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|  PETROBRAS | TECHNICAL SPECIFICATION | | Nº: I-ET-0000.00-6500-940-P9U-007 | | | |
| | CLIENT: | - | SHEET: | | | 1 de 36 |
| | JOB: | - | | | | - |
| | AREA: | PIPELINES | | | - | |
| | TITLE: | PIPELINE TRENCHING IN SHALLOW WATER | | | EDD/EDR | |
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1 INTRODUCTION

1.1 GENERAL

- 1.1.1 This Technical Specification has the objective to establish the scope of work, minimum requirements and deliverables for the Trenching Engineering Design and Trenching Execution of pipelines to guarantee the on bottom stability and protection of the pipeline.
- 1.1.2 This Technical Specification is restricted only to shallow water and consider natural backfilling.
- 1.1.3 This Technical Specification is restricted only to new pipelines, i.e., it is not applicable to pipelines in operation which will require additional considerations.
- 1.1.4 PETROBRAS is considering, for the trenching of pipelines the following trenching methods: jetting, mechanical cutting, plowing.
- 1.1.5 CONTRACTOR shall perform all activities described in this Technical Specification.
- 1.1.6 CONTRACTOR shall be responsible for any other activity, or material, not mentioned within this Technical Specification, which is necessary to conclude the scope of work.
- 1.1.7 The review and approval by PETROBRAS of any drawings, procedures or documents referred to in this Specification shall only indicate a general requirement and shall not relieve CONTRACTOR of his obligations to comply with the requirements of the Contract. Any errors or omissions noted by CONTRACTOR shall be immediately brought to the attention of PETROBRAS.
- 1.1.8 All deviations to this specification and other referenced specifications or attachments listed in the Contract shall be made in writing and shall require written approval by PETROBRAS prior to executing the work.
- 1.1.9 The CONTRACTOR's auxiliary vessels shall present documents and permissions to perform the intended work from Classification Society and Port Authorities.

1.2 DEFINITIONS

1.2.1 The following definitions are used for the purpose of this Technical Specification.

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| 1 | Adjacent seabed: | Seabed close to the pipeline which elevation was disturbed by the pipeline installation, by the trenching, or by the natural backfilling. |
| 2 | Backfilling: | It means the backfilling of the trench being performed by mechanical means and immediately after the pipeline lowering has confirmed. The natural seabed level, or natural beach level, shall be considered the inherent backfilling level. |



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| 3 | Burial: | When the pipeline is required to be trenched and the trench should be backfilled. |
| 4 | Burial depth: | For a trenched pipeline, burial depth is the vertical distance between the top of the buried pipeline and surrounding natural seabed. |
| 5 | CONTRACTOR: | The company responsible for the execution of the scope of work included within this specification. |
| 6 | Depth of lowering: | Depth of lowering is the vertical distance between the bottom of the pipeline and surrounding natural seabed. |
| 7 | KP: | Kilometer post, in accordance with pipeline alignment sheets drawings |
| 8 | Material: | Material, equipment, tools necessary to conclude the scope of work. |
| 9 | May: | A course of action permissible within the limits of this specification (used when referring to contractor). |
| 10 | Must not: | Prohibited requirement (used when referring to contractor). |
| 11 | Natural backfilling: | When the backfilling of the trench is expected to occur through soil sediments displaced by environmental loads. |
| 12 | Natural seabed and/or beach level: | Natural seabed and/or beach level shall mean the lowest undisturbed level at either side of the pipeline at a determined time. |
| 13 | Pipeline(s): | Refers to pipelines to be trenched. |
| 14 | Pipeline components: | Any items which are integral parts of the pipeline such as flanges, tees, bends, stud bolts, nuts, gaskets, anodes and other pipeline fittings. |
| 15 | Pitch: | Angle of the longitudinal axis of the trencher in respect to the horizontal plan. |
| 16 | Propped shape imperfection | Vertical imperfection of the pipeline due to foundation shape. |
| 17 | Pre-trenching survey: | Survey performed before the pipeline trenching to establish the coordinates, profile and to verify the status of the soil and pipeline. |
| 18 | Post-trenching survey: | Survey performed after the pipeline trenching to establish the coordinates, profile and to verify the status of the pipeline. |
| 19 | Roll: | Angle of the transverse axis of the trencher in respect to the horizontal plan. |
| 20 | SGO: | Sistema de gerenciamento de obstáculos (system of managing of subsea obstructions – mainly subsea structures and pipelines). |
| 21 | Shall: | Mandatory requirement (used when referring to contractor). |
| 22 | Should: | Preferred requirement (used when referring to contractor). |
| 23 | SMYS | Specified minimum yield strength. |
| 24 | THIRD PARTY | Recognized company with experience in verifying subsea pipeline design, construction and installation. |

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| 25 | Trenching: | Lowering of the pipeline in respect to the natural seabed through specified methods. Backfilling or natural backfilling, as specified, shall be considered an intrinsic part of the trenching. |
| 26 | Trench depth: | Trench depth is the vertical distance between the top of the pipeline and surrounding natural seabed. |
| 27 | Trenching equipment: | The whole equipment involved in the trenching operation including trencher, instrumentation, auxiliary devices located on the trenching support vessel (tow winch, pumps, deployment system, and others). |
| 28 | Trenching machine (or trencher): | General designation for trenching machines based on the following methods: jetting, mechanical cutting or plowing. |
| 29 | WD | Water depth. |

2 REFERENCES

2.1 CONTRACTOR shall consider the most recent issue of the following technical specifications, codes, standards and recommended practices, as part of this specification.

2.2 Conflicts between the references below and the present specification or between themselves shall be submitted to PETROBRAS for resolutions.

2.3 TECHNICAL SPECIFICATIONS

[A1] I-ET-0000.00-0000-940-P9U-002, RIGID PIPELINE ON-BOTTOM ROUGHNESS AND FREE SPAN DESIGN;

[A2] I-ET-0000.00-0000-275-P9U-002, MINIMUM REQUIREMENTS FOR FREE SPAN CORRECTION

[A3] I-ET-0000.00-0000-295-P9U-001, CALIPER PIG'S REQUIREMENTS;

[A4] I-ET-0000.00-0000-974-P9U-001, HYDROSTATIC TEST OF SUBSEA PIPELINES AND RISERS;

[A5] I-ET-0000.00-0000-978-P9U-001, DEWATERING, CONDITIONING AND NITROGEN PURGING OF SUBSEA PIPELINES AND RISERS;

[A6] I-ET-0000.00-0000-970-P9U-001, MINIMUM REQUIREMENTS FOR PRE-LAY SURVEY

[A7] I-ET-0000.00-0000-970-P9U-002, MINIMUM REQUIREMENTS FOR POST-LAY SURVEY;

2.4 CODES, STANDARDS AND RECOMMENDED PRACTICES

[B1] DNV-ST-F101, SUBMARINE PIPELINE SYSTEMS;

[B2] DNV-RP-F105, FREE SPANNING PIPELINES

[B3] DNV-SE-0474, RISK BASED VERIFICATION

[B4] DNV-SE-0475, VERIFICATION AND CERTIFICATION OF SUBMARINE PIPELINES



[B5] DNV-ST-N001, MARINE OPERATIONS AND MARINE WARRANTY

3 SCOPE OF WORK

3.1 SUMMARY

- 3.1.1 CONTRACTOR shall be responsible for the Engineering Design and Trenching Execution for the pipelines to be trenched.
- 3.1.2 The minimum scope of work for the Engineering Design activity is described in Section 3.3. The minimum scope of work for the Trenching Execution is described in Section 3.5.
- 3.1.3 The Engineering Design activity and the Trenching Execution activity shall be certified in accordance with the minimum requirements included within Section 3.4.
- 3.1.4 The Engineering Design may be performed by a subcontractor. In this case, the subcontracted Engineering Design Company shall be proposed for PETROBRAS` approval.
- 3.1.5 PETROBRAS is providing geotechnical, geophysical and meteocean data for the pipeline trenching. CONTRACTOR shall, at its own expenses and responsibility, acquire any additional data required to ensure the pipeline trenching in accordance with the requirements of this specification. In case of any additional surveys were acquired, CONTRACTOR shall also provide the data and reports for PETROBRAS.

3.2 SCENARIO

- 3.2.1 The pipeline routes, the main characteristics of the pipelines sections at the trenching zone, pipeline data sheets, geotechnical, geophysical and environmental data documents for the pipelines routes are provided in specific documents.
- 3.2.2 The pressure for the hydrotest to be performed prior to the beginning of pipeline trenching is provided in specific documents. After the referred hydrotest, the pipeline is required to be maintained in the flooded condition for trenching operation. The pressure for the hydrotest to be performed after pipeline trenching is also provided in specific documents.
- 3.2.3 Probably the trench will be naturally backfilled to the natural seabed level. CONTRACTOR shall determine the backfilling rate occurred within the period of time from post-trenching survey to as-laid survey.

3.3 ENGINEERING DESIGN

3.3.1 GENERAL

- 3.3.1.1 The Engineering Design for trenching of the pipelines comprises, at least, the following activities:
- 3.3.1.1.1 Engineering Calculations;
- 3.3.1.1.2 Trenching Procedures;
- 3.3.1.2 Calculations, drawings and procedures detailing all aspects of the trenching operations, shall

be prepared and submitted by CONTRACTOR to THIRDY PARTY and PETROBRAS approval. The calculations shall take into account the equipment, soil data and the expected site conditions.

3.3.1.3 The minimum scope of work for the Engineering Calculations activity is described in Section 3.3.2. The minimum scope of work for the Trenching Procedures is described in Section 3.3.3.

3.3.2 ENGINEERING CALCULATIONS

3.3.2.1 The Engineering Calculations shall encompass, at least, the following points:

3.3.2.1.1 Engineering calculations basis;

3.3.2.1.2 Excavation stability calculations;

3.3.2.1.3 Natural backfilling rate estimations and estimated material volume for backfilling zone;

3.3.2.1.4 Calculations detailing the maximum allowable loads imposed on the pipeline by the trencher;

3.3.2.1.5 Calculations of the transitioning in and out of the trench;

3.3.2.1.6 Normal trenching operations;

3.3.2.1.7 Deployment and recovery of the trenching equipment.

3.3.2.1.8 Loads imposed to pipeline during trenching operations.

3.3.2.1.9 Mooring calculations.

3.3.2.2 The minimum requirements for the Engineering Calculations, which shall be considered by CONTRACTOR, are included in Section 5.

3.3.2.3 Minimum contents for the Engineering Calculations Reports, which shall be considered by CONTRACTOR, are included in Section 7.

3.3.2.4 The Engineering Calculations Reports shall be issued by CONTRACTOR for THIRDY PARTY review and approval. After THIRDY PARTY approval, the Engineering Calculations Reports shall be issued for PETROBRAS review and approval.

3.3.3 TRENCHING PROCEDURES

3.3.3.1 The Trenching Procedures shall comprise, at least, the following procedures:

3.3.3.1.1 Positioning procedure and survey procedures;

3.3.3.1.2 Trenching equipment description;

3.3.3.1.3 Monitoring and control procedures;

3.3.3.1.4 Sea trials procedures;

- 3.3.3.1.5 Procedure for trencher deployment and recovery;
- 3.3.3.1.6 Procedure for trenching operations;
- 3.3.3.1.7 Mooring procedures;
- 3.3.3.1.8 Procedure for crossing cables / pipelines (if applicable);
- 3.3.3.1.9 Contingency procedures.
- 3.3.3.1.10 Procedure for trenching pipeline sections in free-span conditions;
- 3.3.3.1.11 Procedure for removing boulders or other large objects from the route;
- 3.3.3.1.12 Procedures for hydrotest;
- 3.3.3.1.13 Procedure for Diving operations;
- 3.3.3.1.14 Procedures for site preparation prior commencement of the work;
- 3.3.3.1.15 Procedures for landfall reinstatement after trenching;
- 3.3.3.2 The minimum requirements for the Trenching Procedures, which shall be considered by CONTRACTOR, are included in Section 6.
- 3.3.3.3 Minimum contents for the Trenching Procedures, which shall be considered by CONTRACTOR, are included in Section 7.
- 3.3.3.4 The Trenching Procedures, shall be issued by CONTRACTOR for THIRDY PARTY review and approval. After THIRDY PARTY approval, the Trenching Procedures shall be issued for PETROBRAS review and approval.
- 3.3.3.5 The trenching procedures shall comprise, at least, the following particular points:
 - 3.3.3.5.1 Environmental conditions in which various phases of the work may be undertaken;
 - 3.3.3.5.2 Proposed methods for performing the work.
 - 3.3.3.5.3 Maximum allowable load, and possible ranges for operational parameters.
 - 3.3.3.5.4 The above information shall cover, at least, marine operations, onshore operations, surveying, post trenching and equipment calibration procedures. Special consideration in the installation manual shall be given to the duration of weather sensitive operations and limiting weather conditions.
- 3.4 VERIFICATION**
 - 3.4.1 CONTRACTOR shall be responsible for contracting a THIRDY PARTY to verify the scope of work in accordance with [B1], [B3], [B4] and issue a Statement of Conformity.

3.4.2 The THIRD PARTY shall be a recognized company with experience in verifying subsea pipeline design, construction and installation and shall present a track record of verifying at least five subsea pipeline projects.

3.4.3 For verification scope, CONTRACTOR shall adopt the requirements of level MEDIUM definitions, according to [B1], [B3], and [B4].

3.4.4 The THIRD PARTY shall be proposed to PETROBRAS` approval. The THIRDY PARTY shall verify all Engineering Calculations Reports and Trenching Procedures. This verification shall meet the terms of ref. [B1].

3.4.5 The THIRD PARTY shall verify, at least, the documentation to be issued by CONTRACTOR according to Section 7 of this Technical Specification. THIRD PARTY shall verify the documentation prior to be sent to PETROBRAS.


3.4.6 CONTRACTOR shall ensure, if required during the execution of the project, a direct communication line from PETROBRAS to THIRD PARTY and vice versa, in accordance with [B4].

3.5 TRENCHING EXECUTION

3.5.1 The Trenching Execution shall comprise, at least, the following particular activities:

- 3.5.1.1 Site preparation prior commencement of the Work
- 3.5.1.2 Pre-trenching survey of the entire length to be trenched of all pipelines.
- 3.5.1.3 Pre-trenching hydrotest for the pipelines, in accordance with the specified hydrotest pressures, if applicable.
- 3.5.1.4 Trenching of the pipelines. Characteristics of the trenching sections are provided in specific documents.
- 3.5.1.5 Post-trenching survey of the entire pipeline trenched.
- 3.5.1.6 Pipelines lowering correction, to make the pipeline achieve the specified trench depth.
- 3.5.1.7 Trenching of pipelines in free-span conditions.
- 3.5.1.8 Repairs or remedial works required as a result of damage to the pipeline (steel linepipe, coatings and anodes) during trenching.
- 3.5.1.9 Post-trenching hydrotest for all pipelines, in accordance with the specified hydrotest pressure.
- 3.5.1.10 As-built survey of the entire trenched (or backfilled) length of all pipelines.
- 3.5.1.11 Pipelines` natural backfilling rate verification.
- 3.5.1.12 Landfall reinstatement after trenching.

3.5.2 CONTRACTOR shall be responsible by any remedial work (burial depth correction, lowering

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correction, freespan correction, out-of-straightness correction, pipeline damages correction, and others), required to be performed as a result of the as-built survey. In this case, a hydrotest shall be performed and an additional as-built survey shall be performed.

3.5.3 CONTRACTOR shall also be responsible for any other trenching construction activity non-mentioned within this Technical Specification which is necessary to conclude the scope of work, in accordance with the requirements of this specification.

3.5.4 CONTRACTOR shall inform the pipeline trench depth daily.

3.5.5 Minimum requirements for the Trenching Execution, which shall be considered by CONTRACTOR, are provided in Section 6.

3.5.6 Minimum contents of the As-Built Trenching Execution Report, which shall be considered by CONTRACTOR, are included in Section 8.

4 MATERIALS TO BE SUPPLIED

4.1 PETROBRAS

NO material will be supplied by PETROBRAS. The Contract requirements shall be considered.

4.2 CONTRACTOR

4.2.1 CONTRACTOR shall be responsible for supplying:

4.2.1.1 All equipment, tools and materials necessary to complete the described scope of work.

4.2.1.2 All materials, equipment and assistance devices necessary to perform field joint and corrosion coating repair, concrete coating repair, anode repair and steel linepipe repair.

5 ENGINEERING CALCULATIONS

5.1 GENERAL

5.1.1 The engineering calculations shall be performed in accordance with ref. [B1].

5.1.2 All the calculations shall be presented in MATHCAD format including all steps of the calculation methodology or on an approved software.


5.2 ENGINEERING CALCULATION BASIS

5.2.1 CONTRACTOR shall issue the Engineering Calculation Basis to consolidate the objective of this project, design methodology and PETROBRAS' data supplied.

5.2.2 The Engineering Calculation Basis shall provide, for each Engineering Calculation to be performed, at least, the following:

5.2.2.1 Summary and the objective of the document;

5.2.2.2 Design data supplied by PETROBRAS;

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5.2.2.3 Clearly define all potential modes of failure, considered for Serviceability Limit State, Ultimate Limit State, Fatigue Limit State, Accidental Limit State, categorization of fluid, location classes, classification of safety classes and all partial safety factors.

5.2.2.4 The method of calculation and all assumptions;

5.2.2.5 All software packages to be used;

5.2.2.6 All calculation sheets to be used;

5.2.2.7 Any other data required to perform the scope of work.

5.2.3 The software packages to be used shall be described and the area of application outlined. The software packages shall be in agreement with the requirements of this specification and shall be approved by PETROBRAS.

5.2.4 The calculation spreadsheets to be used shall be validated.

5.2.5 The pipeline fill status, flooded or empty condition, shall be highlighted within the assumptions for the Engineering Calculations.

5.2.6 The Engineering Calculations Basis shall be submitted to approval prior to the beginning of the Engineering Calculations.

5.2.7 All mooring analysis and position of anchor during the execution of the entire work shall be supplied for THIRD part and PETROBRAS analysis. Final approval depends on the Ambiental group.

5.3 EXCAVATION STABILITY CALCULATION

5.3.1 The excavation stability calculations shall take into account, at least, the following: the soil conditions, trenching speed, trench depth, water depth, seabed slope and loads imposed due to pipeline and trenching machine.

5.3.2 CONTRACTOR shall define, at least, the following:

5.3.2.1 The maximum allowable trench depth, for a single pass, considering the maximum depth to prevent trench collapse and considering allowable combined stresses for the pipeline to be trenched;

5.3.2.2 The maximum expected towline force;

5.3.2.3 The expected loads imposed on the pipeline by the trencher;

5.3.2.4 The maximum expected pitch and roll of the trencher.

5.3.3 The maximum allowable trench depth to prevent the collapse of trench shall take into account the different soil conditions throughout the pipeline route.

5.3.4 The maximum allowable trench depth, considering allowable combined stresses for the pipeline, shall comply with ref. [B1] and shall take into account each thickness of the concrete

weight coating, if applicable, for the pipeline section to be trenched.

- 5.3.5 The maximum trench depth shall consider the accuracy of the trenching monitoring system.
- 5.3.6 The profile configuration, from where the pipeline is resting on the natural seabed to the touchdown point at the bottom of the trench, to enable field checking of pipeline configurations, shall be provided.
- 5.3.7 The maximum expected towline force shall be in agreement with the station keeping capability or the mooring system of the trenching support vessel, considering the provided meteocean data.
- 5.3.8 The maximum expected roll and pitch of the trencher (or the maximum expected variation of the roll and the pitch along the pipeline length) to prevent no-allowable stresses on the pipeline shall be established. CONTRACTOR shall provide a sensitivity analysis relating the roll and the pitch of the trencher in respect to the achieved stress.
- 5.3.9 The expected loads imposed on the pipeline by the trencher shall not exceed the strength of the pipeline coatings. The pipeline stresses from the expected loads imposed on the pipeline by the trencher shall be in compliance with [B1]. The loads and stresses induced in the pipeline wall by the trenching equipment rollers and supports shall be calculated. The effects of currents and wave induced currents on the trenching equipment, and thus on the pipeline shall be included in the calculations.
- 5.3.10 The pipeline trench depth may be achieved within a single pass whilst maintaining stresses within allowable limits and the trench within a stable configuration. Further passes may be performed provided it can be demonstrated that there will be no adverse damage to the pipeline and coatings.

5.4 MAXIMUM ALLOWABLE LOADS AND STRESSES

- 5.4.1 The engineering calculations shall establish the allowable range for the significant parameters to be monitored during the trenching construction in agreement, at least, with the requirements of Section 6.4. The output of the engineering calculations shall include, at least, a sensitivity analysis relating the significant parameters to be monitored and the achieved pipeline stress. The output format shall be in agreement with Section 5.4.8.
- 5.4.2 The trenching parameters to be monitored, in accordance with Section 6.4, shall be, at least, the following:
 - 5.4.2.1 Loads imposed on the pipeline wall by the rollers or by any guidance or position control;
 - 5.4.2.2 Roll and pitch of the trencher;
 - 5.4.2.3 Stability of the trencher on the pipeline;
 - 5.4.2.4 Position of the pipeline relative to trenching machine;
 - 5.4.2.5 Pipeline trench depth;

5.4.2.6 Tension of the tow winch;

5.4.2.7 Position of the trenching support vessel in respect to the trencher.

5.4.3 The limiting allowable values for the monitored parameters shall be in compliancy with the maximum allowable stresses. In addition, the accuracy of the trenching monitoring system shall be taken into account.

5.4.4 The maximum bending stress in the pipeline during trenching shall not exceed the limits defined by ref. [B1].

5.4.5 Local buckling criteria, considering load controlled condition criteria, as outlined in ref. [B1] shall be satisfied.

5.4.6 The limiting allowable side roller reaction forces calculated shall ensure that the pipeline coating, anodes and field joint are not damaged by the trenching operations.

5.4.7 The allowable range for the monitored trenching parameters shall be established to ensure a safe and reliable construction of the pipeline trench.

5.4.8 The output results shall be presented in both tabular and graphical form for ease of use by field personnel during the monitoring and controlling of the trenching operation. It shall include graphical pipeline profiles from where the pipeline is resting on the natural seabed to the touchdown point at the bottom of the trench to enable field checking of pipeline configurations. The proposed format of presenting the output results shall be submitted for approval prior to performing the calculations.

5.5 TRANSITIONING IN AND OUT OF THE TRENCH

5.5.1 CONTRACTOR shall establish the pipeline transition length associated to the specified trench depth difference, considering the maximum allowable stress for the pipeline in accordance with ref. [B1].

5.5.2 The maximum allowable trench depth for each pass and the number of passes required to perform the transitioning of the trench shall be established.

5.5.3 The loads applied by the trencher equipment on the pipeline shall be considered. The maximum permitted pipeline stress shall consider the accuracy of the trenching monitoring system.

5.5.4 The profile of the transition shall be provided, considering the seabed slope, pipeline profile and associated pipeline stresses.

5.5.5 The profile configuration from where the pipeline is resting on the natural seabed to the touchdown point at the bottom of the trench, to enable field checking of pipeline configurations, shall be provided.

5.6 NORMAL TRENCHING OPERATIONS

5.6.1 An assessment shall be made of the limiting weather, sea and current states in which the



trenching spreads can operate, while ensuring the safety and integrity of the personnel, equipment, the work and any other facilities in the working area. CONTRACTOR shall present the basis of this assessment to PETROBRAS for approval.

5.6.2 The referred assessment shall consider, at least, the effects of the limiting weather, sea and currents states, in the monitored trenching parameters (see Section 6.4). Specifically, variation of the monitored trenching parameters, as a result of the movement of the vessel, from environmental loads, shall be considered to establish variations on the out-of-straightness of the trench. Station keeping or mooring system of the vessel shall be considered in the referred assessment.

5.6.3 The assessments for limiting sea/current states for trenching operations shall be considered as indicative only. The trenching superintendent shall have the ultimate responsibility, after consultation with PETROBRAS representative(s). In case of an operation performed beyond the limiting environmental conditions, a video survey of the pipeline section shall be performed immediately after the referred operation. It should be noted that the trenching operation shall be halted in case of the maximum allowable value (see Section 5.4) for any monitored trenching parameter is exceeded. The objective is to prevent pipeline overstress and to prevent the maximum out-of-roundness to be exceeded.

5.6.4 CONTRACTOR shall define the minimum and maximum water depth at which the trenching can take place, considering each equipment and support vessel to be applied in the scope of work.

5.7 DEPLOYMENT AND RECOVERY OF THE TRENCHER

5.7.1 An assessment shall be made of the limiting weather, sea and current states in which the trencher can be deployed and recovered, while ensuring the safety and integrity of the personnel, equipment, pipeline, work and any other facilities in the working area. CONTRACTOR shall present the basis of this assessment to PETROBRAS for approval.

5.7.2 The dynamic loads induced on the pipeline by the trencher during trencher deployment and recovery shall be considered in the referred assessment. The maximum allowable dynamic loads shall ensure that the pipeline, pipeline coating, anodes and field joints are not damaged by the trencher deployment and recovery operation.

6 TRENCHING REQUIREMENTS

6.1 POSITIONING

6.1.1 LOCAL DATUM

6.1.1.1 The local datum parameters shall be in accordance with Ref. [A6] and Ref. [A7].

6.1.2 POSITIONING EQUIPMENT

6.1.2.1 A surface positioning system for the trenching support vessel and for the survey support vessel shall be provided. The surface positioning system shall be provided using two different systems, one being a back-up system. The primary system shall be the Different Global Positioning System - DGPS (with 100% redundancy) with real time correction either by



satellite, reference station or both. Trenching support vessel and survey support vessel shall have independent positioning systems. The system shall be proposed for PETROBRAS` approval.

6.1.2.1.1 The CONTRACTOR shall operate two DGPS providing 100% back-up in the event of system failure, as the method of establishing surface position. Preference shall be given to systems that receive differential corrections via satellite link and provide a multi-reference station capability with weighting given to the nearest station. The positioning accuracy shall be at least ± 0.5 meters.

6.1.2.1.2 In order to achieve this accuracy the following DGPS parameters shall be monitored in real time and operated within the ranges below (95% of the time):

- PDOP (Position Dilution of Precision) < 4;
- Number of satellites above elevation mask > 6;
- Arrival interval for differential corrections < 3 seconds.


6.1.2.1.3 To allow the quality control of the positioning system the CONTRACTOR shall provide in real time a list of the above DGPS parameters. This information can be delivered on digital text file (ASC II format separated by space).

6.1.2.2 A subsea acoustic navigation system (USBL System) shall be provided for positioning of items or equipment underwater for water depths of 10m or more. In shallower areas towed survey equipment may be positioned using cable layback. During the survey PETROBRAS representative may decide for the use or not of the acoustic positioning information according to the efficiency of the equipment in different water depths. The subsea acoustic navigation system shall be proposed for PETROBRAS` approval.

6.1.2.2.1 This USBL system shall be interfaced with the on-line electronic survey manager system and the surface positioning systems.

6.1.2.2.2 The CONTRACTOR shall supply all necessary equipment in order to have a fully operational USBL system interfaced to the on-line electronic survey manager system and the surface positioning systems. The installation of equipment shall comply with supplier`s recommended requirements, and special attention shall be given to the following:

- The hull mounted USBL transducers shall be located as to minimize disturbances from thrusters and machinery noise and/or air bubbles in the transmission channel or other acoustic transmitters;
- The USBL equipment shall be supplied with its own computer display unit and shall be capable of operating as a stand-alone system;
- The system shall be supplied complete with, as a minimum, the supplier`s recommended spares and replacement components.

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6.1.2.2.3 The installation and calibration of the USBL system shall provide an accuracy of better or equal than 0.5% of water depth.

6.1.2.3 The positioning software to be used in the trenching support vessel and survey support vessel shall be able to allow different targets (e.g.: trenching machine, survey support vessel, anchors position, trenching support vessel) to be monitored simultaneously during trenching operations.

6.1.2.4 The accuracy of the surface positioning system and the accuracy of the subsea acoustic navigation system shall be, at least, in compliance with the following:

6.1.2.4.1 The allowable position of the trencher in respect to the trenching support vessel (see Section 5.4);

6.1.2.4.2 The accuracy required for the trenching surveys (see Table 1).

6.1.2.5 CONTRACTOR shall demonstrate that the accuracy of the proposed surface positioning system and the accuracy of the subsea acoustic navigation system are in agreement with the requirements of Section 6.1.2.4, for the full range of the water depths involved in the scope of work. CONTRACTOR shall include this demonstration in the Positioning Procedure.

6.1.2.6 CONTRACTOR shall request to PETROBRAS, a weekly updated version of SGO, regarding the recording of the position of all subsea pipelines, equipment and structures referred to pipelines trenching area.

6.1.2.7 CONTRACTOR shall take in consideration the eventual presence of other vessels or rigs close to the location where the works will be carried out. Thus, CONTRACTOR shall make prior arrangements with the other unit representatives, supported by PETROBRAS representative responsible for the trenching of the pipelines, in order to prevent interruption on the works.


6.1.3 CALIBRATION

6.1.3.1 The calibration certificates of the positioning equipment shall be presented for THIRTY PARTY review and approval, and subsequently to PETROBRAS review and approval.

6.1.3.2 All positioning equipment shall be properly maintained and regularly checked for accuracy.

6.1.4 POSITIONING ACTIVITIES

6.1.4.1 The positioning activity shall be carried out including the following work, but not being limited to them:

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- 6.1.4.1.1 Positioning of the support vessel throughout trenching operations;
- 6.1.4.1.2 Deployment and recovery of the trenching machine;
- 6.1.4.1.3 Positioning of trenching machine (continuously and throughout the trenching operations) in respect to the support vessel and in respect to the previously installed pipeline;
- 6.1.4.1.4 Positioning of the survey vessel, and underwater survey systems, during inspections activities;
- 6.1.4.1.5 Assistance during deployment of mooring anchors, in the event that the trenching support vessel uses a multi point mooring system as means of propulsion. In this case, a surface positioning system, in accordance with the requirements of section 6.1.2.1 shall be provided for the anchor handling support vessels;
- 6.1.4.1.6 Assistance during deployment of subsea structures or subsea devices.

6.2 TRENCHING SURVEY

6.2.1 SURVEY UNCERTAINTIES (ACCURACIES) AND RESOLUTIONS

- 6.2.1.1 The survey uncertainties (accuracies) and resolutions for the location and elevation of the pipeline shall be, at least, within the range, provided in the following Table 1.

Table 1- Survey Uncertainties (Accuracies) and Resolutions for the Location and Elevation of the Pipelines

| Topographic | | |
|---|-----------------------|------------------------------|
| Uncertainties | Range | Observations |
| Total horizontal uncertainty (THU) | THU ≤ 0,5m | 95% confidence |
| Total vertical uncertainty (TVU) | TVU ≤ 0,03m | 95% confidence |
| Equipment | Resolution | Observations |
| Topography | HR ≤ 20cm | - |
| Subsea | | |
| Uncertainties | Range | Observations |
| Total horizontal uncertainty (THU) | THU ≤ 3,0m | 95% confidence |
| Total vertical uncertainty (TVU) | TVU ≤ WD*0,1% + 0,5m | 95% confidence |
| Equipment | Resolution | Observations |
| Sonar | SHR ≤ 10cm | SHR = across and along track |
| Echo Bathymeter | HR ≤ 10cm VR ≤ 1cm | - |
| Sub-bottom profiler and/ or pipetracker | VR ≤ 15cm | - |
| Magnetometer | R ≤ 0,001nT | - |

SHR = sonar horizontal resolution


VR = vertical resolution

HR = horizontal resolution

R = resolution

6.2.2 SURVEY METHOD

6.2.2.1 The survey area shall comprise a corridor of at least 40m wide with the pipeline position as the central axis of the corridor. At least, 3 (three) regular longitudinal lines shall be provided using sonar and bathymetry equipment. The central line shall be positioned along the pipeline position. The lines shall continue for a minimum of 100m beyond the last KP. In the case of buried pipeline sections longer than 25m, the position and pipeline burial depth below the seabed shall be determined with at least regular cross lines at 10m spacing using sub-bottom profiler and/or pipetracker. Free-spans, buried pipeline sections and excessive pipeline propped shape imperfections identified on the pipeline shall be located (KP) and submitted to detailed inspection. The uncertainties (accuracies) and resolutions of the regular


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longitudinal and crossing lines shall be in accordance with Table 1.


- 6.2.2.2 Continuous color video survey of the entire pipeline section to be trenched shall be undertaken. Both sides of the pipeline shall be simultaneously video surveyed to check for any damage. Damages identified on the pipeline (steel linepipes, coatings and anodes) shall be investigate. The position (KP) of the detected damage shall be recorded and a detailed video inspection shall be performed.
- 6.2.2.3 CONTRACTOR shall use a multi-beam echosounder, or similar survey method, to determine the pipeline depth of trench (or depth of lowering) in respect to the natural seabed. In order to determine the pipeline burial depth, in respect to the natural seabed, for buried pipeline sections, the sub-bottom profiler (SBP) and/or pipetracker shall be used or similar survey method. The uncertainties (accuracies) and resolutions of the sub-bottom profiler (SBP) and/or pipetracker or similar survey methodology shall be in agreement with the requirements of Table 1.
- 6.2.2.4 Total station survey system method, or similar survey method, shall be used at beach zone to determine the topography of the entire pipeline section to be trenched, the topography of the trenched pipeline section, and the topography of the backfilled trench. The system shall include, at least, an electronic theodolite, electronic distance measuring instrument, prism poles and an electronic data collecting system, or similar survey methodology. The electronic theodolite and the prism poles shall have leveling bubbles, so to keep them vertical. The uncertainties (accuracies) of the topographic equipment or similar survey method, shall be in
- 6.2.2.5 Survey methods requiring diving assistance works shall be fully monitored and recorded. The monitoring and recording system shall use remote underwater video survey cameras. In case of low visibility, the method for monitoring and record the diving works shall be proposed by CONTRACTOR.
- 6.2.2.6 Diving survey method shall be avoided. ROV method shall be used when applicable.
- 6.2.2.7 The following geophysical survey equipment shall be used to monitor trench depth, pipeline positions and burial depths: Multi-beam echosounder; side scan sonar; Sub-bottom profiler and/or pipetracker and magnetometer. All the geophysical survey equipment shall be in agreement with the requirements of Table 1.
- 6.2.2.8 All data shall be recorded in digital format (XYZ, XTF and GEOTIFF, SEG-Y and ASCII for bathymetry, sonar, sub-bottom profiler and magnetometer files respectively). The calibration of the survey equipment shall be in accordance with Section 6.1.3.
- 6.2.2.9 The entire survey activity shall be witnessed by a PETROBRAS representative.

6.2.3 PRE-TRENCHING SURVEY

- 6.2.3.1 The purpose of the Pre-Trenching Survey is to document the condition of the pipeline, adjacent seabed and natural seabed, previously to the trenching construction.

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- 6.2.3.2 The Pre-Trenching Survey shall be performed throughout the entire pipeline length to be trenched, with a minimum of 100m width corridor and continue for a minimum of 100 m beyond the last KP.
- 6.2.3.3 Contractor shall consider for the pre-lay survey scope the necessary area for the mooring of the support vessel, if applicable.
- 6.2.3.4 The survey shall consist of at least 3 regular longitudinal lines which shall be provided using sonar and bathymetry equipment. The central line shall be positioned along the pipeline position. In the case of buried pipeline longer than 25m, the position and burial depth of the pipeline below the seabed shall be determined with at least regular cross lines at 10m spacing. The uncertainties (accuracies) and resolutions of the regular longitudinal and crossing lines shall be in accordance with Table 1.
- 6.2.3.5 Significant targets detected within the survey corridor shall be investigated. The position (KP) of the detected targets shall be recorded and video inspection shall be performed.
- 6.2.3.6 The results of the pre-trenching survey shall be reported to PETROBRAS. Remedial actions shall be discussed.
- 6.2.3.7 The pre-trenching survey shall acquire, at least, the following data:
- 6.2.3.7.1 As-laid co-ordinates of the installed pipeline;
 - 6.2.3.7.2 Longitudinal profiles of the bottom of pipeline, adjacent seabed and natural seabed;
 - 6.2.3.7.3 Cross profiles to determine the relative elevations of the pipeline, adjacent seabed and natural seabed;
 - 6.2.3.7.4 Identification of the free-spans of the pipeline, with start and end xy coordinates, length and height;
 - 6.2.3.7.5 Identification of any propped shape imperfections exceeding the maximum acceptance criteria, if applicable;
 - 6.2.3.7.6 Identification of any damage to the pipeline (steel linepipes, coatings and anodes);
 - 6.2.3.7.7 Identification of any debris or obstructions with xy coordinates which could affect safe trenching operations;
 - 6.2.3.7.8 Position of all geophysical profiles (bathymetry, side scan sonar, sub-bottom profiler and magnetometer) executed during the pre-trenching survey;
 - 6.2.3.7.9 Position (xy coordinates) of buried pipelines or cables, if any, with corresponding burial depth (z);
 - 6.2.3.7.10 All geophysical data shall be recorded in digital format (XYZ, XTF and GEOTIFF, SEG-Y and ASCII for bathymetry, sonar, sub-bottom profiler and magnetometer files respectively).

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6.2.3.8 CONTRACTOR shall submit to THIRDY PARTY review and approval, and, subsequently, to PETROBRAS review and approval, the pre-trenching survey method, for each pipeline trenching zone. CONTRACTOR shall be responsible to verify the constraints of any survey trenching method to be proposed.

6.2.3.9 CONTRACTOR shall submit to THIRDY PARTY review and approval, and subsequently to PETROBRAS review and approval, the sea trial procedure for the pre-trenching survey method, in accordance with the requirements of Section 6.6.

6.2.4 POST-TRENCHING SURVEY

6.2.4.1 CONTRACTOR shall perform a survey of the entire length of the pipeline that has been trenched, immediately after each trenching operation has been completed.

6.2.4.2 The survey shall demonstrate whether trenching and backfilling, when applicable, have been performed in accordance with the specified requirements and shall be used as the basis for PETROBRAS approval for the 'as-trenched' pipelines.

6.2.4.3 CONTRACTOR shall submit to THIRDY PARTY review and approval, and, subsequently, to PETROBRAS review and approval, the post-trenching survey method, for each pipeline trenching zone (see specified trench depths). CONTRACTOR shall be responsible to verify the constraints of any survey trenching method to be proposed. CONTRACTOR shall consider, at least, the minimum requirements of this specification, the required survey accuracy (see Table 1), the requirements of Section 6.2.2 and the performance of the proposed method for each trenching zone.

6.2.4.4 The post-trenching survey configuration shall consist of as much longitudinal/cross profiles and transects as needed to allow the correct determination of the trench depth, position of the pipeline as well as propped shape imperfections and free-spans. Eventual buried sections shall be surveyed with both sub-bottom profiler and pipetracker or magnetometers with regular cross profiles at 10 m spacing.

6.2.4.5 At the end of the trenching a final report shall be issued by the CONTRACTOR describing the final as-laid coordinates and profiles of the trenched pipeline.


6.2.4.6 CONTRACTOR shall submit to THIRDY PARTY review and approval, and subsequently to PETROBRAS review and approval, the sea trial procedure for the post-trenching survey method, in accordance with the requirements of Section 6.6.

6.3 TRENCHING EQUIPMENT

6.3.1 GENERAL REQUIREMENTS

6.3.1.1 The trenching equipment proposed for operations shall be of a proven design and shall have been demonstrated by track records its capability to trench the pipeline to the required depth, in the expected soil conditions.


6.3.1.2 The trenching machine shall be fitted with a monitoring system, in accordance with Section 6.4.

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- 6.3.1.3 The trenching equipment shall be fitted with a control system, in accordance with Section 6.5.
- 6.3.1.4 The launch system of the trenching machine shall permit a safe deployment, and recovery, of the trenching machine on the pipeline, in accordance with the requirements of Section 6.7.
- 6.3.1.5 The only contacts between the trenching machine and the pipeline shall be guidance controls, position monitors and the rollers of the equipment. Each roller, guidance control and position monitor, shall have a thick polyurethane coating for extra protection, or similar. The orientation of the rollers shall prevent any steel contact to pipeline.
- 6.3.1.6 The trenching machine shall be capable of forming a smooth profile at the ends of trenched sections to ensure that the pipeline will not be subject to spanning and shall be capable of operating in all anticipated soil conditions.
- 6.3.1.7 The trenching machine shall deposit excavated spoil at a sufficient distance from the edge of the trench to ensure that minimal quantities slip back into the trench during excavation.

6.3.2 ACCEPTANCE TRIALS

- 6.3.2.1 New or modified vessels and trenching equipment shall be subjected to an acceptance trial prior to approval being given for the completion of mobilization for the commencement and of any work.
- 6.3.2.2 Procedures for conducting the vessel acceptance trials shall be submitted for THIRDY PARTY and, subsequently, for PETROBRAS approval.
- 6.3.2.3 The location of the trials shall be mutually agreed and shall be close to the Work location.
- 6.3.2.4 The trials shall consist of functional tests of all primary equipment to be used in the trenching spread.
- 6.3.2.5 A field test shall be performed to prove the station keeping capability of the vessel. CONTRACTOR shall include this activity in the schedule of the vessel. PETROBRAS representative shall also witness and approve the test.
- 6.3.2.6 In addition, sea trials to evaluate the functionality of the positioning system, survey system and monitoring system (see Section 6.6) shall be performed. It should be noted that these sea trials shall be performed for any trenching equipment to be used by CONTRACTOR to execute the scope of the work.
- 6.3.2.7 The acceptance trial shall be witnessed by PETROBRAS representative.
- 6.3.2.8 CONTRACTOR shall include in the Project Schedule the referred test(s).
- 6.3.2.9 Personnel who will ultimately perform the work outlined in this Specification shall also undertake the acceptance trials.

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6.3.3 CONTINGENCIES

- 6.3.3.1 CONTRACTOR shall provide sufficient contingency equipment on standby such that immediate action can be taken should an emergency occur.
- 6.3.3.2 The CONTRACTOR shall identify the requirements and demonstrate the adequacy of the proposed contingency methods, equipment and personnel.
- 6.3.3.3 Contractor shall be responsible for any pipeline damage repair during trenching activities and shall provide contingency procedures for, at least, coating repair (concrete, anticorrosion, field joint, etc), anode damage, pipeline damage, etc...

6.4 MONITORING SYSTEM

6.4.1 DESCRIPTION

- 6.4.1.1 The trenching equipment shall be fitted with instrumentation and sensors connected to load cells on the trenching machine to measure and record, continuously, under all circumstances, all vertical and horizontal forces exerted on the pipeline by the trencher. These load cells and recording instruments shall be such that the calculated maximum allowable forces fall between 50% and 90% of the capacities of the cells. The accuracy of these cells and instruments shall be 1% at Full Scale Deflection (FSD).
- 6.4.1.2 All the rollers (or any other guidance controls or position monitors) of the trenching machine, which contact the pipeline, shall be assembled on load cells. The requirements of the instrumentation of the load cells shall be in accordance with Section 6.3.1.1. In addition, alarms shall be set which warn the trenching machine pilot if the maximum loads are being approached.
- 6.4.1.3 The equipment shall be fitted with instrumentation and sensors connected to inclinometers on the trenching machine to measure and record, continuously, under all circumstances, the pitch and the roll of the trencher. These sensors and recording instruments shall be such that the calculated maximum allowable pitch and roll angles fall between 50% and 90% of the capacities of the cells. The accuracy of these inclinometers shall be 1% at Full Scale Deflection (FSD). In addition, alarms shall be set which warn the trenching machine pilot if the maximum allowable values for the pitch and roll angles are being approached.
- 6.4.1.4 Facilities for the continuous underwater video monitoring systems enabling the trenching equipment operator to view the pipeline and seabed profile forward and aft the trencher, as well as viewing all rollers and support points. Recording facilities including a sufficient memory capacity shall be provided and recordings shall be taken of all the video pictures.
- 6.4.1.5 Pipetrackers and profilers, or similar monitoring devices, to identify the pipeline and seabed profile forward and aft the trencher, shall be used to indicate the position of the pipeline relative to the trenching machine and the pipeline trench depth, in particular for low visibility operations, or for buried sections of the pipeline. Recording facilities shall be provided. In addition, a forward looking obstacle avoidance sonar, or similar monitoring device, shall be used.

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- 6.4.1.6 The launch system shall be heave compensated so that the trenching machine shall be deployed and recovered very slowly, unaffected by vessel motions. As an option, CONTRACTOR shall provide, and monitors by accelerometers, or similar technique, the maximum allowable movements of the vessel (from the environment action), to permit deployment and recovery of the trenching machine.
- 6.4.1.7 The fine positioning of the trenching machine on the pipeline is preferably done visually using pan and tilt video cameras. Scanning sonars (front and rear) and pipetrackers, or similar monitoring devices, shall be used instead of the cameras in case of low visibility, or in case of buried sections of the pipeline.
- 6.4.1.8 The tow winch for the trenching machine shall be equipped with tension indicators and line out indicators, and shall be monitored by remote video camera. The tow winch instruments shall produce a continuous record of tow force, tow speed and length of tow cable.
- 6.4.1.9 Devices monitoring depth and speed of the trencher shall be provided. Recording devices shall be provided.
- 6.4.1.10 The position of the trenching machine (X, Y, Z and heading) in respect to the trenching support vessel shall be provided. The position of the trenching machine in respect to pipeline shall also be provided. Recording devices shall be provided.
- 6.4.1.11 All records produced shall be marked every 6 hours and at starts and stops with the date and time of day and CONTRACTOR's signature. CONTRACTOR shall obtain PETROBRAS counter signature on all records.
- 6.4.1.12 Monitoring devices shall be provided to guarantee the specified natural backfilling, if applicable.

6.5 CONTROL SYSTEM

- 6.5.1 CONTRACTOR shall supply a control system based on the monitoring system described in Section 6.4. The control system shall provide a practical and reliable procedure to maintain the pipeline stresses within allowable values, in accordance with the Engineering Calculations.
- 6.5.2 The real-time pipeline stresses shall be obtained from the data collected from the monitoring system of the trencher, which shall be post-processing to achieve the pipeline stresses (in accordance with ref. [B1]).
- 6.5.3 The maximum allowable stress imposed on the pipeline by the trencher shall be in compliancy with the Engineering Design.
- 6.5.4 CONTRACTOR shall provide a continuous indication and recording of the monitored parameters and the maximum allowable value for these parameters. Alarms shall be set which warn the trencher pilot if the maximum allowable loads (or stresses) are being approached. Charts with the trenching control parameters (maximum allowable value and monitored value), shall be supplied to PETROBRAS representative, in accordance with Section 6.8.
- 6.5.5 The control system shall be concentrated in the Trenching Control Room, which should be located in the bridge of the trenching vessel. As an option a repeater scream, including the

trenching monitored parameters, should be located in the bridge.

6.5.6 The trenching machine pilot shall have a navigation screen which shows, at least, the pipeline route ahead of the trencher, the position of the trenching support vessel (X, Y, Z and heading) and the real time position of the trenching machine (X, Y, Z and heading). In addition, all information from the monitoring system shall be included in the navigation screen, or shall be presented to the trenching machine operator in different screens. These screens shall provide for the trencher pilot, clear visual interpretation of the current value and maximum allowable value for the monitored trenching parameter.

6.5.7 All instrument monitors and recorders shall be in a location accessible to PETROBRAS representative. The records collected during the operation shall be presented as part of the as-built documentation.

6.5.8 Alternative control systems are encouraged to be proposed by CONTRACTOR for approval.

6.5.9 CONTRACTOR shall submit to THIRDY PARTY review and approval and, subsequently, to PETROBRAS review and approval the trenching control method. CONTRACTOR shall be responsible to verify the constraints of the trencher control method to be proposed. CONTRACTOR shall consider, at least, the minimum requirements of this specification, the survey accuracy required in Table 1, requirements of this Section 6.5, and the performance of the proposed method for each trenching zone.

6.6 SEA TRIALS

6.6.1 The proposed surface positioning system and the proposed acoustic navigation system (USBL) shall be tested (sea trial) to prove the required accuracy, for extreme water depths (minimum and maximum). CONTRACTOR shall submit the sea trial procedure with the surface positioning system and the proposed acoustic navigation system to THIRDY PARTY approval, and subsequently to PETROBRAS approval.

6.6.2 The sea trial shall be carried out in accordance with the approved procedures, being all equipment tested onshore prior to the departure and witnessed by a PETROBRAS representative.

6.6.3 The proposed survey method shall be tested (sea trial) to prove to be in compliancy with the required uncertainties (accuracies) and resolutions (see Table 1), for the respective trenching zone (see specified trench depths). The sea trial procedure shall be submitted to THIRDY PARTY review and approval and, subsequently, to PETROBRAS review and approval.

6.6.4 The proposed monitoring system shall be tested to prove the required accuracy, for limiting water depths. CONTRACTOR shall submit the test procedure to THIRDY PARTY review and approval, and subsequently to PETROBRAS review and approval

6.6.5 The sea trial shall be witnessed by PETROBRAS representative.

6.6.6 CONTRACTOR shall include the sea trial in the Project Schedule.

6.6.7 The requirements of Section 6.1.2.7 shall be considered for the sea trial.

6.7 TRENCHER DEPLOYMENT AND RECOVERY

6.7.1 The deployment and recovery of the trencher shall comply with the maximum environmental condition established in the Engineering Design, to prevent damages on the pipeline to be trenched.

6.7.2 The trencher deployment and recovery system shall be heave compensated. As an option accelerometers, or similar technique, shall be used, in accordance with the requirements of Section 6.4. Being accelerometers, or similar technique, required the allowable range for trenching deployment and recovery shall be established. The trencher deployment or recovery operation shall not be performed while the indication of the accelerometers (or similar technique), or load variation for the heave compensation system, is greater than the maximum allowable value.

6.7.3 The trencher deployment operation shall be performed with application of a check list to be fulfilled by the CONTRACTOR, including at least:

- a) Sea state and seabed current conditions;
- b) Vessel behavior;
- c) Weather forecast;
- d) Lifting Gear and equipment condition;
- e) Diving equipment checking or ROV;
- f) Procedure knowledge of key personnel;
- f) Tool Box Talk with all personnel.

6.7.4 The assessments for limiting sea/current states for trenching deployment or recovery operations shall be considered as indicative only. The trenching superintendent shall have the ultimate responsibility after consultation with PETROBRAS representative(s). In case of an operation performed beyond the limiting environmental conditions, a video survey of the pipeline section shall be performed immediately after the referred operation.

6.7.5 The trencher deployment or recovery operation shall not be performed while the indication of the accelerometers (or similar technique), or load variation for the heave compensation system, is greater than the maximum allowable value.

6.7.6 In accordance with Section 6.4, CONTRACTOR shall monitor, using accelerometers (or by variation of the load of the heave compensation system, if it occurs), whether or not the existing environmental conditions allow the trencher to be deployed or recovered. The accelerometers, or similar technique, shall have indicators on the Trenching Control Room to allow easy access to the pilot of the trencher and to PETROBRAS representative. The maximum allowable accelerations for trenching deployment and recovery shall be clearly established in the Installation Manual. The accelerations occurred during the deployment of the trencher shall be monitored and recorded. Alarms shall be set which warn the trenching machine pilot if the maximum deployment and recovery accelerations are being approached.

6.7.7 Being the launching system of the trencher heave compensated, CONTRACTOR shall demonstrate the effectiveness of the heave compensation system, considering an actual sea condition in which the trencher will be deployed. It should be noted that the trencher shall be deployed and retrieved very slowly, unaffected by vessel motions. If the heave compensation system of the vessel can not provide this condition, accelerometers shall be used to monitor the deployment and recovery of the trencher. The loads occurred during the deployment of the trencher shall be monitored and recorded. Alarms shall be set which warn the trenching machine pilot if the maximum deployment and recovery loads are being approached.

6.7.8 The heading of the trenching machine shall be controlled during deployment or recovery operations, to permit heading alignment between the trencher and the pipeline. The alignment system of the trencher shall use, at least, one winches, one constant tension winch located on the vessel. Being the alignment system of the trencher self propelled, using thrusters, the winches are not mandatory devices.

6.7.9 The pipeline shall not be used as an anchor point to assist trencher deployment or recovery.

6.7.10 In accordance with Section 6.4 (Monitoring System), pan and tilt video cameras, or front and rear scanning sonar (in case of low visibility), or pipetrackers (in case of buried pipelines), or similar methods, shall assist the positioning of the trenching machine on the pipeline. Divers, or ROV, with underwater video camera or scanning sonar may also assist the positioning of the trenching machine.

6.7.11 The Trenching Control Room, shall gather all the information related to the trencher deployment, or recovery. The referred information shall, at least, include images of the video cameras, `readings` of rear and front sonar, `readings` of the pipetracker, indications of the accelerometer.

6.7.12 Prior to trencher deployment all components of the trenching equipment, or any instrumentation or sensor of the monitoring system, shall be tested for correct functioning. The referred tests shall be witnessed by PETROBRAS representative. Failure of functioning of any component of the trenching equipment or monitoring system shall be corrected before trenching deployment.

6.7.13 Alternative trenching machine deployment and recovery methods are encouraged to be proposed by CONTRACTOR for approval.

6.7.14 CONTRACTOR shall submit to THIRDY PARTY review and approval, and, subsequently, to PETROBRAS review and approval, the trenching machine deployment and recovery method. CONTRACTOR shall be responsible to verify the constraints of the trencher deployment and recovery method to be proposed. CONTRACTOR shall consider, at least, the minimum requirements of this specification, the requirements of this Section 6.7 and the performance of the proposed method for each trenching zone.

6.8 NORMAL PIPELINE TRENCHING OPERATIONS

6.8.1 Prior to commencing trenching on the pipeline, the results of the pre-trenching survey shall be reviewed and confirmation given that no adverse conditions exist which would affect an efficient trenching operation. Any natural obstacles, such as large rocks, boulders, etc., shall be

removed as part of the work in accordance with the approved procedure.

6.8.2 The trenching machine shall lower the pipeline to the required level with a single pass while complying with applicable stress levels. Further passes may be performed, provided it can be demonstrated that there will be no adverse damage to the pipeline and coatings. At the offshore end of the trench, the trench shall be smoothly profiled back to the natural seabed over the transition length. The trench shall also be smoothly profiled at trench depth changes, in accordance with the specified trench depths of the pipeline sections.


6.8.3 Twice daily (minimum) three-day weather forecasts and weather map from a recognized forecasting authority shall be obtained.

6.8.4 During the trenching operations, monitoring personnel shall periodically report, at least every 12 hours on the operation of the trenching machine. This check shall be increased to every 4 hours after the initial start up, for the first 12 hours, and at trench depth changes. This report shall include, at least, the following information:

- 6.8.4.1 Depth and profile of the trench;
- 6.8.4.2 Pipeline trench depth (or pipeline burial depth);
- 6.8.4.3 Condition of the linepipe coating, anodes and field joints;
- 6.8.4.4 Condition of the trenching machine, including wear on any of the rollers;
- 6.8.4.5 Material being trenched;
- 6.8.4.6 Pipeline profile relative to the natural seabed (pipeline trench depth);
- 6.8.4.7 Pipeline freespans;
- 6.8.4.8 Backfilling profile, if applicable;
- 6.8.4.9 Any video survey as back-up and when requested by PETROBRAS.

6.8.5 In addition to the monitoring personnel report, a log of the following shall be kept throughout all trenching operations:

- 6.8.5.1 Vertical and lateral loads imposed on the pipeline by the trencher;
- 6.8.5.2 Pipeline stresses from the monitored trenching parameters;
- 6.8.5.3 Pull force (of the tow winch);
- 6.8.5.4 Envelop of the locations of the vessel in respect to the trenching machine;
- 6.8.5.5 Roll and pitch of the trenching machine;
- 6.8.5.6 Pipeline trench depth (or burial depth);
- 6.8.5.7 Trench profile;

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6.8.5.8 Backfilling profile, if applicable.

6.8.6 If at any time the instrumentation or videos indicate that damage to the pipeline may have occurred, CONTRACTOR shall interrupt the trenching operation and perform a video survey of the suspect area. The video survey shall be witnessed by PETROBRAS representative. The same procedure shall be adopted if a trenching monitored parameter is exceeded. Repairs and remedial works detected during trenching operation shall be performed in agreement with Section 6.10.

6.8.7 The logs shall highlight points at which any monitored trenching maximum parameters have been exceeded and, in accordance with Section 6.8.6, the trenching shall be halted and a video survey performed. The results of the video survey shall be formally reported. If necessary, a proposal to rectify the damage shall be submitted to PETROBRAS` approval.

6.8.8 Failure of any component of the trenching equipment, including failure in any instrumentation and failure in any sensors of the trencher monitoring system, shall be cause for cessation of trenching operations. CONTRACTOR shall provide sufficient spare parts on stand by such that immediate remedial action can be taken should a failure occur.

6.8.9 Trenching operations shall be discontinued whenever the weather conditions are deteriorating to such an extent that there is a risk of the pipeline becoming over-stressed or damage to the coating or pipeline attachments. At this stage of operations, the trenching monitoring system parameters shall have achieve the warning condition.

6.8.10 Where equipment is abandoned on the seabed it shall be made safe to PETROBRAS' satisfaction such that it shall not cause damage to the pipeline.

6.9 MOORING SYSTEMS

6.9.1 In the event that the operations support vessel uses a multi point mooring system as means of propulsion, CONTRACTOR shall demonstrate to the satisfaction of the PETROBRAS that the mooring system is adequate for all phases of operations and complies with Marine Operations Procedures. This will include compliance with the following:

6.9.1.1 All anchor winches shall be equipped with tension indicators and line out indicators, and shall be monitored by remote video camera;

6.9.1.2 CONTRACTOR shall maintain a full certification register of anchor wires;

6.9.1.3 The trenching vessel anchors shall be of a type suitable for the soil conditions along the pipeline routes;

6.9.1.4 Anchor handling vessels shall be capable of operating in weather conditions during which anchor handling is planned;

6.9.1.5 For anchor handling purposes throughout trenching operations, a suitable number of vessels shall be available at all times. Vessels shall be open decked, suitably equipped and able to retrieve anchors onto deck from the seabed;

6.9.1.6 In areas where anchors are to be laid within 500 meters of pipelines or other existing facilities,



reference shall be made to Marine Operating Procedures;

6.9.1.7 CONTRACTOR shall exercise extreme care when anchoring within close proximity to existing cables, pipelines, wellheads or platforms. Anchor positioning, deployment and handling procedures shall be submitted for approval. All anchoring shall subsequently be performed in accordance with approved procedures which shall be developed in compliance with relevant Marine Operations Procedures.

6.9.2 Detailed drawings of anchor patterns shall be prepared for approval by PETROBRAS before anchoring within three kilometers of any platform, two kilometers of any wellhead, one kilometer of any pipeline. All detailed drawings shall also be submitted to Environmental Authorities for approval.

6.9.3 Where an anchor cable cross a pipeline or live cable, the anchor patterns shall be accompanied by drawings of catenary curves for all anchor running and operating anchor cable tensions and configurations. It is not permitted anchor cables contact with pipelines or cables at any time.

6.9.4 The position of any existing pipeline or live cable shall be verified if anchor pattern drawings indicate that an anchor is placed within 1000 meters or crosses the pipeline or cable. CONTRACTOR shall liaise with the regulatory authorities and comply with requirements to clear anchor mounds if requested.

6.9.5 CONTRACTOR shall liaise with PETROBRAS and the operators of third party pipelines/cable that the pipelines cross. The anchoring procedures shall reflect the third party operator's requirements.

6.9.6 If an anchor cable crosses pipeline, live cable, structure or wellheads, then the anchor shall be decked and secured aboard the anchor handling vessel during anchor running/recovery operations.

6.9.7 A log of all anchor positions and anchor movements shall be maintained.


6.10 REPAIRS AND REMEDIAL WORKS

6.10.1 CONTRACTOR shall be responsible for any repairs or remedial work required as a result of damage to the pipeline or its coverings during trenching. Methods for repairing any damage to steel linepipe, corrosion coating and/or concrete coating shall be submitted for THIRDY PARTY and, subsequently, for PETROBRAS approval.

6.10.2 For any portion of the pipeline not trenched to the required depth (in accordance with the specified trench depths), a remedial procedure shall be submitted by CONTRACTOR to THIRDY PARTY and, subsequently, PETROBRAS for approval.

6.10.3 Any free-spans greater than the maximum allowable, regarding the pre-trenching survey, shall be trenched in accordance with the procedure "Trenching of Pipeline sections in free Span Conditions".

6.10.4 Repairs shall only be performed in accordance with approved procedures. PETROBRAS representatives shall witness and approve any performed repair.

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6.11 POST-TRENCHING HYDROTEST

- 6.11.1 The hydrotest shall be performed in accordance with the requirements of ref. [A4] and ref. [B1], considering the specified hydrotest pressures and the holding period.
- 6.11.2 The hydrotesting is required to be provided twice, being the first time after pre-trenching, if applicable, and the second time before the as-built survey.
- 6.11.3 The pipelines are required to be cleaned, dewatered and conditioned after the second hydrotesting is accepted, in compliance with [A5], if specified in the project.

6.12 LANDFALL REINSTATEMENT

- 6.12.1 CONTRACTOR shall propose a landfall reinstatement specification for approval by PETROBRAS, if applicable.

6.13 ONSHORE SITE PREPARATION


- 6.13.1 Prior to the commencement of the Work the CONTRACTOR shall carry out a pre-entry survey to agree and record with the PETROBRAS the existing condition of areas where work is to be carried out or access provided. These surveys shall be recorded in external Hard Disk with USB connection.
- 6.13.2 All the onshore works necessary for equipment and personal installation including safety procedures and area isolation are in the scope of work of the CONTRACTOR.

6.14 DRAWINGS

- 6.14.1 Contractor shall provide clear and detailed engineering drawings which shall include, at least, the following:
- 6.14.1.1 Drawing showing the configuration of the towing equipment (if applicable) at various stages of the operation.
- 6.14.1.2 Deployment and recovery of the equipment.
- 6.14.1.3 Vessel(s) positions relative to the equipment as well as existing facilities.
- 6.14.1.4 Anchor patterns and anchor handling methods (as applicable).
- 6.14.1.5 As-built drawings for the pipeline. The as-built drawings shall be geo-referenced and delivered in .DWG format.

7 DOCUMENTATION

- 7.1 Contractor shall issue, at least, the documents mentioned in the section 3.3.
- 7.2 All documents shall contain the following sections, when applicable:
- 7.2.1 Project Description;

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7.2.2 Document Scope;

7.2.3 Executive Summary;

7.2.4 Definitions & Abbreviations

7.2.5 Pipeline Features (wall thickness, linepipe material, coatings, etc)

7.2.6 Design Data (design and hydrotest pressures, geophysical and geotechnical data, environmental conditions, reference datum, etc)

7.2.7 Project Software Packages & Calculation Spreadsheets

7.2.8 Input Data;

7.2.9 Premises;

7.2.10 Methodology;

7.2.11 Equipment Description;

7.2.12 Vessel Description;

7.2.13 Maximum Allowable Values for the Trencher Deployment, Recovery and Control Parameters;

7.2.14 Weather Limitations for Trenching Deployment and Recovery Operations;

7.2.15 Control of Pipeline Stresses and Loads During Trenching;

7.2.16 Control of the Upright Position of the Trencher;

7.2.17 Contingency for Temporary Abandonment of Trencher;

7.2.18 Drawings and Graphs;

7.2.19 Analyses and Results;

7.2.20 Conclusions;


7.2.21 Design Codes and References.

7.2.22 In case of reports containing analytical calculations, a detailed spreadsheet (original file format) showing step by step the calculation shall be presented. No blocked or hidden areas are allowed.

7.2.23 In case of reports containing numerical models, at least the following items shall be presented:

7.2.23.1 Detailed description of the model;

7.2.23.2 Critical case input electronic files;

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7.2.23.3 Critical case output electronic files.

7.2.23.4 List or table of all cases run containing main inputs and outputs.

8 AS BUILT REPORTS

8.1 GENERAL

8.1.1 During the operations, the CONTRACTOR shall prepare and collect information which will form the basis for, and be included, in the As Built Report which the CONTRACTOR is required to produce following completion of the Work.

8.1.2 These reports shall consist at minimum of:

8.1.2.1 Survey Documentation;

8.1.2.2 Trenching/Backfilling Control System Parameters Registers;

8.1.2.3 Corrected Freespans;

8.1.2.4 Pipeline As Built Alignment Sheets;

8.1.2.5 Hydrotest Report;

8.1.2.6 Performed Repairs.

8.2 SURVEY DOCUMENTATION

8.2.1 Survey documentation shall be produced on board the survey vessel as the survey work proceeds.

8.2.2 The survey shall also include the landfall section of the pipeline whether the pipeline is installed into a pre-formed trench or trenched concurrently.

8.2.3 The Survey Documentation shall include:

8.2.3.1 A written report of survey findings and observations along the pipeline;

8.2.3.2 Records (all records shall be fully indexed);

8.2.3.3 Cross profiles of the pipeline indicating trench depths;


8.2.3.4 Electronic media with all relevant data in a format to be approved by PETROBRAS. (This item may be produced onshore after completion of the work);

8.2.3.5 Selected still photos from pipeline damages or other notable areas;

8.2.3.6 Trenched data is to be adjusted to same absolute level as the 'as laid' survey data.

8.3 TRENCHING CONTROL SYSTEM PARAMETERS REGISTERS

8.3.1 At least, the following trenching control parameters shall be registered:

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- 8.3.1.1 Vertical and lateral loads applied on the pipeline;
- 8.3.1.2 Pipeline maximum stresses, from the loads applied on the pipeline;
- 8.3.1.3 Pull force (of the tow winch);
- 8.3.1.4 Location of the vessel in respect to the trenching machine;
- 8.3.1.5 Roll of the trenching machine.

8.4 CORRECTED FREE-SPANS

- 8.4.1 Any free-spans greater than the maximum allowable as specified during detail engineering shall be trenched in accordance with the procedure "Trenching of Pipeline Sections in Free Span Conditions.
- 8.4.2 The corrected freespans shall be included in the pre-trenching survey documentation.

8.5 HYDROSTATIC TEST

- 8.5.1 Summary of the work performed.
- 8.5.2 Hydrostatic test charts, which shall be remarked and the requirements presented in ref. [A3], when applicable, ref. [A4] and ref. [A5], when applicable.

8.6 COATING AND ANODE REPAIR

- 8.6.1 A report containing the detailed location and extension of the performed pipeline repairs shall be provided.

8.7 DOCUMENTATION FORMAT

- 8.7.1 All final documents included within the Sections 7 and 8, shall be compiled into an external Hard Disk with USB connection with a navigator, to be issued to PETROBRAS at the end of the work. Three (3) units shall be provided.
- 8.7.2 The video survey shall be recorded on digital means and delivered to PETROBRAS in an external Hard Disk with USB connection Those videos shall be voice commented at relevant spots or edited with explicative subtitles. The system shall have an introductory menu to guide to that relevant parts of the inspection.
- 8.7.3 All documents shall be delivered in pdf with text recognition.
- 8.7.4 CONTRACTOR shall also deliver the geo-referenced drawings in .DWG format.