounds shall be as per the recommendation of the manufacturer so as to obtain an efficiency of 90% as specified by BS-8110. This film of curing compound shall be fully removed from the concrete surface after the curing period specified earlier. Engineer-in-Charge may not allow curing by curing compounds for those surfaces where use of curing compound may be detrimental to application of future finishes over the concrete. Impermeable membranes such as polyethylene sheeting closely covering the concrete surface may also be used.

14.2 For concretes containing Portland pozzolana cement or Portland slag cement, the curing period as given in Cl. 14.1 shall be doubled. Curing by ponding shall, however, commence after the first 24 hours of concreting.

15.0 FIELD TESTS

15.1 Materials Testing

15.1.1 Aggregates

Grading test on fine and coarse aggregates shall be carried out as per IS 2386 at intervals specified by the Engineer-in-Charge.

The mandatory tests and their frequencies shall be done as given in Table-3A & 3B below:

TABLE – 3A
(For Concrete prepared at site by using Mechanical mixers)

MANDATORY TESTS ON SAND & STONE AGGREGATES

S. No	MATERIAL	TEST	FIELD / LAB TEST	MIN. QTY OF MATERIAL/ WORK FOR CARRYING OUT TEST	FREQUENCY OF TESTING*
1.	Sand	(a) Bulking of sand	Field Test	20 m^3	Every 20 m^3 or part thereof or more frequently as decided by the Engineer-in-Charge
		(b) Silt content	Field Test	20 m^3	
		(c) Particle size distribution	Field or Lab as decided by the Engineer-in-Charge	40 m^3	1) Every 40 m^3 of fine aggregate/sand required in RCC works only 2) Every 80 m^3 of fine aggregate/ sand required for other items
2.	Stone aggregate	a) Percentage of soft or deleterious materials	General visual inspection, laboratory test where required by Engineer -in-Charge or as specified	As required by Engineer-in-Charge	For all quantities
		b) Particle size distribution	Field or lab. as required by Engineer-in-Charge	45 m^3	For every 45 m^3 or part thereof as decided by Engineer-in-Charge
		c)Ten percent Fine value	Laboratory	45 m^3	Initial test and subsequent test as & when required by Engineer-in-Charge

* Fresh testing is mandatory whenever there is change in Source of materials.

TABLE – 3B
(Refer Cl. 4.4 & 4.6.1 of IS 4926)

(For Ready Mixed Concrete supplied by Ready Mixed Concrete Plants or from on/off-site Batching Plants)

MATERIALS TESTING REQUIREMENTS

S. No	AGGREGATE PROPERTY/ PARAMETER	TYPE OF AGGREGATE	ASSESSMENT OF TYPICAL PROPERTIES AND HIGH TEST RATE*	NORMAL MONITORING AND LOW TEST RATE*	REQUIREMENT FOR NORMAL MONITORING AND LOW TEST RATE
1.	**Grading**	Sand/Fine	Weekly	Monthly	Last 8 results conform to IS 383 or representative values
		Coarse-Single sized/ Graded	Weekly	Monthly	
2.	**Particle density** -Oven Dry -Saturated Surface Dry -Apparent	All Types	Weekly	3 Monthly	Last 4 results ±0.04 percent
3.	**Absorption**	All Types	Weekly	3 Monthly	Last 4 results ±0.04 percent

S. No	AGGREGATE PROPERTY/ PARAMETER	TYPE OF AGGREGATE	ASSESSMENT OF TYPICAL PROPERTIES AND HIGH TEST RATE*	NORMAL MONITORING AND LOW TEST RATE*	REQUIREMENT FOR NORMAL MONITORING AND LOW TEST RATE
4.	**Bulk Density** - Loose - Compacted	All Types	Monthly	6 Monthly	Last 4 results ± 75kg/m³
5.	**Fines(Silt) Content**	Sand	Weekly	Monthly	Last 10 results <75 percent maximum allowed
		Coarse	Monthly	3 Monthly	
6.	**Aggregate Impact Value**	Coarse	As specified	As specified	-
7.	**10 % Fines**	Coarse	Yearly	Yearly	-
8.	**Flakiness**	Coarse	2 Weekly	6 Monthly	Last 3 results conform to standard
9.	**Chloride Content**	All Types	Weekly	6 Monthly	Last 3 results < 0.01 percent
10.	**Aggregate Abrasion Value** (Los Angeles Method)	Coarse	-	Yearly/ Source Change	-
11.	**Soundness**	Fine and Coarse	-	Yearly/ Source Change	-
12.	**Potential Alkali Aggregate Reactivity Including Petrography**	Fine and Coarse	-	5 Yearly/ Source Change	-
13.	**Petrographic Description** (General)	All Types	-	5 Yearly	-

***Note** : The high or low test rates apply in accordance with the following conditions:

a) High test rate
   i) To establish the typical characteristics of an aggregate, and
   ii) When significant changes in properties occur outside the tolerances for low test rates given.

b) Low test rate
   i) When the typical characteristics of the aggregate have been established, and
   ii) When subsequent tests lie within the tolerances for low test rates given

15.1.2 Water

The minimum testing frequencies shall be as follows:

SOURCE	PARAMETERS	FREQUENCY	REQUIEMENT
Non mains water (Untreated water extracted from wells, ponds, lakes, rivers, underground, etc.)	p^H value, Chloride ion content, Sulphate content and any other parameter in accordance with IS 456	Initially every week for first 6 weeks (average of test results to be taken) and then at 3-monthly interval	Need further investigation in case significant deviation observed in test results of 3-monthly interval samples from the original 6 weeks average
Mains water (Treated water supplied through piped network)	Same as above	Annual basis once all tests for source are satisfactory	In case Chloride content > 0.01%, testing frequency shall be reduced to 3 months

15.2 Compaction Factor Test /Slump Test of Concrete

15.2.1 For structural quality concrete (excluding pavements, flooring etc.) at least one Slump Test shall be made for every compressive strength test carried out. More frequent tests shall be made if there is a distinct change in working conditions or if required by the Engineer-in-Charge.

In case of Ready Mixed Concrete, provisions of IS 4926 shall be followed.

15.2.2 For structural quality concrete for pavements & floorings, measurement of workability shall be by determination of compacting factor. Value of compacting factor of 0.75 to 0.8 shall generally be acceptable.

15.3 Strength Test of Concrete

15.3.1 Samples from fresh concrete shall be taken as per IS 1199 and cubes shall be made, cured and tested at 28 days in accordance with IS 516.

15.3.2 In order to get a relatively quicker idea of the quality of concrete, optional tests on beams for modulus of rupture at 72±2 hours or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength tests. For this purpose, the values shall be arrived at based on actual testing. In all cases, the 28 days compressive strength specified in Table-1 shall alone be the criterion for acceptance or rejection of the concrete in accordance with clause 15.3.9.

15.3.3 Sampling Procedure

A random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested that is, the sampling should be spread over the entire period of concreting and cover all mixing units.

15.3.4 Frequency of Sampling

The minimum frequency of sampling of concrete for each grade shall be in accordance with Table-4.

TABLE – 4
(Refer Cl. 15.2.2 of IS 456)

FREQUENCY OF CONCRETE SAMPLING

Quantity of concrete in the work (m^3)	Number of samples
1-5	1
6-15	2
16-30	3
31-50	4
51 & above	4 plus one additional sample for each additional 50m^3 or part thereof.

At least one sample shall be taken from each shift.

When concrete is produced at continuous production units such as ready mixed concrete/ batching plants, atleast one sample shall be taken for every 50m^3 of concrete or after every 50 batches, whichever occurs at a greater frequency or as decided by the Engineer-in-Charge. Samples shall be avoided from the first and the last cubic metre of concrete mix in a lot.

15.3.5 Test Specimen

Three test specimens shall be made for each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or at the time of striking the formwork or to check the testing error. Additional samples may also be required for testing samples cured by accelerated methods as described in IS 9013. The specimen shall be tested as described in IS 516.

15.3.6 Identification mark on concrete test cubes:

The following numbering system shall be adopted on each 150 mm cube:

First line: ZZ	(Alpha code assigned by the Engineer -in-Charge to the Contractor for a particular contract starting with AA and progressing to AB, AC and so on).
Second line: XXXX	(Unique integer in ascending order starting from 1).
Third line: DD-MM-YY	(Date of casting of cube)

15.3.7 Test Results of Sample

The test results of the sample shall be the average of the strength of three specimens. The individual variation should not be more than $\pm$ 15 percent of the average. If more, the test results of the sample shall be considered invalid.

15.3.8 Standard Deviation

Standard deviation for each grade of concrete shall be calculated separately.

Standard deviation based on test results of samples:

a) The total number of test samples required to constitute an acceptable record for calculation of standard deviation shall be not less than 30. Attempts shall be made to obtain the 30 samples, as early as possible, when a mix is used for the first time.

b) For design of mix in the first instance, the value of standard deviation given in Table 8 of IS 456, Amendment No. 4 may be assumed.

c) As soon as sufficient results of samples are available, actual calculated standard deviation shall be used and the mix design shall be revised/ updated. However, when adequate past records for a similar grade exist and justify to the designer a value of standard deviation different from that shown in Table 8 of IS 456, Amendment No. 4, it shall be permissible to use that value.

d) For additional requirement on standard deviation refer clause 9.2.4 of IS 456.

15.3.9 Acceptance Criteria

15.3.9.1 Compressive Strength

The concrete shall be deemed to comply with the strength requirement when both the conditions as given in col. 2 & col.3 of Table-5 for that particular grade of concrete are simultaneously met. For working out standard deviation compressive test result of date wise serially logged 30 sample test result shall be used.

15.3.9.2 Flexural Strength

The concrete shall be deemed to comply with flexural strength requirements when both the following conditions are simultaneously met:

a) The mean strength determined from any group of four non-overlapping consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm^2.

(For non overlapping consecutive compressive test result any one alternate set of four samples shall be used for verification of compliance to clause no. 16.1.a of IS 456)

b) The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm^2

Table-5
(Refer Cl. 16.1 & 16.3 of IS 456)

Characteristic Compressive Strength Compliance Requirement

Specified Grade	Mean of the Group of 4 Non-Overlapping Consecutive Test Results in N/mm^2	Individual Test Results in N/mm^2
M15 or above	$\geq f_{ck}$ + 0.825 x established standard deviation (rounded off to nearest 0.5N/mm^2) or $\geq f_{ck}$ + 3 N/mm^2, Whichever is greater	$\geq f_{ck}$ – 3 N/mm^2

NOTE : 1) In the absence of established value of standard deviation, the values given in Table 8 of IS 456, Amendment No. 4, may be assumed, and attempt should be made to obtain results of 30 samples as early as possible to establish the value of standard deviation.

2) For concrete of quantity 30 m^3 (where the number of samples to be taken is less than four as per the frequency of sampling given in cl. 15.3.4, Table 4), the mean of test results of all such samples shall be f_{ck} + 4 N/mm^2, minimum and the requirement of individual test results shall be f_{ck} – 2 N/mm^2, minimum. However, when the number of sample is only one as per Table 4, the requirement shall be f_{ck} + 4 N/mm^2.

15.3.9.3 Quantity of Concrete Represented by Strength Test Results

The quantity of concrete represented by group of four consecutive test results shall include the batches from which first and last samples were taken together with all intervening batches. Acceptance of concrete shall be applicable for serially logged 30 samples. In case serially logged samples are less than 30 then standard deviation of adjoining previous sample sets will be used for establishing acceptance criteria as per clause 16.1.a of IS 456.

For the individual test result requirements given in col. 3 of Table-5 or in item (b) of 15.3.9.2, only the particular batch from which the sample was taken shall be at risk.

Where the mean rate of sampling is not specified, the maximum quantity of concrete that four consecutive test results represent shall be limited to 60m^3.

15.3.9.4 If the concrete is deemed not to comply pursuant to Cl. 15.3.9.1 or 15.3.9.2, the structural adequacy of the parts affected shall be investigated and any consequential action as needed shall be taken (Refer Cl. 16.0).

15.3.9.5 Concrete of each grade shall be assessed separately.

15.3.9.6 Concrete is liable to be rejected if it is porous or honey-combed, its placing has been interrupted without providing a proper construction joint, the reinforcement has been displaced beyond the tolerances specified, or construction tolerances have not been met. However, the hardened concrete may be accepted after carrying out suitable remedial measures and tests to the fullest satisfaction of the Engineer-in-Charge.

15.3.9.7 Tolerance in leveling of concrete surface at foundation/ pedestal top level where grouting is to be done:

Maximum Plan Dimension	≤ 2m	>2m but ≤4m	> 4m
Tolerance in leveling	+ 10 mm	+ 10 mm	+ 10 mm
	- 10 mm	- 20 mm	- 25 mm

15.3.9.8 Tolerance in dimensions of pocket:

20 mm overall maximum tolerance on the size of pocket.

For pockets, chemically dissolvable moulds shall be preferred. Smooth removal of moulds without affecting the pocket size shall be ensured.

16.0 INSPECTION AND TESTING OF STRUCTURES

16.1 Inspection

To ensure that the construction complies with the design, an inspection procedure shall be set up by the contractor and duly approved by the Engineer-in Charge covering materials used, receipt of materials, their test results, records, workmanship and construction etc.

Contractor shall ensure that the surface which is to receive the grout is at proper level and so are the openings for pockets as per Cl. 15.3.9.7 & 15.3.9.8.

16.2 Immediately after stripping the formwork, all concrete shall be carefully inspected and any defective work or small defects either removed or made good before concrete has thoroughly hardened.

16.3 Testing

In case of doubt regarding the grade or soundness of concrete used, either due to poor workmanship or based on results of cube strength, compressive strength tests of concrete on the basis of clause 17.4 of IS 456 and/or load test as per clause 17.6 of IS 456 shall be carried out.

The Engineer-in-Charge shall be the final authority for interpreting the results of all tests and shall decide upon the acceptance or otherwise. The decision of the Engineer-in-Charge shall be final and binding on the contractor. In case the results of the tests are unsatisfactory, the Engineer-in-Charge may instruct the contractor to demolish and reconstruct the structure or part thereof without any extra cost to the Owner.

16.4 Members other than Flexural Members

Members other than flexural members like columns etc. shall be referred to the designer to investigate the structural adequacy. The decision of the designer shall be final and binding on the contractor.

16.5 Non-destructive Tests

Non-destructive tests using Ultrasonic Pulse Velocity and Rebound Hammer methods shall be resorted to for checking the soundness of concrete placed and shall be as per the directions of Engineer-in-Charge. The testing shall be based on IS 13311, Part-1. However, the Rebound Hammer test (IS 13311, Part-2) shall only be used in combination with other tests (Destructive or Non-Destructive) for checking the concrete quality.

17.0 FINISHING OF CONCRETE

17.1 On striking the formwork, all surface defects such as bulges, ridges and honey-combing etc. observed shall be brought to the notice of the Engineer-in-Charge. The Engineer-in-Charge may, at his discretion allow rectification by necessary chipping and packing or grouting with concrete or cement mortar. However, if honey-combing or sagging is of such extent as being undesirable, the Engineer-in-Charge may reject the work totally and his decision shall be binding. No extra payment shall be made for rectifying these defects, demolishing and reconstructing the structure. However, quantity of cement actually used for this purpose may

be considered for reconciliation of materials. All burrs and uneven faces shall be rubbed smooth with the help of carborundum stone.

The surface of non-shuttered faces shall be smoothened with a wooden float to give a finish similar to that of the rubbed down shuttered faces. Concealed concrete faces shall be left as from the formwork except that honey-combed surface shall be made good as specified above. The top faces of slabs not intended to be covered shall be levelled and floated to a smooth finish to the rises or falls shown on the drawings or as directed. The floating shall not be executed to the extent of bringing excess fine materials to the surface. The top faces of slabs intended to be covered with screed, granolithic or similar finishes, shall be left with a rough finish.

17.2 Repair and Replacement of Unsatisfactory Concrete

17.2.1 Repair shall be made as soon as possible after the forms are removed and before the concrete becomes too hard with prior permission from the Engineer-in-Charge, in writing. Stone pockets, segregation patches and damaged areas shall be chipped out and the edges undercut slightly to form a key. All loose material shall be washed out before patching. No excess water shall be left in the cavity, but the concrete shall be damp. A good bond between the patch and parent concrete shall be obtained by sprinkling dry cement on the wet surface or by throwing mortar with force on to the wetted concrete, or by brush in a coat of thick cement grout of about 1:1 (1 cement:1 sand) just before applying the patching material. Before this has dried, the remainder of the patch shall be filled with mortar or concrete, depending on the extent of the repair.

17.2.2 Cement concrete/mortar used in repair of exposed surfaces shall be made with cement from the same source as that used in concrete and blended with sufficient amount of white Portland cement to produce the same colour as in the adjoining concrete. The proportions of ingredients shall be same as those used in parent concrete. The mortar shall be as dry as possible and well compacted into the cavity. All filling shall be tightly bonded to the concrete and shall be sound, free from shrinkage cracks after the filling has been cured and dried.

17.2.3 For larger repairs to hardened concrete, necessary formwork bearing tightly at the edges of the cavity shall be provided. Concrete shall be chipped out to a depth of at least 100 mm and preferably 150 mm. Mortar shall be scrubbed into all surfaces with a wire brush before placing the concrete. Damaged reinforcement shall be adequately spliced with new steel so as to maintain the original strength. Additional reinforcement, if required in the patch, shall be provided as per the instructions of Engineer-in-Charge.

17.2.4 In case, in the opinion of the Engineer-in-Charge, defects in the concrete is excessive or beyond repair, the contractor shall either redo the structure or take other remedial measures as instructed by the Engineer-in-Charge. The decision of the Engineer-in-Charge shall be final and binding to all in this respect.

17.2.5 Approved epoxy formulation for bonding fresh concrete used for repairs with already hardened concrete shall be used by the Contractor if asked by the Engineer-in-Charge. Epoxy shall be applied in strict accordance with EIL Specification 6-68-0056 and the instructions of the manufacturer.

17.2.6 All repair works due to non-conformance or non-adherence to specification, if allowed by the Engineer-in-Charge, shall be carried out free of cost to the owner.

17.3 Curing of Patched Work

Immediately after patching is completed, the patched area shall be covered with an approved non-staining water saturated material which shall be kept wet and protected against sun and wind for a period of 12 hours. Thereafter, the patched area shall be kept continuously wet by a fine spray or sprinkling for not less than 10 days.

18.0 WATERPROOF CEMENT PAINT

Wherever specified, concrete elements (whether cast-in-situ or precast) exposed to atmosphere shall be provided with three coats of cement based waterproof paint as per IS 5410 provided these surfaces shall not contain any protective coating. Prior to application of the paint, the surface shall be prepared to remove all foreign particles, loose materials, extra deposited concrete lumps, etc. using appropriate mechanical/ manual means.

19.0 FORM WORK

19.1 General

19.1.1 Forms for concrete shall be of plywood conforming to IS 6461 (Part-5) or steel or as directed by the Engineer-in-Charge and shall give smooth and even surface after removal thereof.

19.1.2 If it is desired by Engineer-In-Charge, the Contractor shall prepare, before commencement of actual work, design and drawings for formwork and get them approved by the Engineer-in-Charge. For details regarding design, detailing etc., reference may be made to IS 14687.

19.1.3 Form work and its supports shall maintain their correct position and be to correct shape and profile so that the final concrete structure is within the limits of dimensional tolerances specified below, unless required otherwise, for functional/aesthetic reasons. The decision of the Engineer-in-Charge shall be final and binding in this regard.

(a) Deviation from specified dimensions of cross section of columns and beams. — - 5 mm to +10 mm

(b) Deviation from dimensions of footings (see Note below)

i)	Dimensions in plan	-10 mm to +50 mm
ii)	Eccentricity	0.02 times the width of the footing in the direction of deviation but not more than 50 mm.
iii)	Thickness	-10 mm to +50 mm or $\pm$0.05 times the specified thickness, whichever is less

Note: These tolerances apply to Cast-in-situ concrete dimensions only, not to positioning of vertical reinforcing steel or dowels.

(c) Deviation in length (major dimension of single unit)

upto 3m	$\pm$6 mm
3m to 4.5m	$\pm$9 mm
4.5m to 6m	$\pm$12 mm
Additional deviation for every subsequent 6m.	$\pm$6 mm

(d) Deviation in straightness or bow (deviation from specified line) for a single or continuous member) e.g. beam, column or slab edge.

upto 3m	6 mm
3m to 6m	9 mm
6m to 12m	12 mm
additional for every subsequent 6m.	6 mm

(e) Deviation in squareness shall be measured taking the longer of two adjacent sides as the base line.

The shorter side shall not vary in its distance from a perpendicular so that the difference between the greatest and shortest dimensions exceeds 6 mm. For this purpose, any error due to lack of straightness shall be ignored. Squareness shall be checked with respect to the straight lines that are most nearly parallel with the features being checked. When the nominal angle is other than 90 degree, the included angle between check lines shall be varied accordingly.

(f) Deviation in twist shall be within a limit such that any corner shall not be more than the limit given below from the plane containing other three corners:

upto 600 mm wide and upto 6m in length	:	6 mm
over 600 mm wide and for any length	:	12 mm

(g) Maximum deviation in flatness from a 1.5m straight edge placed in any position on a nominally plain surface shall not exceed 6 mm.

(h) Tolerance in leveling of concrete surface at foundation/ pedestal top level where grouting is to be done : As per Cl. 15.3.9.7

19.2 Form Requirement

19.2.1 The formwork shall be true, rigid and adequately braced both horizontally as well as diagonally. The forms shall have smooth and even surface and be sufficiently strong to carry, without deformation, the dead weight of the green concrete, working load, wind load and also the side pressure exerted by the green concrete. As far as practical, clamps shall be used to hold the forms together. Where use of nails is unavoidable minimum number of nails shall be used. Projected part of nail shall not be bent or twisted for easy withdrawal.

19.2.2 Where through tie rods are required to be put to hold the formwork and maintain accurate dimension, they shall always be inserted through a precast concrete block (of same mix proportion as is to be used for concreting) with a through hole of bigger diameter. The Precast block shall tightly fit against in inner faces of formwork. The holes left after the withdrawal of tie rods shall be fully grouted with cement-sand mortar of same proportion as that used for concrete. However, use of such precast block shall in no case impair the desired appearance or durability of the structure. No such tie rods shall be used in any liquid retaining or basement structure.

19.2.3 Tie wires shall be permitted only upon approval of the Engineer-in-Charge and shall be cut off flush with the face of the concrete or counter sunk, filled and finished in the manner specified in clause 17.

19.2.4 Form joints shall not permit any leakage. The formwork shall be strong enough to withstand the effect of vibrations practically without any deflection, bulging, distortion or loosening of its components.

19.2.5 Forms for beams and slabs (span more than 6.0m) shall have camber of 1 in 500 so as to offset the deflection and assume correct shape and line after deposition of concrete. For cantilevers, the camber at free end shall be 1/100th of the projected length. Where architectural considerations and adjunctive work are critical, smaller form cambers shall be adopted as decided by the Engineer-in-Charge.

19.2.6 All vertical wall forms may be designed and constructed for the following minimum pressure. The pressures listed in Table-6 are intended as guide only and the Contractor shall ensure that the formwork is adequately strong and sturdy.

TABLE - 6
MINIMUM DESIGN PRESSURE FOR WALL FORMWORK

Rate of pour in meter/hour	Pressure in KN/m^2	
	at 10^0 (in Celsius)	at 24^0 (in Celsius)
0.6	36.0	29.0
0.9	40.0	32.0
1.2	44.0	35.0
1.5	46.0	37.0

All horizontal forms shall be designed and constructed to withstand the dead load of the green concrete, reinforcement, equipment, material, embedment and a minimum live load of 2.0 kN/m^2.

19.3 Inspection of Forms

Temporary openings shall be provided at the base of column and wall forms and other places necessary to facilitate cleaning and inspection. Before concrete is placed, all forms shall be carefully inspected to ensure that they are properly placed, sufficiently rigid and tight, thoroughly cleaned, properly treated and free from foreign material. The complete form work shall be inspected and approved by the Engineer-in-Charge before the reinforcement bars are placed in position. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the work shall be stopped until the defects have been rectified as per the instructions of the Engineer-in-Charge.

19.4 Cleaning and Treatment of Formwork

The surfaces of forms that would come in contact with concrete shall be well treated with approved non-staining form release agents such as soft soap, oil, emulsions etc. Release agents shall be applied so as to provide a thin uniform coating to the forms without coating the reinforcement.

19.5 Chamfers and Fillets

All corners and angles shall be formed with 45 degree mouldings to form chamfers or fillets on the finished concrete. The standard dimensions of chamfers and fillets, unless otherwise detailed or specified shall be 25x25 mm. For heavier work chamfers or fillets shall be 50x50 mm. Care shall be exercised to ensure accurate mouldings. The diagonal face of the moulding shall be planed or surfaced to the same texture as the forms to which it is attached.

19.6 Reuse of forms

Before reuse, all forms shall be thoroughly scrapped, cleaned, examined and when necessary, repaired and retreated, before resetting. Formwork shall not be reused, if declared unfit or un-serviceable by the Engineer-in-Charge.

19.7 Removal of Forms/Stripping Time

In the determination of time for removal of forms, consideration shall be given to the location and character of the structures, the weather and other conditions including the setting and curing of the concrete and material used in the mix.

Forms and their supports shall not be removed without the approval of the Engineer-in-Charge. Forms shall not be released until the concrete has achieved a strength of at least twice the stress to which the concrete may be subjected at the time of removal. The formwork shall be removed without shock and methods of form removal likely to cause over stressing or damage to the concrete shall not be adopted. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

In normal circumstances when average air temperature exceeds 15 degree Celsius during the period under consideration after pouring of concrete and where ordinary Portland cement is used, forms may generally be removed after expiry of following periods.

(a) Walls, columns and vertical faces of all structural members	16 to 24 hours as may be decided by the Engineer-in-Charge.
(b) Slabs (props left under)	3 days.
(c) Beam Soffits (props left under)	7 days.
(d) Removal of props under slabs:	
Spanning upto 4.5m.	7 days.
Spanning over 4.5m.	14 days.
(e) Removal of props under beams and arches:	
Spanning upto 6m	14 days.
Spanning over 6m	21 days

(f) Cantilever Construction Formwork shall remain till structures for counter acting or bearing down have been erected and have attained sufficient strength (minimum 14 days).

Notes:

i) For other cements, the stripping time recommended for ordinary Portland cement shall be suitably modified as per the instructions of the Engineer- in-Charge.

ii) The number of props left under, their sizes, supporting arrangement, and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

iii) Where the shape of the element is such that the formwork has re-entrant angles, the form work shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed.

iv) For rapid hardening cement, 3/7 of the above mentioned periods shall be considered subject to a minimum of 16 hours.

v) For Portland pozzolana or low heat cement, 10/7 of the above mentioned periods shall be considered.

19.8 Staging/Scaffolding

19.8.1 Staging/Scaffolding shall be properly planned and designed by the Contractor. Use of only steel tubes is permitted for staging/scaffolding. The Contractor shall get it reviewed by Engineer-in-Charge before commencement of work. While designing and during erection of scaffolding/staging, the following measures shall be considered:

(a) Sufficient sills or underpinnings in addition to base plates shall be provided particularly where scaffolding is erected on soft grounds.

(b) Adjustable bases to compensate for uneven ground shall be used.

(c) Proper anchoring of the scaffolding/staging at reasonable intervals shall be provided in each direction with the main structure wherever available.

(d) Horizontal braces shall be provided to prevent the scaffolding/staging from rocking.

(e) Diagonal braces shall be provided continuously from bottom to top between two adjacent rows of uprights.

(f) The scaffolding/staging shall be checked at every stage for plumb line.

(g) Wherever the scaffolding/staging is found to be out of plumb line it shall be dismantled and re-erected afresh and effort shall not be made to bring it in line with a physical force.

(h) All nuts and bolts shall be properly tightened and care shall be taken that all clamps/couplings are firmly tightened to avoid slippage

(i) Erection work of a scaffolding/staging under no circumstances shall be left totally to semi-skilled or skilled workmen and shall be carried out under the supervision of a technically qualified civil engineer of the Contractor.

19.8.2 For smaller works or works in remote areas, wooden ballies may be permitted for scaffolding/staging by the Engineer-in-Charge at his sole discretion. The contractor must ensure the safety and suitability of such works as described under clause 19.8.1 above.

20.0 EXPOSED/ARCHITECTURAL CONCRETE WORK

20.1 Form Work

Other things remaining same as per clause 19.0, formwork shall be of high quality. Care shall be taken to arrange the forms so that the joints between forms correspond with the pattern indicated in the drawings. The forms shall be butting with each other in straight lines, the corners of the boards being truly at right angles. The joints between the forms shall cross in the two directions at right angles. The size of forms shall be so selected as to exactly match with the pattern of forms impression on the concrete face indicated in the drawings. Maximum care shall be taken to make the form work watertight. Burnt oil shall not be used for treatment of forms. The Contractor shall be permitted reuse of forms brought new on the work place only if forms are properly cared for, stored and treated after each use.

The Engineer-In-Charge may, at his absolute discretion, order removal of any forms considered unsuitable for use in the work.

20.2 Finishing

Repairing to exposed concrete work shall be avoided. Rendering and plastering shall not be done. Minor repairing, if unavoidable shall be done as specified in clause 17.0 with the written permission of the Engineer-in-Charge.

21.0 REINFORCEMENT

21.1 The Contractor shall develop the bar bending schedule for all RCC structures/ structural parts at no extra cost to the Owner and shall get it reviewed by the Engineer-in-charge. Reinforcement shall be cut and bent to shape as per dimensions shown in the bar bending schedule/ drawings.

If protective fusion bonded epoxy coating is required to be applied on reinforcement bars, the same shall be done as per IS 13620. All repairs to applied protective coating required due to mishandling and/ or bending of reinforcement bars shall also be done as per relevant clauses of IS 13620.

21.2 Straightening, Cutting and Bending

Procedure for cutting and bending shall be as given in IS 2502. Bars shall be bent in a slow and regular movement to avoid fractures by mechanical means only. In case bars are supplied in coils, they shall be smoothly straightened without any kinks.

Cold twisted deformed bars shall be bent cold. Bars larger than 25 mm in size (except cold twisted deformed bars) may be bent hot at cherry red heat to a temperature not exceeding 850^0 Celsius as per the instructions of the Engineer-in-Charge. The bars shall be allowed to cool gradually without quenching.

Bars shall be cut & bend in a Bar Bending Machine. Bars which develops cracks or splits after bending shall be rejected. A second bending of reinforcement bars shall be avoided but when reinforcement bars are bent aside at construction joints and afterwards bent back into their original position, care should be taken to ensure that at no time is radius of the bend less than 6 times bar diameter for high strength deformed bars. Care shall also be taken when bending back the dowel bars to ensure that concrete around the bars is not damaged. All bars shall be properly tagged for easy identification.

21.3 Placing and Fixing

All reinforcement shall be cleaned to ensure freedom from loose mill scale, loose rust, oil, form releasing agents, grease or any other harmful material before placing them in position. Reinforcement shall not be surrounded by concrete unless it is free from all such materials. Rough handling and dropping of reinforcement from a height shall be avoided.

All reinforcement shall be fixed in the correct position and shall be properly supported to ensure that displacement will not occur when the concrete is placed and compacted.
The uncoated reinforcement bars shall be tied at every intersection by two strands of 16 SWG black soft annealed binding wire. The Epoxy coated reinforcement bars shall be tied with 2 strands of PVC coated GI 18 SWG wire at every intersection. Crossing bars shall not be tack welded for assembly of reinforcement. The reinforcement bars shall be kept in position by using the following methods:

a) In case of beam and slab construction, precast cover blocks (having the same sand contents as the concrete which shall be placed) of size 40 x 40 mm and thickness equal to the specified covers shall be placed firmly in between the bars and forms so as to secure and maintain the specified covers over the reinforcement.

When reinforcement bars are placed in two or more layers in beams, the vertical distance between the horizontal bars shall be maintained by introducing spacer bars at 1 to 1.2m centre to centre.

b) In case of thick rafts & pile caps having two or multi layers of reinforcement, the vertical distance between the horizontal bars shall be maintained by introducing suitable chairs, spacers, etc.

c) In case of columns and walls, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them. The templates shall be removed after the concreting has been done below it.

d) Exposed portions of reinforcement bars shall not be subjected to impact or rough handling and workmen will not be permitted to climb on extending bars until the concrete has attained sufficient strength so that no movement of the bars in the concrete is possible.

21.4 Special requirements for Handling, Stacking, Placing of Epoxy coated Reinforcing bars.

Epoxy coated reinforcing bars shall be carefully handled and it shall be ensured that these do not rub on any hard surface or against another epoxy coated/uncoated reinforcing bar whether during conveying/transportation, stacking or placing.

During transportation and while stacking the epoxy coated reinforcing bars shall be placed on wooden planks not spaced farther than 600 mm. When placed in stacks the epoxy coated reinforcing bars shall be neatly tied in bundles using PVC binding material.

The cut ends of bars shall be touched up with special touch up material of specifications as provided by the coating agency. After cutting of the bar the application of touch up material shall be completed within four hours.

While bending the bars the pins of work bench(s) shall be provided with a PVC or plastic sleeve. Each bending operation on epoxy coated reinforcing bar shall be completed in time not less than 90 seconds.

Epoxy coated reinforcing steel bar shall not be directly exposed to sun rays or rain, and shall be protected with opaque polyethylene sheets or similar means as approved by the Engineer in Charge.

While doing concreting the workmen or machinery shall not rest or move on the epoxy coated reinforcing bars. Wooden planks shall suitably be placed to create proper gang-way.

21.5 Splicing/Overlapping

Only bars of full length shall be used as shown in the drawings. But where this cannot be done, overlapping of bars shall be done as directed by the Engineer-in-Charge. The overlapping bars shall be tied with two strands of 16 SWG black soft annealed binding wire. The overlaps shall be staggered for different bars and located at points along the span where neither shear nor bending moment is maximum.

21.6 Welded Joints

Welding of reinforcing bars shall not be permitted without the written permission of the Engineer-in- Charge. Where welding of reinforcing bars is permitted, it shall be in accordance with the recommendations of IS 2751 and IS 9417. Welded joints shall be located at suitable staggered positions. Tests shall be made as directed by the Engineer-in-Charge to prove that the joints are of the full strength of the bars. Maximum one welded joint shall be allowed per bar.

21.7 Mechanical Connections

The mechanical splices in reinforcement by means of couplers, clamps etc. shall be used (as per manufacturer's specifications) with the written approval of the Engineer-in-Charge. Following tests, at the minimum, shall be conducted in advance to prove efficiency of the coupled joint before putting them in actual use. This covers requirements of couplers to be used with bars conforming to grades less than & equal to Fe550D of IS 1786.

Name of the Test	Testing Requirement	Code of conformance
Static Tensile test: 1. Tensile strength	Each connection shall develop at least 125% of the specified yield strength of the reinforcing bar & 100% of the specified tensile strength. Bar break requirement shall be satisfied to avoid splice failure & to develop full tensile strength of the bar.	ASTM A370/ ACI 318/ **AC 133**/ ISO 15835/ IS 16172
Static Tensile test: 2. Percentage elongation (Ductility)	The minimum percentage elongation (at maximum forces), in the reinforcing bar outside the length of the mechanical splice shall be minimum 3% before the failure of the test piece.	ISO 15835 IS 16172
Static compression test	Each connection shall develop atleast 125% of the specified yield strength of the reinforcing bar.	ASTM A370/ ACI 318/ AC 133
Permanent Elongation (Slip)	Permanent elongation across the coupled joint shall be less than 0.1 mm after loading at 60% of the yield strength of the reinforcing bar	BS 8110/ ISO 15835 IS 16172
Cyclic tensile test	Mechanical splice shall withstand 100 cycles of stress variation from 5% to 90% of the yield strength of reinforcing bar & without loss of static tensile strength capacity when compared with like specimen.	IS 16172
Moderate Oligocyclic (Seismic) Test (Cyclic Tension & Compression Test) **(Refer note- 1)**	Deformation across the coupled joint shall be less than 0.3 mm after subjecting the joint to a series of 20 cycles with 95% tension as well as 50% compression of the yield strength of the reinforcing bar & without loss of static tensile strength capacity when compared with like specimen.	ISO 15835/ ASTM A370/ ACI 318/ AC 133
Violent Oligocyclic (Seismic) Test (Cyclic Tension & Compression Test) **(Refer note- 2)**	The joint shall be subjected from zero strain upto twice the yield strain in tension followed by compression stress of 50% of yield strength of reinforcing bar for 4 cycles. Thereafter, from zero strain upto five times the yield strain in tension followed by compression stress of 50% of yield strength of reinforcing bar for 4 cycles. Deformation across the coupled	ISO 15835/ ASTM A370/ ACI 318/ AC 133

Name of the Test	Testing Requirement	Code of conformance
	joint shall be less than 0.3 mm after 4 cycles & less than 0.6 mm after 8 cycles & without loss of static tensile strength capacity when compared with like specimen.	
Low cycle fatigue test **(Refer note- 3)**	Mechanical splice shall withstand 10,000 cycles of alternating tension & compression load from +173Mpa to -173Mpa & without loss of static tensile strength capacity when compared with like specimen.	IS 16172

Notes-

1) Moderate Oligocyclic (Seismic) test shall be performed for structures in seismic zone II.

2) Violent Oligocyclic (Seismic) test shall be performed for structures in seismic zone III, IV & V.

3) Low cycle fatigue test shall be performed for all structures except for concrete structures which are subjected to high cycle of fatigue like machine foundations etc.. For concrete structures which are subjected to high cycle of fatigue, High cycle fatigue test shall be performed as per IS 16172.

All operations relating to reinforcement coupling shall be done by using manufacturer's patented machine/ equipment in the presence of Engineer-in-Charge. Mechanical connections shall be placed away from points of high stress and shall be staggered.

21.8 Tolerances on Placing of Reinforcement

Unless otherwise directed by the Engineer-in-Charge, reinforcement shall be placed within the following tolerances:

a) For effective depth 200 mm or less $\pm$ 10 mm

b) For effective depth more than 200 mm $\pm$ 15 mm

21.9 Substitution

When indicated diameter of reinforcement bar is not available, the Contractor shall use other diameter of reinforcement bars on written approval of the Engineer-In-Charge.

21.10 Tolerance to Cover

The actual concrete cover shall not deviate from the required nominal cover by + 10 mm measured over the steel reinforcement including links.

22.0 PAYMENT

22.1 Plain and Reinforced Concrete

22.1.1 Payment for plain and reinforced cement concrete shall be made on cubic metre basis of the volume of the actual finished work done or as per approved construction drawings, whichever is less and shall be inclusive of providing pockets, openings, recesses of all sizes, chamfers, fillets, grooves, separation/ expansion/ isolation/ construction/ movement joints, curing by normal moist curing or using curing compound etc. as directed by Engineer-in-Charge etc. The rates shall be deemed to include complete cost of getting the

respective mix designs approved, making and testing concrete cubes and carrying out other tests including tests of various ingredients, as per specifications and as directed by Engineer-in-Charge. Payment shall, however, be separately made for tests on concrete cubes done by accelerated methods of curing as defined in IS 9013.

22.1.2 No separate payment shall be made for any additive/ admixture/ Plasticizer/ Fibres used by the contractor for accelerating or retarding the strength of concrete or for achieving specified workability. The rate quoted shall be deemed to be inclusive of all costs related to any such additive/admixture/ Plasticizer/ Fibres.

22.1.3 The rate shall however be exclusive of reinforcement, metal inserts, pipe sleeves, formwork, water stops and any filler material in expansion/isolation joints.

22.1.4 Where the strength of concrete mix as indicated by tests, lies in between the strengths of any two grades given in Table-1 and it is accepted by the Owner/Engineer-in-Charge, such concrete shall be classified as a grade belonging to the lower of the two grades between which it lies. In case the cube strength shows higher results than those specified for the particular grade of the concrete, it shall not be placed in the higher grade nor shall the Contractor be entitled for any extra payment on such account. The concrete giving lower strength than specified may be accepted at reduced rates after satisfying the safety of the structure by checking it with tests as specified or rejected entirely at the discretion of the Engineer-in- Charge. The rejected concrete shall be dismantled at no extra cost to the owner and no payment or extension of time shall be granted for the concrete so rejected and the formwork and reinforcement used for the same. Cost of any material supplied by the Owner free of cost shall be recovered from the Contractor at double the prevailing market rate. In case the concrete of lower strength can be improved by carrying out some strengthening measures entirely at the discretion of the Engineer-in-Charge, then the said measures including all related tests shall be carried out by Contractor at his own cost. If the Contractor is able to make up the strength to the required grade by such improvement measures to the entire satisfaction of Engineer-in-Charge, payment shall be made for the grade achieved. However, if the strength of concrete is not made up to the strength of required grade, payment shall be made only for the lower strength if such concrete is accepted by the Engineer-in-Charge.

22.1.5 Deductions for openings, pockets etc. shall be as specified in relevant parts of IS 1200.

22.1.6 The rate quoted for reinforced cement concrete, also includes single pour concreting wherever specified. The rate shall be inclusive of all extra cost related to labour, shuttering, staging and making all other arrangements for such continuous casting e.g. provisions for adequate movement and storage spaces, special gangways, scaffolding, additional construction equipments, adequate lighting and supervision while the work continues round the clock etc. The rate shall also be inclusive of all costs related to concreting in any thickness, shape and position and at any height or depth so as to avoid any cold joint between specified construction joints.

22.1.7 Form Work

Unless otherwise specified, payment for form work shall be on square metre basis of the actual area in contact with the concrete cast. The rates shall be inclusive of keeping the formwork for the full period as specified in the above clauses and removing the same after the period is over. No extra payment shall be made for providing scaffolding/ staging/ access/ stairways/ ladders etc.

The rates shall be inclusive of any provision to be made or kept in the formwork for providing dowels, inserts etc.

Superior quality formwork for exposed/architectural concrete work shall be measured and paid separately under the relevant item in the schedule of rates.

22.2 Reinforcement

22.2.1 Payment for plain round mild steel reinforcement bars, high strength deformed steel bars and epoxy coated reinforcing steel bar shall be on the basis of weight of bare steel irrespective of any coating applied in metric tons. The weight of the bar shall be derived from the sizes and corresponding nominal unit weight given in Table-1 of IS 1786. In case actual unit weight of the bars is less than nominal unit weight, but within permissible tolerances, the weight of reinforcement shall be calculated on the basis of actual unit weight. In case actual unit weight of the bars is more than nominal unit weight, the payment shall be made on the basis of nominal unit weight. Standard hook lengths, chairs, spacer bars and authorized laps only shall be included in the weight calculated. Binding wire shall not be weighed nor otherwise measured. Measurements for weight shall not include cutting allowance etc.

22.2.2 Rate quoted for reinforcement shall include cost of supplying, decoiling, straightening, cleaning, cutting, bending, placing, binding, welding (if required) and providing necessary cover blocks of concrete.

22.2.3 Payment for a mechanical threaded coupler/ clamp shall be made by measuring the Lap length of the respective rebar on which coupler/ clamp is used. The rate shall include supply of complete assembly, fixing, testing etc. all complete.

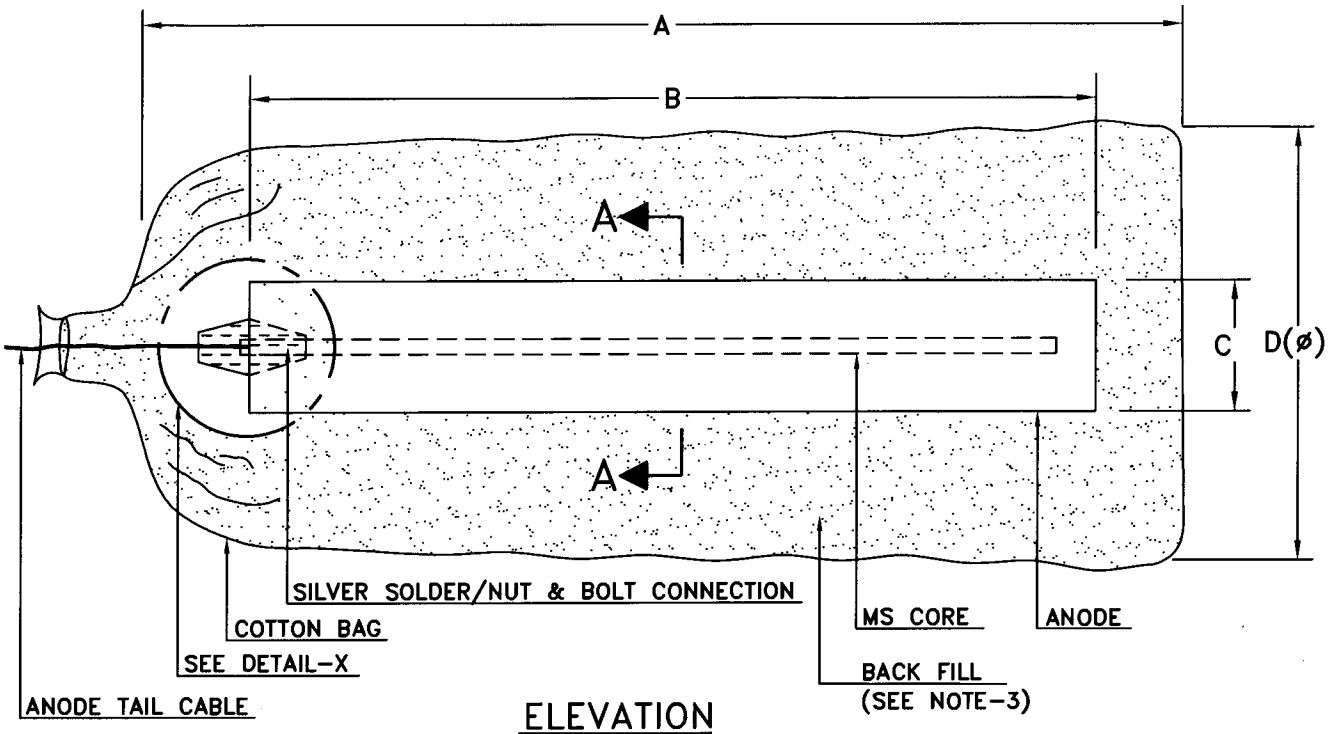
22.3 Water Stops/Water Bars & Expansion/Isolation Joints

22.3.1 Payment for water bars shall be made on running metre (RM) basis of the water stops provided in position. Rate shall include supplying, cutting, fixing, jointing by vulcanising or any other approved method, wastage, etc. complete.

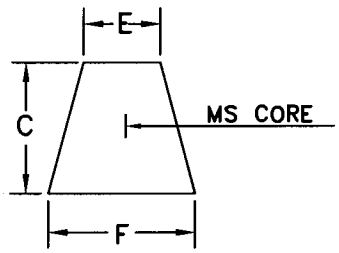
22.3.2 Payment for filler materials in Expansion/Isolation joints shall be made on running metre basis of the joint provided. For boards provided at expansion/isolation joints, the measurement shall be made on square metre basis. Rate shall be inclusive of supply, cutting, fixing, jointing, wastage etc. complete.

22.4 Waterproof Cement Paint

22.4.1 Payment for waterproof cement paint as per Cl. 18.0 shall be made separately on Sqm basis.



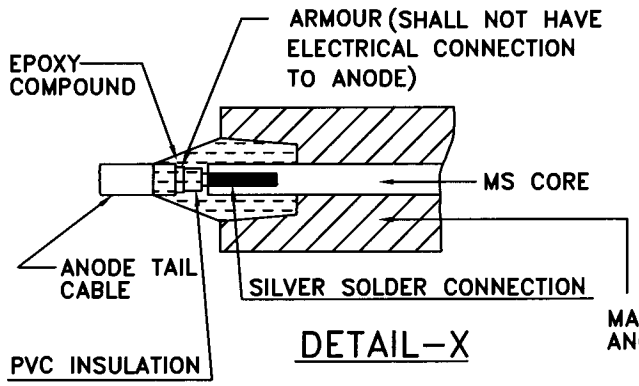
ELEVATION



SECTION-AA

CHEMICAL COMPOSITION OF ANODE (%WEIGHT):-

ELEMENT	LOW POTENTIAL TYPE	
Al	5.3-6.7(max)	
Mn	0.15-0.7	
Cu	0.02(max)	
Fe	0.003(max)	
Ni	0.002(max)	
Zn	2.5-3.5	
Si	0.1(max)	
Ca	-	
OTHER METALLIC ELEMENTS		
-EACH	0.05(max)	
-TOTAL	0.3(max)	0.3(max)
Mg	BALANCE	BALANCE



DETAIL-X

BACK FILL COMPOSITION

GYPSUM ---------- : 75%
BENTONITE---------- : 20%
SODIUM SULPHATE ---- : 5%

NOTES:-

1. ANODE COMPOSITION, NET WEIGHT, GROSS WEIGHT, PREPACKED ANODE WEIGHT AND DIMENSIONS (A,B,C,D,E & F) SHALL BE FURNISHED BY CONTRACTOR.
2. ANODE TAIL CABLE SHALL BE HIGH CONDUCTIVITY, STRANDED, COPPER CONDUCTOR, 650V GRADE, PVC INSULATED, PVC SHEATHED & ARMOURED.
3. THICKNESS OF BACK FILL SHALL BE ADEQUATE TO SAFEGUARD THE ANODES AGAINST EFFECT OF CARBONATES, BICARBONATES, NITRATES etc. IN SOIL. ANODES SHALL BE PROVIDED WITH MIN. 50mm. THICK BACK FILL ON ALL THE SIDES OF THE ANODE OR MIN. 20kg. NET, WHICHEVER IS HIGHER.

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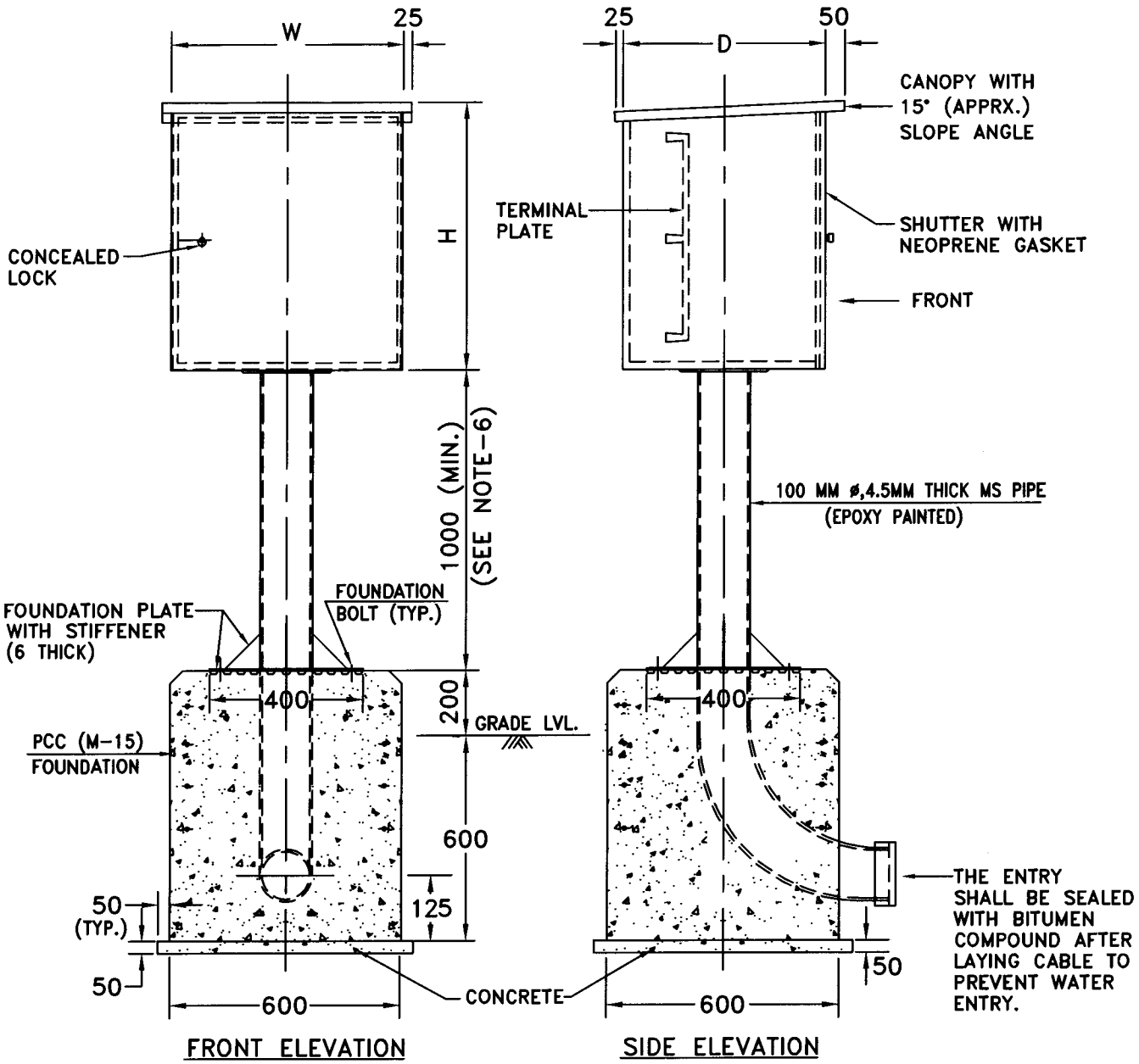
1	28.07.17	REVISED AND ISSUED AS STANDARD	PTR/AKD	NSB	BRB	RN
0	14.03.13	ISSUED AS STANDARD	NSB	RC	PPL	DM

Approved by



NOTES :-

1. THE SHUTTER SHALL BE HINGED TYPE WITH CONCEALED LOCK & SHALL HAVE DOOR GASKET TO MAKE THE TEST STATION WEATHER PROOF (IP:55)
2. THE INNER & OUTER SURFACE OF THE TEST STATION SHALL BE EPOXY PAINTED OR Zn/Al COATED IN COASTAL AREA.
3. THE NAME PLATE SHALL BE OF ANODISED ALUMINIUM WITH BLACK BACKGROUND & WHITE LETTERS & SHALL BE FIXED TO THE INNER SIDE OF SHUTTER.
4. TEST STATION SHALL BE ERECTED WITH THEIR SHUTTERS PARALLEL TO THE LINE OF AXIS & FACING THE PIPE LINE.
5. THE CHAINAGE OF TEST STATION SHALL BE WRITTEN WITH BLACK PAINT ON THE OUTER SIDE OF THE FRONT SHUTTER.
6. HEIGHT OF THE TEST STATION SHOWN ABOVE GROUND LEVEL IS MINIMUM ONLY. THE ACTUAL HEIGHT SHALL BE DECIDED BASED ON LOCAL FLOOD LEVELS TO BE ASCERTAINED.
7. CONTRACTOR SHALL FURNISH ALL THE DIMENSIONS OF THE TEST STATION.
8. ALL THE DIMENSIONS ARE IN MM.

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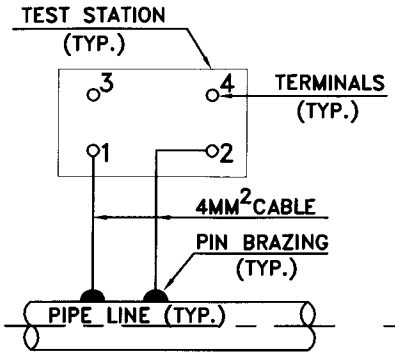
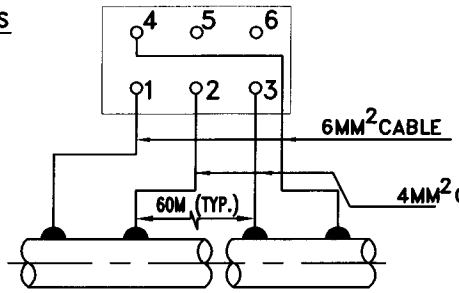
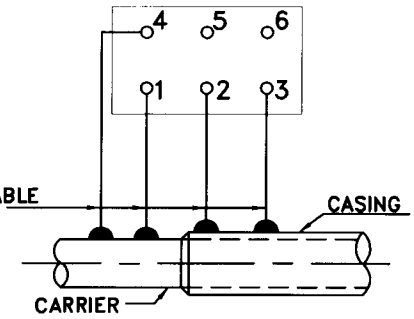


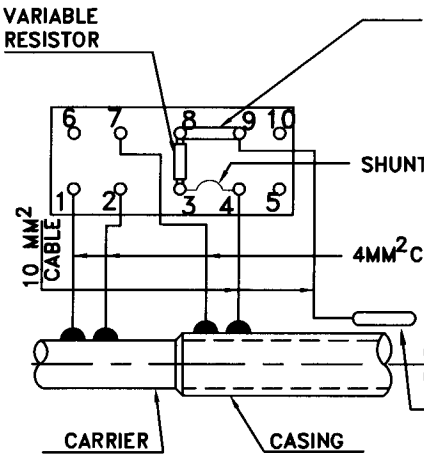
POTENTIAL MEASUREMENT
(CONNECTION SCHEME-A)



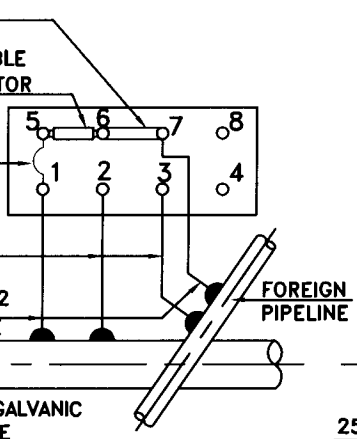
CURRENT MEASUREMENT
(CONNECTION SCHEME-B)



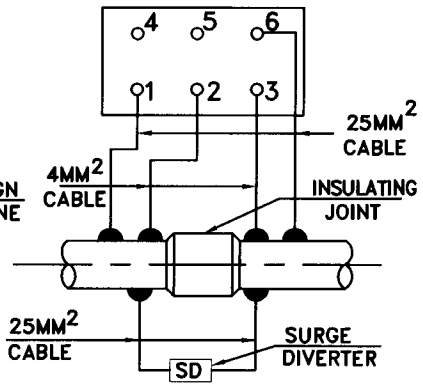
CASED CROSSING WITH
UNCOATED/UNPAINTED CASING
(CONNECTION SCHEME-C)



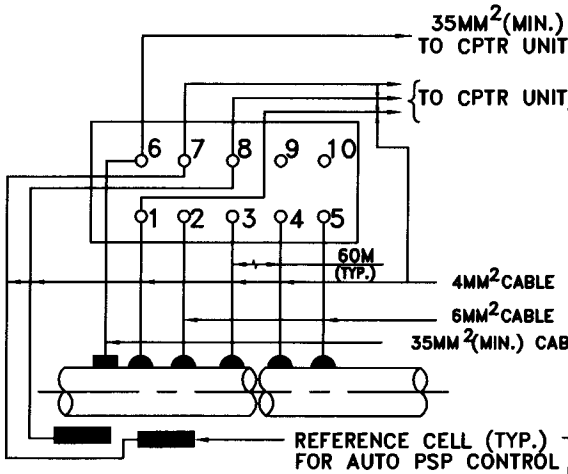
CASED CROSSING WITH
COATED CASING
(CONNECTION SCHEME-D)



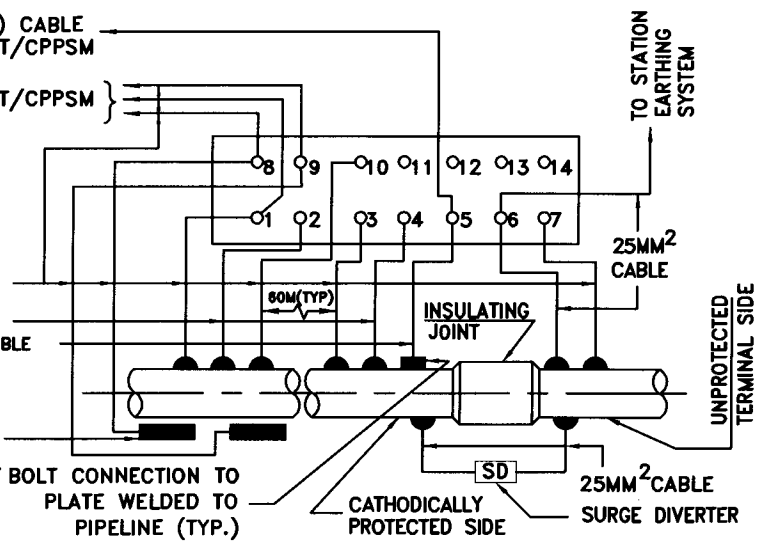
FOREIGN PIPELINE
CROSSING
(CONNECTION SCHEME-E)



INSULATING JOINT
(CONNECTION SCHEME-F)



INTERMEDIATE CP STATION (WITHOUT
IJ ON PIPE LINE AT THE STATION)
IMPRESSED CURRENT DRAINAGE POINT
(CONNECTION SCHEME-G)



TERMINAL STATION IMPRESSED
CURRENT DRAINAGE POINT
(CONNECTION SCHEME-H)

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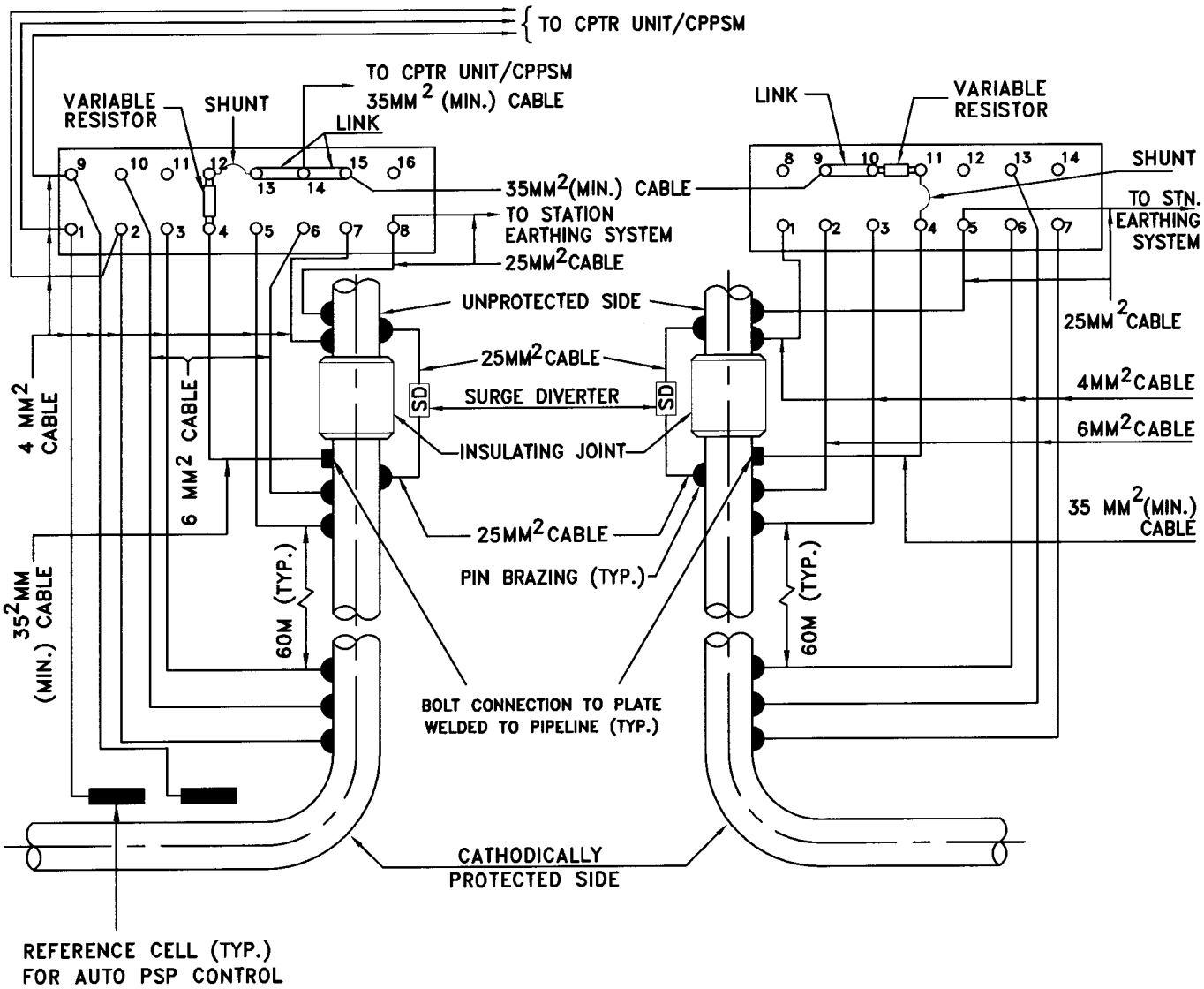
TEST STATION 1-1

TEST STATION 1-2



INTERMEDIATE PIGGING STATION IMPRESSED CURRENT DRAINAGE POINT CONNECTION SCHEME-I

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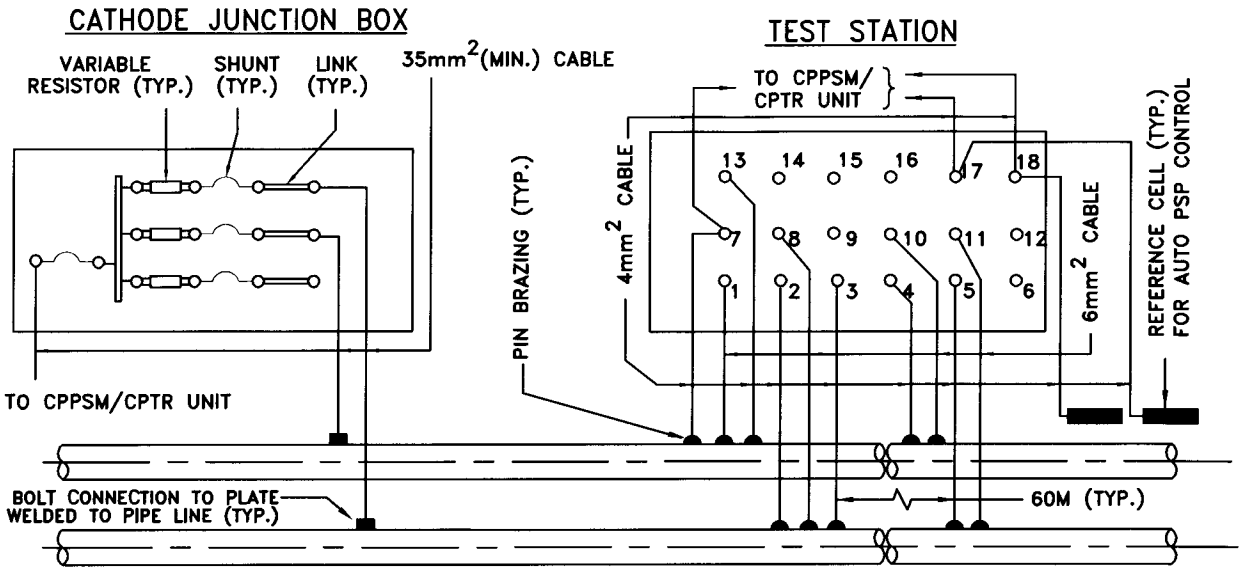
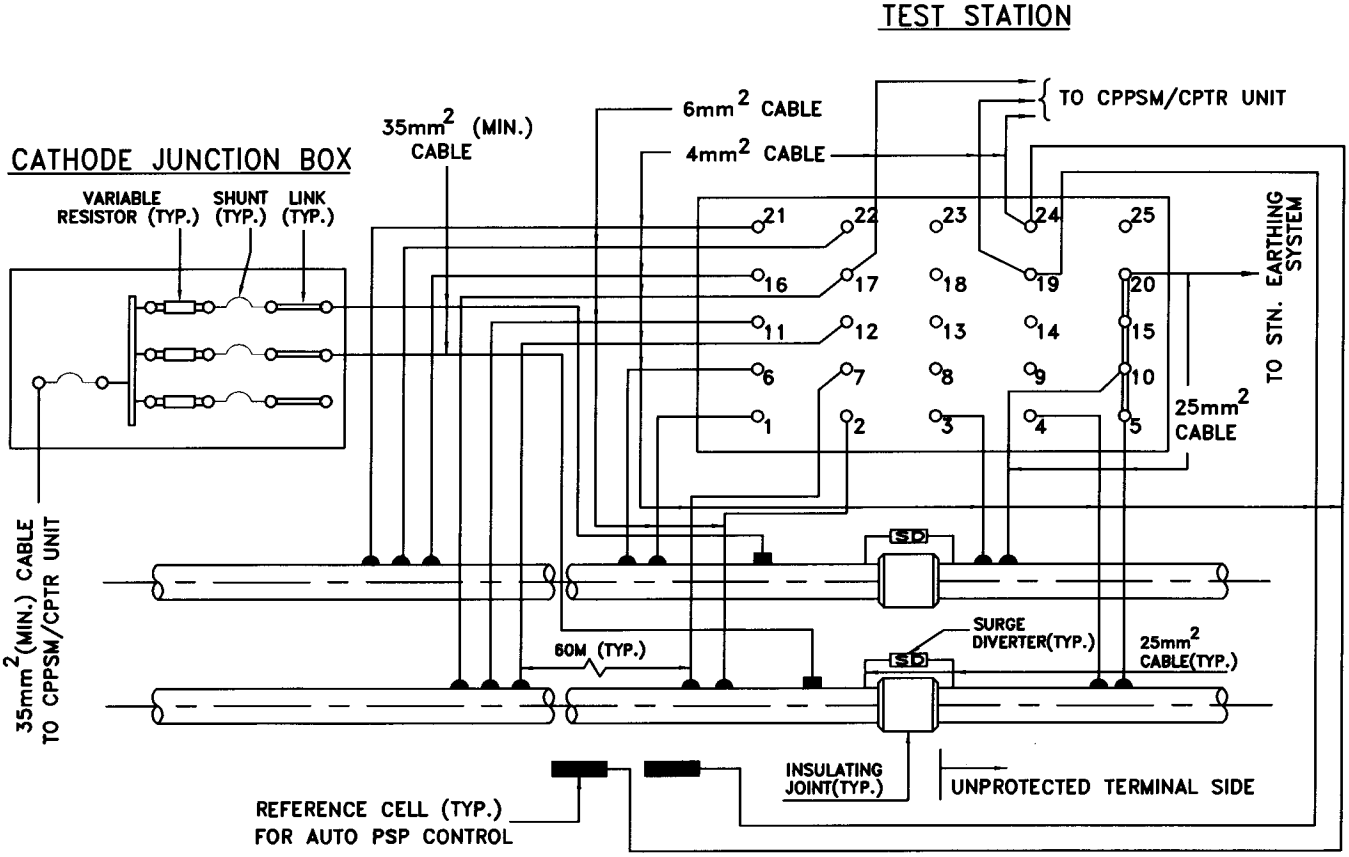


INTERMEDIATE CP STATION MULTIPLE PIPELINES (TYP. FOR TWO PIPE LINES) IMPRESSED CURRENT DRAINAGE POINT (WITHOUT IJs ON LINE PIPES AT THE STATION) (CONNECTION SCHEME-J)



TERMINAL STATION MULTIPLE PIPELINES (TYP. FOR TWO PIPELINES) IMPRESSED CURRENT DRAINAGE POINT. (CONNECTION SCHEME-K)

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
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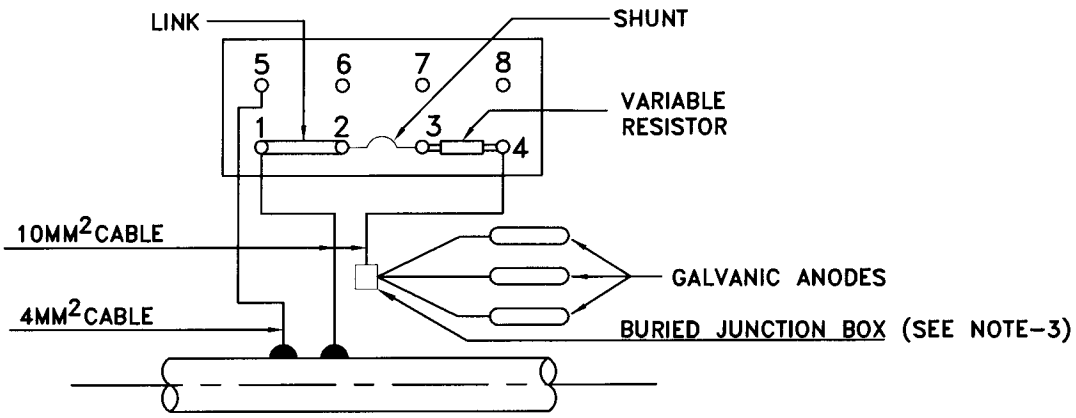
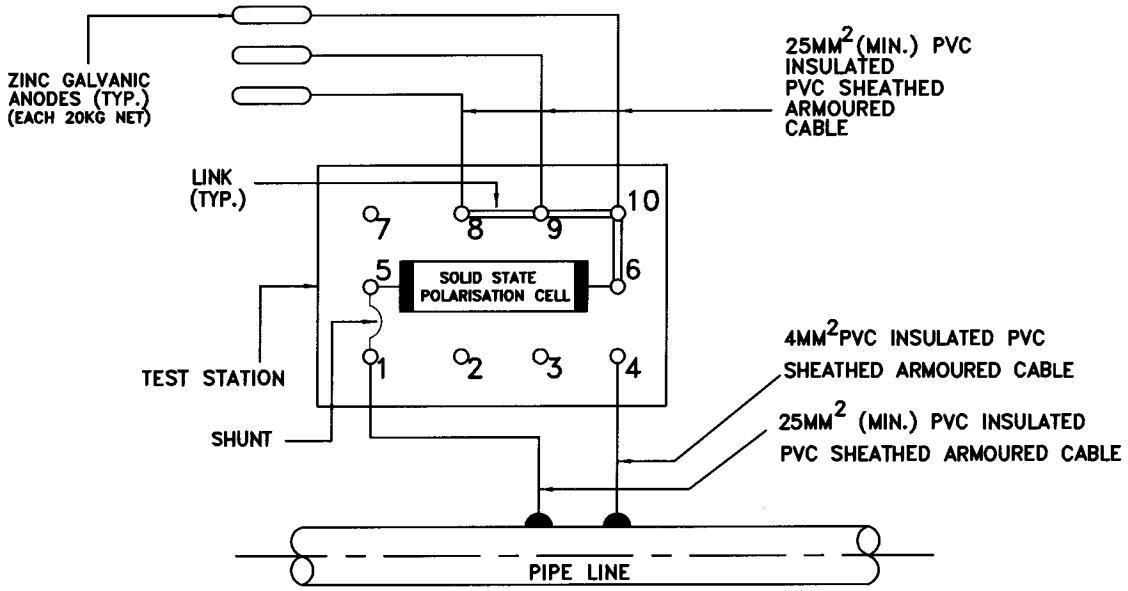


TCP GALVANIC ANODE INSTALLATION
(CONNECTION SCHEME-L)



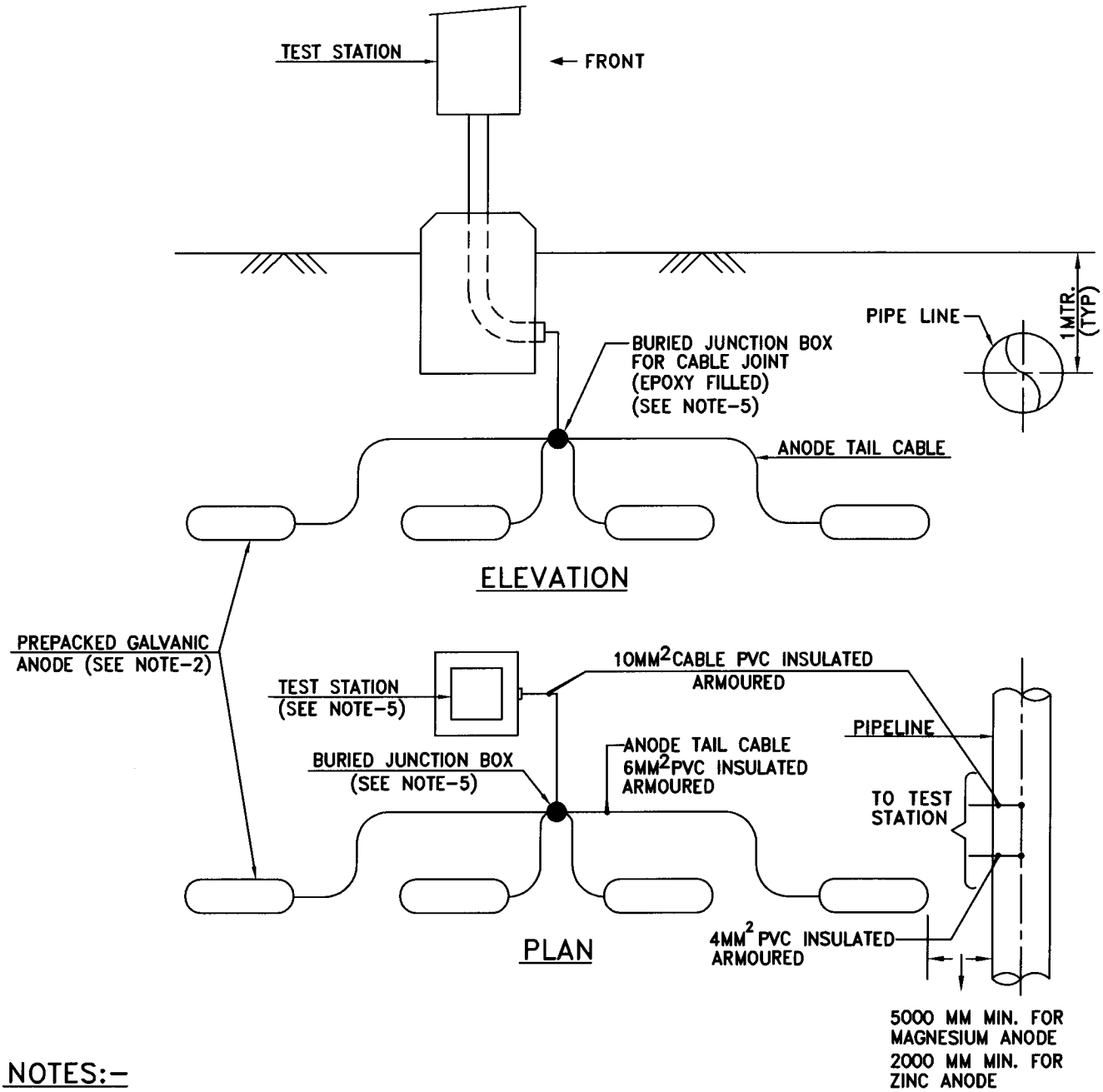
PIPELINE GROUNDING THROUGH POLARISATION CELL AND GALVANIC ANODE
CONNECTION SCHEME-M

NOTES:-

1. NUMBER OF TERMINALS FOR TEST STATION OF DIFFERENT CONNECTION SCHEME SHALL BE AS SHOWN ON THE RESPECTIVE SCHEME DRAWING. TEST STATION FOR ANY OTHER SCHEME SHALL PREFERABLY BE SIMILAR TO ANY OF THE ABOVE TYPES.
2. ELECTRICAL CONNECTIONS SHALL BE CLEANED TO BRIGHT SURFACE & TIGHTENED WITH NON-OXIDE GREASE APPLIED ON MECHANICALLY MATED SURFACE.
3. FOR SACRIFICIAL ANODE GROUND BED WHICH IS INTENDED FOR PERMANENT CP SYSTEM AND/OR TO BE INTEGRATED WITH PERMANENT CP SYSTEM, THE LEADS OF ALL ANODES SHALL BE BROUGHT UP TO THE TEST STATION AND SHALL BE TERMINATED INDIVIDUALLY. ACCORDINGLY, THE NUMBER OF TERMINALS FOR TEST STATION SHALL BE DECIDED BASED ON NUMBER OF ANODES.
4. WHERE INSULATING JOINT (IJ) ON THE PIPELINE IS BURIED, THE SURGE DIVERTER MOUNTED ACROSS THE IJ SHALL BE HOUSED SUITABLY SO THAT OPERATION OF THE SAME IS NOT AFFECTED.
5. THE DISTANCE BETWEEN TWO SUCCESSIVE PIN BRAZING POINTS SHALL BE MIN. 300MM.
6. CATHODE DRAINAGE CABLE SHALL BE CONNECTED TO A BOLT WELDED TO A METAL PLATE WHICH IS WELD CONNECTED TO PIPE LINE. THE MATERIAL OF THE PLATE SHALL BE SAME AS THAT OF THE MATERIAL OF THE PIPE LINE.

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
1	28.07.17	REVISED AND ISSUED AS STANDARD	PTR/AKD	NSB	BRB	RN
0	06.03.13	ISSUED AS STANDARD	NSB	RC	PPL	DM

Approved by



NOTES:-

1. THE PREPACKED GALVANIC ANODE SHALL BE INSTALLED AT A MINIMUM DEPTH, EQUAL TO BOTTOM LEVEL OF THE PIPELINE.
2. THE ANODES ARE SHOWN HORIZONTALLY LAID. ALTERNATIVELY THE ANODES MAY BE VERTICALLY INSTALLED WITH TOP OF THE ANODE AT A MINIMUM DEPTH EQUAL TO BOTTOM LEVEL OF THE PIPE LINE.
3. ALL NATIVE BACKFILL SOIL SHALL BE FREE OF ROCKS, GARBAGE, PAPERS, PLASTICS ETC.
4. CABLE SHALL BE LAID WITH ENOUGH SLACKNESS TO AVOID DAMAGE TO CABLES DURING BACK FILLING ETC.
5. THIS DRAWING SHOWS TYPICAL ANODE INSTALLATION ARRANGEMENT FOR TEMPORARY CATHODIC PROTECTION SYSTEM. ANODES FOR PERMANENT CATHODIC PROTECTION SYSTEM SHALL BE INSTALLED IN A SIMILAR MANNER, BUT ANODE TAIL CABLES OF EACH ANODE SHALL BE BROUGHT INDIVIDUALLY UPTO TEST STATION & TERMINATED. NO BURIED JUNCTION BOX SHALL BE USED FOR PERMANENT CP SYSTEM.
6. ANODE TAIL CABLE SHALL NOT BE USED FOR LIFTING THE ANODE. ROPE SLINGS SHALL BE USED FOR LIFTING THE ANODE DURING INSTALLATION INTO GROUND BED.

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
					Approved by	
1	28.07.17	REAFFIRMED AND ISSUED AS STANDARD	PTR/AKD	NSB	BRB	RN
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मानक विनिर्देशन
सिविल एवं संरचनात्मक कार्य

STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS

मिट्टी का कार्य

EARTHWORK

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	18.03.21	REVISED & REISSUED	TK	AJS	AS	SM
5	21.08.14	REVISED & REISSUED	AJS	AS	PKM	SC
4	19.06.09	REVISED & REISSUED	AS	SCH	VINAY KUMAR	N. DUARI
3	22.01.02	UPDATED & REISSUED	R SOOD	R SOOD	H MATHUR	GRR
2	AUG'94	UPDATED & REISSUED	-	H MATHUR	GP LAHIRI	A. SONI

Abbreviations:

CNS : Cohesive Non Swelling

Structural Standards Committee

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Members:
Mr. C Damodaran
Mr. V.K.Panwar
Mr. Samir Das
Mr. Amitabh Kishore
Mr. Gyasuddin
Mr. Charanjit Singh (Projects)
Mr. Ravindra Kumar (Constn.)

CONTENTS

1.0 SCOPE

This specification deals with earth work in excavation and filling.

2.0 CLASSIFICATION OF SOIL

2.1 Ordinary Soil

2.1.1 Soft Soil/ Loose Soil

Generally any soil which yields to the ordinary application of pick and shovel, or to phawra, rake or other ordinary digging implements such as:

a) Sand, gravel, loam, clay, mud, black cotton soil
b) Vegetables or organic soil, turf, peats, soft shale or loose murrum
c) Mud concrete below ground level
d) Any mixture of soil mentioned above.

2.1.2 Hard/ Dense Soil

Generally any soil, which requires close application of picks or jumpers or scarifier and rippers to loosen the same, such as:

i) Stiff heavy clay, hard shale or compact murrum requiring grafting tool and/ or pick and shovel
ii) Shingle and river or nallah bed boulders
iii) Soling of roads, paths etc. and hard core
iv) Macadam surface of any description (water bound, grouted tarmac etc.)
v) Lime concrete, stone masonry in lime or cement mortar below ground level
vi) Soft conglomerate when the stone can be detached from the matrix with picks and shovels

2.2 Soft Rock

This is fissured/ disintegrated rocky strata, boulders (volume more than 0.028 m^3 and less than 0.400 m^3) and also which cannot be quarried/ excavated by using above manual tools but can be quarried/ excavated manually by using crow bars is classified as soft rock. Soft rock shall include all kinds of stiff and stratified rock, such as shales, thinly bedded phillites, laterite hard conglomerate, lime stone, sand stone and unreinforced cement concrete below ground level. Soft rock may be quarried or split with crow bar or picks and can also be excavated by rippers, dozers and other mechanical equipment, but without the aid of blasting. If required and permitted, light blasting may be restored to, for loosening the materials, but this will not, in any way entitle the material to be classified as "Hard Rock".

2.3 Hard Rock

2.3.1 Hard Rock (Not Requiring Blasting)

This shall include all types of hard and compact rock, having closely spaced fissures or joints, on account of which blasting is not considered necessary and shall not be resorted unless permitted by the Engineer-in charge.

2.3.2 Hard Rock (Requiring General Blasting)

This shall include all types of hard and compact rock occurring in unfissured masses or similar foundations, boulders (volume more than 0.4 m^3) for excavation in which blasting is

considered necessary such as quartzite, granite, basalt stones, reinforced cement concrete (reinforcement to be cut through but not separated from concrete) below ground level and the like.

2.3.3 **Hard Rock (Requiring Controlled Blasting (Explosive/ Non-explosive)**

This type of excavation becomes necessary when excavation is done in formations, mentioned in Clause 2.3.2, in the vicinity of existing foundations/ structures. Mode of blasting shall be decided by Engineer-in-Charge, keeping in view the sensitivity of structures.

2.3.4 **Hard Rock (Blasting Prohibited)**

Hard rock requiring blasting as described in clause 2.3.2 above, but where blasting is prohibited for any reason and excavation has to be carried out by chiseling, wedging, pneumatic/ hydraulic/ electro-mechanical breaking by using splitter or by chemical means or any other agreed method.

The use of excavation shall not be considered as a reason for classification under hard rock requiring blasting unless clearly found necessary in the opinion of Engineer-in-Charge.

3.0 BACKFILLING MATERIAL

3.1 Suitable Materials:

3.1.1 Back filling suitable material shall be approved by the Engineer-in-charge. Additionally, they shall be free from refuse, large stones or rocks or other material which might prevent proper compaction or cause the compacted fill or embankment to perform inadequately or to have insufficient stability or bearing capacity for the superimposed loads to which it is likely to be subjected.

3.1.2 Back filling of excavation in trenches, foundations and elsewhere shall consist of one of the following materials as shown on drawing, or directed by the Engineer-in-charge.

i) Soil
ii) Selected earth from heaps or brought from borrow areas.

In case i) or ii) are not available, the Engineer-in-charge may approve use of any of the following:

iii) Stone/ Gravel
iv) Sand
v) CNS material.

3.1.3 The material shall be free from refuse, debris, roots, hard lumps and any other foreign organic material.

3.2 Unsuitable Materials

Unsuitable material shall include particles in excess of 75 mm size and that which is:

a) Organic material, logs, stumps and perishable materials.
b) Material susceptible to spontaneous combustion
c) Materials with undefined properties
d) Materials having a moisture content greater than the maximum specified
e) Building rubble and domestic and industrial wastes
f) Soils and rock susceptible to deterioration/ change of their properties.

g) Clay, silt and other loose or soft soils not in accordance with compaction criteria.
h) Dredged material
i) Material containing gypsum or other soluble salts.

4.0 SETTING OUT

4.1 The Contractor shall be responsible for the true and proper setting out of the work in relation to original points, ***lines**** and ***levels**** of reference and for the correctness of the levels, dimensions and alignment of all parts of the work. If at any time during progress of the work any error appears or arises in the position of level, dimension, or alignment of part of the work, the Contractor at his own expense shall rectify such errors to the satisfaction of the Engineer-in-Charge. The checking of any line or level by the Engineer-in-Charge shall not in any way relieve the Contractor of his responsibilities.

4.1.1 Tolerances*

The grade shall be properly shaped to the required elevations and parallel to the required surface. The elevation of any point and the line of any edge or center of the earthworks shall conform to that shown on the drawings within the tolerances stated below:

	Tolerances from True Level	Tolerances from True Line
Basic Grading	- 25 mm	- 75 mm
Embankments	+75 mm - 0	+75 mm - 75 mm

4.2 The Contractor shall lay out and construct one or more permanent bench marks in some central place before the start of the work, from which all important levels for the excavations will be set.

These permanent bench marks shall consist of masonry pillars with top neatly plastered and leveled as per the directions of the Engineer-in-Charge. Bench marks shall be well connected with triangular grid system or any other bench mark approved by the Engineer-in-Charge.

5.0 EARTHWORK IN EXCAVATION

5.1 Excavation shall be carried out in any material met on the site to the lines, levels and contours shown on the detailed drawings and the Contractor shall remove all excavated materials to spoil heaps on site or transport for use in filling on the site or stack them for reuse as directed.

5.2 Excavated material shall not be deposited within 1.5 m from the top edge of the excavation.

5.3 The sides of the excavation may be cut sloping, or shored and strutted to hold the face of earth as per site requirements and as directed by the Engineer-in- Charge.

5.4 Foundation pits/ trenches shall not be excavated to the full depth unless construction is imminent. The last 15 cm depth of the excavation shall not be done until concreting work is imminent. The full depth may at the discretion of the Engineer-in-Charge be excavated and the bed covered with a 50 mm (minimum) thick (or as indicated on drawing) layer of lean concrete 1:5:10 mix (1 cement : 5 coarse sand : 10 crushed stone aggregate) or as specified in schedule of rates/ shown on drawing, after watering if required, and consolidating the bed.

5.5 If the bottom of any excavation has been left exposed by the Contractor and in the opinion of the Engineer-in-Charge, that has become badly affected by the atmosphere or by water, then the Contractor shall remove such portions of the deteriorated material as the Engineer-

in-Charge may direct and shall make good with lean concrete 1:5:10 mix (1 cement : 5 coarse sand : 10 crushed stone aggregate). All expenses for such additional concrete and excavation shall be borne by the Contractor.

5.6 Where excavation is made in excess of the depth required, the Contractor shall, at his own expense, fill upto required level with lean concrete 1:5:10 mix (1 cement : 5 coarse Sand : 10 crushed stone aggregates) or as decided by Engineer-in-Charge.

5.7 The Contractor shall provide suitable drainage arrangement to prevent surface water from any source entering the foundation pits at his own cost.

5.8 The Contractor shall make all arrangements for dewatering during excavation and subsequent works, the accumulated water from any source (including subsoil water) in the excavated pits/trenches and keeping the excavated pits/ trenches dry for subsequent works.

5.9 The Contractor shall make necessary arrangements for lighting, fencing and other suitable measures for protection against risk of accidents due to open excavation.

5.10 Where the excavation is to be carried out below the foundation level of an adjacent structure, the precaution to be taken such as under pinning, shoring and strutting etc. shall be determined by the Engineer- in-Charge. No excavation shall be done unless such precautionary measures are carried out as per directions of the Engineer-in-Charge. The payment for such precautionary measures shall, however, be made separately.

5.11 Loose or soft bed ground encountered in excavation at the required depth shall on the Engineers-in-Charge's instructions be excavated to a firm bed and difference made up to the required level with lean concrete 1:5:10 mix (1 cement : 5 coarse Sand : 10 crushed stone aggregates).

5.12 In those cases where during excavation, side slips occur for reasons not attributable to the Contractor (e.g. side slips which take place on their own but not due to surcharge of earth kept near the edge of excavation and cracking of excavation top strata due to clay drying out leading to collapse of excavation sides), the Engineer-in-Charge shall admit payment at his discretion.

5.13 Any obstacle encountered during excavation shall be reported immediately to the Engineer-in-Charge and shall be dealt with as instructed by him. Removal of buried pipes or cables shall not be done without prior permission of the Engineer-in-Charge and the Contractor shall provide all measures to protect the same. Cost of such protective measures are deemed to be included in the rates for various items of excavation.

5.14 The Contractor shall not undertake any concreting in foundation until the excavation pit/trench is approved by the Engineer-in-Charge.

5.15 The specification for earth work shall also apply to excavation in rock in general.

5.16 In case of hard rock requiring blasting, the provisions mentioned below shall be strictly followed.

5.16.1 **General**

Where hard rock is met with and blasting operations are considered necessary, the Contractor shall intimate about the same to the Engineer-in-Charge, and obtain his approval in writing for resorting to blasting operation.

The Contractor shall obtain license from the district authorities for undertaking blasting work as well as for obtaining and storing the explosive as per the Explosive Rules 2008, corrected upto date. He shall purchase the explosives, fuses, detonators etc. only from a licensed dealer. He shall be responsible for the safe custody and proper accounting of the explosive materials. The Engineer-in-Charge or his authorised representative shall have the access to check the Contractor's store of explosive and his accounts.

In case where explosives are required to be transported and stored at site, relevant clauses of the Explosive Rules, 2008 as amended subsequently, shall apply.

The Contractor shall be responsible for any accident to workmen, public or property, due to blasting operations.

5.16.2 **Precautions**

Blasting operations shall be carried out under the careful supervision of a responsible authorised and licensed blaster of the Contractor (referred subsequently as "blaster" only) during specified hours, as approved in writing by the Engineer-in-Charge. The blaster shall be fully conversant with the rules of blasting.

Proper precautions for safety of persons shall be taken. Red flags shall be prominently displayed around the area to be blasted and all the people on the work except those who actually light the fuses, shall withdraw to a safe distance of not less than 200 m from the blast. Precautions as per Explosive Rules 2008 with amendment shall be followed.

5.16.3 **Fuses**

All fuses shall be cut to the lengths required before being inserted into the holes. Joints in fuses shall be avoided. Where these are unavoidable, a semicircular niche shall be cut in one piece of fuse about 2 cm. deep from the end and the end of other piece inserted into this niche, and the two pieces then wrapped together with a string. All joints exposed to dampness shall be wrapped with rubber tape. Fuse and detonators shall be kept separated from the explosives.

5.16.4 **Blasting with Gun Powder**

Blasting shall normally be done with gun powder. Dynamite, gelatine or any other high explosive shall only be used in special cases with the written permission of the Engineer-in-Charge.

In case of blasting with gun powder, the position of all bore holes to be drilled shall be marked out in circles with white paint. The bore holes shall be jumped or drilled in the rock face. The depth of bore hole shall be about the same as that of the line of least resistance and its size shall be such that the cartridges can easily pass down to the bottom. The bore holes must be dried before being charged and these shall be inspected by the Contractor's agent.

Gun powder may be used in the form of pellet blasting cartridges or as powder or granules. Cartridges are provided with tapered central hole. One end of fuse is passed through the narrow end of the hole and a sufficient length of the fuse is doubled back so that when the fuse is pulled, it is held tight in the tapered hole of the cartridge. Other cartridges are then inserted in the fuse to make up the required charge. The cartridge along with the fuse is lowered down in the bore hole, placed in position and gently filled and pressed home with dry hay or turf. The rest of the bore shall then be filled with dry clay, which shall be tamped with copper or brass rod until it becomes compact. Care shall be taken to avoid any possibility of an air space around the fuse. The safety fuses shall be taken to the required distance so as to allow the blasting to take place after the person lighting the fuse has withdrawn to a safe distance.

Where gun powder is used in the form of powder or granules it shall be introduced in the bore hole by means of funnel or copper tube. The bore holes shall be loaded with two thirds of the quantity of charge required, and safety fuse then directly introduced over the charge. Remaining one third charge shall then be introduced, and gently filled and pressed home with dry hay or turf. The rest of the bore hole shall be filled with dry clay in the same way as for cartridges, and the safety fuse taken to the required distance.

The charges shall be fired by igniting the fuse. The number of charges to be fired and the actual number of shots heard, shall be compared, and the Contractor's blaster shall satisfy himself by examination that all the charges have exploded, before workmen are permitted to approach the site. The charge which has not exploded, shall not be permitted to be withdrawn. The tamping and charge shall be flooded with water and the holes marked with a red cross (X) over it. Another hole shall be jumped at a distance of about 45 cm from the old hole and fired in the usual way. This operation shall be continued, till the original and any subsequent unfired charges are exploded.

5.16.5 **Blasting with Dynamite or any other High Explosive**

In case of blasting with dynamite or any other high explosive the position of all bore holes to be drilled shall be marked out in circle with white paint. These shall be inspected by the Contractor's blaster. Bore holes shall be of a size that the cartridge can easily pass down. After the drilling operation, the blaster shall re-inspect the holes to see that the holes marked out by him have been drilled. The Blaster shall then prepare all charges necessary for the bore holes. The bore holes shall be thoroughly cleaned before a cartridge is inserted. Wooden tamping rods (not pointed but cylindrical throughout) shall be used, in charging holes. Metal rods shall never be used for tamping. One cartridge shall be first placed in the bore hole, gently pressed and not rammed down. Other cartridges shall then be added as may be required to make up the necessary charge for the bore hole. The top most cartridge shall be connected to the detonator which shall in turn be connected to the safety fuse of required length.

The maximum of eight (8) bore holes shall be loaded and fired on each occasion. The charges shall be fired successively and not simultaneously.

Immediately before firing a blast, due warning shall be given and the blaster shall see that all persons have retired to a place of safety. The safety fuses of the charged holes shall be ignited in the presence of the blaster, who shall see that all the fuses are properly ignited.

Careful count shall be kept by him and others of each blast as it explodes. After the blast the blaster shall inspect the work and ascertain that all the charged holes have been exploded. In case of misfired holes, the Blaster shall inspect the same after half an hour and mark red crosses (X) over the holes. During this interval of half an hour, no body shall approach the misfired holes. None of the drillers shall work near such holes, until one of the two following operations has been done by the blaster.

a) Either the Contractor's blaster shall very carefully (when the tamping is of damp clay) extract the tamping with a wooden scraper and withdraw the fuse, primer and detonator, after which a fresh detonator, primer and fuse shall be placed in the misfired holes and fired.

OR

b) The hole shall be cleaned for 30 cm of tamping and its direction ascertained by placing a stick in the hole. Another hole shall then be drilled 15 cm away and parallel to it. This hole shall be charged and fired. The misfired hole should also explode along with the new one.

Before leaving the work, the blaster of one shift shall inform another blaster relieving him for the next shift, of any cases of misfire, and shall point out their positions denoted by red crosses and also state the action, if any, to be taken in the matter.

The Engineer-in-Charge shall also be informed by the blaster of all cases of misfire, their causes and steps taken in that connection.

5.16.6 **Controlled Blasting (Explosive/ Non-explosive)**

Whenever required by the Engineer-in-Charge, rock blasting shall be carefully controlled so that vibrations generated during the blasting do not cause damage to the buildings and installation around. Similarly, the rock pieces should not fly off and endanger the buildings and installations around. Apart from the general precautions mentioned in the preceding paragraphs, following protective measures and limits for use of explosive are suggested as guidelines. Bidders are requested to carefully check the site conditions and submit details of the scheme they propose to adopt for controlling the blast.

Following protective measures shall be adopted while carrying out blasting operations.

The hole shall be covered with mild steel plate of minimum 12 mm thickness.

Reinforcement rod mesh not less than 20 mm dia. at 150 mm centre in both directions shall be placed over the steel plates.

Steel plate and reinforcement shall be inspected after every blasting operation and all twists shall be removed before reuse to the satisfaction of the Engineer-in-Charge.

Sand filled bags of 6 to 8 layers shall be placed over the mesh suitably covering the whole region under blasting operation.

The thickness of covering plate and the kind of dead weight is to be duly approved by the Engineer-in-Charge.

5.16.7 Hard rock requiring blasting as described under Clause 2.3.2 above, but where blasting is prohibited for any reason(s), breaking up of rock can be done by using Splitter and/or chemical substances of approved manufacturer mixed in an appropriate proportion. The method involves drilling holes into rock and then inserting Splitter (hydraulic/ pneumatic/ electro-mechanical) or injecting Chemical solvents into the holes. The breaking-up of rock takes place in a controlled fashion without much noise and spark. Any other method as agreed with Engineer-in-Charge may also be used.

5.17 Excavation in areas where existing under ground cables are envisaged, to be carried out carefully by manual means taking proper safety precautions.

The earth work machinery be deployed after ensuring from the trial pits that no cable is crossing the proposed area of excavation.

5.18 Payment (applicable for item rate tenders only)

5.18.1 The payment clause shall be operated only if the earthwork is to be measured separately as per relevant tender item.

5.18.2 Payment for earth work in excavation shall be made on cubic meter (m^3) basis on the measurement of volume of pit/ trench of excavation with working space as per relevant Indian Standards (IS:1200) and slopes/ steppings as permitted by the Engineer-in-Charge. The rate shall include cost of all the operations of blasting with explosives & accessories, making of all

arrangements for dewatering the accumulated water from any source in the excavated pit or trench, removal and disposal of surplus excavated soil within a lead of 100 m from construction areas. The rate shall also include setting out and line out work required for the excavation.

5.18.3 The following works shall not be measured separately and allowance for the same shall be deemed to have been made in the description of main item:

a) Setting out works, profiles, etc.;
b) Site clearance, such as cleaning grass and vegetation;
c) Unauthorized battering or benching of excavation;
d) Forming (or leaving 'dead men' or 'tell-tales' in borrow pits and their removal after measurements;
e) Forming (or leaving) steps in sides of deep excavation and their removal after measurements;
f) Excavation for insertion of planking and strutting;
g) Unless otherwise specified, removing slips or falls in excavations;
h) Bailing out or pumping of water in excavation from rains;
i) Bailing out or pumping of water in excavation from sub-soil water, and
j) Slinging or supporting pipes, electric cables, etc, met during excavation.

5.18.4 Special pumping other than what is included in 5.18.3 (h and i) and well point dewatering where resorted to, shall each be measured separately, unless otherwise stated, in Kilo Watt Hour against separate specific provision(s) made for the purpose.

5.18.5 The Contractor shall intimate to the Engineer-in-Charge as soon as different classification of soils are met with. The measurements of various soil classifications then shall be worked out by either of the following alternatives in the order of their decreasing importance.

a) Joint levels shall be taken as to the levels of different soil classifications and volume worked out on the basis of levels only.

b) Where levels of different strata cannot be clearly marked and defined, the Contractor shall stack different soils of various classifications separately for measurement purpose and then dispose it off.

c) If the quantum of work involved in (b) above is extensively large & time consuming, then the total area may be divided into various zones and reasonably representative samples as in (b) above may be taken and quantities of soils of various classifications finalized for the entire zone based on the representative.

If soil of any classification other than that specified in the Schedule of Rates is met with during excavation, the decision of the Engineer-in-Charge as to the classification of soil, levels of the strata of different classifications and their location shall be binding.

In above case, the total quantity of excavation shall be computed from the measurement of the pit/ trench excavated. The hard rock and soft rock shall be measured separately from the relevant stacks and each shall be reduced by fifty percent for voids, and paid under the relevant items. The balance, that is the total quantity of excavation minus the reduced (for voids) quantity of excavation for rocks shall be paid as soft/ hard soil as per the direction of the Engineer-in-Charge (However, the maximum payment shall be limited to the volume of the excavated pit/ trench as approved by Engineer-in-Charge).

6.0 SHORING AND STRUTTING

6.1 The shoring and strutting of the sides to withhold the face of excavation pits/trenches shall be done when approved or directed by the Engineer-in-Charge.

6.2 The shoring shall be of close or open timbering type or by Sheet Piling, Soldier Piling, etc. depending upon the site requirements and as directed by the Engineer-in-Charge whose decision shall be final and binding as to the type of shoring to be used.

6.3 The arrangement of the shoring and strutting shall be sound and safe and shall be got approved from the Engineer-in-Charge before installation. The approval shall not absolve the Contractor of his responsibilities of safety and any other requirements of the contract.

6.4 The shoring and strutting shall be kept in position till all the relevant work in the excavated area is completed and approved. It shall be dismantled and removed only after the permission to do so is obtained from the Engineer-in-Charge.

6.5 Sheet Piling

The contractor shall design, supply and install hot rolled steel sheet piles including all associated structural steel members viz. waler & runner beams, strut, cross ties, vertical members, guide frames, suitable interlocks, suitable corner sections, splicing & cutting of sheet piling. The contractor shall also apply recommended sealant for complete water tightness (as required) and ensure pre-drilling for installation into bedrock (as necessary), etc. as per site conditions.

The contractor shall mobilize/ demobilize all necessary tools & tackles, hammer (vibratory/ impact), crane(s) etc., shifting plant/ machinery and carryout all ancillary works (as required) and ensure subsequent removal of entire arrangement after completion of works.

6.6 Payment (applicable for item rate tenders only)

Payment for shoring and strutting by close and open timbering shall be made on square meter (m^2) basis as separate items. In both the cases, the measurement shall be done on the basis of the surface area of the sides of the excavation actually shored and strutted.

The rate shall include all labour, materials, erection of the poling boards, wales, struts, ballies etc., fixing and keeping the same in position as required, dismantling and removing the same after the work is over as directed.

Payment for shoring and strutting by sheet piling shall be made on the basis of shoring area of sheet pile exposed after complete excavation.

The rate shall include all labour, design, supply and installation of hot rolled steel sheet piles including all associated structural steel members, application of recommended sealant, pre-drilling for installation into bedrock etc., mobilization/ demobilization of all necessary tools & tackles, hammer, crane(s) etc., shifting plant/ machinery & all ancillary works, fixing and keeping the sheet piling in position, dismantling and removing the same after the work is over, etc. all complete as directed by the Engineer-in-Charge.

No extra payment shall be made for cost of extraction and replacement for installing of sheet pile deviating the specification or rejected by Engineer-in-charge. Extracted sheet piles shall be contractor's property and contractor shall remove the same from site without any extra cost to client.

7.0 BACK FILLING AROUND FOUNDATIONS AND IN PLINTH

7.1 Back filling around completed foundations, structures, trenches and in plinth shall be done to the lines and levels shown on the drawings including any trimming of the surfaces, as may be necessary. This shall be done with selected and approved earth from excavation or otherwise with suitable materials described under Clause 3.1 as directed by the Engineer-in-Charge. Where sufficient suitable material is not available from the excavation, the Engineer-in-Charge may direct to import suitable earth from other sources. The filling shall be done in layers of thickness not exceeding 15 cm with watering, rolling and ramming by manual methods/ mechanical compactors to grade and level as shown on drawings to obtain 90% laboratory maximum dry density.

7.2 The Contractor shall not commence filling in and around any work until it has been permitted by the Engineer-in-Charge.

7.3 Backfilling around liquid retaining structures and pipes shall be done only after approval of the Engineer-in-Charge is obtained.

7.4 **Payment (applicable for item rate tenders only)**

Payment for backfilling with earth shall be based on volume in cubic meters (m^3) of consolidated fill. This volume shall be derived from the difference between the volume of excavation and the structure or trenches as the case may be. The rate shall include cost of extracting suitable approved earth from available excavated soil from spoil heaps within a lead of 100 m, placing, watering, rolling, ramming compacting in layers, trimming and dressing finished surface and disposal of surplus material upto a lead of 100 m.

However, backfilling done with materials other than earth shall be paid separately under relevant items.

8.0 TRANSPORTATION OF SURPLUS EARTH

8.1 Surplus earth and soil from excavation shall be removed from construction area to the area demarcated by the Engineer-in-Charge.

8.2 **Payment (applicable for item rate tenders only)**

8.2.1 Payment shall be made only for the lead beyond initial 100 m from construction area. Rate shall include re-excavation, loading, transportation, dumping, stacking or spreading (as per directions of the Engineer-in-Charge) the surplus earth and the soil in the area demarcated by the Engineer-in-Charge. Payment shall be made on cubic metre (m^3) basis on the difference of measurements of the volume of the excavated pits and the measurement of the back filling. Quantity generated due to voids in back filled volume of earth shall also be removed by the Contractor at no extra cost and this disposal of earth shall not be measured and paid under any item.

8.2.2 In exceptional circumstances the Engineer-in-Charge may direct the Contractor to remove surplus earth, concrete debris or any other waste material from site to the areas of disposal on the basis of truck measurement. In such cases volume of material shall be calculated on the basis of truck volume reduced by 30% for voids in case of soft/hard soils and 50% for soft/ hard rock. All other provisions of disposal such as spreading, levelling, grading shall apply in this case also.

9.0 PROTECTION OF PROPERTY AND PERSONNEL

9.1 The Contractor shall protect all active utility lines shown on the drawings or encountered during the excavation. If he damages those lines, the Contractor shall repair or replace them. If existing utilities interfere with his work, the Contractor shall inform to the Engineer-in-charge and secure written instructions for further action.

9.2 The Contractor shall barricade open holes and depressions which he creates or exposes as part of this, and he shall post warning signs and lights on property adjacent to or with public access. He shall operate warning lights during hours from dusk to dawn each day and as otherwise required for safety.

9.3 The Contractor shall protect structures, utilities, pavements, and other facilities from damage caused by settlement, lateral movement, washout, and other hazards created by his operations.

9.4 The Contractor shall plan and execute all aspects of the earthwork so that the safety of personnel, the work and adjacent property is guaranteed and such that a minimum of inconvenience is caused.

10.0 CLEAN UP

Upon completion of work, the Contractor shall leave the project site clear of debris and surplus materials off plant limits in a manner meeting all location authority requirements.

पाइपलाइनों की सैक्रिफिशियल एनोड कैथोडिक संरक्षण प्रणाली के लिए विनिर्देश

SPECIFICATION FOR SACRIFICIAL ANODE CATHODIC PROTECTION SYSTEM FOR PIPELINES

Rev.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2	09 09 2019	REVISED & ISSUED AS STANDARD SPECIFICATION	PTR	NSB	SA	RKT
1	17 07 14	REVISED AND REISSUED	NSB	RC	PPL	SC
0	21 05 12	SPECIFICATION NO 6-51-0027 REVISED, RENUMBERED AND ISSUED AS STANDARD SPECIFICATION	GSH	BC	PPL	DM

Abbreviations:

$\mu A/mm^2$	:	Micro-Ampere per square millimeter
AC	:	Alternating Current
ASTM	:	American Society for Testing and Materials
BIS	:	Bureau of Indian Standards
BS	:	British Standards
CMRI	:	Central Mining Research Institute
CP	:	Cathodic Protection
CPPSM	:	Cathodic Protection Power Supply Module
CPTR	:	Cathodic Protection Transformer Rectifier
CTE	:	Coal Tar Enamel
DC	:	Direct Current
DNV	:	Det Norske Veritas
EHV	:	Extra High Voltage
EN	:	European standards
FBE	:	Fusion bonded Epoxy
HDD	:	Horizontal Directional Drilling
HMWPE	:	High Molecular Weight Polythylene
HV	:	High Voltage
HVDC	:	High Voltage Direct Current
IS	:	Indian Standards
MOV	:	Motor Operated Valve
NACE	:	National Association of Corrosion Engineers
PE	:	Polyethylene
PVC	:	Polyvinyl Chloride
ROU	:	Right of Use
SV	:	Sectionalizing Valve

Electrical Standards Committee

Convenor: Ms. Sumita Anand

Members:
Mr. Parag Gupta
Mr. M K Sahu
Ms. ANP Singh
Ms. Nivedita S Bhattacharyya
Mr. Amrit Dey
Mr. RajKishore (Projects)
Mr. Rajesh Sinha (Inspection)

CONTENTS

1.0 SCOPE

1.1 This specification defines the requirements of design, engineering, installation, testing and commissioning of sacrificial anodes cathodic protection system for external surface of cross country onshore underground pipelines/ structures including supplementing of corrosion survey, investigation for interference/ interaction problems and mitigation of the same.

1.2 This specification defines the basic guidelines to develop a suitable sacrificial anode cathodic protection system for the pipelines/ structures required to be protected. All data required in this regard shall be taken into consideration to develop an acceptable design and for proper engineering of the system.

1.3 Compliance with these specifications and/ or approval of any of the contractor's documents shall in no case relieve the contractor of his contractual obligations.

2.0 APPLICABLE CODES AND STANDARDS

2.1 The system design, performance and materials to be supplied shall conform to the requirements of the latest revision of following standards as a minimum:

NACE Standard SP0169	:	Control of External Corrosion on Underground orSubmerged Metallic Piping Systems
NACE Standard SP0177	:	Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems
NACE Standard SP0207	:	Performing Close-Interval Potential Surveys and DC Surface Potential Gradient Surveys on Buried or Submerged Metallic Pipelines
NACE Standard SP0286	:	The Electrical Isolation of Cathodically Protected Pipelines
NACE Standard SP-0200	:	Steel-Cased Pipeline Practices
BS EN 15280	:	Evaluation of AC corrosion likelihood of buried pipelines.
BS EN 50162	:	Protection Against Corrosion by Stray Current from DC Systems
ISO 15589	:	Petroleum and natural gas industries, Cathodic Protection of Pipelines transportation System
IS 8062	:	Code of Practice for Cathodic Protection of Buried Pipeline/ Structure for Transportation of Natural Gas, Oil and Liquids
IS1554, Part I	:	PVC Insulated (Heavy Duty) Electric Cables: For Working Voltages up to and Including 1100V
IS/ IEC: 60079	:	Electrical Apparatus for Explosive Gas Atmosphere
IS/ IEC: 60529	:	Classification of Degree of Protection Provided by Enclosures
OISD 141	:	Design, Construction And Inspection Requirements For Cross Country Liquid Hydrocarbon Pipelines
OISD 214	:	Cross Country LPG pipelines
PNGRB GSR INFRA/ T4S S.R. 612(E), G.S.R. 808 (E)	:	Petroleum And Natural Gas Regulatory Board
ASTM B843/ ASTM B418	:	Standard Specification for Magnesium Alloy Anodes/ Zinc Alloy Anodes for Cathodic Protection

2.2 In case of imported equipments standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian/ International Standards.

2.3 The equipment shall also conform to the provisions of Indian/ International Electricity rules and other statutory regulations currently in force in the country.

2.4 In case of any contradiction between various referred standards/ specifications/ data sheet and statutory regulations the most stringent requirement shall govern and decision of owner in this regards shall be final.

3.0 SYSTEM IMPLEMENTATION

All work to be performed and supplies to be effected as a part of contract shall require specific review by Owner or his authorised representative. Major activities requiring review shall include but not be limited to the following:

a) Corrosion survey data interpretation report and design basis for CP system
b) CP system design package
c) Detailed engineering package
d) Field testing and commissioning procedure
e) Procedures and report for interference testing and mitigation
f) Close interval potential logging survey procedure and report
g) CAT/ DCVG survey procedure and report
h) System monitoring procedures and commissioning report
i) As built documentation

4.0 CORROSION SURVEY

4.1 The details of corrosion survey including soil resistivity data along ROU and other data required for CP design if available with the Owner shall be included as part of project specification/ data sheet. However, verification of its veracity and adequacy shall be the entire responsibility of the contractor. In addition, contractor shall collect additional data as per clause 4.2 below required for proper implementation of the protection system. Contractor shall also carry out soil resistivity survey at sacrificial anode ground bed locations for proper design of ground beds. Wenner's 4-pin method or approved equal method shall be used for such measurements. Survey instruments shall have maximum AC and DC ground current rejection feature. The resistivity shall be measured at every 1 Km on pipeline route at minimum 1m, 2m and 3m spacing as per pipeline depth.

Care shall be taken to ensure that the resistivity observations are not influenced by the presence of foreign pipelines/ structures, and earth currents in the vicinity of EHV/ HV lines and installations using earth return in their power system etc.

Where specified in the project specification/ data sheet, the contractor shall carry out corrosion survey along the ROU of the pipeline conforming to the specifications included in the tender document.

4.2 Additional Data to be Collected

The following data shall be collected to generate design data for evaluation of interaction/ interference possibilities due to presence of other services in ROU/ vicinity. Owner shall provide assistance for liaison work to the extent possible:

i) Route and types of foreign service/ pipeline in and around or crossing the right of use (including those existing and those which are likely to come up during contract execution).

ii) Diameter, wall thickness, pressure, soil cover, and coating scheme used, type of cathodic protection system provided, if any, and year of laying/ commissioning in case of foreign pipelines.

Details of the existing cathodic protection systems protecting the services i.e. type of protection system, location (distance from the proposed pipeline), type, rating of anode beds, test station locations and their connection schemes. Present output current and voltage readings of the CP power supply units.

iii) Remedial measures existing on foreign pipelines/ services to prevent interaction.

iv) Graphical representation of existing structure/ pipe-to-soil potential records.

v) Possibility of integration/ isolation of CP systems, which may involve negotiations with owners of other services.

vi) Crossing and parallel running of electrified and non-electrified traction (along with information regarding, operating voltage, AC/DC type etc.) as well as abandoned tracks near ROU having electrical continuity with the tracks in use.

vii) Information on existing and proposed DC/AC power sources and systems using earth return path such as HVDC substations/ earthing stations, fabrication yards with electric welding etc. in the vicinity of the entire pipeline route.

viii) Crossing or parallel running of any existing or proposed 11 KV and above AC/DC overhead power lines along with details of voltage, AC/DC type etc.

ix) Voltage rating, phases, sheathing details of underground power cables running along ROU or in its vicinity.

x) Any other relevant information that may be needed in designing and implementing proper protection scheme for the proposed pipeline.

Contractor shall conduct necessary potential gradient surveys for any existing anode ground beds that may interfere with the CP system of the pipelines covered under this project.

4.3 Report

On completion of all fieldwork, a report incorporating all the results generated from surveys and details of additional data collected shall be prepared. The report shall also contain soil resistivity data and detailed interpretation of survey results, probable interference prone areas etc. to form design basis for the cathodic protection system. This report shall also include various drawings prepared in connection with the above work. The soil resistivity values shall be plotted on semi-log graph sheets.

5.0 CATHODIC PROTECTION DESIGN PARAMETERS

Unless otherwise specified in the data sheet, following parameters shall be used for design of cathodic protection system.

Where the cathodic protection system is specified for temporary protection, those parts of sacrificial anode cathodic protection system which will be integrated with the permanent CP system shall be designed based on permanent CP parameters.

5.1 Protection Current Density

i) Pipelines having Coal Tar Enamel (CTE) coating with two/ three layers of reinforcement:

Minimum Protection Current Density *	
Temporary CP (μ A/m^2)	Permanent CP for 30-Year Design Life (μ A/m^2)
40-80	500-600

ii) Pipelines having Dual Layer Fusion Bonded Epoxy (DLFBE) coating or 3-Layer Polyethylene (3LPE) coating:

Minimum Protection Current Density *	
Temporary CP (μ A/m2)	Permanent CP for 30-Year Design Life (μ A/m2)
25-50	250-300

The above current density values for temporary CP system are applicable for CP system design life up to two years.

*Actual current density to be adopted shall be decided based upon soil and other environmental conditions, current drainage survey data (where included in contractor's scope), proximity of foreign pipe lines/ structures and other interference areas affecting the installation. Where considered necessary for satisfactory protection of pipeline the current density shall be suitably increased by contractor.

5.2 The pipe protection Current Density indicated in the clause 5.1 above shall be applicable where the temperature of the fluid transported by the pipeline/ the surface temperature of the buried portion of the pipeline does not exceed 30 °C. Where this temperature exceeds 30 °C, the protection Current Density shall be increased in minimum by 25% for every 10 °C rise in temperature over 30 °C.

For all pipeline sections which are having intermediate HDD (Horizontal Directional Drilling) crossings, Current measurement test station shall be provided at both end of HDD section for 500 meter and above length for measurement of pipeline current. PSP reading and coating conductance test to be done using temporary arrangement by applying DC current from reliable source to maintain coating integrity and remedial measure if required.

5.3 Safety factor for current density : 1.3

5.4 Anode utilisation factor : 0.85 for solid anodes
: 0.6 for ribbon anodes

5.5 Pipeline natural potential : (-) 0.45V *

* Natural potential shall be considered as per actual pipe material.

5.6 Unless otherwise specified in data sheet the design life for temporary CP system shall be minimum one year till commissioning of PCP and that for permanent CP system shall be 30 years .

5.7 Unless otherwise specified in the project specification/data sheet, temporary CP for the pipeline may not be provided along the ROU where soil resistivity is higher than 150 Ohm-m for whole year

6.0 CATHODIC PROTECTION DESIGN CRITERIA

Cathodic protection system shall be designed to meet the following criteria using sacrificial anode (TCP) by galvanic system:

6.1 The pipe to soil potential measurements shall be between (-) 0.95 V (ON) and (-) 1.5 V (ON) for polyethylene coated pipe lines, between (-) 0.95 V (ON) and (-) 1.7 V (ON) for fusion bonded epoxy/ coal tar coated pipe lines with respect to a copper/copper sulphate reference electrode. At saline soil Ag/ AgCl reference electrode shall be used and not $Cu/CuSO_4$ electrode.

Where polarisation coupons are provided along the pipeline the coupon to soil potential measurements shall be between (-) 0.9 V (OFF) and (-) 1.18V (OFF) with respect to a copper/ copper sulphate reference electrode.

6.2 A positive potential swing of 50 milli volts or more shall be considered sufficient to indicate the presence of an interaction/ interference situation requiring investigation and incorporation of mitigation measures by the Contractor.

7.0 SYSTEM DETAILS

The system shall include the following major equipment/sub-systems unless otherwise specified in project specifications.

- Sacrificial anodes and anode ground beds
- CP system at cased crossings
- Test stations
- Polarisation coupons
- Surge diverter and DC Decoupling device
- Permanent reference cells
- Interconnecting cables
- Cables to pipe connections

All equipment shall be new and procured from approved manufacturers. Equipment offered shall be field proven. Equipment requiring specialised maintenance or operation shall be avoided as far as possible. Prototype equipment shall not be accepted.

Equipments shall conform to the relevant specifications enclosed with the tender document. All equipment including test stations, etc. shall be located in safe non-hazardous areas.

Where it is essential to install electrical and electronic instrument enclosures and its accessories in hazardous area, such equipment shall be flame proof type and shall meet the requirements as per IS/ IEC: 60079 and shall be weather proof to IP-65 also as per IS/ IEC:60529.

A copy of approval from local statutory authority, as applicable such as Petroleum & Explosives Safety Organization (PESO)/ Chief Controller of Explosives (CCE), Nagpur or Director General of Mines Safety (DGMS) in India, for the electronic instruments installed in electrically hazardous area along with:

i) Test certificate from recognized test house like Central Institute of Mining and Fuel Research (CIMFR)/ Electronics Regional Testing Laboratory (ERTL) etc. for flameproof enclosure/ intrinsic safety, as specified in the data sheet, as per relevant standard for all Indian manufactured equipments or for items requiring Director General of Mines Safety (DGMS) approval.

ii) Certificate of conformity from agencies like Laboratorie Central Des Industries Electriques (LCIE), British Approval Service for Electrical Equipment in Flammable Atmospheres (BASEEFA), Factory Mutual (FM), Physikalisch-Technische Bundesanstalt (PTB), Canadian Standards Association (CSA), Underwriters Laboratories (UL) etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

7.1 Anode Ground Beds

Along ROU, where soil resistivity is within 10 Ohm-m and pH value is within 9, either Zinc anodes or Magnesium anodes shall be provided.

In case of Zinc anodes, anode of type I as per ASTM B418 standard shall be used for seawater, brackish water having resistivity not exceeding 10 Ohm-m and for grounding/ earthing of pipelines anode of type II as per ASTM B418 standard shall be applicable.

7.1.1 Along ROU, where soil resistivity exceeds 10 Ohm-m, Magnesium anodes shall be provided.

7.1.2 Anodes shall be installed along the pipeline at suitable intervals as per pipeline protection voltage attenuation calculations and ground bed resistance/current output of anode installations. At high resistivity area the Magnesium ribbon anodes shall be installed all along the pipeline by the side of the pipeline in the pipeline trench.

7.1.3 Suitability for proper operation of the selected type of sacrificial anodes for the soil conditions with particular attention to carbonates, bicarbonates, phosphates and nitrates shall be checked by the contractor. The anodes shall be laid in proper type of back fill, such that the effect of soil is minimum on the anode performance and life. Suitable safe guards against anode passivation in prevailing soil shall be taken care by the contractor.

7.1.4 Each electrically continuous section of pipeline shall be protected completely by single type of anode to avoid inter-anode circulation currents.

7.1.5 The anodes shall be installed at sufficient depth to reach moist soil and shall be separated from the pipeline by at least 5 m and 2 m for Magnesium and Zinc anodes respectively. The Magnesium ribbon anode shall be separated from the pipeline by at least half a meter. The anode connections to pipeline shall be routed through test stations.

7.1.6 For sacrificial anode ground bed which is intended for permanent CP system and/or which is to be integrated with permanent CP system, the leads of all the anodes shall be brought up to the test station and shall be terminated individually.

7.1.7 The number of anodes at each ground bed shall be sufficient for providing the specified pipe protection current density taking into consideration the ground bed resistance, cable resistance etc. For permanent cathodic protection system, contractor shall prepare a table for number of anodes required at different soil resistivity to produce the specified protection current for the

specified designed life. For temporary cathodic protection system, an indicative design data for sacrificial anodes ground bed in tabular form is given in data sheet. The number of anodes at each anode ground bed, spacing of anode ground beds based on the applicable soil resistivity, size of pipeline, type of coating for the pipeline shall be chosen from the table after necessary verification by the CP contractor.

For temporary protection of pipelines, Magnesium anodes shall be installed at 1 Km interval along the pipeline. At each location suitable number of anodes shall be installed in parallel, so as to achieve the desired current output for the given soil resistivity and pipeline protection current density or coating resistivity. Minimum separation of the nearest anode from the pipeline shall be 5 m. The group of anodes at each location shall be laid in a single row perpendicular to the pipeline. Each anode shall be of minimum 14.5 Kg. net weight (excluding backfill). Anode cable from each anode shall be terminated inside the test station. Individual cable ends at the test station shall be linked through a Copper bus bar. Above 150 Ohm-m soil resistivity, the installation of sacrificial anodes may not be required for temporary protection of the pipeline unless otherwise specified in the project specification/ data sheet.

7.1.8 For the portion of the pipeline for which the CP system has been specified based on the permanent CP system parameters, the contractor shall ascertain the requirement of the cathodic protection current density indicated in clause 5.1 above. Where specified in the project specification/ data sheet the requisite current requirement/ drainage survey shall be conducted by the contractor to establish the adequacy of CP current requirement and number of anode ground beds.

7.2 Test Stations

7.2.1 Test stations shall be provided along the pipeline ROU for monitoring the performance of the cathodic protection system at the following locations. Test stations shall be provided at additional locations, if required, so that distance between any two adjacent test stations does not exceed 1000 meters in inhabited areas and 2000 meters in uninhabited areas like forest/ deserts:

a) At the locations of anode ground beds.

b) At both sides of metalled road crossings where cased crossing is considered for the crossing. At one side of the road crossing where casing pipe is not considered for the crossing. In case more than one such uncased road crossing occurs within 1Km, then only one such uncased road crossing shall be provided with test station within 1Km.

c) At all insulating joints.

d) At vulnerable locations with drastic changes in soil resistivity.

e) At locations of reference cells, surge diverters, polarisation coupons, pipeline grounding through DC Decoupling device s, Zinc and Magnesium anodes.

f) At railway line crossings and at selected locations along railway lines running parallel to the pipeline.

g) At both sides of major river crossings.

h) At EHV/HV cable crossings or along routes where EHV/HV cables are running in parallel.

i) At EHV/HV, AC/DC overhead line crossings and along routes where EHV/HV overhead line are running in parallel.

j) In the vicinity of DC networks or grounding systems and HVDC grounding systems where interference problems are suspected.

k) At crossings of other pipelines/ structures.

l) Locations where interference is expected.

m) At locations of Sectionalising Valve (SV) stations.

n) At any other locations considered necessary by Owner/ Owner's representative.

7.2.2 Test stations used for sacrificial anodes shall have shunt for measurement of anode current, provision for resistance insertion to limit the anode current output and anode-disconnecting link.

7.2.3 Test stations for bonding shall be provided with a link and shunt, resistor as a means to monitor and control current flow between the pipeline and foreign pipelines or structures that may exist in common ROU.

7.2.4 Unless otherwise specified in the project specification/ data sheet, Test station with current measuring facility shall be provided at interference prone areas, on both sides of major river crossings, and minimum one for every 10 km max. along the pipeline and at SV, IP, RT, DT locations where CP Stations shall be considered.

7.2.5 The test stations shall be installed with the face of the test station facing the pipeline. The nameplate of test stations shall carry the following minimum information:

- Chainage in km.
- Test station connection scheme
- Distance from pipeline in metres.
- Direction of product flow.

7.2.6 Terminals and different schemes of wiring shall be provided as per the test station connection scheme. Minimum twenty percent spare terminals shall be provided in each test station.

7.2.7 Minimum two cables shall be provided from the pipeline at any test station.

7.2.8 The location of all the test stations shall be marked with their connection schemes and other relevant information on alignment sheets. A detailed test-station schedule shall be prepared.

7.3 Polarization Coupons

7.3.1 Unless otherwise specified in the project specification/ data sheet steel coupons of pipeline material shall be provided along the pipeline to monitor the adequacy of the CP system to polarize/ protect coating holidays. Coupon shall be installed at permanent CP station drainage points, predicted cathodic protection mid points along the pipeline, at locations where the pipeline is bonded to foreign pipeline/ structures, interference prone areas, marshy areas, At every 10 km approximate along the pipe line etc.

7.3.2 Coupons shall be installed at bottom 1/3rd portion of the pipeline and 200 mm approx away from the pipe surface.

7.3.3 The coupons shall be constructed from the pipeline material and shall have one side uncoated surface area of 10 mm x 10 mm exposed to soil. Two cables one for connection to pipeline for coupon protection and other for coupon potential measurement shall be provided for each coupon. The coupon protection cable shall be connected through magnetic reed switch inside the test station to enable measurement of coupon 'OFF' potential.

7.3.4 A permanent reference electrode shall be installed adjacent to the coupon in a manner so as to measure the representative potential of the coupon.

7.3.5 Magnets for operation of reed switch shall be provided as specified in the project specification/data sheet.

7.3.6 Polarization coupons with Magnetic Reed switch shall be installed at every test station in the parallel section and at crossings for monitoring the representative polarized Pipe to Soil Potentials.

7.4 Permanent Reference Cells

7.4.1 High purity copper-copper sulphate permanent reference cells with proven high reliability shall be provided for stable coupon to soil potential measurement at the locations of polarisation coupons.

7.4.2 The reference cells shall be of Silver/ Silver Chloride type in place of Copper/ Copper Sulphate cells, at locations where chloride ion concentration is more than 200 ppm.

7.4.3 The life of reference cells shall be minimum 10 years under burial conditions.

7.4.4 The test station connection scheme inside the test station shall clearly indicate the type of reference cell (Cu $CuSO_4$/Ag AgCl).

7.5 Surge Diverter

7.5.1 Explosion proof solid state surge diverter shall be connected across each insulating joint to protect it from high voltage surges.

7.5.2 The total system including surge diverters, cables, cable termination, etc shall be suitable for the anticipated fault current at the location of installation. There shall not be any joint in the cable in between Surge Diverter and Insulating Joint Cleat. Length of Surge Diverter cable shall be as per Manufacturer Standard. Surge Diverter with pre wired specific length based on pipeline diameter to ensure energy coordination with IJ, to be confirmed by OEM .

7.5.3 The surge diverter shall be suitable for the design life of permanent CP system.

7.6 DC Decoupling Device

7.6.1 Wherever the pipeline is either crossing or running in parallel with overhead EHV/HV transmission lines of voltage grade 66 kV and above, it is mandatory that the pipeline shall be grounded to discharge any accumulated potential/ surge that may appear in case of transmission line faults, as per below:

7.6.2 The pipeline shall be grounded through DC Decoupling device with Zinc galvanic anodes of either block anode or ribbon type. Copper wire with coke back filled and inhibitor shall be used for grounding purpose at locations where chloride ion concentration is more than 200 ppm. Sizing and quantity of anode shall be decided so as to achieve maximum total earth resistance of 1 Ohm for each location where pipeline crosses EHV/ HV transmission lines.

The pipeline shall be grounded at regular intervals of maximum 1km where EHV/HV transmission lines run parallel within 25m of the pipeline. Also, where EHV/HV transmission lines run parallel beyond 25 m of the pipeline and it is expected from software simulations that surge would appear in case of transmission line faults or any abnormal operating conditions.

7.6.3 Locations along pipeline where continuous induced over-voltage due to overhead transmission lines/ underground cables is expected or observed by software simulations or observed during commissioning, the pipeline shall be grounded through DC Decoupling device to the earth system of the transmission tower causing the voltage induction or to a separate earthing system of Zinc anodes/ Copper wire through Solid State type DC Decoupling device.

7.6.4 The solid state type DC Decoupling device shall be installed inside test station.

7.6.5 Areas where soil resistivity is higher than 50 Ohm-m Zinc ribbon anodes installed in carbonaceous backfill instead of 20kg net pre-packed Zinc solid anodes may be provided for grounding or Copper wire filled with coke breeze and inhibitor.

7.6.6 The total system including cable, cable termination, DC Decoupling device s and anodes shall be suitable for the anticipated fault current at the location of its installation.

7.6.7 The DC Decoupling device and anode system shall be suitable for the design life of permanent CP system. The grounding system shall have minimum resistance to earth to restrict the pipeline voltage as per NACE/ BSEN criteria but shall not exceed 1Ohms.

7.6.8 The anodes shall be pre packed with special backfill adequately so that the performance of the anode is not affected by the carbonates, bicarbonates, nitrates, etc, present in the soil. In any case, the thickness of back fill shall not be less than 50mm on all the sides of the anode.

7.7 Motor operated valves where located on the cathodically protected portion of the pipeline shall be grounded by a Zinc or Magnesium anode of 20 kg net where the type of anode provided for the CP system of the pipeline is Zinc or Magnesium respectively. Alternatively DC Decoupler to be installed in the valve earth circuit to block the DC current drain to earthing. The MOV power supply cable armour shall be insulated (by cutting and taping with insulation tape) at MOV end to avoid armour carrying CP current.

7.8 The above ground cathodically unprotected pipeline at intermediate SV stations, pigging stations, etc. and terminals shall be earthed with GI earth electrodes. The resistance to earth of grounding shall be limited to 1 Ohms max.

7.9 CP at Cased Crossing

7.9.1 At cased crossings where casing will have coating on its external surface, it shall be protected by sacrificial anode installations provided at both ends of casing. The anode installation shall be sized based on the permanent CP design parameters and design life of permanent CP system.

For protection of the carrier pipe inside casing pipe having external or internal coated, Petroleum Jelly / Vapour Corrosion Inhibitor (VCI) to be filled at the annular space between casing and carrier. The casing filler shall be a specially formulated Petroleum wax-based / Visco-elastic based compound or specially formulated VCI which is pumped in the annulus space as per required volume calculation and shall be supplied with associated filler materials (as applicable) and end seals.

A trained team shall be engaged for filling up the annulus space as per manufacturer standard procedure for application of Petroleum Jelly or VCI.

In case of VCI application, Electrical Resistance corrosion rate monitoring probes should be utilized to monitor the effectiveness of the corrosion inhibitor and identify any need for replenishment of the inhibitor. The casing vents should be capped with devices that control and significantly limit the exchange of air inside the casing system.

7.10 Reference Cell Access Points

Reference cell access points shall be provided over the pipe near insulating joint locations and at SV stations, where the ground is paved, for measurement of pipe to soil potentials. A perforated PVC pipe filled with native soil and buried at the location shall be provided for the purpose. The length of the PVC pipe shall be adequate to reach the native soil below the paving.

7.11 Cables

7.11.1 Cables shall be with annealed high conductivity, stranded copper conductor, HMWPE insulated, 650/ 1100V grade, armoured, HMWPE sheathed. The size of the copper conductor shall be 6 sq mm for anode tail cable from anode to buried junction box, 10 sq.mm. from buried junction box to test station and 10 sq.mm. from test station to pipeline. The size of cable for bonding, DC Decoupling device, grounding anodes and surge diverter connections shall be suitable for the maximum fault current subject to minimum 25 sq.mm. The length of anode tail cable shall be sufficient for routing from anode to buried junction box or test station for anodes for temporary CP or permanent CP respectively.

7.11.2 The cables for reference cells, pipeline potential measurements and polarisation coupon potential measurements shall be of 4 sq.mm copper conductor, HMWPE insulated, Aluminium backed by Mylar/ polyester tape shielded, HMWPE sheathed, armoured, HMWPE overall sheathed type.

8.0 INSTALLATION

8.1 Cable Laying

8.1.1 Cables shall be laid in accordance with the layout drawings to be prepared by the contractor. No straight through joint shall be permitted. Cable route shall be carefully measured and cables cut to required length. Minimum half metre cable slack shall be provided near anodes, pipeline and test stations to account for any settling.

8.1.2 All cables inside station/ plant area shall be laid at a depth of 0.75 M. Cables outside station/ plant area shall be laid at a depth of minimum 1.5 m. Cables shall be laid in sand under brick cover and back filled with normal soil. For cables laid outside the station/plant area, polyethylene warning mats shall placed at a depth of 0.9 m from the finished grade, to mark the route. Inside plant area cable routes shall be marked by means of cable markers located at maximum intervals of 30M and at locations of changes in direction of cable route.

8.1.3 In case of above ground cable, all unarmoured cables shall be laid in GI conduits of sufficiently large size, up to accessible height for protecting against the mechanical damage.

8.1.4 All underground unarmoured cables including anode tail cables shall run through PE sleeves. The cables routed along the pipeline shall be carried at the top of the carrier pipe by securely strapping it at intervals with adhesive tape or equivalent as required.

8.1.5 PVC pipes of proper size shall be provided for all underground cables for road crossings.

8.1.6 Cables shall be neatly arranged in trenches in such a manner that crisscrossing is avoided and final take-off to equipment is facilitated.

8.1.7 The cables for reference cells and pipeline potential measurement shall be routed in a separate trench other than the trench provided for the rest of the CP system cables, AC/DC power supply cables for CPTR units/ CPPSM etc.

8.1.8 The armour of all the cables from pipeline to test station (potential measurement, current measurement, reference cell cables, cathode cables, bonding cables, grounding cables, etc) and test station to ground bed (anode cable) shall be earthed only at test station end of the cable to avoid armour carrying CP current. The armour of the bonding cables between test stations shall be earthed at any one end of the cable only. The cable armour shall be insulated by cutting and taping with insulation tape.

8.2 Permanent Reference Cells

The permanent reference cells shall be installed with special backfill material and as per the recommendations of the cell manufacturer. Installations in highly acidic/ alkaline soil and soil contaminated by hydrocarbons shall be avoided.

8.3 Cable to Pipe Connections

All cable connections of other than cathode drainage cables to the new pipeline shall be made by an approved exothermic process or by pin brazing. However, cable connection to charged pipelines shall be made by pin brazing. Approved exothermic welding may be adopted for pipelines carrying water. Coating shall be repaired after connection of cable conductor to pipeline. The coating repair material shall be compatible with the original coating and shall prevent ingress of water along the cable surface and at the interface of coating repair with the original pipe coating.

8.4 Ground Bed Fencing

Where specified in project specifications/ data sheet chain link fencing shall be provided around the location of each ground bed designed based on the temporary CP design parameters.

9.0 FIELD TESTING AND COMMISSIONING

9.1 System Testing at Site

9.1.1 Field tests as per the reviewed field testing and commissioning procedures prepared by the Contractor shall be carried out on the equipment/ systems before these are put into service. Acceptance of the complete installation shall be contingent upon inspection and test results.

9.1.2 Before the CP system facilities are put into operation, necessary tests shall be carried out to establish that all equipment, devices, wiring and connection have been correctly installed, connected and are in good working condition as required for the intended operation. Owner/ Owner's representative may witness all tests. Intimation shall be given at least one week before commencing the tests.

9.1.3 All tools, equipment and instruments required for testing shall be provided by Contractor.

9.1.4 Generally, the following minimum tests shall be carried out and recorded.

a) Visual Inspection : Comparison with drawings, specifications, detailed physical inspection.

b) Testing : Simulation tests of equipment to determine its operational fitness.

i) Cables

- Cable No.
- Voltage grade.
- Conductor cross section.
- Continuity check.
- Voltage test.
- Insulation resistance values between each core & earth, between cores. All cables shall be tested by 500 V megger.

ii) Insulating Joint

- Location.
- Pipe to soil potential of both protected and non-protected sides of the insulating joint before and after energisation of CP system.

iii) Surge Diverter

- Location/identification number.
- Rating
- Type
- Explosion proof enclosure.
- Check for healthiness.
- Check for proper connection.

iv) DC Decoupling device

- Location/ Identification number.
- Type.
- Ratings.
- Check for wiring.
- Check standby current drain after CP system energisation.
- Details of grounding provided for the DC Decoupling device.

v) Polarisation Coupon

- Location/ Identification number.
- Exposed area/ size of coupon.
- Depth and distance from pipeline of coupon
- Type of reference cell
- Distance of reference cell from coupon
- Magnetic reed switch rating
- Operation of magnetic reed switch with magnet
- Check for wiring.
- Coupon On and OFF potentials.

vi) Reference Cell

- Location
- Type of cell
- Depth and distance from pipeline of reference cell
- Potential reading

vii) Anode Ground Bed

- Location/ Station
- Horizontal/ Vertical
- Check for actual layout and compliance with drawings.
- Current output of ground bed.
- Current output of each anode (in case of permanent CP anode ground beds)

9.2 Commissioning

9.2.1 Natural pipe to soil potential for the complete pipeline and casing pipelines at the locations of cased crossings shall be measured at all the test station locations and recorded prior to connecting anodes to pipe line and casing pipelines.

9.2.2 The anodes shall be connected to pipeline in the test station and the pipe to soil potential observation shall be made after allowing sufficient time for polarisation. The current output of each anode at permanent CP anode ground bed or the total current output of anode bed at temporary CP anode ground bed shall also be measured to ensure that it does not exceed the output current capacity of the anodes. In case the anode output current exceeds the rated capacity, it shall be controlled by insertion of resistance element in the anode circuit inside test station and the pipe to soil potential shall be rechecked for adequacy of protection. At locations of polarisation coupons the coupon 'OFF' potential shall be measured by switching off the reed switch. Additional anodes shall be provided where required to achieve desired level of protection and to keep the anode output current within the rated value. In case pipe to soil potential exceeds the specified value, suitable resistance shall be inserted in the anode circuit to limit the potential.

9.2.3 Anode installation shall become individually operational as above.

9.2.4 At the locations of cased crossings where anode installations are provided for the protection of the casing pipe, these anode installations shall be commissioned as per the procedure detailed in clause 9.2.2 above.

9.2.5 After connecting all the anode ground beds to the pipe line, measurement of pipe to soil potentials shall be taken at each of the test stations to ensure conformity to protection criteria.

9.2.6 In case of insufficient protection as per the CP design criteria, on any portion of the pipeline/ pipeline at cased crossings where casing is cathodically protected, Contractor shall carry out necessary additions/ modifications to the provided protection in consultation with the Owner/ Owner's representative.

9.2.7 Healthiness of the insulating joints provided on the pipeline shall be checked by measuring the pipe to soil potentials on both protected and non protected sides of the IJs.

9.3 Inspection, Testing And Acceptance

9.3.1 During fabrication, the equipment shall be subjected to inspection by EIL / Owner or by an agency authorised by the Owner, if specified / agreed in Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector (as applicable) . All routine / acceptance tests shall be carried out at manufacturer's works under his care and expense.

9.3.2 Type test certificates from CIMFR or equivalent test house, applicable PESO/ DGMS approval certificates, BIS license and original drawings referred in type test certificates (as applicable) shall be shown to the inspection agency on demand during inspection. The certificates must be valid at the time of dispatch.

9.3.3 Test certificates of bought out components (as applicable) shall be shown to the inspection agency on demand during inspection.

10.0 INTERFERENCE MITIGATION

10.1 Investigations shall be made for stray current electrolysis of the pipeline, mutual interference between the pipeline and foreign pipelines/ structures, interference on foreign pipelines/ structures due to the CP of the pipeline and ground bed, AC induction on pipeline due to 11 KV and above overhead HV/ EHV line, interference due to high voltage DC line, HVDC groundings, electric traction, DC mining, DC welding operations, impressed current anode ground beds on other pipelines, etc.

10.2 Where transmission lines cross the pipeline or run in parallel within 25m from the pipeline, AC voltage measurements shall also be made on the pipeline to find out continuous induction of voltage as well as AC current density on cathodically pipeline. In case of induced voltage being beyond safe limits, the pipeline shall be grounded in line with clause no.7.6 above. Where transmission lines run in parallel more than 25m from the pipeline, however, continuous induced AC of voltage beyond safe limits are noticed on the pipeline the same shall be mitigated by grounding the pipeline in line with clause no.7.6 above. To protect from AC corrosion , necessary mitigation shall be done if AC current density is more than the safe limit.

10.3 Measurements including pipe/ structure to soil potential and pipeline/ structure current etc. on the pipeline/ structure being CP protected and on foreign pipelines/ structures shall be made to investigate the current discharge and pickup locations. In case of fluctuating stray current, investigations shall be made continuously over a period of time and if required simultaneously at different locations to find out the stray current source(s). For measurements over longer durations, recorders shall be used.

10.4 Where foreign pipelines (unprotected or protected by independent CP system) run in parallel to the pipeline in same trench or very near to the pipeline, and are not bonded to the pipeline then investigation shall be made for current discharge points on both the pipelines.

10.5 Mitigation measures shall be provided depending on type of stray current electrolysis/ interference. These shall include installation of bond with variable resistor, diodes, installation of galvanic anodes for auxiliary drainage of current, adjustment/ relocation (if possible) of offending interference source, provision of electrical shield etc. depending on the type of interference.

10.6 Bonding with foreign pipeline/ structure, as a mitigation measure shall be provided where the owner of the foreign pipeline/ structure have no objection, otherwise alternative mitigation measure shall be provided. Where bonding is provided for mitigation, the bonding resistor shall be adjusted for optimum value for minimum/ no interference. Galvanic anodes installed as a mitigation measure shall be sized for the design life specified for permanent CP system.

11.0 SYSTEM MONITORING

Where the CP system provided is temporary, the CP system shall be monitored at all test stations once in a month for healthiness/ adequacy of protection till commissioning of permanent CP system or for design life of temporary CP system specified, whichever is less. During this period if any deficiency/ interference in protection system is noticed, the same shall be rectified/ augmented by providing additional anodes as required. The monitoring report shall be submitted regularly to owner for his review/ information.

12.0 CLOSE INTERVAL POTENTIAL LOGGING SURVEY

Where specified in project specification/ data sheet, contractor shall carry out a close interval potential survey over the entire length of pipeline by computerised potential logging method with GPS Synchronize (including Trailing Wire method/ Others like cell to cell for river crossing, Nallah or any other watery location as applicable) and identify the under protected/ over protected area, any major coating damage on the pipeline, after the back-filling has been consolidated sufficiently and CP system has stabilized. However, in some particular areas wherever GPS system is not available due unforeseen reason, Survey shall be performed in Minimum/ Maximum Mode. Contractor shall provide required mitigation measures and rectify the under/ overprotected zones, identify if any, the major pipeline coating defects required to be repaired. During the survey the reference cell shall be calibrated minimum once in 24 hours.

Where specified in the project specification/ data sheet, additional tests for detailed identification of coating defects by physically verification of the coating defects, CAT "A" frame (minimum 50 meter interval) with GPS Data logging & DCVG survey with GPS Synchronize and identify the chainage locations of coating defects / holidays shall be conducted by the contractor. Repairing of the coating defect/ holidays shall be done by the pipeline contractor.

मानक विनिर्देशन

सिविल संरचना

STANDARD SPECIFICATION
CIVIL - STRUCTURAL

एकमुश्त टर्न-की कार्य

(एल.एस.टी.के. कार्य)

LUMP-SUM TURN-KEY WORKS
(L. S. T. K. WORKS)

सामान्य आवश्यकताएँ

GENERAL REQUIREMENTS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
1	04 07 2019	REVISED AND ISSUED AS SPECIFICATION	AVM	AJS	RS	RKT
0	30 08 2013	ISSUED AS SPECIFICATION	GV	AS / RS	PKM	DM

Abbreviations:

AFC	: Approved for Construction
BIS	: Bureau of Indian Standards
DCI	: Document Control Index
EDB	: Engineering Design Basis
EIL	: Engineers India Limited
GAD	: General Arrangement Drawing
LOI	: Letter of Intent
LSTK	: Lump-sum Turn-key
MTO	: Material Take-off
PC	: Personal Computer
RCC	: Reinforced Cement Concrete
VDMS	: Vendor Document Management System
VDR	: Vendor Document Requirement

Structural Standards Committee:

Convenor: Mr. Rajanji Srivastava

Members:
Mr. Anurag Sinha
Mr. VK Panwar
Mr. Samir Das
Mr. Amitabh Kishore
Mr. Gyasuddin
Mr. Charanjeet Singh (Projects)
Mr. Ravindra Kumar (Construction)

CONTENTS

1.0 GENERAL

1.1 The design considerations given hereunder establish the minimum basic requirements for civil-structural works for LSTK contracts.

This standard specification shall be read in conjunction with the Engineering Design Basis document (EDB) issued for the Job and Standard Specification No. 6-68-0022 for Material & Construction requirements.

All structures shall be designed for satisfactory performance and functions for which the same are to be constructed.

a) Whenever any reference to BIS/ other code is made, the same shall be taken as the latest revision (with all amendments issued there to) on the notified date of submission of tender.

b) Apart from the codes mentioned in particular in the EDB document, all other relevant codes related to the specific job under consideration and/ or referred to in the above-mentioned codes, shall be followed wherever applicable. Reference to some of the codes does not limit or restrict the scope of applicability of other relevant codes.

c) In case of any variation/ contradiction between the provisions of BIS codes and the requirements given in EDB document, the provisions given in EDB document shall have precedence over all others. In absence of relevant BIS codes, reference to corresponding British or American codes may be made (in that order of preference).

All designs, detailing and construction shall strictly conform to the standards, specifications and 'specific requirements' enclosed with the tender. Only if relevant information is not available in these documents, reference to relevant BIS code shall be made.

1.2 A Document Control Index [DCI, i.e. detailed list of drawings/ documents, including specifications, standards, design philosophy (foundation & superstructure), general notes, design calculations, design drawings, Bulk Material Take-off (Bulk MTO), bar bending schedules (for RCC works) and fabrication drawings (for structural steel works)] indicating the document/ drawing category (review or record as applicable) together with the scheduled and actual date of submission of the documents, shall be submitted by the Contractor through the Vendor Document Management System (VDMS) and kept updated at all times in the DCIM for review by Owner/ owner's representative.

1.3 The Bulk MTO document containing Cement, Re-bars (*diameter-wise*) and Structural Steel (*section-wise*) shall be submitted within 45 days from the date of receipt of LOI. The same shall be updated at 50% & 90% stages of the engineering.

1.4 Structure-wise quantity statements (showing anticipated, released and balance quantities of concrete, structural steel and piles) shall be submitted by the Contractor and kept updated at all times in the Vendor Document Management System (VDMS) for review by Owner/ owner's representative. The DCI shall also indicate the document/ drawing category (review or record as applicable) together with the scheduled and actual date of submission of the documents.

1.5 Vendor Document Management System (VDMS) is a web application that lets suppliers/ contractors manage their Document Control Index (DCI) through an interface, submit their documents for review/ record and get the reviewed/ approved documents/ drawings.

2.0 DESIGN & DOCUMENT REVIEW

2.1 Before proceeding with design and drawing preparation, the Contractor shall submit detailed philosophy of design of various parts of (all) the structures and foundations (including equipment foundations) along with explanatory sketches for review by Owner/ owner's representative. Only after the approval (including review and incorporation of comments as offered during the review) of the design philosophy, the Contractor shall submit any design document and/ or drawing for review or record or issue the same for construction.

2.2 The Contractor shall carry out the structural design of all structures and prepare complete set of civil and structural approved for construction (AFC) drawings needed for correct and accurate construction. The design/ drawing shall be strictly in accordance with the approved design philosophy prepared for the structure (including "Design Criteria" given in the EDB) and architectural/ structural general arrangement and shall incorporate all the comments/ suggestions given by Owner/ owner's representative without any extra cost to the Owner and without any implication on the time-schedule for completion of works.

2.3 Design and detailing of the structures and foundations shall fulfill all functional requirements for which the same is intended and it shall be ensured that adequate accesses, clearances, clearing of interferences, provision of cutouts, etc. have been provided to make the structure/ foundation fully operational.

2.4 Construction of units/ structures identified for design/ drawing review (as referred in Vendor Document Requirement (VDR) attached in the bid document or DCI) by Owner/ owner's representative shall not be taken up at the site till these documents are reviewed by Owner/ owner's representative and comments/ suggestions given by Owner/ owner's representative are incorporated along with submission of compliance sheet indicating incorporation of all comments. For all other foundations and structures the Contractor shall directly submit the AFC drawings to Engineer-in-Charge and construction of such works shall be taken up immediately. Design and drawings for such foundations/ structures shall also be simultaneously submitted in VDMS for Owner/ owner's representative's record. In the event Owner/ owner's representative offers any comment on documents/ drawings of record category, it shall be ensured by the Contractor that these comments are duly incorporated in the documents/ drawings and revised set of document/ drawing is issued to site for construction and simultaneously submitted in VDMS for Owner/ owner's representative's record.

2.5 Submission of typical review category documents shall be taken up prior to corresponding record category documents. Owner/ Owner's representative comments on typical review category documents shall be duly taken care in all relevant record category documents as well before issuing them for construction and simultaneously submitted in VDMS for Owner/ owner's representative's record.

Wherever review is carried out the same shall be restricted to following:

a) Conformance of general arrangement of the structure to approved design philosophy and design basis.
b) Overall framing of the building/ conceptual foundation system.
c) Detailed design and drawings including input/ output of computer analysis and design vis-a-vis actual drawing.

Irrespective of the identified structures requiring review, the Contractor shall submit complete set of design and drawings of all structure/ foundation systems.

2.6 To facilitate an overall systematic review, the Contractor shall ensure the following:

a) Structural design/ drawings for any structure/ foundation are submitted for review only if referenced input (e.g. architectural drawing, equipment layout, piping general arrangement drawing (GAD), equipment data sheet, vendor drawing, etc.) have been reviewed by the concerned Owner's specialist in approval/ review Code-2 or Code-1 and are available in the VDMS on or before the date of submission of structural design/ drawings.

b) Complete set of design and drawings of each independent building/ structure are submitted simultaneously

c) Relevant checklist(s) duly filled-up, signed (by the approver of civil-structural design/ drawing) & stamped, shall accompany each deliverable of civil-structural document/ drawing submitted by the contractor. The checklist(s) are to be used as a guide while performing the related activities. The same are attached as annexure. All points listed therein are mandatory check point. Other points/ observations/ comments may be added based on need and judicious discretion depending on the importance of activity/ deliverables.

d) Soft copy of files created as input for computer analysis/ design are also part of the respective design documents.

e) All re-submissions are accompanied with a compliance statement (a document stating point-wise compliance to all comments by Owner/ owner's representative on previous submission)

2.7 In case the referenced input (e.g. geotechnical recommendations, architectural drawing, equipment layout, piping general arrangement drawing (GAD), equipment data sheet, vendor drawing, etc.) as applicable, reviewed by the concerned Owner's specialist in approval/ review Code-2 or Code-1 are not available in the VDMS on or before the date of submission of structural design/ drawings for any structure/ foundation, the date of submission of structural design/ drawings shall deemed to be considered as the date of submission of approved reference drawing.

2.8 To ensure accuracy, correctness and completeness of documents before submission to Owner/ owner's representative, the Contractor shall ensure that all such submitted designs and drawings are complete in all respects, thoroughly checked, stamped APPROVED FOR CONSTRUCTION, and signed APPROVED by the Contractor's own responsible civil/ structural graduate (minimum) engineer (irrespective of the fact that the same are prepared in the Contractor's own design office or by an approved agency/ sub-contractor).

Incomplete, unchecked, unsigned and unstamped design documents/ drawings shall not be reviewed/ accepted for construction and shall be deemed to be considered as void/ withdrawn.

2.9 The accuracy/ correctness of all designs and drawings shall be the sole responsibility of the Contractor and any delay/ loss/ damage to the Owner in respect of any mistake/ discrepancy/ anomaly in such designs and drawings shall be entirely borne by the Contractor.

2.10 Owner/ owner's representative reserves the right to review any/ all or none of the designs and drawings. Review by Owner/ owner's representative shall not relieve the Contractor of his responsibility for correct design and execution of the works.

2.11 Revision of any design/ drawing/ detailing shall not be permitted unless the same is necessitated due to comments on review of such documents by Owner/ owner's representative. Such revisions shall be restricted to incorporation of these comments only and no new details shall be added in the drawings unless called for by comments during review. All revised portion shall be clearly marked and clouded on the respective drawing for easy

identification. Subsequent review of such revised documents, if required shall be limited to revision as clouded.

2.12 All fabrication/ erection drawings and bar bending schedules shall be prepared by the Contractor and shall be directly issued through VDMS for construction to the work. Such drawings together with design calculations for all splices, joints and gusset plates shall simultaneously be reviewed by Owner/ owner's representative at site (Resident Construction Manager). The Owner/ owner's representative at site at his discretion may review all or some or none of these designs & drawings.

Wherever such review is carried out the same shall be restricted to the following:

a) Structural layouts, orientation, elevation of structural members.
b) Section/ size of members.
c) Adequacy of few critical connections and joints for their required strength.

2.13 For analysis and design of structures, latest version of internationally accepted commercial software viz. STAAD.PRO or equivalent are permitted.

In case software packages (commercially available or in-house developed) other than above are intended to be used for analysis and design, the same shall be informed in writing to Owner/ owner's representative. A validation report consisting of calculations and relevant computer files containing input and detailed output (also refer clause 2.14) shall be submitted by the Contractor through VDMS. Only after getting written approval from Owner/ owner's representative, to this effect, such intended software be put to use for detailed analysis and design.

2.14 The following minimum documentation shall be submitted through VDMS for computer aided analysis and design as a part of structural analysis & design document:

a) Complete input and output files in native format.
b) Relevant sketches of structure geometry with node and member numbering, loading, bending moment, shear force, deflected shape diagrams, etc.
c) Summary of member end forces, support reactions, stress ratio, deflections, etc.

2.15 Contractor shall depute the concerned Civil-Structural design engineer to the review office of Owner/ owner's representative as and when required for review of contractor's documents. During such reviews involving computer aided analysis/ design/ drafting of structures, the contractor shall make his own arrangement of Personal Computer (PC) in the form of Lap-top in the premises of review office of Owner/ owner's representative. This is required to expeditiously resolve all the comments including those involving the use of PC by contractor in his submission. The contractor shall ensure that these PC's are fully operational along with necessary software already loaded including the input/ output/ drawing files of the structures being reviewed. The contractor shall revise and re-submit the analysis/ design and drawings as required during review, through VDMS.

Reviewing of designs/ drawings is not obligatory on the part of Owner/ owner's representative and complete correctness/ soundness of the designs/ drawings and their execution at the site shall be the sole responsibility of the Contractor irrespective of the fact whether the same has been reviewed by Owner/ owner's representative or not. Any defect observed during construction or till the defect liability period of works' shall be rectified and removed by the Contractor. The Contractor shall carry out whatever modification or reconstruction is needed for the purpose, to the entire satisfaction of the Engineer-in-Charge/ Owner without any extra cost and/ or time implication to the Owner.

Filled-up, signed (by the approver of civil-structural design/ drawing) & stamped checklist shall accompany each submission of civil-structural document/ drawing by the contractor:

Project:		Job No.:	
Document No.:		Rev. No.:	
Document Title:			

Sl. No.	PMC Requirement	Contractor's Response	Remarks
1.	The submission is as per submission schedule as per approved DCI.	□ Yes	
2.	The submission is as per submission sequence as per approved DCI.	□ Yes	
3.	Basic documents prepared by the contractor (e.g. design philosophy, specifications, standards, general notes, etc.) are already approved.	□ Yes	
4.	Bulk MTO has been submitted.	□ Yes	
5.	All the referenced input (e.g. geotechnical recommendations, architectural drawing, equipment layout, piping general arrangement drawing (GAD), equipment data sheet, vendor drawing, etc.) as applicable have been reviewed by the concerned Owner's specialist in approval/ review Code-2 or Code-1 and are available in the DCIM on or before the date of submission of structural design/ drawings.	□ Yes	
6.	The design calculations being submitted herewith are complete in all respects, thoroughly checked and confirm to approved engineering design basis, relevant approved input documents and applicable codes & standards, stamped APPROVED FOR CONSTRUCTION, and signed APPROVED by the Contractor's own responsible civil/ structural graduate (minimum) engineer (irrespective of the fact that the same are prepared in the Contractor's own design office or by an approved agency/ sub-contractor).	□ Yes	
7.	The drawings being submitted herewith are complete in all respects, thoroughly checked and confirm to approved design calculations, approved general arrangement, stamped APPROVED FOR CONSTRUCTION, and signed APPROVED by the Contractor's own responsible civil/ structural graduate (minimum) engineer (irrespective of the fact that the same are prepared in the Contractor's own design office or by an approved agency/ sub-contractor).	□ Yes	
8.	The documents/ drawing being submitted are complete with respect to the whole structure.	□ Yes	
9.	In case this submission is for drawings only, the related analysis & design have already been submitted.	□ Yes	
10.	Structure-wise quantity statements (showing anticipated, released and balance quantities of concrete, structural steel and piles) are updated & submitted.	□ Yes	
11.	In case this submission is of record category document/ drawing, similar review category documents/ drawings have already been submitted.	□ Yes	

Sl. No.	PMC Requirement	Contractor's Response	Remarks
13.	In case this submission is of record category document/ drawing, the submitted document/ drawing incorporates comments on the similar review category document/ drawing.	□ Yes	
14.	The accuracy/ correctness of all designs and drawings shall be the sole responsibility of the Contractor and any delay/ loss/ damage to the Owner in respect of any mistake/ discrepancy/ anomaly in such designs and drawings shall be entirely borne by the Contractor. Review by Owner/ owner's representative shall not relieve the Contractor of his responsibility for correct design and execution of the works	□ Yes	

Date: Name & Signature

Note:

Contractor to check & confirm that the submission meets the above requirements of PMC and categorically tick ☑ mark in the "☐ Yes" response.

Filled-up, signed & stamped compliance sheet shall accompany each re-submission of civil-structural document/ drawing by the contractor:

Document No. :

Rev. No.:

Date of Submission:

Date of Review:

Review Code: □ 1 □ 2 □ 3 □ R □ V

Sl. No.	Reference Clause	PMC Comments	Contractor's Response
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			

Review Code Legend:

Code 1 : No comments.

Code 2 : Proceed with manufacture/ fabrication as per commented document. Revised document required.

Code 3 : Document does not confirm to basic requirement as marked. Resubmit for review.

R : Retained for Records.

V : Void.

Project:		Job No.:	
Document No.:		Rev. No.:	
Document Title:			

SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
1	Founding level/ depth of foundation with respect to HPP/ FGL/ NGL/ EGL/ FFL (strike out whichever is not applicable).	
2	Requirement & Level of plinth/ tie beams.	
3	Type, Shape & Dimensions of footing.	
4	Adequacy of loading for foundation.	
5	Correctness of the design forces as per analysis.	
6	Selection of critical loading cases/ combinations.	
7	Long/ short column effect for pedestal.	
8	Size of pedestal: a) type of anchor bolts b) bolt spacing (with respect to clearance between the bolts) c) edge distance of anchor bolts d) depth of embedment of anchor bolts	
9	Location co-ordinates & Orientation with respect to North direction.	
10	Conformance to Geotechnical recommendations: a) check for SBC at founding depth (w.r.t. settlement/ shear) b) consideration of ground water table. c) check for FOS against overturning, sliding d) increase in SBC (limited to 25% for wind or seismic/ 100% for blast) e) spacing of piles (within group & inter-group) f) pile cut-off level g) load check conforming to pile capacity h) increase in pile capacities (limited to 50% for vertical & 25% for lateral for wind/ seismic/ 50% for blast)	
11	Projection of foundation outside battery limit is co-ordinated with Civil Department for under-ground piping, etc.	
12	Ductile detailing requirements for reinforcement, wherever applicable.	
13	Internal co-ordination with all concerned departments.	

Date: Name & Signature

Legend :

✓ : Check carried out and found OK

✓ NA : Check carried out and found not applicable

Project:		Job No.:	
Document No.:		Rev. No.:	
Document Title:			

SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
1	Approved (at least review code 2) inputs available.	
2	Complete loading data: a) reference line of machine, base frame dimensions and suction side & discharge side (for pumps) b) size of block/ deck, pedestal above HPP c) static/dynamic loads (or dynamic load factor) & their location of application (as per vendor) d) permissible limiting values of vibration parameters e) pocket dimensions, locations f) grout type & thickness g) whether anti-vibration pads are provided	
3	Founding level/ depth of foundation w.r.t. HPP/ FGL/ NGL/ EGL/ FFL	
4	Value of C_u & net SBC from soil recommendations. For pile foundations, the pile stiffness value.	
5	Amplitude of vibration and resonance check in required modes.	
6	No fouling with adjacent foundation as per equipment layout.	
7	Check for limiting size of element(s).	
8	Check for critical speed, whether the machine is variable speed or fixed speed? If variable speed motor is used, whether amplitude has been checked considering the machine speed same as the natural frequency of the foundation system.	
9	Minimum reinforcement requirement as per IS:2974.	
10	Specified number of construction joints & their details.	
11	Note for single pour.	
12	Internal co-ordination with all concerned departments.	

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SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
1	Design method (cracked or un-cracked) to be identified for each element.	
2	Check for stability & uplift as per respective structure/ pit/ tank w.r.t. water table at various stages of construction.	
3	Requirement of minimum thickness & reinforcement.	
4	Reinforcement provided on both faces (for slab & walls).	
5	Treatment to be given on surfaces in contact with earth.	
6	Anti-corrosive treatment for structures storing corrosive liquids.	
7	Requirement of joints, water stops, puddle flanges, giving notes for execution sequences.	
8	Internal co-ordination with all concerned departments.	

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SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
1.0	**Availability of Inputs**	
1.1	Approved Architecture drawings of building	
1.2	Approved Plot Plan	
1.3	Approved related Area Drawings	
1.4	Contour plan	
1.5	Approved Geotechnical Recommendation	
1.6	Approved Electrical Drawings for Substation Building	
1.7	Approved Instrumentation Drawings for Control Room Building	
1.8	Vendor Inputs for: a) Air Conditioning Equipments b) Transformers etc. c) Lift	
2.0	**Correctness of Inputs**	
2.1	With respect to Architecture Drawings: a) Framing arrangement. b) Level & Location: i) Co-ordinate of building ii) Finished Ground Level iii) Finished Floor Level iv) Approach Road Level c) Brickwork arrangement i) Length/ height of brickwork. ii) Stability check for brickwork with Steel frame. iii) Flushing of Brickwork with frame structure. iv) Brick supporting arrangement for Rain water Pipe encasing. d) Requirement of expansion joints as per codal provisions. e) Arrangement & levels of false flooring & false ceiling. f) Clear height of floors. g) Cross-checking of elevations at FFLs of Ground Floor, Upper Floors, Roof etc., w.r.t. FGL, Approach Road Level. h) Monorail location & extent of monorail beam for Substation building.	
2.2	With respect to Mechanical Drawings: a) Lift Pit Size and loading available in Approved Mechanical/ Vendor Drawing. b) Machine Room Details available in Approved Mechanical/ Vendor Drawing. c) Cut-out details for duct in AC Plant room/ AHU rooms in Approved Mechanical/ Vendor Drawing. d) Details of pedestals for AC Plant/ AHU in Approved Mechanical/ Vendor drawing. e) Monorail location & Capacity as per Approved Mechanical drawing.	

SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
2.3	With respect to Electrical Drawings: a) Transformer details. b) LT-HT Switch gear panel location. c) Cable trench layout.	
2.4	With respect to Instrumentation Drawings: a) Panel resting arrangements. b) Cable tray details. c) Pipe sleeves details. d) MCT location. e) Cable tray in superstructure. f) Cable trench layout.	
2.5	With respect to General Civil Area Drawings: a) Co-ordinates of building b) Orientation of building with respect to North direction. c) Approach Road level/ Finished Ground Level. d) Contour for NGL from Plot Plan. e) Fouling with existing/ proposed facilities from Area/ Foundation drawing. f) Underground facilities from Area Drawing.	
2.6	With respect to Geotechnical Recommendation: a) Type of foundation (Shallow or Pile). b) Depth of foundation. c) Net Allowable SBC for foundation from Geotechnical Report. d) Pile Capacity from Geotechnical Report. e) Diameter of Pile & Spacing of Piles from Geotechnical Report. f) Specification of Piling. g) Drawing of Pile.	
3.0	**Design Aspects**	
3.1	Structure is analysed as 3D Framed Structure.	
3.2	Uses of Codes as per approved EDB: a) For Concrete (IS:456/ IS:13920) b) For Steel (IS:800)	
3.3	Grade of Material as per approved EDB: a) Concrete b) Reinforcement c) Structural Steel	
3.4	Covers as per approved EDB: a) Foundation b) Column c) Beam d) Slab e) Wall	
3.5	Checking of Minimum thickness as per approved EDB: a) Foundation b) Column c) Beam d) Slab e) Wall	
3.6	**Loadings**	

SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
3.6.1	Dead Load: a) Self weight b) Slab load c) Brick load d) Gutter/ Parapet load	
3.6.2	Live/ Imposed load as per approved EDB for panels, ducts, cables etc. on floor, roof canopy, passage, lobby & stair case: a) Office Building b) Administrative building c) Substation building d) Control room	
3.6.3	Seismic Load as per approved EDB: a) Method of Seismic Analysis (Seismic Coefficient/ Response Spectra). b) Importance factor (Mention Value). c) Response reduction factor accordingly consideration of ductile detailing (Mention Value). d) Damping factor (Mention Value). e) Type of soil. f) Type of structure. g) Time period for frame structure as per IS:1893.	
3.6.4	Wind load for Shed type Building a) Basic Wind Speed (Mention Value). b) Probability Factor (k_1) (Mention Value). c) Terrain, Height, Structure Size Factor (k_2) (Mention Value). d) Topography Factor (k_3) (Mention Value).	
3.6.5	Blast load for Control Room shall be as per RRA report (Mention Blast Pressure).	
3.6.6	Load combination shall be as per approved EDB:	
3.7	Design of concrete member of building shall be as per IS:456/ IS:13920.	
3.8	Ductile detailing requirements for Reinforcement, wherever applicable.	
3.9	Slenderness check for design of columns.	
3.10	Crack width of beam/ slab.	
3.11	Deflection of slab/ staircase.	
3.12	**Foundation design.**	
3.12.1	Fouling of under-ground cable trench with foundations/ plinth beams etc.	
3.12.2	Alignment of plinth beams with brick walls.	
3.12.3	Factor of safety against overturning & Sliding as per approved EDB.	
3.12.4	Checking of SBC/ pile capacity as per approved Geotechnical Recommendation.	
3.12.5	Maximum allowable settlement of soil as per approved EDB	
3.12.6	Checking of modified pressure calculation in case of tension occurred.	
3.12.7	Increase in stress shall be as per Geotechnical Recommendation.	
3.12.8	Minimum percentage of reinforcement as per approved EDB	
3.12.9	Minimum spacing of reinforcement bar as per approved EDB.	
4.0	Internal coordination with other departments.	

SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
5.0	MTO for super structure & Substructure a) Area of building b) Concrete in foundation c) Concrete in superstructure d) Reinforcement in foundation e) Reinforcement in superstructure f) Reinforcement per Cu. M. of Concrete for foundation g) Reinforcement per Cu. M. of Concrete for superstructure	

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SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
A	**SUB-STRUCTURE**	
1	Refer separate checklist for foundation.	
2	Check fouling with machine/equipment foundation.	
B	**SUPER-STRUCTURE**	
1	Check the clear gap for isolation of rotating machine foundation.	
2	Requirement of roof monitor, extent of side cladding & height of parapet wall.	
3	Identification of braced bay & maintenance bay.	
4	Whether provision of extension of shed by one bay considered (for future).	
5	Live loads & superimposed loads at various locations, including crane loading & centerline distance between rails	
6	Check the critical load combination for design.	
7	Check the horizontal (transverse & longitudinal) deflections.	
8	Check flooring details conforming to likely superimposed load.	
9	Compatibility between pedestal level & anchor bolts with base plate details.	
10	Check whether correct limiting values of slenderness ratios for structural elements (columns, beams, bracings, etc.) used in design.	
11	Check whether correct effective lengths of structural elements (columns, beams, bracings, etc.) used in design.	
12	Check whether minimum 90% mass participation achieved (in both horizontal directions) for calculating seismic forces.	
13	Check over-all compliance to approved Architectural drawings.	
14	Internal co-ordination with all concerned departments.	

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SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
A	**SUB-STRUCTURE**	
1	Refer separate checklist for foundation.	
2	Check fouling with equipment foundation.	
B	**SUPER-STRUCTURE**	
1	Material of construction as per engineering design basis of the project and departmental guidelines.	
2	Check the application of equipment load (correction, magnitude & location).	
3	Live load/ superimposed load considered for respective level/ floor, air-coolers, fire proofing load, etc. where applicable.	
4	Whether loading due to one extra floor considered (for future expansion).	
5	Check the estimation of seismic/ wind force to be applied at respective level/ floor.	
6	Check whether critical design forces from various likely load combinations have been considered for the design of structural element/ foundation.	
7	Identify critical areas where limiting beam sizes need to be provided for avoiding any fouling.	
8	Location of braced bay, co-ordinated with Piping. Bracing angle is within 30° & 60°. Plan bracing considered.	
9	Check the horizontal (transverse & longitudinal) deflections.	
10	Check the capacity of overhead mono-rails & its location with extent (in & outside plan dimensions) w.r.t. the respective equipment.	
11	Verify whether all vertical & horizontal piping loads have been correctly & completely taken care.	
12	Equipment supporting arrangement - check fouling with bottom nozzle or hood.	
13	Arrangement of intermediate/ secondary beams to clear opening requirements.	
14	Inter-connection with pipe rack.	
15	Compatibility between pedestal level & anchor bolts with base plate details.	
16	Joint details: a) reference standard no. is furnished b) details for connections not available in standard are furnished	
17	Compatibility between member sizes in General Arrangement & Reinforcement Details (in drawing).	
18	Whether integrated analysis done with equipment/ piping.	
19	Check whether correct limiting values of slenderness ratios for structural elements (columns, beams, bracings, etc.) used in design.	
20	Check whether correct effective lengths of structural elements (columns, beams, bracings, etc.) used in design.	
21	Check whether minimum 90% mass participation achieved (in both horizontal directions) for calculating seismic forces.	

SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
22	Check requirement of ductile detailing for reinforcement (for concrete elements).	
23	Summation of applied forces matched with reactions.	
24	Internal co-ordination with all concerned departments.	

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SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
A	**FOUNDATION**	
1	Refer separate checklist for foundation.	
B	**SUPER-STRUCTURE**	
1	Layout and configuration of pipe rack conforming to piping inputs/ approved equipment layout.	
2	Levels of pipe rack/ tiers conforming to piping inputs/ approved equipment layout.	
3	Whether load due to one extra tier considered (for future expansion) to be confirmed by Piping/ PMC.	
4	Location of expansion joints and braced bays coordinated with Piping department.	
5	Material of construction as per engineering design basis of the project, including fire-proofing requirements.	
6	Check the loading considered given by piping conforming to the requirement of design basis, including for fire proofing where applicable.	
7	Check consideration of friction/ anchor/ guide loads as per design basis and as forwarded by piping.	
8	Check the layout & loading of Air-coolers including supports required for inlet & outlet piping.	
9	Check the routing of electrical cable trays & instrument duct to be supported on the pipe rack and their respective loading as per design basis.	
10	Check the horizontal & vertical clearances at road/ railway crossings.	
11	Location and arrangement of vertical & horizontal bracing fulfilling design requirements and confirmed by piping	
12	Check whether additional load due to extra length of pipes have been considered or not at the location where pipes are rising or getting dropped.	
13	Check the level at top of grout w.r.t. actual profile of ground levels for off-site pipe rack.	
14	Local design checks at junction locations	
15	Whether any two-phase flow lines are there? If yes, have these been taken care as per the Design basis.	
16	Compatibility between pedestal level & anchor bolts with base plate details.	
17	Joint details: a) reference standard no. is furnished b) details for connections not available in standard are furnished	
18	Compatibility between member sizes in General Arrangement & Reinforcement Details (in drawing).	
19	Transverse beams are designed for horizontal bending.	
20	Tray support members are provided as per electrical guidelines.	
21	Battery Limit platform & approach for the same.	
22	Bracing angle is within 30° & 60°.	
23	Inter-connection with technological structures.	

SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
24	Fouling of vertical bracing with anchor bolt in pedestal (in drawing).	
25	Check whether correct limiting values of slenderness ratios for structural elements (columns, beams, bracings, etc.) used in design.	
26	Check whether correct effective lengths of structural elements (columns, beams, bracings, etc.) used in design.	
27	Check whether minimum 90% mass participation achieved (in both horizontal directions) for calculating seismic forces.	
28	Check requirement of ductile detailing for reinforcement (for concrete elements).	
29	Internal co-ordination with all concerned departments.	

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SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
A	**SUB-STRUCTURE**	
1	Refer separate checklist for foundation.	
B	**SUPER-STRUCTURE**	
1	Check wind & seismic parameters considered.	
2	Check estimation of wind forces.	
3	Check estimation of seismic loads.	
4	Check structural configuration and bracing system (vertical & horizontal).	
5	Check analysis corresponding to critical wind/ seismic direction.	
6	Check whether correct limiting values of slenderness ratios for structural elements (columns, beams, bracings, etc.) used in design.	
7	Check whether correct effective lengths of structural elements (columns, beams, bracings, etc.) used in design.	
8	Check whether critical maximum design forces have been considered from various load combinations for the design of respective elements.	
9	Check for permissible horizontal (transverse & longitudinal) deflections.	
10	Internal co-ordination with all concerned departments.	

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A	**SUB-STRUCTURE**	
1	Refer separate checklist for foundation.	
B	**SUPER-STRUCTURE**	
1	Check the system stability & dynamic analysis as per design basis/Job specification.	
2	Check the correctness in estimation of wind pressure corresponding to right shape factor for exposed members.	
3	Check the lateral load transfer from gallery to top of trestle.	
4	Check the supporting arrangement of gallery for keeping proper provision for expansion, check limiting vertical deflection.	
5	The analysis & design shall conform to the erection scheme being adopted.	
6	Internal co-ordination with all concerned departments.	

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SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
1	Check equality of bottom pressure below ring wall and intermediate compacted soil mass.	
2	Check the detailing/ arrangement of ring wall w.r.t. anchor bolts and clean out drain, requirement of minimum edge clearance for Anchor Bolt.	
3	Check the thickness, size, shape and spacing of piers with protective coating/ lining for tanks storing corrosive liquid.	
4	Check the special requirements/ consideration (size, solid concrete slab below bottom plate, anchorage, counter weights etc.) for storage tanks storing liquids at high pressure and/ or high/ low temperature.	
5	Location co-ordinates & Orientation w.r.t. North direction.	
6	Internal co-ordination with all concerned departments.	

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SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
1	Design loads as per approved data sheet.	
2	Check the input files for: a) depth of foundation b) depth of water table c) wind/ seismic load as per Design Basis d) support details as per data sheet	
3	Check the out-put file for: a) SBC conforming to Geo-Tech Recommendations b) FOS against overturning c) size restriction for likely fouling	
4	Internal co-ordination with all concerned departments.	

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SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
1	Loading as per approved data sheet of equipment	
2	Additional load due to supported ducts/ lining	
3	Check for SBC at founding level and FOS against overturning	
4	Size limitations if any to avoid fouling	
5	Internal co-ordination with all concerned departments.	

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SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
1	**GENERAL**	
a	Drawing number is as per approved DCI	
b	Electronic file number is as per approved DCI	
c	Draughting is as per design requirements	
d	North line/ orientation as per input data	
e	Notes comply with Job Specifications and General Notes	
f	Field notes for specific instructions/ scope of work defined	
g	Layout of grids and spacing/ dimensions/ equipment location, support, orientation etc. as per input data	
h	Referenced Drawings specified	
i	Referenced Standards specified	
j	If not adequately clear in General Notes, grade of concrete and grade of reinforcement bars specified	
k	Bill of materials furnished (for the detailed portion)	
l	Necessary internal co-ordination done with relevant departments as per requirements	
m	Resolution/ incorporation of comments received	
2	**FOUNDATIONS**	
a	Coordinates/ location is as per input data, suction side & discharge side (for pump foundations) as per layout drawing	
b	Referenced level and elevations specified are as per approved General Civil/ Architectural drawings/ Piping GAD (viz. NGL/ FGL/ HPP)	
c	Elevation/ depth of foundation bottom furnished	
d	Fouling with surrounding foundations/ services cleared	
e	Any extra cover for rebar required and specified	
f	Any extra minimum cement content required and specified	
g	Thickness, projection and grade of lean concrete specified	
h	Anchor bolt location and orientation specified	
i	Adequacy of foundation depth checked to accommodate anchor bolt assemblies	
j	Anchor bolt description (as per standard) specified	
k	Depth of pockets specified	
l	Minimum cover on anchor bolts/ pockets checked	
m	Fouling between anchor bolt assembly and pedestal rebar checked	
n	Grout thickness specified	
o	Reinforcement provided as per design/ codal requirements	

SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
p	Links and ties detailed	
q	Dowel lengths for column rebars staggered and specified	
r	Depth of machine foundations with respect to building foundations checked	
s	Separation detail for machine foundations and pouring sequence given	
t	Requirement of water bars at construction joints for liquid retaining structures furnished	
u	Requirement of protective painting	
v	Field note for sequence of construction, if adjoining foundations are at different level	
w	For pump foundations, following field note shall compulsorily be added in foundation drawings: "The pump discharge nozzle is facing towards North/East/West/South". (appropriate direction shall be selected as per layout drawing, in case discharge is upwards, direction of suction nozzle shall be specified)	
3	**SUPER STRUCTURE Reinforced Cement Concrete**	
a	Layout is as per approved Piping GAD/ Architectural drawings	
b	Requirement of expansion/ separation joints checked	
c	Anchor bolt location and orientation specified	
d	Anchor bolt description (as per standard) specified	
e	Pockets for bolts located/oriented and specified	
f	Depth of pockets/ length of bolts in RCC members checked	
g	Minimum cover on anchor bolts/ pockets checked	
h	Fouling between anchor bolt assembly and rebar checked	
i	Grout thickness specified	
j	Reinforcement provided as per design/ codal requirements	
k	Cut-outs as per requirement provided with edge protection	
l	Slope has been provided over RCC roof	
m	Curb around all openings	
n	Insert plates & pipe sleeves provided wherever required	
o	Extra reinforcement around cut-outs & openings	
p	Dowel bars for lap length & anchorage length	
q	Nominal links in column, stirrups for beams & their arrangement	
4	**SUPER STRUCTURE Structural steel**	
a	Layout is as per approved Piping GAD/ input drawings	
b	Requirement of expansion/ separation joints checked	
c	Bolting details for equipments specified	
d	Member sizing and connection details furnished	
e	Grating/ chequered plate requirements with supporting members furnished	
f	Welding requirements furnished	
g	Fire-proofing requirements furnished	

SR. NO.	CHECK/ CONTROL POINTS	Tick Mark as per Legend
h	Requirement of removable floor/ handrails checked	
i	Requirement of grouting holes in base plates specified	
j	Vertical & Horizontal bracings provided as per piping clearance	
k	Splicing location has been proposed/ suggested	
l	Approach staircase/ ladder provided with proper landing at entry point	
m	Toe plate around openings	
n	Stiffness/ diaphragm plates have been suitably provided	
o	Vertical clearance below monorail beam checked	
p	Capacity of monorail specified & structurally stable cantilever projection given	
5	Drawing issued through DCIM (Document Control Index Module)	

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पाइपलाइनों की कैथोडिक सुरक्षा प्रणाली के उपकरण व मेटिरियल के लिए विनिर्देश

SPECIFICATION FOR EQUIPMENT / MATERIAL FOR CATHODIC PROTECTION SYSTEM FOR PIPELINES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
1	30.10 19	REVISED AND ISSUED AS STANDARD SPECIFICATION	PTR	NSB	SA	RKT
0	17 07 14	ISSUED AS STANDARD SPECIFICATION (OLD DOC NO 6-51-0029, REV 1)	NSB	RC	PPL	SC

Abbreviations:

AC	:	Alternating Current
ASTM	:	American Society for Testing and Materials
BIS	:	Bureau of Indian Standards
BS	:	British Standards
CMRI	:	Central Mining Research Institute
CP	:	Cathodic Protection
CPPSM	:	Cathodic Protection Power Supply Module
CPTR	:	Cathodic Protection Transformer Rectifier
DC	:	Direct Current
DNV	:	Det Norske Veritas
EN	:	European standards
HMWPE	:	High Molecular Weight Polyethylene
HV	:	High Voltage
IS	:	Indian Standards
KEMA	:	Keuring van Elektrotechnische Materialen te Arnhem
MMO	:	Mixed Metallic Oxide
MOV	:	Motor Operated Valves
NACE	:	National Association of Corrosion Engineers
PE	:	Polyethylene
PVC	:	Polyvinyl Chloride
ROU	:	Right of Use

Electrical Standards Committee

Convenor: Ms. S Anand

Members: Mr. Parag Gupta
Mr. K Sahu
Ms.ANP Singh
Ms. Nivedita S Bhattacharyya
Mr. Amrit Dey
Mr. Raj Kishore (Projects)
Mr. Rajesh Sinha (Inspection)

CONTENTS

1.0 SCOPE

This specification covers the requirements for the design, manufacture, supply and testing of various equipment and materials for Cathodic Protection System for underground pipelines/ structures.

These equipment and materials shall broadly include:

- Sacrificial Anodes
- Test Stations
- Anodes for impressed current CP system
- Anode junction boxes
- Cathode junction boxes
- Permanent reference cells
- DC Decoupling device and surge diverters
- Polarisation coupons
- Cables

Requirement of cathodic protection TR units (CPTR unit) and cathodic protection power supply modules (CPPSM) are covered in separate specifications.

2.0 CODES AND STANDARDS

2.1 All equipment and material covered in this specification shall conform to the requirements of the latest revision of following standards:

NACE Standard SP0169	:	Control of External Corrosion on Underground or Submerged Metallic Piping Systems
ASTM B843	:	Magnesium Alloy Anodes for Cathodic Protection
ASTM A518 M	:	Corrosion Resistant High Silicon Iron Castings ASTM B418 Cast and Wrought Galvanic Zinc Anodes
ASTM B861	:	Specification for Seamless and Welded Titanium and Titanium Alloy Tubes
NACE Standard SP-0200	:	Steel-Cased Pipeline Practices
NACE Standard SP0572	:	Design, Installation, Operation and Maintenance of Impressed Current Deep Ground beds .
NACE Publication No. 54276	:	Cathodic Protection Monitoring for Buried Pipelines.
BS EN 15280	:	Evaluation of AC corrosion likelihood of buried pipelines.
BS EN 50162	:	Protection Against Corrosion by Stray Current from DC Systems
ISO 15589	:	Petroleum and natural gas industries, Cathodic Protection of Pipelines transportation System
IS 8062	:	Code of Practice for Cathodic Protection of Buried Pipeline/ Structure for Transportation of Natural Gas, Oil and Liquids
IS1554, Part I	:	PVC Insulated (Heavy Duty) Electric Cables: For Working Voltages up to and Including 1100V
IS 3043	:	Code of Practice for Earthing

IS/ IEC: 60079	:	Electrical Apparatus for Explosive Gas Atmosphere
IS/ IEC: 60529	:	Classification of Degree of Protection Provided by Enclosures
EN/IEC 62561-3	:	Lightning protection system components - Requirement of isolating spark gap
IS/ IEC 62305	:	Protection against Lightning
OISD 141	:	Design, Construction And Inspection Requirements For Cross Country Liquid Hydrocarbon Pipelines
OISD 214	:	Cross Country LPG pipelines
PNGRB GSR INFRA/ T4S S.R. 612(E), G.S.R. 808 (E)	:	Petroleum And Natural Gas Regulatory Board

2.2 In case of imported equipments standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case of any contradiction between various referred standards/ specifications/ data sheet and statutory regulations the most stringent requirement shall govern and decision of owner in this regards shall be final.

3.0 SITE CONDITIONS

The equipment and materials shall be suitable for installation in locations having generally corrosive, warm and humid or dusty atmosphere. Service conditions shall be as specified in the project specification/ data sheet. If not specifically mentioned therein, a design ambient temperature 45^0C and an altitude not exceeding 1000 M above mean sea level shall be considered.

4.0 EQUIPMENT/ MATERIAL SPECIFICATIONS

All equipments/ materials shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

Make and construction of all equipments/ materials shall be subject to approval by Owner/ Owner's representative.

4.1 Sacrificial Anodes

4.1.1 Magnesium Anode

The anode shall conform to the requirements of ASTM B843 standard. The anode shall be of high manganese, Magnesium alloy packed with special back fill. The metallurgical composition, potential and capacity of anode shall be as below:

i) Composition

Element	Weight
Manganese	0.15 - 0.7%
Copper	0.02% max.
Silicon	0.1% max.

	Zinc	2.5% - 3.5%
	Aluminium	5.3% - 6.7%
	Iron	0.003% max.
	Nickel	0.002% max.
	Calcium	-
	Other metallic elements (Total)	0.3% max
	Magnesium	Balance
ii)	Anode open circuit Potential ($Cu/CuSO_4$ Reference)	1.55 volts
iii)	Anode Capacity	1050 - 1200 AH/Kg.

4.1.2 **Zinc Anode**

The anode shall conform to the requirements of ASTM B418 standard. The metallurgical composition of anode, potential and capacity of anodes shall be as below. Anode of type I shall be used for seawater, brackish water having resistivity not exceeding 1 Ohm-m and for grounding/ earthing of pipelines. Anode of type II shall be used for ribbon anodes for protection of carrier pipes for application in saline soil having resistivity less than 10 Ohm-m. The anode (other than ribbon anode) shall be packaged with special backfill.

i) Composition:

Element	**Weight** (Type I)	**Weight** (Type II)
Aluminium	0.1% to 0.5%	0.005% max.
Cadmium	0.025-0.07%	0.003% max.
Copper	0.005% max.	0.002% max.
Iron	0.005% max.	0.0014% max.
Lead	0.006% max.	0.003% max.
Others (Total)	0.1% max.	-
Zinc	Remainder	Remainder

ii)	Anode open circuit Potential ($Cu/CuSO_4$ Reference)	-1.1 volts	-1.1 volts
iii)	Anode Capacity	790 - 810 AH/Kg.	790 - 810 AH/Kg.

4.1.3 The anodes shall be provided with cable tail of sufficient length to reach test station/ buried junction box, as applicable without any intermediate joint in the cable and with minimum of 0.5m cable slack provided at each anode and test station ends.

4.1.4 The anodes for grounding/ earthing or for saline soil application shall be pre packed with special backfill adequately so that the performance of the anode is not affected by the carbonates, bicarbonates, nitrates, etc, present in the soil. In any case, the thickness of back fill shall not be less than 50mm on all the sides of the anode or minimum 20 Kg. net, whichever is higher.

4.1.5 The other details of anodes shall be as shown in the applicable EIL standard drawings.

4.1.6 The anodes for grounding of cathodically protected above ground pipelines at intermediate SV stations, pigging stations etc., grounding of motor operated valves on cathodically protected portion of the pipeline, grounding of pipeline through DC Decoupling device at EHV/HV line crossings or running in parallel etc., shall be either of block anode or ribbon type. Sizing and quantity of anode shall be decided so as to achieve maximum total earth resistance of 5 Ohm

for each location. The anode and cable terminations shall be suitable for the anticipated fault current at the location of installation.

4.1.7 Special Backfill

The composition of special back fill for anodes shall be as below:

-	Gypsum (Commercial Purity)	:	75%
-	Bentonite (Commercial Purity)	:	20%
-	Sodium Sulphate (Commercial Purity)	:	5%

4.2 Test Stations

Test stations shall be provided along the pipeline ROU for monitoring the performance of the cathodic protection system.

i) Test station enclosure shall be made of sheet steel of at least 3 mm thickness and shall be suitable for GI pipe post mounting. Test stations shall have weather proof enclosure having degree of protection IP-55 and hinged lockable shutter. The inner and outer surfaces of test stations shall be Epoxy painted.

ii) The resistors for control of current provided in the test stations, anode/ cathode junction box etc. shall be of variable, grid coil type. The resistors shall be suitable for operation over the design life for the permanent CP system specified in the project specification/ data sheet.

iii) Number of terminals and different schemes of wiring shall be as per the applicable EIL standard drawing. Minimum twenty percent spare terminals shall be provided in each test station.

iv) At locations where solid state DC Decoupling device s are provided, the test station size shall be suitable for mounting the DC Decoupling device inside the test station.

v) A nameplate of Anodised Aluminium with black back ground and white letters shall be fixed to the inner side of the test station. The nameplate shall carry the following minimum information:

- Chainage in km
- Test station connection scheme
- Distance form pipeline in metres
- Direction of product flow

vi) The constructional features of test stations shall be as per the applicable EIL standard drawings.

4.3 Anodes for Impressed Current CP System

4.3.1 High Silicon Cast Iron Anodes

i) High silicon cast iron type anodes shall be center-connected hollow type or end connected solid type. Cable to anode joint shall be reliable and long lasting for total design life of anode. Composition of anodes shall be as below and shall also conform to ASTM A518 M-86 Gr. III.

Element	Weight
Silicon	14.2 - 14.75 %

Manganese	1.5% max.
Carbon	0.7% - 1.1 %
Chromium	3.25 - 5.0 %
Copper	0.5% max.
Molybdenum	0.2% max.
Iron	Remainder

ii) Surface current density rating of the anode for continuous operation shall be 15Amp./sq.m for shallow anode ground bed and 10 Amp./sq.m for deep well anode ground beds.

iii) Anode consumption rate shall not be more than 0.2 kg./Amp-Yr

iv) The design life of anode under burial condition, at the design operating current shall be in minimum the design life of the CP system specified in the project specifications/ data sheet.

v) For shallow anode ground bed sheet steel anode canisters of adequate size shall be provided for each anode. Anode canisters shall be filled with petroleum coke breeze with following specification conforming to IS: 8502, Grade-A type.

a) Chemical Composition

-	Fixed carbon content by mass	:	99% min.
-	Ash by mass	:	0.5% max.
-	Moisture by mass	:	0.1% max.
-	Volatile matters by mass	:	0.5% max.

b)	Bulk density	:	800 kg./M^3 to 1200 kg./M^3
c)	Real density	:	2.03 kg/litre (min.)
d)	Particle size	:	1 mm max, dust free
e)	Resistivity	:	0.1 ohm cm max at 150 PSI

vi) For deep well ground beds, anodes shall be non canistered type. Calcined petroleum coke breeze slurry conforming to clause 4.3.1 v) above shall be supplied along with the anodes.

4.3.2 Mixed Metal Oxide Coated Titanium Anode

i) Mixed metal oxide coated titanium anodes shall be of pure titanium having substrate composition of titanium of ASTM B-861, Grade I, over laid with mixed oxide of noble metals (MMO coated). These anodes shall be dimensionally stable. The anodes shall be centre connected sealed tubular type. The design life of anode under burial condition, at the design operating current in minimum be the design life of the CP system specified in the project specifications/ data sheet.

Maximum allowable anode current density	:	100 A/m^2 (in coke backfill) 50 A/m^2 (soil without backfill) 100 A/m^2 (Fresh Water)
Allowable anode current density for continuous operation	:	70 A/m^2 (in coke backfill) 30 A/m^2 (soil without backfill) 70 A/m^2 (Fresh Water)

Maximum coating consumption (wear) rate at maximum anode current density	:	2 mg./A-Yr in coke backfill 6 mg./A-Yr in fresh water

The guaranteed design parameters of anode regarding current density, consumption rate, design life, rated current output, dimensions, shape, noble metal oxide coating thickness (gm./square meter), their physical and mechanical properties shall be substantiated by manufacturer's published catalogues and backed up by type test reports. Each anode shall be supplied with anode lead cable connected to it.

ii) The anodes shall be provided with sheet steel canisters and coke breeze as per clause No. 4.3.1 (v) & (vi) above.

4.3.3 Each anode shall be supplied with anode tail cable connected to it, which shall be long enough for termination on their associated anode lead junction box without intermediate joint. Anode cable tail shall be connected/ jointed to the anode and the joint insulated at the anode manufacturer's shop before despatch of anode.

4.3.4 For deep well ground beds steel pipe casing for active portion of the ground bed and non metallic pipe casing for the top inactive portion of the ground bed shall be provided. The top non metallic casing and the lower metallic pipe casing shall have threads for jointing each other. Anode supporting pipe, anode centralisers and gas venting pipes shall be provided for the ground bed.

4.4 Anode Junction Box

Depending on the size and configuration of anode ground beds, requisite main and sub anode junction boxes (where required) shall be supplied for each ground bed.

i) Each junction box shall have provision of termination of cable tails from individual anodes of the ground bed and provision of connection of anode cable coming form main anode junction box (in case of sectionalised ground bed) or from CP station power source.

ii) Junction boxes shall have sheet steel enclosure of minimum 3 mm thickness and hinged lockable shutters. Junction boxes shall be weather proof with degree of protection IP-55. It shall be epoxy painted on inside and outside surface. Junction boxes shall have anode bus of copper with nickel/ silver plated or tinned. Provision shall be made for measurement and control of individual out going circuit/ anode current by providing suitable shunt and resistors of grid coil type. Disconnecting links shall be provided for each out going/ anode circuit. 30% spare out going circuits shall be provided in each anode junction box. Terminals shall be of anti loosening type and provided with identification labels. Each outgoing circuit shall be labelled clearly to indicate the circuit/ sub anode junction box to which it is connected.

iii) The constructional features of junction boxes shall be as per the applicable EIL standard drawing enclosed with the data sheet for impressed current cathodic protection system for pipelines.

iv) A nameplate of anodised aluminium with black back ground and white letters shall be fixed to the inner side of the junction box. The nameplate shall carry the following minimum information:

- Ground bed current rating
- Ground bed resistance
- Connection scheme

- Distance form pipeline in metres
- Distance form CP station in metres

4.5 Cathode Junction Box

Where output of the CP power supply unit is connected to multiple pipelines a cathode junction box shall be supplied for providing near the pipelines at the location of connection of the negative drainage cable to the pipelines.

i) The junction box shall have a bus bar with an incoming circuit for connecting to negative of the CP power source and separate out going circuits for collection of negative drainage current from each of the pipelines.

ii) The incoming circuit shall have a current measurement shunt. Each out going circuits shall have isolation link, variable resistance of grid coil type and a current measurement shunt. One number spare outgoing circuit shall be provided.

iii) Junction box shall have sheet steel enclosure of minimum 3 mm thickness and hinged lockable shutters. Junction box shall be weatherproof with degree of protection IP-55. The
inside and outside surfaces of the junction box shall be epoxy painted. The terminals shall be of anti loosening type. Proper identification labelling shall be provided for each terminal. Each outgoing circuit label shall clearly indicate the size and identification of the pipeline to which it is connected.

iv) A nameplate of anodised aluminium with black back ground and white letters shall be fixed to the inner side of the junction box. The nameplate shall carry the following minimum information:

- Chainage in km
- Connection scheme
- Distance form the nearest pipeline in metres
- Direction of product flow

4.6 GI Earth Electrodes

For earthing of above ground cathodically unprotected pipelines at intermediate SV stations, pigging stations etc. and at terminals GI earth electrodes shall be supplied. Earth electrodes shall be 100 mm dia, 3000 mm long and 13 mm thick conforming to IS 3043.

4.7 Permanent Reference Cells

High purity Copper/ Copper Sulphate reference cells as specified in project specification/data sheets, with proven high reliability shall be supplied for providing stable pipe to soil potential measurement reference at CP stations and at locations of polarisation coupons along ROU.

Silver/ Silver Chloride type reference cells shall be supplied for marshy area/ brackish water/ saline soil locations where water table is high and chloride ion content is more than 200 ppm.

i) The reference cells shall have high accuracy and stability and maintain the same over its design life.

ii) The permanent reference cells shall have a minimum design life of 10 years under installed/ buried condition.

iii) The reference cell for high resistivity areas shall be suitable for the prevailing dry soil conditions to give maximum service life.

iv) The reference cells shall be provided with cable tail long enough for connection to test station without any joint in between.

4.8 DC Decoupling device and Surge Diverter

4.8.1 DC Decoupling Device :

DC Decoupling device shall be a solid state device as specified in project specification/ data sheets, designed to simultaneously provide isolation for DC current and low resistance path for AC current. The device shall require minimum maintenance. The solid state device shall have weather proof enclosure and shall be suitable for mounting inside a test station. Unless other wise specified in project specification/ data sheet the DC blocking voltage shall not be less than 1.2 volts. The DC leakage current at 1.2 volt shall not be more than 0.5 mA. The device shall have internal components designed to be suitable for continuously conducting maximum AC steady state current, short time AC short circuit current and lightning impulse (10/ 350µs or 4/10 and 8/20 micro sec) current expected to flow through the pipeline under the normal operating condition/ any kind of fault on the EHV/ HV line at respective sites, subject to minimum ratings as indicated in clause 4.8.3 below. The device shall be fail safe for AC fault current and/ or lighting surge current such that failure will occur in shorted mode. The device shall have testing facility (either on field testing or remote testing interface) for periodic health check up during maintenance and commissioning. The device shall be periodically tested and documented every year.

4.8.2 Surge Diverter

The surge diverter when connected in parallel across the insulating joints shall protect the insulating joint against surges coming across it due to lightening strikes, electrical faults, etc, on the above ground portion of the pipeline. The surge diverter shall be of spark gap type. The device shall have weatherproof enclosure suitable for out door mounting. The surge diverters shall be of explosion proof type for use in hazardous area. The surge diverter shall be lightning (10/350µs) impulse current tested as per EN/IEC 62561-3 from OEM lab accredited by UL / KEMA. The surge diverter shall be pre-wired with specific length as per pipeline requirement, to be confirmed by OEM. The surge diverter shall be periodically tested and documented for healthiness status every year.

4.8.3 The minimum ratings of DC Decoupling devices and surge diverters shall be as below unless otherwise specified in the project specification/ data sheet.

i) **DC Decoupling Devices :**

Type : Solid state type passive device
Steady state current (50 Hz) : min. 45A RMS (-45 °C to +65 °C)
AC Fault current : min. . 5.0 kA AC RMS Symmetrical at minimum 30 Cycle, 50 Hz
DC-blocking : min: -3V / +1V
Max. leakage current : ≤ 100 mA at 65 °C at maximum blocking voltage
AC current for 1s (50Hz) : minimum 100kA Crest
Nominal Discharge Current (8/20 µs) : 50 kA
Degree of Protection : Minimum IP 65
Approval (optional) : ATEX, IEC Ex , PESO as applicable

ii) **Surge Diverter :**

Type : Spark gap, explosion proof type
Lightning impulse current, 10/350 micro sec : 100kA
Spark over voltage, lightning Impulse (1.2/50microsec) : ≤1.3kV
Nominal current, 8/20 micro sec : 100kA
Spark overvoltage, power frequency-50Hz : 0.5kV
Rated discharge current, 50Hz : ≥100 A / 0.5 s
Rated short-duration power frequency withstand voltage (50 Hz): <250 V;
Lightning current capability tested : as per standard EN/ IEC 62561-3 from an international lab accredited by KEMA / UL
Degree of Protection : Minimum IP 65
Approval for use in hazardous area : ATEX, IEC Ex, UL, PESO.

iii) The DC Decoupling devices, surge diverters, anodes, connecting cables, cable joints, etc, shall be adequately sized and suitable for the design life of permanent CP system. The anodes shall be pre packed with special backfill adequately so that the performance of the anode is not affected by the carbonates, bicarbonates, nitrates, etc, present in the soil. In any case, the thickness of back fill shall not be less than 50mm on all the sides of the anode.

4.9 Polarisation Coupons

The Polarisation Coupons shall be made from the material of the pipeline. The coupon shall have one side exposed area of 100 mm x 100 mm unless otherwise specified in project specification/ data sheet. Cable connection of 10 mm^2 and 4 mm^2 shall be provided to the coupon for connecting it to pipeline for cathodic protection and potential measurements respectively.

Connection of coupon to pipeline shall be through a magnetic reed switch housed inside the test station. The magnetic reed switch shall be rated to carry and break minimum 50 mA at 50 V DC.

Magnet for operation of reed switches shall be provided as specified in project specification/ data sheet.

4.10 Miscellaneous Requirements

i) The sheet steel used for fabrication shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under surface shall be free from all imperfections before undertaking the finishing coat. After preparation of the under surface, final spray painting with two coats of epoxy based paint shall be done. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint etc.

ii) All unpainted steel parts shall suitably treated to prevent rust formation. Copper bus bars, interconnection copper link shall be tinned or nickel/ silver coated.

iii) Test station/ junction box cabling

Adequate space shall be provided inside the test station/junction box for termination of cables. Termination shall be performed using crimped lugs. The lugs shall be of tinned copper. Requisite cable lugs shall be supplied.

4.11 Cables

4.11.1 Cables shall be of annealed high conductivity stranded copper conductor, 650/ 1100V grade HMWPE insulated, armoured, HMWPE sheathed conforming to IS-1554 part-I, except for reference cell, potential measurement and impressed current CP anode tail cables. The size of the copper conductor of the cables shall be as below:

i) Minimum 4 mm^2 for potential measurement, reference cells, 6 mm^2 for current measurement and 25 mm^2 for bonding/ grounding.

ii) For sacrificial anode CP system the cable size shall be minimum 6 mm^2 copper for anode tail cable from anode to buried junction box and 10 mm^2 copper from buried junction box to test station in case of temporary CP anodes. In case of sacrificial anodes for permanent CP system the size of anode tail cable from anode to test station shall be minimum 6 mm^2 copper.

iii) For impressed current CP system the size of conductor of cables shall be based on the current to be carried, ground bed loop resistance and shall be minimum 35mm^2 copper for positive, negative drainage cables and 10 mm^2 copper for anode tail cables. The size of CPTR unit AC incomer cables shall be of minimum 4mm^2 copper conductor.

4.11.2 Impressed current CP anode tail cables shall be of minimum 10 mm^2, annealed high conductivity stranded copper conductor, single core, PVDF/ ECTFE insulated, unarmoured, HMWPE sheathed. The primary insulation shall be 0.04 inch thick irradiated cross-linked polyvinylidene floride (PVDF) or Ethylene Chlorotrifloroethylene (ECTFE) 1100 Volt grade. The secondary insulation shall be 0.065 inch thick HMWPE (Refer Sr. no. 3 of Table-1) sheathing jacket over the primary insulation. Refer below Table -1

Table-1

Sr no.	Insulation type	Insulation Specification*	
1.	polyvinylidene floride (PVDF) Irradiation cross linked	Tensile Break Strength	4500 PSI (min)
		Break Elongation	50%
		Flexural Strength	8600 PSI (min)
		Resistivity	$2X10^{14}$ (min)
		Dielectric Constant	8 (min) at 100Hz
2.	Ethylene Chlorotrifloroethylene (ECTFE)	Tensile Break Strength	6500 PSI (min)
		Break Elongation	100%
		Resistivity	$1X10^{15}$ (min)
		Dielectric Constant	2.5 (min) at 1MHz
3.	High Density Molecular Weight Polyethylene (HMWPE)	Color	Black
		Density	0.941 gm/cm^3
		ASTM D1248, Type 3, Class C, Category 5 or IEC 60502-1	
		Temperature rating	90°C

* Standard Test Method ASTM D638 shall be used to determine the tensile strength, Flexural Strength and Break Elongation. For the resistivity and dielectric constant tests, standard test methods ASTM D257and ASTM D150 shall be utilized.

* Contractor may suggest cables with alternative insulation/ sheathing having proven track record for impressed current anode ground bed application, for Owner's/ Consultant's approval.

4.11.3 The cables for reference cells and pipeline potential measurements shall be of 4 mm^2 copper conductor, HMWPE insulated, Aluminium backed by mylar/ polyster tape shielded, HMWPE sheathed, armoured, HMWPE over all sheathed type. The tape shield shall be helically applied with metallic side down, with either side 25% overlap and 100% coverage. The minimum shield thickness shall be 0.05 mm.

4.11.4 Cables for connecting various transducers from CPTR Unit/ CPPSM to telemetry interface junction box shall be copper conductor, HMWPE insulated, twisted pair with individual pair shielded and overall shielded with Aluminium backed by mylar/ polyster tape, HMWPE sheathed, armoured, HMWPE over all sheathed type.

4.11.5 Cable conductor sizes indicated above are minimum only and where necessary for proper operation of the CP system higher sized cables shall be provided.

4.11.6 Length of anode tail cables shall be sufficient for routing and terminating the cable inside anode junction box/ buried junction box/ test station as applicable without any intermediate joint.

5.0 EQUIPMENT FOR CLASSIFIED AREAS

All electrical and electronic instrument enclosures and its accessories for hazardous area shall be flame proof type.

The flame proof equipment shall meet the requirements as per IS/ IEC: 60079 and shall be weather proof to IP-65 also as per IS/ IEC:60529.

A copy of approval from local statutory authority, as applicable such as Petroleum & Explosives Safety Organization (PESO)/ Chief Controller of Explosives (CCE), Nagpur or Director General of Mines Safety (DGMS) in India, for the electronic instruments installed in electrically hazardous area along with:

i) Test certificate from recognized test house like Central Institute of Mining and Fuel Research (CIMFR)/ Electronics Regional Testing Laboratory (ERTL) etc. for flameproof enclosure/ intrinsic safety, as specified in the data sheet, as per relevant standard for all Indian manufactured equipments or for items requiring Director General of Mines Safety (DGMS) approval.

ii) Certificate of conformity from agencies like Laboratorie Central Des Industries Electriques (LCIE), British Approval Service for Electrical Equipment in Flammable Atmospheres (BASEEFA), Factory Mutual (FM), Physikalisch-Technische Bundesanstalt (PTB), Canadian Standards Association (CSA), Underwriters Laboratories (UL) etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

6.0 TESTS AND ACCEPTANCE

6.1 Unless other wise agreed by the Engineer-in-Charge, all the equipment/ material shall be subject to inspection by Owner/ EIL or by an agency authorised by the Owner/ EIL. All necessary information concerning the supply shall be furnished to EIL/ Owner's inspector. Two weeks notice shall be given to Owner/ EIL for witnessing the final testing.

6.2 Routine tests and final acceptance tests shall be carried out at manufacturer's works under his care and expense. Instruments and equipment required for testing shall be arranged by the manufacturer. Final acceptance shall be subject to successful testing. Type test certificates instead of conducting the tests may be accepted where specified in the project specifications.

6.3 Sacrificial Anodes

i) Inspection

a) Visual inspection shall be carried out on all the anodes regarding surface finish excessive shrinkage, cracks, cable joint to anode cone, etc.

b) Minimum 10% of number of anodes from each heat for conformity to dimensions and weight.

c) The anode surface shall be free from cracks, which may reduce the performance of the anode.

Any cracks which follow the longitudinal direction of elongated anodes shall not be acceptable.

Small cracks in the transverse direction of elongated anodes and in anodes of other shapes may be accepted provided the cracks would not cause any mechanical failure during service of the anode considering that the combination of cracks and lack of bond to the anode core is detrimental.

For transverse cracks the acceptable limits shall be furnished by the bidders along with the offer.

d) The anode shall be free from excessive shrinkage. The following limits shall be used:

Maximum 10% of the depth of anode or 50% of the depth of the anode core whichever is less. The depression may be measured for the edges of one side.

The surface of the anodes shall be free from coatings and slag/ dross inclusions etc.
The maximum deviation from straightness shall not exceed 2%.

The weight tolerance of individual anode may be taken as $\pm$ 5%. The total weight of the anodes shall not have negative tolerance.

Recommended dimensional tolerance shall be as follows:

- Length : $\pm$ 2.5%
- Width/ thickness : $\pm$ 5%

ii) One anode per heat shall be subjected to radiographic test completely to evaluate cracks, voids, slag inclusion etc.

iii) Destructive Testing

At least one anode per heat shall be subject to close inspection by destructive testing for slag inclusions, bond between the anode material and steel inserts. If the anode fails the test, two more anodes shall be tested. If the second lot of anodes also fails the test, all the anodes of the heat shall be rejected.

iv) Chemical Analysis

One anode sample per heat shall be subject to chemical analysis by spectrography. Sample shall be taken in the beginning for first heat, at the end for the second heat, at the beginning for the 3rd heat and so on.

In case the chemical compositions of the tested anode do not meet the requirements of this specification, all the anodes of the heat shall be rejected. Vendor shall indicate specific method of spectrography for each element (e.g. atomic absorption/ emission/ photometrics etc).

v) Electrochemical Tests

- Open circuit potential, closed circuit potential and anode capacity test shall be carried out for one anode per heat for a duration of 96 hours as per DNV-RP-B401 in the synthetic sea water conforming to ASTM D1144
- Consumption rate by weight loss method
- Visual examination of corrosion pattern (uneven consumption, inter granular attack etc.)

The anode open circuit potential shall lie within (+) 10 MV and (-) 50 MV of the guaranteed value. The anode consumption rate shall not be less than the specified value. In case of anode closed circuit potential and/or the anode consumption rate do not meet the acceptance criteria, all the anodes of the heat shall be rejected.

vi) Manufacturer's test reports regarding reference cell calibration shall be furnished. The report shall also indicate the month and year of manufacture of reference cell.

6.4 Impressed Current Anodes

6.4.1 High Silicon Cast Iron Anode

i) Visual inspection

Visual inspection regarding surface finish, surface cracks & craters, shrinkage, cable joint, measurements of dimension, weight, radiographic tests etc. shall be conducted as per clause 6.3 i) above. The anode acceptance criteria shall be as specified in the clause except that no crack in the anode shall be acceptable unless the cracks are only superficial.

ii) Destructive testing
Destructive testing and acceptance criteria shall be as per clause 6.3 iii) above.

iii) Chemical analysis
Chemical analysis test and acceptance criteria shall be as per clause 6.3 iv) above.

iv) Electrochemical tests
Electrochemical tests for anode consumption, visual examination of corrosion pattern and the anode acceptance criteria shall be as per clause 6.3 v) above.

v) Spectrographic analysis

The anodes from each heat shall be tested for chemical composition by spectrographic analysis and for homogeneity, dross inclusion, voids etc. by radiography. Destructive tests shall be carried out where asked by owner based on the radiographic test results.

6.4.2 Mixed Metal Oxide Coated Titanium Anode

Contractor shall furnish list/ details of the tests that will be conducted by manufacturer of anode and their acceptance criteria.

6.4.3 Petroleum coke breeze and special back fill

The petroleum coke breeze material shall be tested for chemical composition, bulk density, real density, particle size and resistivity and test certificate shall be furnished.

The special back fill material for the sacrificial anodes shall be tested for composition and test reports shall be submitted.

6.5 Inspection, Testing and Acceptance

6.5.1 During fabrication, the equipment shall be subjected to inspection by EIL / Owner or by an agency authorised by the Owner, if specified / agreed in Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector (as applicable) . All routine / acceptance tests shall be carried out at manufacturer's works under his care and expense.

6.5.2 Type test certificates from CIMFR or equivalent test house, applicable PESO/ DGMS approval certificates, BIS license and original drawings referred in type test certificates (as applicable) shall be shown to the inspection agency on demand during inspection. The certificates must be valid at the time of dispatch.

6.5.3 Test certificates of bought out components (as applicable) shall be shown to the inspection agency on demand during inspection.

7.0 PACKING AND DESPATCH

All equipment/ material for CP system along with one set of final drawings shall be dispatched to site packed in wooden crates.

All the equipment shall be divided in to several sections for protection and ease of handling during transportation. The equipment shall be properly packed for transportation by ship/ rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in crates/ cases to prevent damages to finish. Crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Centre of gravity', 'Weight', 'Owners particulars', 'PO nos.' etc. shall be clearly marked on the package together with other details as per purchase order.
The equipment may be stored out doors for long periods before installation. The package shall be completely suitable for out door storage in areas with heavy rain/ high ambient temperature unless otherwise agreed.