CORROSION MONITORING

OF

OFFSHORE & ONSHORE PIPELINES

OISD STANDARD 188

Oil Industry Safety Directorate

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Ministry of Petroleum & Natural Gas
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CORROSION MONITORING OF OFFSHORE & ONSHORE PIPELINES

Prepared by

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Preamble

Indian petroleum industry is the energy lifeline of the nation and its continuous performance is essential for sovereignty and prosperity of the country. As the industry essentially deals with inherently inflammable substances throughout its value chain – upstream, midstream and downstream – Safety is of paramount importance to this industry as only safe performance at all times can ensure optimum ROI of these national assets and resources including sustainability.

While statutory organizations were in place all along to oversee safety aspects of Indian petroleum industry, Oil Industry Safety Directorate (OISD) was set up in 1986 Ministry of Petroleum and Natural Gas, Government of India as a knowledge centre for formulation of constantly updated world-scale standards for design, layout and operation of various equipment, facility and activities involved in this industry. Moreover, OISD was also given responsibility of monitoring implementation status of these standards through safety audits.

In more than 25 years of its existence, OISD has developed a rigorous, multi-layer, iterative and participative process of development of standards – starting with research by in-house experts and iterating through seeking & validating inputs from all stake-holders – operators, designers, national level knowledge authorities and public at large – with a feedback loop of constant updation based on ground level experience obtained through audits, incident analysis and environment scanning.

The participative process followed in standard formulation has resulted in excellent level of compliance by the industry culminating in a safer environment in the industry. OISD – except in the Upstream Petroleum Sector – is still a regulatory (and not a statutory) body but that has not affected implementation of the OISD standards. It also goes to prove the old adage that self-regulation is the best regulation. The quality and relevance of OISD standards had been further endorsed by their adoption in various statutory rules of the land.

Petroleum industry in India is significantly globalized at present in terms of technology content requiring its operation to keep pace with the relevant world scale standards & practices. This matches the OISD philosophy of continuous improvement keeping pace with the global developments in its target environment. To this end, OISD keeps track of changes through participation as member in large number of International and national level Knowledge Organizations – both in the field of standard development and implementation & monitoring in addition to updation of internal knowledge base through continuous research and application surveillance, thereby ensuring that this OISD Standard, along with all other extant ones, remains relevant, updated and effective on a real time basis in the applicable areas.

Together we strive to achieve NIL incidents in the entire Hydrocarbon Value Chain. This, besides other issues, calls for total engagement from all levels of the stake holder organizations, which we, at OISD, fervently look forward to.

Jai Hind!!!

Executive Director

Oil Industry Safety Directorate
FOREWORD

The Oil Industry in India is 100 years old. Due to various collaboration agreements, a variety of international codes, standards and practices are in vogue. Standardisation in design philosophies and operating and maintenance practices at a national level was hardly in existence. This, coupled with feedback from some serious accidents that occurred in the recent past in India and abroad, emphasised the need for the industry to review the existing state of art in designing, operating and maintaining oil and gas installations.

With this in view, the then Ministry of Petroleum and Natural Gas in 1986 constituted a Safety Council assisted by Oil Industry Safety Directorate (OISD), staffed from within the industry in formulating and implementing a series of self regulatory measures aimed at removing obsolescence, standardising and upgrading the existing standards to ensure safer operations. Accordingly OISD constituted a number of Functional Committees comprising of experts nominated from the industry to draw up standards and guidelines on various subjects.

The present standard on “Corrosion Monitoring of Offshore & Onshore pipelines”, was prepared by the Functional Committee on “Corrosion Monitoring of Offshore & Onshore pipelines”. This document is based on the accumulated knowledge and experience of industry members and the various national and international codes and practices. This standard is meant to be used as a supplement and not as a replacement for existing codes and practices. It is hoped that the provision of this standard, if implemented objectively, may go a long way to improve the safety and reduce accidents in the Oil and Gas Industry. Users are cautioned that no standard can be a substitute for the judgement of a responsible and experienced engineer. Suggestions are invited from the users after it is put into practice to improve the standard further. Suggestions for amendments to this standard should be addressed to the Coordinator, Committee on “Corrosion Monitoring of Offshore & Onshore pipelines”,

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These documents are intended to supplement rather than replace their prevailing statutory requirements.
Committee on Corrosion Monitoring of Offshore and Onshore Pipelines

List of Members

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In addition to the above, several other experts from the industry contributed in the preparation, review and finalisation of this document.
CORROSION MONITORING OF OFFSHORE & ONSHORE PIPELINES

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CORROSION MONITORING OF OFFSHORE & ONSHORE PIPELINES

1.0 INTRODUCTION: Corrosion is one of the major causes of failure of oil field pipelines both in offshore and onshore. A systematic approach should be applied for monitoring corrosion of these pipelines to enhance life of the pipelines and to ensure safe and reliable operations.

2.0 SCOPE:

2.1: This standard describes various corrosion monitoring requirements and test methods for offshore and onshore pipelines.

2.2: This standard is applicable to the following pipelines both offshore and onshore:
   a) Multi phase pipelines
   b) Gas pipelines
   c) Oil pipelines
   d) Water injection pipelines

3.0 DEFINITIONS:

Anode: The electrode of an electrochemical cell at which oxidation occurs. (Electrons flow away from the anode in the external circuit, which is normally metallic. The anode is usually the electrode where corrosion occurs and metal ions enter solution.)

Cathode: The electrode of an electrochemical cell at which reduction occurs.

Cathodic Disbondment: The destruction of adhesion between a coating and the coated surface caused by products of a cathodic reaction.

Cathodic Protection: A technique to control the corrosion of a metal surface by making that surface the cathode of an electrochemical cell.

Coating: A dielectric material applied to a structure to separate it from the environment thereby stopping flow of current.

Conductor: A material suitable for carrying an electric current. It may be bare or insulated.

Continuity Bond: An intentional metallic connection that provides electrical continuity.

Corrosion: The deterioration of a material, usually a metal, that results from a chemical reaction with its environment.

Corrosion Rate: The rate at which corrosion proceeds (It is usually expressed as either weight loss or penetration per unit time).

Cross-country pipeline: For the purpose of this standard, Cross Country Pipelines are pipelines which carry crude petroleum, petroleum products and natural gas from producers facilities such as Tank Farms, Natural Gas Processing Plants, Refineries, Pump/Compressor Stations, Terminals (Marine, Rail and Truck) to other delivery and receiving points, designed and constructed conforming to OISD 141, ANSI B 31.4 and ANSI B 31.8 or equivalent codes.

Current Density: The current to or from a unit area of an electrode surface.

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Electrical Isolation: The condition of being electrically separated from other metallic structures or the environment.

Electrolyte: A chemical substance containing ions that migrate in an electric field. For the purpose of this standard, electrolyte refers to the soil or liquid adjacent to and in contact with a buried or submerged metallic piping system, including the moisture and other chemicals contained therein.

Foreign Structure: Any structure that is not intended as a part of the system of interest.

Galvanic Anode: A metal which, because of its relative position in the galvanic series, provides protection to metal or metals that are more noble in the series, when coupled in an electrolyte.

Gas pipelines: Conduits used to transport gas and associated condensate.

Galvanic Series: A list of metals and alloys arranged according to their corrosion potentials in a given environment.

Holiday: A discontinuity in the coating.

Impressed Current: Direct current supplied by a cathodic protection system utilizing an external power source.

Intelligent pigging: Electronic equipment used to check the health of pipeline

IR Drop: The voltage across a resistance in accordance with Ohm's law.

“J” Tube: A conduit that supports and guides one or more pipe risers.

Line Current: The direct current flowing on a pipeline.

Multi phase pipelines: Conduits used to transport crude oil, associated gas and associated water from well platform to process platform.

Oil pipelines: Conduits used to transport crude oil.

Pipeline: The terms “pipeline”, as used in this document are conduits on the platform, between offshore structures, or between offshore structures and onshore cross-country pipelines or between onshore structures and onshore cross-country pipelines.

Platform: An offshore structure used to accommodate pipeline and related appurtenances.

Pipe to Electrolyte Potential / Structure to Electrolyte voltage: The potential (voltage) difference between the pipe metallic surface and electrolyte that is measured with reference to an electrode in contact with the electrolyte.

Polarization: The deviation from the corrosion potential of an electrode resulting from the flow of current between the electrode and the electrolyte.

Polarized Potential: The potential across the structure / electrolyte interface that is the sum of the corrosion potential and the cathodic protection.

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**Pig** : Device used to remove accumulated water, dirt, deposits, scales and wax from the inner surface of the pipeline.

**Planktonic bacteria** : Bacteria which are free swimming and move with fluid flow.

**Riser** : That section of pipeline extending from the ocean floor up the platform.

**ROU/ROW** : Right of use/Right of way

**ROV** : Remote Operated Vehicle

**ROTV** : Remote Operated Tow Vehicle.

**Reference Electrode** : A reversible electrode with a potential that may be considered constant under similar conditions of measurement (Examples : saturated copper / copper sulfate, saturated calomel, and silver/silver chloride) i.e. A device whose open circuit potential is constant under similar conditions of measurement.

**Scrapper traps** : Facility used to launch and receive pigs.

**SPM** (Single Point Mooring System) : Single point mooring system is a terminal system for loading/unloading of crude petroleum and other petroleum products from ocean going tankers with in the environmental conditions existing at the installation area.

**Shall** - The word ‘Shall’ is used to indicate that the provision is mandatory.

**Should** - The word ‘Should’ is used to indicate that the provision is recommendatory as sound engineering practice

**Sessile Bacteria** : Bacteria, which attach and grow on the wall of the metal surface

**Shielding** : Preventing or diverting the cathodic protection current from its intended path.

**Stray Current** : Current through paths other than the intended circuit.

**Stray-Current Corrosion** : Corrosion resulting from stray current transfer between the pipe and electrolyte.

**Splash zone** : The area of pipeline that is intermittently wet and dry because of wave and tidal action.

**Voltage** : An electromotive force or a difference in electrode potentials expressed in volts

**Water injection pipelines** : Conduits used to transport treated water from water injection facility

**Weight coating** : A coating applied to a pipeline to counteract buoyancy.

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4.0 CORROSION MONITORING OF OFFSHORE PIPELINES: Following methods should be adopted for monitoring of corrosion in the pipelines:

4.1 EXTERNAL CORROSION:

4.1.1: COATING SURVEY:

Following test should be performed using suitable technique for field inspection of protective coatings (except concrete coating):

i) Conduct visual examination

ii) Determine the location of discontinuities (holidays)/coating damage.

iii) Check cathodic protection potential in and around damaged area

Besides above, critical areas should be surveyed using above techniques in case of natural calamities.

4.1.2: Cathodic Potential Measurement of Pipelines:

(i) Continuous potential logging should be carried out initially once in every three years. Results of such 2-3 surveys shall guide further frequency. However, it is recommended that these surveys are carried out not later than five years for at least important/critical lines.

(ii) The potential measurement system (all required equipment viz. ROTV/ROV/Tow Fish etc.) shall be capable of measuring and recording potentials with respect to a silver/silver chloride reference electrode by direct contact. The system shall be fully capable of providing a continuous record of the potential along the pipe.

(iii) Direct contact calibration on anode shall precede the start of an inspection run wherever possible. The equipment calibration shall be checked against zinc and silver/silver chloride reference cells and a log of all calibration information shall be maintained.

(iv) Wherever CP readings show less potential (below -0.95V), anode shall be checked for its efficacy by measuring its volume/weight and if required necessary remedial measures shall be taken.

4.2 External Inspection of Risers (Above Splash Zone):

This section covers inspection requirements for risers (Above splash zone).

4.2.1 Above splash zone:

(i) Inspection of risers above the splash zone to be performed between the limits +1.5m above spider deck clamp top and the branch to the scrapper trap at deck level. Visual inspection should cover all necessary aspects such as coating condition, pitting salient features (clamps, fitting etc.), insulation/flange joint etc. Details for guidance are provided in Appendix-1.

(ii) Wall Thickness Measurement: Wall Thickness Measurement shall be performed at intervals of approximately 2m beginning immediately above the spider deck clamp top (except concrete coated pipe). Readings shall be taken at 90 degree intervals around the circumference of the riser at each location. At any areas of coating breakdown where external corrosion has taken place, and also in the heat affected zone on either side of each circumferential weld, wall thickness measurements as described above shall be taken.
made. At bends in the riser irrespective of the locations defined above, wall thickness measurements shall be made at intervals of 100mm around the inner and outer radii.
The use and calibration of ultrasonic testing equipment shall be in accordance with ASTM E797. This is except concrete coated pipe.

4.2.2 Frequency of Inspection:
Riser inspection shall be performed at intervals of not more than twelve months.

4.2.3 Record
Ideally the locations of wall thickness testing will be recorded upon a copy of the original isometric for the riser. Where this is not available a simple hand drawn sketch showing the riser configuration shall be prepared on-site. The sketch shall show clearly the limits of the riser inspection, the designation of the riser in terms of its diameter and service and the origin or destination of its associated pipelines. The points of wall thickness measurement should be marked on pipe surface. A sample format for recording wall thickness measurement is enclosed at Appendix - 1.

4.3 Inspection of risers (Splash zone & subsea portion):
This involves full inspection of the riser / riser clamps commencing at the insulation joint or 2 metres above the spider deck, whichever is higher, and finishing at the bottom butt-weld of the tube turn:

(i) To establish the precise number, size and location of all risers on a structure and to confirm the structural integrity of the risers and their clamps.
(ii) To locate any damage or corrosion on all risers.
(iii) To determine the extent of marine fouling on all risers.
(iv) To establish the condition and effectiveness of the cathodic protection system on all risers.
(v) To measure the wall thickness of bare portion of all risers and quantify any metal loss.
(vi) To establish the type and condition of all riser coatings and record any areas of bare metal.

A sample inspection procedure is provided at Appendix-1 for guidance purpose.

4.3.1 Frequency of Inspection
Splash zone inspection shall be carried out at a frequency of not more than 12 months. Sub-sea portion riser inspection should be carried out at a frequency of 3 years.

4.3.2 Reporting:
Riser inspection results should be presented in detail including, but not be limited to, the following:

(i) Text summarising the riser status on the structure.

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(ii) A key plan showing the position and designation of all risers.
(iii) Photographs showing the splash zone region of all risers.
(iv) Detailed isometric drawings illustrating the types of clamps used
(v) Riser ‘profile’ drawings showing the position of the risers on the jacket faces.
(vi) Riser Inspection Summary Sheets.
(vii) Riser Splash zone Inspection Sheets
(viii) Riser/Riser Clamp Inspection Sheets.
(ix) Riser/tube turn elevation Sheets.
(x) Marine Growth Data Sheets.
(xi) Photographs/detailed drawings of any anomalies.

4.4 SINGLE POINT MOORING SYSTEM (SPM):

Visual inspection of buoys, sacrificial anodes and equivalent for external corrosion shall be carried out once in a month.

4.5 INTERNAL CORROSION:

4.5.1 Following information should be maintained in the form of a records before installation and removal of corrosion monitoring devices
   a) Operating pressure and temperature
   b) Fluid analysis results:
      i) Water content and its composition
      ii) CO₂ and H₂S content
      iii) Number and types of bacteria
   c) Flow rate
   d) Pigging frequency
   e) Corrosion inhibitor and bactericides dose, frequency and injection methods

4.5.2 Following monitoring techniques should be used in the pipelines for internal corrosion monitoring:

   a) Corrosion coupons
   b) Corrosion monitoring equipment based on Electric resistance (ER) technique, electrochemical noise (ECN) technique, & Linear polarisation (LPR) technique
   c) Bacterial monitoring by Serial dilution technique, Bioprobe and Rapid check kit
   d) Iron count analyses
   e) chemical analysis for other parameters
   f) Any other available technique

The above methods may be used in combination for more realistic picture of corrosion in the pipeline. These methods can also be used by installing the skid mounted by- pass or loop system to facilitate uninterrupted operation.

4.5.3 Monitoring frequency :

   a) Corrosion coupons :-
      Monitoring frequency should be 6 months

   b) Corrosion monitoring probes :-

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Monitoring frequency should be 3 months. However frequency of monitoring can be reduced depending upon the corrosivity of the system.

c) Bacterial Monitoring :-

Both planktonic (free moving) and sessile bacteria should be monitored where every presence of bacterial activity is suspected. Planktonic bacteria should be monitored quarterly basis as well as before and after injection of the every bactericides treatment. Sampling of water should be carried out twice daily at least three to five days to establish a trend. Sessile bacteria should also be monitored using bio-probes or coupons to check the efficacy of bactericides. Monitoring frequency should be 3-6 months in case of well fluid pipelines where as in case of water injection pipelines it should be monthly basis at both the end of pipelines.

d) Iron count:

Monitoring frequency should be once in two months at both the ends of the pipeline.

e) Chemical analysis for various parameters:

Detailed chemical analysis should be carried out at least twice in a year in well fluid and gas pipelines. However hydrogen sulphide (H₂S) concentration shall be monitored at least once in two month. For analysis of injection water, frequency of monitoring shall be at least 3-4 times daily at process (water treatment) platform and once in a month at well platform side for following parameters:

i) Suspended solids
ii) Turbidity
iii) Dissolved oxygen
iv) Residual Sulphite
v) Sulphide
vi) Chlorine

Suspended solids by weight shall be monitored on daily basis.

5.0 CORROSION MONITORING OF ON-SHORE OIL PIPELINE

5.1 GENERAL

Corrosion Control by protective coating supplemented with cathodic protection, shall be provided in the initial design based on the study of environment and soil condition along the pipeline route and maintained during the service life of the pipeline system.

During construction and initial phase of operations, temporary arrangement should be made to protect the pipeline cathodically. However the pipeline system shall be permanently protected within a year of pipeline installation.

Facilities to use in-line inspection tools
Shall be provided during design/construction of pipelines.

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5.2 EXTERNAL PROTECTIVE COATING:

High quality Hydrocarbon resistant, electrically non-conducting protective coating shall be used to isolate the external surface of the under ground pipeline system and its components (joints, fittings, valves etc.) from the environment to reduce cathodic protective current requirements.

External coating must be properly selected and applied. Coated pipeline shall be carefully handled and installed. For various types of external coating and its desirable characteristics. NACE standard section 5 of RP 0169-96 and Indian standard IS:10221:1982 or other national / International standards/ codes and specification shall be referred.

5.3 CRITERIA FOR CATHODIC PROTECTION:

5.3.1 The minimum pipe to soil potential (PSP) shall be more negative than ( - )0.85 volts with respect to copper/copper sulphate half cell. In areas where anaerobic bacteria are active minimum PSP shall be more negative than ( - )0.95 volts instead of ( - ) 0.85 volts.

5.3.2 Over protection of coated pipelines shall be avoided by ensuring that polarisation potential is below –1.2 volts with respect to copper/ copper sulphate reference electrode. Polarisation potential can be measured at a given location on a coated pipeline by measuring pipe to earth potential immediately (within the first second or two) after simultaneously interrupting the current output from all cathodic protection sources affecting that portion of the pipeline.

5.3.3 A minimum negative (Cathodic) polarisation voltage decay of 100mV measured between the pipeline surface and a reference electrode in contact with the electrolyte. This voltage decay is to be determined by interrupting the protective current and measuring the decay. When the current is initially interrupted, an immediate voltage decrease will occur. The voltage reading after immediate decrease shall be used as the base reading from which to measure polarisation decay.

5.4. ELECTRICAL ISOLATION

5.4.1 Isolation of cathodically protected pipeline is recommended to minimise current requirement, facilitate testing and troubleshooting, and improve current distribution.

5.4.2 For effective electrical isolation, specially designed fittings like flanges, prefabricated isolation joints, unions, spools, isolating tapping sleeve should be used (Ref NACE Standard: section 3 of RP O286-97)

5.5 CASINGS

Underground pipelines are generally routed under roads and railways in steel casings. Where ever these are essential, casing pipes should be electrically isolated from the carrier pipes by providing isolating spacers. The isolating spacers should be designed and spaced to withstand the loads caused by the movement of the carrier pipe under operational conditions.

The use of proper end sealing and casing filling methods can prevent possible contact as well as the ingress of foreign substances (Ref. NACE standard section 4.1.13 of RP 0286-97)

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5.6 METALLIC BRIDGE

Pipelines supported on metallic bridge shall be provided with pads (Neoprene, Plastics, fiberglass reinforced plastic or glassed ceramics may be used for these pads) to isolate the pipe electrically from the support cradles).

If the cathodic protection system is so designed that a portion of the pipeline on the bridge is isolated from the buried pipelines, by providing isolating devices at both ends of the bridge, then a jumper wire can be bonded at the isolating devices to provide the electrical continuity to the pipeline and isolate the portion on the bridge (Ref. NACE standard section 4.1.2.2 of RP0 286-97)

5.7 FOREIGN STRUCTURE CROSSING

A minimum separation of 30 cm should be maintained between all buried metallic structures at pipeline crossings.

Where this is not possible consideration should be given for installation of isolating materials between the pipeline and metallic structure. (Ref. NACE standard section 4.1.3 of RP-0286-97)

If a foreign underground pipeline crosses the carrier pipeline a suitable mitigating method shall be adopted to avoid interference between the lines.

5.8 PARALLEL PIPELINES

When two or more pipelines are laid in the same ROW/ROU periodical interference survey shall be conducted and suitable mitigating measures to be taken to avoid interference between the lines.

Where stray current is known to exist which adversely affects the level of C.P. of the pipeline, additional monitoring should be carried out on monthly basis.

5.9 CP TEST STATION

Sufficient number of test stations shall be installed to check the adequacy of CP System. The test station for potential, current or resistance measurement shall be provided at sufficient locations to facilitate cathodic protection testing (Ref. NACE standard RP 0169-97, section 4.5).

5.10 FREQUENCY OF MONITORING

Effective monitoring of CP system consists of two complementary activities, validation and routine monitoring.

Validation establishes that the CP system is effectively protecting the whole of the pipeline system at a given time.

Routine monitoring is used to check at frequent intervals of time that the CP system is operating as designed and that the general levels of protection established during CP system validation are being maintained.

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5.10.1 Inspection of TR Unit shall be carried out fortnightly to check its operation & reliability of power supply.

5.10.2 Pipe to Soil Potential (PSP) ON readings at feeding points should be monitored fortnightly.

5.10.3 Pipe to soil potential (PSP) ‘ON’ readings at the test lead points for entire pipeline shall be taken once in a quarter. Instant pipe to soil OFF potential readings at the test lead points for entire pipeline shall be taken once in year. The PSP survey results shall be plotted graphically to identify and locate cathodic holidays.

5.10.4 Instant pipe to soil ‘OFF’ potential readings at the test lead points of entire pipeline shall be taken once in a year. The PSP survey results shall be plotted graphically to identify and locate cathodic holidays.

5.10.5 As far as possible current consumption data should be taken on yearly basis at test stations where current measurement facility exist.

5.10.6 External coupons/Probes at critical location should be used to evaluate the effectiveness of mitigation programme. (Refer NACE TN 0497, 97) Monitoring frequency shall be quarterly.

5.10.7 At sacrificial anode locations the following data shall be recorded half yearly:
- Open Circuit Anode Potential
- Pipeline Potential (Anode‘OFF’)
- Pipeline Potential (Anode ‘ON’)
- Current Anode Output

5.11 COATING SURVEYS

5.11.1 Continuous potential logging (CPL) survey once in 5 years or whenever inadequate CP is observed, whichever is earlier.

5.11.2 Pearson survey, Direct Current Voltage Gradient (D.C.V.G.), Current Attenuation Test (C.A.T.) surveys to elaborate the coating defects as and when required.

5.12 INSPECTION OF PIPELINE CROSSING

5.12.1 Rail bridge, Road bridge, suspended crossing shall be checked once in a quarter to find out wear and tear of supports/structures and conditions of protective coatings at points where the pipe exits and enters the ground. Ultrasonic thickness measurement shall be taken on exposed sections of the pipelines once in two years. This thickness measurement shall be taken at 4 locations (i.e. 12, 3, 6, 9 O’clock positions) at the exits, bends and at every ten meter interval of exposed piping.

5.12.2 Road, River, Rail and Cannel crossings shall be checked once in a quarter. The carrier/casing pipe annulus shall be kept free of water (Ref OISD standard 138 section 4.3)

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5.13 INSULATING JOINT/COUPLING INSPECTION

Insulating joints and Couplings shall be inspected once in a year.

5.14 ABOVE GROUND PIPELINE PORTION

The pipelines laid above ground shall be checked once in a quarter to find out wear and tear of insulated support & condition of paints/ coating. Thickness measurement shall be taken once in two years.

5.15 SOIL TESTING

Soil samples within the ROW shall be tested once in 10 years to determine the variations in soil resistivity for system. In addition, if any industrial effluents are flowing over the ROW soil sample shall be tested for determining the efficacy of the existing coating and wrapping of the pipeline.

6.0 PIGGING

6.1 DESCALING

the frequency of descaling of pipelines transporting crude petroleum, petroleum products and natural gas shall be as under:

i) Non-ATF Petroleum Product Pipelines—Once in six months.
ii) ATF Pipelines also carrying other petroleum products—Once in a quarter.
iii) Dedicated ATF Pipelines—Once in a year.
iv) Crude Oil Pipelines—Once in a year.
v) Crude Oil Pipelines (Injecting Sections)—Once in a quarter.
vi) Gas Transmission Pipelines—Once in a year.

Record of quantity and quality of deposits (Pig Residue) collected after descaling shall be examined to monitor condition of the pipeline and to determine subsequent frequency of pigging.

6.2 INTELLIGENT PIGGING

Pipelines should be inspected with Geometry pig for dent/ovality and other geometrical deformities at the time of construction.

Metal loss inspection using intelligent pig should be carried based on corrosion growth rate established through corrosion coupon/probe monitoring, corrosion history and results of special surveys like Pearson, CAT and CPL Survey.

In case of Pipelines carrying sour crude or sour gas intelligent pigging having capability to detect cracks should be run once in five year.

7.0 DOCUMENTATION

Formats for recording monitoring/Inspection parameters shall be designed suiting specific pipeline system. Sample formats are given in the Appendix-5.

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Detailed records shall be kept of all corrosion control information. These records shall include design, construction, commissioning, monitoring, and maintenance data.

8.0 REFERENCES

1) NACE Standard RP0775-91 “Preparation and installation of corrosion coupons and interpretation of test data in oil field operation”

2) NACE Standard RP0194-94 “Field monitoring of bacterial growth in oil field system”

3) NACE Standard TM-01 69-96 “Control of external corrosion on underground or submerged metallic piping systems”

4) NACE Standard RP06 75-88 “Control of external corrosion on offshore steel pipelines”

5) NACE Standard TM-0497-97 “Measurement technique related to criteria for cathodic protection on underground or submerged piping system”

6) API RP-38 “Recommended practice for biological analysis of subsurface injection waters”

7) NACE Standard RP01 92-92 “Monitoring Corrosion in oil & gas production with iron counts”

8) NACE 286-97 “Electrical isolation of cathodically protected pipeline

9) ASTM-E797-

APPENDIX-1

1.0 INSPECTION PROCEDURE - (for splash zone & subsea portion):

1.0.1 Mark on a key plan of the structure the location of all risers.

1.0.2 Measure the diameter of all risers at an uncoated location as near to the spider deck as possible and at another location as close to the tubeturn as possible.

1.0.3 Record the type and condition of all coatings. Record the water-depth at which each coating type starts/stops.

1.0.4 Measure and record the distance from water level to the top of the splashzone coating (ie ‘zone’ VI) and record the time and date at which the measurement is taken.

1.0.5 Measure the length of ‘zones’ from II to V individually. Refer to enclosed figure for the location of each ‘zone’.

1.0.6 Note any abrasion, distortion or other physical damage to either the coating or the riser itself.

1.0.7 Measure the position of each riser at all horizontal bracing plans in the following manner:
   a) Measure from the inside of the nearest main leg to the centre back of the riser.
   b) Measure from the outside of the horizontal member to the back of the riser.

1.0.8 Where accessible triangulate the location of the bottom butt-weld of the tubeturn relative to the structure.

1.0.9 Remove all debris around riser/clamps/tubeturn.

1.0.10 Record all areas of bare metal. All such areas are to be cleaned, subjected to wall thickness and C.P. measurement. Visually inspected for damage and/or corrosion to the parent metal shall also be recorded.

1.0.11 Record the position of the tubeturn relative to the sea bed. If the tubeturn is firmly supported any knee brace present is to be removed. Tubeturns clear of the sea bed are to be supported with grout-bags or similar, after which any knee brace present shall be removed.

1.1 MARINE GROWTH INSPECTION

As a result of vibration and/or the elevated surface temperature of risers there is often a marked difference in the extent of marine growth on risers when compared to that on the associated plat form. Since risers are often installed at various stages during the service life of a platform that fact also has a major effect on the degree of fouling present. For these reasons it is desirable to measure the extent of marine growth on each and every riser four probe readings at 90 degree spacing around the riser at 5m depth increments from Mean Sea Laval down to Elevation(-) 50m and thereafter at 10m intervals down to the top of the
tube turn. Excess marine growth than the design limit shall be removed. The probe readings should relate to ‘hard’ or ‘firm’ marine growth, which does not readily yield to the effects of water movement, and should not include ‘films, ‘soft’ species such as algae (seaweed) and filamentous hydroids.

1.2 RISER CLAMP

1.2.1 Prior to inspection, water blast cleaning of all riser clamp flange faces, bolts, attachment welds, clamp ends and 0.3m of riser above and below each clamp to allow visual inspection and verification of bolt/liner/- clamp and riser coating integrity. DO NOT clean non-commissioned clamps.

1.2.2 Report the type of clamp present at each level. Clamps will be identified by standard ‘Mark’ numbers. Appendix-4 at the back of this standard illustrates the standard clamp types used and their designations.

1.2.3 Inspect all clamps (including telescope and brace clamps) for damage/mis-alignment. Check the conditions of all clamp bolts, bolt tightness shall be checked using a suitable wrench. All loose/missing bolts are to be tightened/replaced. To aid reporting, the terminology convention detailed in enclosed figure shall be adhered with. The numbers refer to clock positions.

1.2.4 Replace any missing or severely damaged clamps.

1.2.5 Inspect all riser clamps for the presence of neoprene liners. In the case of non concrete-coated risers replacement of any missing clamp liners is mandatory. In the case of concrete coated risers missing liner need only be replaced were their absence results in tolerances between the clamp and the riser.

1.2.6 Visually inspect and confirm the integrity of all attachment welds to jacket bracings, particularly at the ends of all gusset plates.

1.2.7 Measure all (riser, telescopic, member) clamp tolerances and if unacceptable (i.e. the clamp is not secure) packing is to be installed.

1.2.8 Report any evidence of vibration or movement of risers.

1.2.9 Where an area of bare metal extends behind as clamp remove the clamp and clean and inspect the riser prior to applying new coating.

1.2.10 Inspect the riser for corrosion/damage at the clamp edges.

1.3 WALL THICKNESS INSPECTION OF RISER

Refer to Appendix-4 figure for the locations at which readings are to be taken in the splashzone on risers. Do not remove riser coatings unless there is evidence of corrosion occurring beneath the coating. Any and all areas of removed coating/paint shall be
cleaned to bare metal and new coating/paint applied after the inspection. Wherever a wall thickness reading is taken through the coating it should be so noted in the final report.

Wall thickness readings shall be taken on all risers at the locations listed below:-

Readings to be taken at 90 degrees spacings around the circumference of the riser at:

1.3.1 Immediately above the insulation joint if and only if this location is within 2 meters of the spider deck.
1.3.2 Immediately below the insulation joint. Ensure that these readings are not taken on the insulation joint but on the riser itself.
1.3.3 If there is evidence of corrosion on insulation joint, four additional readings should be taken at 90 degree spacings around its circumference.
1.3.4 At not greater than 0.5m intervals from immediately below the insulation joint down to the top of the spider deck clamp.
1.3.5 Immediately above the spider deck clamp.
1.3.6 Immediately below the spider deck clamp.
1.3.7 If there is evidence of corrosion to the riser in the vicinity of the spider deck clamp, additional inspection shall be carried out by opening the clamp.
1.3.8 At not greater than 0.5m intervals from immediately below the spider deck clamp to the top of the splash zone coating.
1.3.9 Immediately above the termination point of the splash zone coating. Since this area of the riser is most susceptible to corrosion damage one additional set of reading shall be taken.
1.3.10 At all areas of coating damage where bare metal is exposed.
1.3.11 On all areas of general surface corrosion after removal of corrosion products.
1.3.12 On all un-coated field joints, both sides of the weld at four points around the circumference.
1.3.13 At 100mm intervals around the inner and outer radii of tubeturns. Such readings shall only be taken on un-coated tube-turns and where the riser is not in a J-tube. If the readings obtained indicate a reduction in wall thickness by 1.5mm or greater, a more detailed examination of the tubeturn shall be carried out, on a 25mm x 25mm grid.
1.3.14 In areas where loss of wall thickness of 1mm or more is present due to pitting, pit depth shall be measured using an standard pit gauge.

1.4 CATHODIC PROTECTION OF RISERS

(i) Confirm the presence and secure attachment of all anodes.

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(ii) Record the depth at which each anode is situated.
(iii) Comment on and then remove all marine growth and corrosion product from the surface of all anodes. Any painted or partially painted anodes shall be reported and the paint shall be removed, by water blasting if necessary. Estimate the volumetric wastage of all anodes. For anodes more than 70% depleted, replacement should be considered after detail analysis.
(iv) Photograph the most severely depleted anode on each riser.
(v) Take cathodic potential readings as follows:
- on each anode field joint welds.
- on all areas of exposed bare metal.
- on either side of any mechanical pipe joints.
- on riser clamp caps, clamp saddles and the risers adjacent to all clamps.
- at the back of all uncoated tubetorns.

2.0 INSPECTION PROCEDURE FOR RISERS - ABOVE SPLASH ZONE:

2.1 COATING
Riser coating shall be visually inspected. The general condition of coating shall be recorded. The condition of the coating, including superficial deterioration, discolouration, cracking or disbonding shall be recorded at each location where wall thickness measurement is performed.

2.2 PITTING
Where pitting or any other form of localised corrosion is noted the location shall be recorded by annotating the sketch referred to above. In addition the length affected and the depth of the corrosion should be estimated and recorded. For pitting, the narrative comment should include an estimated corrosion diameter of the pits and their distribution (e.g. 2mm dia, approx 4 pits per cm²).

2.3 SALIENT FEATURES
The positions of other salient features of the riser including, clamps and fittings shall be recorded.

2.4 COATING RE-INSTAMENT
Where coating is removed for the measuring of wall-thickness it shall be re-instatement. The procedure to be followed for coating re-instatement shall be as advised and approved by owner for touch-up painting.

2.5 INSULATION FLANGE/JOINT
The insulation flange/joint shall be visually inspected over its entire area. Any visible defect including coating defects or any form of distortion shall be recorded.
2.1 CORROSION COUPONS

Corrosion coupons should be used to evaluate corrosivity of flowing fluids, to monitor the effectiveness of mitigation programs. High corrosion rates on coupons may be used to verify the need for mitigating steps. Following precautions should be taken:

i) Minimum two coupons should be used at one time for evaluating the corrosion rate.

ii) Initial weight & area of coupons should be measured after surface preparation. Each coupons should be given identification number.

iii) After removing the coupons, it should be photographed and any erosion or mechanical damage and appearance of scale or corrosion product should be recorded.

iv) Weight the coupon after proper cleaning and determine the weight loss. For cleaning, coupons should be immersed in 15% hydrochloric acid solution (having 5% stannous chloride and 5% Antimony trioxide as inhibitor) and then should be cleaned with running water followed by acetone to dry it.

v) Measure the corrosion rate (CR) using following formulate in the form of mm / year or MPY (mils per year)

\[
CR = \frac{W \times 365 	imes 1000}{3.65 \times 10^5 \times W} = \frac{141.616 \times 10^5 \times W}{ATD} \approx \frac{MPY}{ATD}
\]

Where \( CR \) = Average corrosion rate millimeters/year (mm/year)

\( W \) = Weight loss, (grams, g)

\( A \) = Initial exposed surface area of coupon, square millimeters (mm²)

\( T \) = Exposure time, days (d)

\( D \) = Density of coupon metal grams per cubic centimeter (g/cm³)

(for iron it is 7.87 g/cm³)

39.4 MPY = 1 mm / y

vi) Qualitative guidelines for interpretation of corrosivity of fluid in carbon steel systems given in the following table and is recommended by NACE for use as only guide lines.

<table>
<thead>
<tr>
<th>Average corrosion rate (MPY)</th>
<th>Pitting rate (MPY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>&lt; 1.0</td>
</tr>
<tr>
<td>Moderate</td>
<td>1.0 - 4.9</td>
</tr>
<tr>
<td>High</td>
<td>5.0-10.0</td>
</tr>
<tr>
<td>Severe</td>
<td>&gt; 10.0</td>
</tr>
<tr>
<td></td>
<td>&lt; 5.0</td>
</tr>
<tr>
<td></td>
<td>5.00-7.90</td>
</tr>
<tr>
<td></td>
<td>8.0-15.0</td>
</tr>
<tr>
<td></td>
<td>&gt; 15.0</td>
</tr>
</tbody>
</table>

vii) For coupon installation, location, surface finishing, cleaning and other precautions NACE standard RP-0775-91 should also be referred.

viii) When evaluating corrosion inhibitor efficiency short term exposure (15 to 45 days) of coupons are required. For evaluation of bacterial attack and pitting tendency long term exposure (60 to 90 days) are required.

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2.2 CORROSION MONITORING EQUIPMENT

i) Corrosion monitoring devices normally include Electrical resistance measuring instrument (ER), Linear polarisation resistance probes (LPR), and electrochemical noise based (ECN) instrument. These instruments are useful in detecting short term upsets that may not be detected by coupons.

ii) Some of these devices provides instantaneous results.

iii) The probes are installed inside pipelines either from 12 o’clock position or 6 o’clock position.

v) The instrument maybe permanently installed to provide continuous information, or may be portable to gather periodic data from a number of locations, in fluid.

vi) In pipelines having higher water content in fluid and lower flow velocity, these probes should be installed flush mounted to the wall of pipelines at 6 O’Clock position for realistic results.

2.3 BACTERIAL MONITORING

Both planktonic (free moving) and sessile bacteria (surface attached) shall be detected using serial dilution technique.

2.3.1 PLANKTONIC BACTERIA

i) For planktonic bacteria, samples shall be taken randomly over several days to establish a base line.

ii) Two daily sampling over three to five days is often used.

iili Samples should be collected from flowing systems (pipe lines). During sampling of systems containing both oil and water, phase separation should be permitted to occur before using the water.

iv) For sample collection, sterile containers/bottles shall be used.

v) Inject 1 ml of water sample using sterile syringe in to 9ml media voil. Rigorously agitate the inoculated vial and using another sterile syringe withdraw 1 ml of the inoculated broth from this vial and inject into another 9ml media voil. Repeat this procedure in the same manner upto $10^8$ dilution factor.

vi) Incubate these voils at a temperature +/- 5°C of the recorded temperature of the water when sampled.

vili) Change in colour of media will indicate the presence of bacteria.

villl To minimise changes, the sample should be analyzed without delay, preferably on site. If a delay of more than one hour is unavoidable, samples should be processed as per clause No. 2.2 of NACE standard TM -01 94-94.


2.3.2 SESSILE BACTERIA MONITORING

For sampling of sessile bacteria, bioprobe or metal coupons should be installed at 6 O’clock position in the pipe lines. These probes should be removed after 60-90 days. After exposure, bio film growth should be removed immediately from the bioprobes by scraping with a sterile scalpel. Scrape approximately 1.00 cm² of deposit from coupon or bioprobe surface and transfer into 10 ml. of clean bacteria free water. Follow steps (v) to (ix) above.

2.3.3 RAPID TEST METHODS FOR DETECTION OF BACTERIA

The techniques described above for detection of bacteria do not allow rapid evaluation of bacterial contamination. For rapid bacterial evaluation, various techniques are used. These are:

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1) **ATP photometry** - in laboratory for general bacteria
2) **Fluorescent microscopy** - in laboratory for total bacteria
3) **Hydrogenase test** - both in field and laboratory for SRB detection
4) **APS reductase or immunoassay test**:
   Both in field & laboratory for SRB above techniques should be used if required and results should be compared with those of serial dilution technique.

2.4 **IRON COUNT**:
   i) By monitoring the iron content of the water, a indirect indication of effectiveness of corrosion control measures can be obtained.
   ii) Iron counts are used for monitoring the iron content of the water phase in a flowing system.
   iii) Test must be performed at once because the iron will oxidise and fall out of solution in a short time.
   iv) Use of 10 drops of 10% HCl per 100 ml to preserve the sample.
   v) Calorimetric method should be used for onsite analysis in field where as atomic absorption spectrophotometer should be used in laboratory.
   vi) Corrosion rate in mils/year can be calculated using following formula for carbon steel:

   \[
   \text{MPY} = \frac{11.94 \times \text{ppm Fe} \times \text{barrels water/day}}{\text{Length of pipeline (ft) \times inner diameter of pipeline (inches)}}
   \]

   vii) Refer NACE standard RP-01-92-92 for further details.

2.5 **CHEMICAL ANALYSIS FOR VARIOUS PARAMETERS**

   Chemicals analysis gives relative information about corrosivity of the fluids flowing through the pipelines. Chemical analysis includes Water analysis, Gas analysis and Deposit / Corrosion product analysis (e.g. on coupons, residue received after pigging).

   Following important parameters should be analysed for corrosion monitoring purpose in various samples -

A) **Water sample of well fluid & Gas pipeline:**

   1. Dissolved gases like (CO₂ & H₂S)
   2. Sulphide content
   3. Chloride content
   4. Sulphate content
   5. Carbonate content
   6. Iron count
   7. Bicarbonate content

B) **Water sample of water injection pipeline:**

   1. Suspended solids

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2. Dissolved oxygen
3. Residual sulphite
4. Sulphide
5. Chlorine
6. Iron count

C In Gas Sample of well fluid and gas pipeline
1. Carbon dioxide
2. Hydrogen sulphide
3. Water content

D Deposits / Corrosion products
1. Sulphide, chloride, carbonate & Sulphate ions
2. Bacteria
3. pH of accumulated liquid received during pigging.

2.6 INSTALLATION OF SKID MOUNTED BY PASS OR LOOP SYSTEM

This is a skid mounted by pass system used for on line internal corrosion monitoring in pipe lines. This unit uses multiple monitoring techniques including ER probes, LPR probes, ECN system, and fluid analysis. This system should be used for

i) Continuous real time monitoring of pipe line fluids and gases under actual operating condition.

ii) Corrosion measurements for evaluating corrosion and bacteriological control programmes

iii) On line analysis of chemical treatment programme

iv) Can be used during pigging also with out affecting the production operations.
APPENDIX -3

INTELLIGENT PIG SURVEY (IPS)

Intelligent pigging is one survey that is capable of meeting almost all the requirement for assessment of health of a pipeline from corrosion failure point of view. Intelligent pig also known as smart pig is a device which is launched into the pipeline and propelled by the fluid flow, till it comes out at the other end of the pipeline. The intelligent pigging is a special pig which is fitted with either ultrasonic probes or magnets all around its periphery along with sensors. The intelligent pigging also carries on board electronics that stores the data which was finally processed out side and corrosion data generated. Thus intelligent pigging is a device which provides complete metal loss profile of pipeline. An intelligent pigging is capable of providing the following information about a pipeline:

- Location, Extent, Shape and Size of metal loss.
- Discrimination of Metal loss between external and internal corrosion.
- Location of valves and other ferro-magnetic fittings.
- Pipeline ground Profile.
- Gauges, dents and presence of other geometric deformities.

Types of Intelligent Pig:

Among the popular variety generally operators are selecting from following two types of intelligent pigs:

1. Magnetic Flux Leakage (MFL) Type.
2. Ultrasonic types

There are other types of special intelligent pigs like eddy current type, elastic wave type, acoustic emission type etc. The special type of intelligent pigging are utilised mostly for specific purposes like detection of SCC (Sulphide stress corrosion cracking) etc.
APPENDIX-4

RISER AND TUBETURN ELEVATION

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# RISER INSPECTION SUMMARY

<table>
<thead>
<tr>
<th>PLATFORM TO/FROM</th>
<th>RISER No.</th>
<th>DIAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>SERVICE</td>
<td></td>
<td>NOMINAL WT.</td>
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<tr>
<td>TEMP. °C</td>
<td>PRESSURE(PSI)</td>
<td>INSTALLATION DATE</td>
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<table>
<thead>
<tr>
<th>SUBJ.</th>
<th>COMMENTS/WORK COMPLETED</th>
<th>RECOMMENDATIONS/REFERENCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAMAGE/ CORROSION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COATING TYPE AND COND.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLAMP TYPES AND COND.</td>
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<tr>
<td>CLAMP LINER STATUS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MARINE GROWTH STATUS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WALL THICKNESS STATUS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANODES AND CP.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TUBE TURN SCOUR ETC.</td>
<td></td>
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</table>

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## Riser Inspection Report

<table>
<thead>
<tr>
<th>STRUCTURE</th>
<th>RISER No.</th>
<th>DIAM.</th>
</tr>
</thead>
<tbody>
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<td>TO:FROM</td>
<td></td>
</tr>
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<td>DEPTH RANGE</td>
<td>MSL TO</td>
<td>(-)</td>
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<tr>
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### Cathodic Protection Readings

<p>| | | | | |</p>
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<thead>
<tr>
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<td>6</td>
<td>7</td>
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### Dive No.

<table>
<thead>
<tr>
<th>Riser Wall Thickness Report (mm)</th>
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<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>11</td>
</tr>
</tbody>
</table>

### Spec. T (mm) Dive No.

### General Report - Observations

---

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RISER PROFILE FOR RISER Nos. 1, 2 AND 3

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## Riser-Marine Growth Survey

![Diagram of a platform and riser system](image)

(Viewed from above)

<table>
<thead>
<tr>
<th>Platform</th>
<th>Riser No.</th>
<th>O.D.</th>
<th>% Cover</th>
<th>Prominent Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (m)</td>
<td>Thickness (cm.)</td>
<td>Avg. of Probes</td>
<td>Hard</td>
<td>Soft</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td></td>
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</tbody>
</table>

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### Riser Inspection Report Above MSL

<table>
<thead>
<tr>
<th>Location (m above spider deck clamp)</th>
<th>WALL THICKNESS (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0° (6 O’ Clock)</td>
<td>90°</td>
</tr>
<tr>
<td></td>
<td>180°</td>
</tr>
<tr>
<td></td>
<td>270°</td>
</tr>
</tbody>
</table>

**Complex** | **Riser** | **Service** | **Platform** | **Pipeline** | **Dia.** |
|------------|-----------|-------------|--------------|--------------|----------|

**Date** | **Inspector** | **Date** |
|----------|----------------|----------|

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APPENDIX-5

REPORT OF CATHODIC PROTECTION STATIONS

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Date</th>
<th>Chainage in Kms.</th>
<th>C.P. Station Location</th>
<th>D.C. Volts</th>
<th>D.C. Amps</th>
<th>Circuit Resistance</th>
<th>P.S.P. Volts</th>
<th>Tapping setting</th>
<th>A.C. Volts</th>
<th>A.C. Amps</th>
<th>Energy Meter Reading</th>
<th>Hour Meter Reading</th>
<th>Rectifier efficiency %</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Coarse</td>
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<td></td>
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Prepared by:
Reviewed

DISTRIBUTION:
## STRAY CURRENT DETECTION (FOREIGN LINE INTERFERANCE)

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<th>Sl. No</th>
<th>Location of Foreign Lines</th>
<th>Potential w.r.t. Reference Electrode (Volts)</th>
<th>Interrupter output Current</th>
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<td>Current On</td>
<td>Current Off V₁</td>
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### Remarks

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QUARTERLY PIPE TO SOIL POTENTIAL SURVEY

FORM NO:

PSP Survey for the Qr. _________ ending

Report No: ____________________________ Section: __________________________

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<th>Sl. No</th>
<th>Chainage in KMs</th>
<th>Date</th>
<th>C.P. Location</th>
<th>P.S.P (Volts)</th>
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Remarks

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SOIL RESISTIVITY SURVEY

FORM NO

Reporting Stn.

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Remarks

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Reviewed by

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