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| <p><b>FUNCTIONAL SPECIFICATION</b></p> <p><b>FOR</b></p> <p><b>HYDROSTATIC TESTING OF</b></p> <p><b>SUBMARINE PIPELINES</b></p> <p><b>OIL AND NATURAL GAS CORPORATION LTD.</b></p> <p><b>INDIA</b></p>   |                               |  |                    |            |      |            |                    |           |          |            |              |                    |    |    |            |
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| 1.0 SCOPE   |                               |  |                    |            |
| 1.1 This specification covers the minimum requirements for hydrostatic testing of submarine pipelines transporting hydrocarbons in liquid or gaseous phase and injection water.                                 |                               |  |                    |            |
| 1.2 This specification shall be read in conjunction with the requirements of all specifications and documents included in the Contract.   |                               |  |                    |            |
| 2.0 REFERENCE CODES, STANDARDS AND SPECIFICATIONS   |                               |  |                    |            |
| 2.1 Reference has been made in this specification to the latest edition of the following codes, standards and specifications:   |                               |  |                    |            |
| a. ANSI B 31.8 : Gas Transmission and Distribution Piping Systems   |                               |  |                    |            |
| b. ANSI B 31.4 : Liquid Petroleum Transportation Piping System.   |                               |  |                    |            |
| c. API RP 1110 : Pressure Testing of Liquid Petroleum Pipelines.  |                               |  |                    |            |
| d. ASME Sec VIII Div.1 : Boilers and Pressure Vessels Code  |                               |  |                    |            |
| e. DNV 81 : Rules for Submarine Pipelines   |                               |  |                    |            |
| f. IP Part : Institute of Petroleum Model Code of Safe Practice   |                               |  |                    |            |
| 2.2 In case of conflict between the requirements of this specification and that of the above referred codes, standards and specifications, the requirement of this specification shall govern.                  |                               |  |                    |            |
| 3.0 GENERAL   |                               |  |                    |            |
| 3.1 Hydrostatic testing of submarine pipeline system shall commence only after completion of all installation works of pipelines, risers, crossings, burial/back-filling operations and remedial works, if any. |                               |  |                    |            |
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3.2 Hydrostatic testing shall be carried out on the entire pipeline i.e. from pig launcher to pig receiver. For incomplete pipelines, the test shall be done from stub end to the pig barrel on the originating platform.

Where Pig launcher/receiver are not required or specified, the Contractor shall provide and install temporary launcher/receiver at the specified battery limits of the pipeline test section during the testing operations.

3.3 Laterals and Pipe Line End Manifolds (PLEMS) which are already pre-tested at the fabrication yard, shall also be tested again along with the submarine pipeline.

3.4 Contractor shall perform all works required for hydrostatic testing, only after obtaining prior written approval from Company Representative.

3.5 Contractor shall furnish all the required materials, supervision, labour, equipment, including pigs, testing, inspection, monitoring services necessary for the successful cleaning, gauging, filling, batching, logging and hydrostatic testing of the pipeline system as specified herein in a manner satisfactory to the Company Representative.


3.6 Supervisors and personnel deployed by the Contractor for the hydrostatic operations shall have adequate experience of such operations.

3.7 In case of submarine pipelines from platform to shore, Contractor shall carry out filling operations from the offshore platform end.

3.8 In case any in-line full bore ball/full port check valves are installed in the pipeline, Contractor shall deploy divers and ensure that the ball valves are in open position and the flapper of the check valve is locked in open position prior to carrying out any pigging operations. Valves located on the lateral connections and PLEMS shall be kept in partially open position.

3.9 Subsequent to completing hydrostatic testing operations and acceptance by Company, Contractor shall open the flapper lock of the check valves and leave the check valve disc in normal operating position. In addition, the valves installed in lateral connections and PLEMS shall be kept in closed/open position as per the instructions of the Company Representative.

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4.0

EQUIPMENT AND INSTRUMENTATION

The Contractor shall furnish all necessary materials, equipment, instruments and consumables for performing the work. Materials and equipment shall be in good working conditions and include, but not be limited to the following:

a)

Pigs for filling, cleaning and gauging

-

Bi directional cleaning pigs with spring loaded steel wire brushes to cover the entire internal surface of the pipe, along with magnetic flange attachment to pick-up ferrous debris in the line. Pigs shall be mounted with pinger transmitters to enable tracking.

-

Bi-directional batching/displacement pigs with at least four discs.

-

Bi-directional gauging pig with 12.7 mm thick aluminum gauging plate and polyurethane discs. The aluminium plate shall have radial incision at 45° intervals. Gauging plate diameter shall be determined as per the following formula :

d

=

D-2t – (0.01 D + 0.4t + 5 I)

where

d

=

Gauging plate diameter

D

=

Nominal outer diameter of pipe

t

=

Nominal wall thickness of pipe

I


=

0.2 t, maximum 5 mm

-

Caliper pig capable of recording changes in internal pipe geometry, locating all girth welds and locating suspected faults, dents, wrinkles, buckles, out of roundness and flat spots. Caliper pig shall be capable of completing its survey in a single pass.

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The Contractor shall provide sufficient number of pigs, including spares. Unless otherwise specified, all pigs shall be capable of negotiating a minimum bend radius of 5 times pipe diameter. In case any full port check valves are installed in the pipeline. Contractor shall ensure that the distance between the driving cups of the pigs are of sufficient length to prevent bypassing while passing through the full port check valve.

b. Fill pumps : Filling pumps shall be capable of filling the pipeline at the volume rate required to maintain pig speeds as specified in section here in after. Suction piping and pump construction shall be such that the entry of air is prevented. Pump shall have minimum differential head 20% greater than the maximum head required and shall have a minimum flow rate of 400 m³/hr. If a single pump is used, a standby unit must be available.

c. Variable speed positive displacement pumps equipped with a stroke counter to pressurize the line with a known stroke and capable of exceeding the maximum test pressure by at least 20 bar.

d. Two positive displacement meters to measure the volume of water used for filling the line. These meters shall be provided with a calibration certificate not older than one month.


e. Portable tanks of sufficient size to provide a continuous supply of water to the pump during pressurizing.


f. Bourdon pressure gauges of suitable pressure range and accuracy.

g. Dead weight testers with an accuracy of 0.01 bar measuring in increments of 0.05 bar provided with a calibration certificate not older than one month.


h. Two 48 hours recording pressure gauges having an accuracy of ± 0.1% of the full scale value, with charts and ink gauges tested with dead weight tester prior to use. These shall be installed at the test heads.

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| <p>shall include the details of all materials, equipment and procedures etc. as given below:</p> <p>a. A diagram indicating all equipment, instruments, fitting, vents, valves, thermocouples, temporary connections, relevant elevations and ratings. The diagram shall also indicate injection locations and test water intake and discharge lines.</p> <p>b. Laboratory test results of the test water, estimated amount of test water including required dosages of oxygen scavenger, bactericide corrosion inhibitor and fluorescent dye; procedure for chemicals and dye injection and control of dosages.</p> <p>c. Filling and flushing procedures, including a complete description of all proposed equipment and instruments (including spares) their location and set-up.</p> <p>d. Direction of pigging for the filling, cleaning and gauging operation.</p> <p>e. The type and sequence of pigs and the pig tracking system for cleaning and removal of air pockets. Pig inspection procedures, including procedure to be followed in case the gauging pig indicates damage.</p> <p>f. Procedure for thermal stabilization after filling.</p> <p>g. Pressure testing procedure including a complete description of all proposed equipments and instruments (including spares), their location and set-up and proposed system for observation and recording of data during the pressure test.</p> <p>h. Theoretical calculations for temperature corrections and entrapped air volume calculations.</p> <p>i. Procedure for hydrotest acceptance</p> <p>j. Procedure for detection/location and rectification of leaks.</p> <p>k. Formats for logging/recording the test data</p> <p>l. Safety precautions proposed during the test.</p> |  |  |                    |                          |
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Upon approval by Company any change in the procedure shall be notified to Company whose approval in writing of all such changes shall be obtained prior to start of the hydrostatic testing operations.

**6.0 PROCEDURES**

6.1 All necessary equipment shall be set up and checked by the Contractor to ensure conformance with the Company approved hydrotest procedure so that the pipeline is ready for hydrotesting operations.

6.2 Contractor shall be fully responsible for checking dimensions of the proposed pigs against pig-trap dimensions to ensure that the pig receipt/retrieval sequence in the proposed procedure can be achieved. All pigs shall be inspected by the Company prior to their insertion into the launcher.

6.3 Water used for cleaning and hydrotesting of the pipeline shall be clean and free from impurities. Contractor shall conduct tests on samples of water prior to its use. The analysis shall determine oxygen concentration (dissolved oxygen), suspended solids presence of micro organisms, biological growth etc.

6.4 The Contractor shall then start cleaning, filling and gauging operations. While filling the pipeline with water. Contractor shall provide a 0.150 mm screen filter, to prevent pumping mud and other foreign materials into the pipeline.

Air vents at test heads shall be kept closed at the start of filling to allow pressure to build up in front of the pig train. First filtered sea-water of volume equivalent to one percent of the length of the pipeline test section or 250 m whichever is more shall be introduced ahead of the first pig to ensure wetting, washing and rinsing away of foreign materials. This shall be followed by launching of first pig train consisting of four pigs in following sequence:


i. Cleaning pig


ii. Batching/displacement pig


iii. Cleaning pig


iv. Gauging pig

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| <p>These pigs shall be separated by volumes of filtered sea-water equivalent to one percent of the length of the pipeline test section or 250 m whichever is more. The bypass of the leading cleaning pig in the first pig-train shall be kept open to make up for water ahead of the pig running down to low-sports. The first pig-train shall be propelled forward by introducing filtered sea-water into the pipeline behind it and thereby filling the entire pipeline with filtered sea-water.</p> <p>Pinger transmitter shall be installed on the leading and/or trailing pigs of each pig train. In addition, tracking equipment for these pinger transmitters shall also be provided by the Contractor.</p> <p>6.5 The pig-train speed shall be maintained between 0.5 m/s and 1 m/s by suitable adjustment of vent valve provided on the receiving test head in order to minimize the amount of air by-passing the filling pig.</p> <p>6.6 The progress of the pig-train shall be monitored continuously and the locations of the pigs in the first pig-train reported to the Company at regular intervals as and when requested to do so by the Company Representative.</p> <p>6.7 Regular samples of sea-water leaving the pipeline system after receipt of pigs shall be analyzed. The solid contents shall be measured and the results recorded. Cleaning is considered to be completed when the quantity of debris in the samples directly ahead of the last pig is less than one percent by volume.</p> <p>In case higher solid contents are noted, additional pig trains consisting of pigs as mentioned in clause 6.4 shall be run until the pipeline is cleaned of debris. However the gauging pig mentioned in clause 6.4 shall be replaced with batching/displacement pig, in case of successful gauging pig run. In case the gauging pig run made previously was not acceptable to the Company, the last pig in this pig-train shall be a gauging pig equipped with a pinger transmitter. Subsequent pig runs shall have the same requirements as those established for the first pig-train run.</p> <p>6.8 Subsequent to arrival of the pigs at the receiver, the pigs shall be removed by the Contractor in the presence of the Company Representative. Recovered pigs shall be carefully examined and details recorded. The gauging pig shall be carefully examined for any damage. A deformed,</p> |                               |  |                     |            |
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| <p>bent or severely nicked plate or damaged pig shall be evidence of gauging pig run failure and the same is not acceptable to Company. In such cases, the Contractor shall repair and rectify the line and repeat the gauging pig-run to the satisfaction and approval of Company Representative. Any obstructions and/or faults such as dents, buckles, flat spots etc. analyzed and noted during the gauging pig-run shall be located and any necessary repair work shall be performed to rectify the same to the satisfaction of the Company.</p> |  |  |                     |            |
| 6.9   | <p>After the pipeline is cleaned of debris and gauging pig has been run, a caliper pig run shall be made. A caliper pig shall be launched using treated water as mentioned in clause 6.11, in order to check possible out-of-roundness, locate suspected faults like dents, wrinkles and flat spots along the pipeline. The pig train in this run shall consist of one batching/displacement pig and one caliper pig.</p> <p>The results of the caliper pig run and interpretation of the data gathered by it shall be analyzed by the Contractor to evaluate the internal status of the pipeline and shall be made available to the Company as soon as possible after that particular run has been completed.</p> <p>Contractor shall furnish a detailed report to the Company giving results with interpretation/analysis of caliper pig run to Company for information.</p> |  |                     |            |
| 6.10  | <p>The quantities of sea-water, oxygen scavenger, bactericide, corrosion inhibitor and dye pumped into the pipeline section shall be measured and recorded at intervals decided in consultation with the Company Representative.</p>   |  |                     |            |
| 6.11  | <p><b>Treatment of Hydrotest Water</b></p> <p>The hydrotest water shall be treated with suggested dosages of hydrotest chemicals as mentioned below:</p> <ul style="list-style-type: none"><li>- Oxygen scavenger (Sodium/ammonium bisulfite) @ 100 mg/l on 100% basis</li><li>- Bactericide (Quarternary ammonium compound Quat 2c or equivalent) @ 100 mg/l as such</li><li>- Corrosion inhibitor (Polyphosphate) @ min. 15 mg/l as PO<sub>4</sub></li></ul>   |  |                     |            |
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| <p>However the actual dosages of these chemicals shall be decided by the Contractor taking into account the quality of the test water indicated in clause 6.3 above the Manufacturer’s recommendations. Company approval shall be obtained regarding the dosages prior to its injection into the test water. In addition test water shall be charged with fluorescent dye “Rhodamine B or equivalent” to a concentration of 15 – 20 mg/l, before being put into the pipeline system. The use of other chemicals and dyes shall be subject to Company approval.</p> |  |  |                     |            |
| 6.12   | <p>If any of the pigs are blocked at any location in the pipeline, the Contractor shall locate the position of the blocked pig and ascertain the cause of the blockage and report the results of his investigations to the Company. The Contractor shall then carry out remedial and/or repair work acceptable to Company, required to restore the pipeline system to a working condition satisfactory to the Company Representative. On completion of the repair work, the Contractor shall start-up the filling, cleaning and gauging of the pipeline system again with treated test water as described earlier.</p> |  |                     |            |
| 6.13   | <p>Hydrotesting shall commence only after gauging pig run and caliper pig run are satisfactory and accepted by Company Representative.</p>   |  |                     |            |
| 7.0  | <p><b>PRESSURE TEST</b></p>  |  |                     |            |
| 7.1  | <p>After the pipeline system has been cleaned, gauged and filled with treated sea-water and approval of the Company to commence hydrostatic pressure test has been obtained, the pressurization of the pipeline system may be commenced by the Contractor.</p>   |  |                     |            |
| 7.2  | <p>The Contractor shall observe the temperature of the pipeline till it equalizes to the surrounding sea water (thermal stabilization) regularly at every 4 hours intervals. For this purpose thermocouples shall be installed on the pipeline at suitable locations.</p>  |  |                     |            |
| 7.3  | <p><b>Test Pressure</b></p> <p>The minimum hydrostatic test pressure at any section of the pipeline system shall be 1.25 times the pipeline design pressure, unless a higher test pressure is specified elsewhere in the Contract.</p>   |  |                     |            |
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7.4

### Pressurization

The pressurization of the pipeline shall be commenced after thermal stabilization, at a constant rate not exceeding 2 bar/minute. One pressure recording gauge shall be installed in parallel with the dead weight tester that shall permit reading of atleast 0.05 bar. Volume of Water added to the pipeline section shall be measured through a positive displacement meter and shall be recorded periodically throughout the pressurization as follows:

- Each 5 bar increment upto the 80% of test pressure as recorded by the dead weight tester.
- Each 2 bar increment between 80% to 90% of test pressure as recorded by the dead weight tester.
- Each 0.2 bar increments between 90% and full test pressure as recorded by the dead weight tester.

The pressurizing shall be cycled according to the following sequence:

- Pressurize to 50% of test pressure, hold pressure for 1 hour.
- Drop pressure to static head of test section at test head.
- Pressurize to test pressure.


In case, during the pressure hold period indicated above, a decrease in pressure is observed, the above operations shall not be repeated more than twice, after which the test section shall not be considered capable of test, until the Contractor has isolated and eliminated the cause for the lack of water tightness.


7.5


### Air entrapment test

During the pressurization to full test pressure, one test shall be carried out for the calculation of air volume in the pipeline under test when the pressure is at 50% of the test pressure. Contractor shall take pressure and added volume readings and plot the same, on a suitable graph having a plot of theoretical added volume vs pressure [p = f(v)] plot. The air content in the test section shall then be established. In case the air content exceeds 0.2% of the volume of the test section, the further pressurization shall be stopped. The pressure shall be released and the air in the test

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| <p>section vented off. If after successive trails of venting the air in the test section vented off. If after successive trails of venting the air content still remains at more than 0.2% of the volume of the test section, the Contractor shall pass additional batching/displacement pigs and refill the entire pipeline with treated sea-water as mentioned above to remove the air pockets. The procedure for establishing the air content shall be repeated till the air content in the test section does not exceed the allowable limit of 0.2% of the volume of the test section. In case the air content is within 0.2% of the test section, then the pressurizing can continue.</p> |  |  |                     |          |
| 7.6  | <b>Testing</b>   |  |                     |          |
| <p>After air entrapment test has given acceptable results and the test section has been pressurized to the specified test pressure, the test pressure the test pressure shall be held for a minimum period of 24 continuous hours, unless a higher holding period is specified elsewhere in the Contract. The injection pump shall be disconnected and all connections at the test heads shall be checked for leakage. The pressure recorders shall then be started with the charts in a real time orientation for continuous recording throughout the holding period.</p>   |  |  |                     |          |
| <p>During the pressure holding period the following measurements shall be recorded/reported:</p>   |  |  |                     |          |
| <ul style="list-style-type: none"><li>- Every one hour pressure measurements from dead weight testers.</li><li>- Every two hours the ambient temperature and the pipe temperature at the thermocouples.</li></ul>  |  |  |                     |          |
| <p>All data shall be recorded on appropriate forms attached to the hydrostatic test procedure manual.</p>  |  |  |                     |          |
| 8.0  | <b>ACCEPTANCE</b>  |  |                     |          |
| 8.1  | <p>The hydrostatic test shall be considered positive if test pressure has kept a constant value throughout the specified hold period, except for change due to temperature difference.</p> |  |                     |          |
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| <p>In case of temperature difference, the pressure change due to temperature change shall be calculated and algebraically added to the pressure value as read on the recorders. The pressure value thus adjusted shall be compared with the initial value and the test shall be considered as acceptable if the difference is <math>\leq \pm 0.2\%</math> of test pressure. In the event the test is unacceptable, the test period shall be extended by 24 hours.</p> |  |  |                     |            |
| 8.2   | <p>If test section fails to maintain the specified test pressure after isolation, Contractor shall determine by search the location of leakage/failure and carry out the necessary repair/rectification measures by suitable methods approved by Company. After completion of repairs, the hydrostatic test shall be repeated in full, as per this specification.</p>  |  |                     |            |
| 8.3   | <p>The cost of repairs or replacements, followed by refilling and repressurizing the line, due to poor workmanship, shall be borne by the Contractor. In the event of leaks or failures resulting from faulty Company furnished materials, Contractor shall be reimbursed for furnishing all labour, equipment, materials except those materials furnished by the Company, and transportation necessary to repair and repressurize the section of the pipeline to the pressure at the time of recognition of leak or line failure. Contractor shall be entitled for compensation as per the provisions of the Contract.</p> <p>All work of reinstalling line pipe, to replace failures, shall be done in accordance with the relevant specifications included in the Contract.</p> |  |                     |            |
| 8.4   | <p>Contractor shall stockpile all damaged and defective pipes to storage locations designated by the Company Representative. All cracks and splits resulting from failures shall be coated with an application of grease to preserve the characteristics of failures from corrosion. Joint of failed pipes shall be marked with paint, with a tag indicating failure details, date and location of failure and pressure at which failure occurred.</p>   |  |                     |            |
| 9.0   | <p><b>TERMINATION</b></p> <p>After the positive results of testing and all the data have been gathered, the test shall be terminated upon written approval given by the Company Representative.</p>  |  |                     |            |
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Rigid pipelines shall be slowly depressurized at a moderate and constant rate not exceeding 2 bar/ minute. In case of flexible pipelines, maximum depressurization rate shall be as per manufacturer’s guidelines/ recommendations.

10.0      **PRESERVATION OF PIPELINE**

In case the pipeline is specified in the Contract to be preserved, and the hydrotest water is intended to be kept in the pipeline for more than 2 months (but not exceeding 12 months) as a preservation measure, the test water shall be dosed with the chemicals as mentioned below, instead of the chemicals and dosages mentioned at clause 6.11.

- Oxygen scavenger (Sodium/Ammonium bisulphate) @ 100 mg/1 on 100% basis.
- Bactericide (Alkyl Aryl Trimethyl ammonium chloride Quat 2C or equivalent @ 250 mg/1 as such)
- Corrosion inhibitor (Alkyl pyridinium chloride Quat CPC or equivalent ) @ 250 mg/1 as such.

In case of preservation, the pipeline system under such circumstances shall be kept under a positive pressure of 0.5 kg/cm². All valves isolating the pipeline system shall be kept closed.

11.0      **TEST REPORT**


A complete report signed by Contractor and the Company Representative shall be submitted upon completion of the hydrostatic testing operations for each test section.

The report shall contain as a minimum :

- Cleaning, flushing, filling and testing procedure used
- Schematic layout of cleaning, filling and testing facilities
- Instruments calibration certificates
- A profile of the pipeline that shows the test sites, all instrument and injection connections
- Pipe filling logs and records

|              |                    |           |          |            |
|--------------|--------------------|-----------|----------|------------|
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|---|--|--|---------------------|--------------------------|
|    | OFFSHORE<br>DESIGN<br>SECTION            | FUNCTIONAL SPECIFICATION<br>FOR<br>HYDROSTATIC TESTING OF<br>SUBMARINE PIPELINES | SPEC. No.           | 2022                     |
|   |  |  | Rev. No.            | 0                        |
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| <div><ul style="list-style-type: none"><li>- Hydrotest chemicals specification, dosage, injection records</li><li>- Pig specifications</li><li>- Pig inspection records including photographs of the damages</li><li>- Records of gauging pig survey and photographs</li><li>- Records of caliper pig survey and interpretation of results</li><li>- Pressurization and stabilization records</li><li>- Pressure and temperature recording charts with appropriate information inscribed thereon</li><li>- Dead weight tester logs and recordings</li><li>- Air volume calculations</li><li>- Pressure – temperature change calculations</li><li>- Environmental data</li><li>- Depressurization logs and records</li><li>- Records and photograph of all leaks/failure</li></ul></div> |  |  |                     |                          |
| <div><div>12.0</div><div><div>PRECAUTIONS DURING THE TEST</div><div><p>In addition to all that has been expressly described in the procedures for carrying out the test, the following requirements shall also be complied with</p></div></div></div>   |  |  |                     |                          |
| <div><div>12.1</div><div><p>During the hydrotest, no other activities shall be performed on or near the pipeline being tested.</p></div></div>  |  |  |                     |                          |
| <div><div>12.2</div><div><p>Signs stating “PIPE UNDER TEST – KEEP OFF” shall be placed where the test head/scrapper traps are located. Such areas shall be suitably guarded throughout the duration of the test. In case pressurizing is done from the shore end, the entire operational area shall suitably be fenced to prevent entry of unauthorized personnel.</p></div></div>  |  |  |                     |                          |
| <div><div>12.3</div><div><p>All personnel working on the hydrotest spread shall be instructed on the possible dangers connected with the high pressure test operations. During the testing, operations, no unauthorized personnel shall be allowed near by the test head location. Test cabin at shore shall be atleast 10 m from the pipeline so that it is not affected by the pipeline failure.</p></div></div>  |  |  |                     |                          |
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