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|  | TECHNICAL SPECIFICATION | | Nº: I-ET-3000.00-1516-823-PEK-058 | |
| | CLIENT: | E&P | FOLHA: 1 of 15 | |
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| DP&T- SUB/ES/EECE/ECE | TITLE: WET ELECTRICAL CONNECTOR FOR PERMANENT DOWNHOLE GAUGE | | | |

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TITLE: WET ELECTRICAL CONNECTOR FOR PERMANENT DOWNHOLE GAUGE

INDEX

| | | |
|---|---|----|
| 1 | SUBJECT..... | 3 |
| 2 | GENERAL..... | 3 |
| 3 | SPECIFICATIONS | 4 |
| 4 | QUALITY ASSURANCE PROVISIONS | 7 |
| 5 | SITE INTEGRATION TEST AND TRAINING..... | 12 |
| 6 | DOCUMENTATION | 12 |
| 7 | APPLICABLE DRAWINGS | 14 |



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TECHNICAL SPECIFICATION

Nº

I-ET-3000.00-1516-823-PEK-058

REV.

0

PAGE

3

of

15

TITLE:

WET ELECTRICAL CONNECTOR FOR PERMANENT DOWNHOLE GAUGE

1 SUBJECT

This specification gives the detailed technical information and requirements for the WET ELECTRICAL CONNECTOR for Permanent Downhole Gauge (PDG) installations to be mounted into the tubing hanger and the X-mas tree at a water depth up to 2500 m.

1.1 DEFINITIONS AND ACRONYMS

PDG Permanent Downhole Gauge.

“Shall” or “must” Indicates a mandatory requirement.

“Should” Indicates a requirement for the good engineering practice.

TH Tubing Hanger.

2 GENERAL

The TH/Xmas Tree wet connector will provide a reliable method of breaking and reconnecting the PDG sensor installed inside the well and the electrical system installed on the Xmas-tree. The connectors must be capable of withstanding multiple mate/demate cycles in this environment.


The connectors shall have the following general features:

2.1 They shall have only one contact;

2.2 They shall be capable of connecting and disconnecting in sea water and completion fluid at a water depth up to 2500m;

2.3 They shall be resistant to tree and TH installation conditions (shock and vibration) and storage (under weather).

Each one of these connectors, the tubing hanger mounted connector assembly and the Xmas-tree connector assembly, have to follow the electrical specifications listed below.

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|---|-------------------------|----------------------------------|--------------|
|  | TECHNICAL SPECIFICATION | Nº I-ET-3000.00-1516-823-PEK-058 | REV. 0 |
| | TITLE: | | PAGE 4 of 15 |
| WET ELECTRICAL CONNECTOR FOR PERMANENT DOWNHOLE GAUGE | | | |

3 SPECIFICATIONS

3.1 GENERAL

- 3.1.1 The plug (female) connector shall be mounted on the X-mas tree and the receptacle (male) connector on the tubing hanger;
- 3.1.2 The male and female connectors shall be capable of being mounted into the tubing hanger and on the X-mas tree, without breaking the electrical connections with the cables on the rear of the connectors.
- 3.1.3 The male and female connector must be manufactured to be mounted in the standard interfaces as showed in drawing DE-3000.00-1500-823-SRP-001 and **Figure 2**.
- 3.1.4 The tubing hanger connector assembly shall be rigidly fixed.
- 3.1.5 The tree mounted connector assembly shall be designed to absorb all misalignment between the tree and tubing hanger as specified in section 3.4.
- 3.1.6 The cable connection at the rear of the connector assemblies shall provide a redundant sealing system with at least two mechanical barriers against water ingress.
- 3.1.7 The electrical contacts shall be protected from seawater contamination during mating by placing the contact in some type of controlled environment, such as an oil or gel filled chamber, with a minimum of two mechanical barriers against water ingress.
- 3.1.8 Connector assemblies shall be capable of withstanding normal oil well completion and production fluids.
- 3.1.9 Connector assemblies shall be capable of withstanding tree installation and gas production conditions (shock and vibration) and storage (weather).
- 3.1.10 The male (tubing hanger) connector pin shall be capable of exposure to seawater environment for a minimum of one year without corroding.
- 3.1.11 The cable connection at the rear of the connector assemblies shall provide a redundant sealing system with at least two mechanical barriers against water ingress.
- 3.1.12 Connector assemblies shall be capable of mating and de-mating in seawater at a depth of 2500m (8200 ft).
- 3.1.13 The rear of the connector to be mounted on the X-mas tree shall be designed to absorb the above misalignment and shall be compatible with the 3 mm encased wire. A minimum of 3 m length of this wire shall be furnished with this connector.

- 3.1.14 The connector shall be capable of maintaining electrical and mechanical integrity over 100 operations (connections/disconnections).
- 3.1.15 The connector to be mounted on the X-mas tree shall use an integral flange to assembly it bellow the X-mas tree.
- 3.1.16 The connector to be mounted on the Tubing Hanger must have metal to metal seal, inside and outside (between the connector and the TH body), to provide a gas seal.
 - 3.1.16.1 The metal to metal seal between the connector and the TH body must be at the bottom interface of the TH, which is detailed in page two of the drawing DE-3000.00-1500-823-SRP-001.
 - 3.1.16.2 The part of the connector to be installed at the bottom interface of the TH must have a testable metal-metal sealing interface with the PDG cable.
- 3.1.17 The cable terminations, in both connectors, shall be capable of being field assembled and tested (the barriers must be field testable);
- 3.1.18 The rubber seals should be compatible of petroleum, gas and silicon oil.
- 3.1.19 The length of the space bar to be mounted into the tubing hanger must be at least 2 m long.
- 3.1.20 The connector body shall provide a ground return path when the connector is mated.

3.2 ENVIRONMENT

| | |
|-----------------------------|-------------------------------|
| Maximum Working Pressure | 10,000 psi (689 bars) |
| Pressure test (1.5 times) | 15,000 psi |
| Operating Temperature | 0°C to 135 °C (32 F to 275 F) |
| Minimum Storage Temperature | -18 °C (0 F) |

3.3 ELECTRICAL

| | |
|--|-----------|
| Number of isolated Contacts | 1 |
| Working Voltage | 500 Vdc |
| Dielectric Voltage (contact to connector body) | 1,000 Vdc |
| Continuous Current (at maximum temperature) | 5.0 A |
| Insulation Resistance (at ambient temperature and after 100 connections) | > 1 GΩ |
| Insulation Resistance (at maximum temperature) | > 100 MΩ |
| Contact Resistance (system TH + TREE) | ≤ 25 mΩ |
| Resistance through connector body when mated | ≤ 100 mΩ |

3.4 MECHANICAL

| | |
|--|----------------------|
| Allowable axial misalignment (between male and female connectors while mating) | ± 12.7 mm (± 0.5 in) |
| Allowable lateral misalignment (between male and female connectors while mating) | ± 2.54 mm (± 0.1 in) |
| Allowable angular misalignment (between male and female connectors while mating) | 1.0 degree |

3.4.1 Body/backshell Material: Inconel 718 or UNS in compliance with NACE MR0175

3.4.2 Welding (if any) shall be in compliance with NACE MR0175.

3.4.3 All the threads of the TH connector and the nut must be covered with anti sizing material like nyflor.

3.4.4 The connector assembly shall be non-latching. The function of locking the male and female connectors together shall be performed by the Petrobras Tree/Wellhead assembly.

3.4.5 Maximum mating velocity in the installation environment: 1 ft / sec

3.5 OPERATIONAL LIFE REQUIREMENTS

3.5.1 Number of mating/de-mating cycles: 100 under specified environmental conditions.

3.5.2 Life Duration: 10 years minimum under specified environmental conditions.

3.6 CONDUCTOR INTERFACE

3.6.1 The termination of both connectors listed below shall be capable of being field assembled.

3.6.2 The termination barriers of both connectors shall be field pressure testable.

3.6.3 The electrical terminations shall be marked so that the polarity of the electrical connections can be ensured through the connectors.

3.6.4 Xmas Tree Connector Assembly

The connector assembly, which mounts to the Xmas tree shall be terminated with wire encased in 1/8" diameter tubing to fit the Petrobras Xmas tree electrical system.

3.6.4.1 Wire specification:

| | |
|----------------|--------------------------|
| Size | 18 AWG minimum |
| Material | Nickel-plated copper |
| Insulation | PTFE |
| Voltage Rating | 1000 Vdc minimum |
| Length | 3 meters (10 ft) minimum |

3.6.4.2 The test connector used to test the Xmas Tree connector in surface shall have a lock mechanism to keep it mated to the Xmas Tree connector during the tests. It shall not be required an external force to keep the connectors mated.

3.6.4.3 The force necessary to de-mate the test connector from the Xmas Tree connector shall not exceed 100 N.

3.6.4.4 The dimensions of the test connector shall not exceed the dimensions of the Xmas Tree connector.

3.6.5 Tubing Hanger Connector Assembly

The connector assembly which mounts to the tubing hanger shall be designed to terminate and seal to the downhole cable.

Downhole cable specifications (reference):

| | |
|------------------------------|--|
| Configuration | Single Wire encased in epoxy filled tubing |
| Tubing O.D. | 0.254-0.250 in / 6.45 mm – 6.35 mm |
| Tubing Material ¹ | Alloy 825 or 316SS |
| Wire Gauge ² | 18 AWG or 16 AWG |
| Material | nickel-plated copper |

¹ The connector shall be compatible with both metallurgies.

² The connector shall be compatible with both wire gauges.

4 QUALITY ASSURANCE PROVISIONS

The connector shall meet the quality assurance provisions listed in this section. All requirements are subject to verification by Petrobras.

4.1 Design Qualification Testing

Listed below are minimum qualification test requirements to be completed to verify the connector meets the design specifications.



PETROBRAS

TITLE:

WET ELECTRICAL CONNECTOR FOR PERMANENT DOWNHOLE GAUGE

4.1.1 Proof Voltage Test

A minimum of 1,000 Vdc shall be applied between the contact and the connector body (shell) for one minute.

Acceptance criteria: Leakage current: ≤ 0.005 mA. No breakdown or evidence of flashover.

4.1.2 Insulation Resistance

The insulation resistance shall be measured and verified to be within specification between the contact and the connector body (shell) with a test voltage of 500 ± 50 Vdc.

Acceptance criteria: Insulation Resistance: ≥ 10 G Ω @ 1 min. No breakdown or evidence of flashover.

4.1.3 Contact Resistance

The contact resistance shall be measured and verified to be within the design specification through the contacts and through the connector body (shell) when the connectors are mated.

Acceptance criteria: Contact Resistance: ≤ 0.025 m Ω . No breakdown or evidence of flashover.

4.1.4 Pressure Test

The connectors shall be pressure tested to 1.5 times the maximum working pressure in both de-mated and mated states. Electrical properties shall be verified to be within specification. There shall be no sign of leakage into the connector. The connector shall be tested such that the pressure is applied in a similar manner to what the connector will actually experience during use.

Acceptance criteria: electrical properties within specification. No breakdown or evidence of leakage.

4.1.5 Long Term Test (Mating Cycle Test)

The connectors shall be placed in a pressure vessel filled with a turbid seawater (35,000 ppm of NaCl) solution (1.0% of river silt and 0.5% of sand by weight). The connectors shall be mated and de-mated 100 times under the following conditions:

Pressure: sufficient to simulate 2500 m (8200 ft) seawater depth.

Misalignment: the full tolerance range shall be simulated and tested.

Every 10 mating cycles, the following measurements shall be taken/recorded and verified to be within specification:


Proof voltage test at 1,000 Vdc.

Acceptance criteria: maximum leakage current ≤ 0.005 mA

Insulation Resistance

Electrical Continuity

Acceptance criteria: no evidence of leakage into connector body or backshell

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|---|-------------------------|----------------------------------|--------------|
|  | TECHNICAL SPECIFICATION | Nº I-ET-3000.00-1516-823-PEK-058 | REV. 0 |
| | TITLE: | | PAGE 9 of 15 |
| WET ELECTRICAL CONNECTOR FOR PERMANENT DOWNHOLE GAUGE | | | |

At completion of test, the connectors shall be tested at 100% rated voltage and current for minimum of 24 hours. At the completion of this test, the electrical measurements listed above shall be taken/recorded and verified to be within specification.
Acceptance criteria: electrical properties within specification.

4.1.6 Life Test

The connectors shall be placed in a pressure vessel filled with a salt water solution. The connectors shall be mated and left in the salt water solution for a minimum of 14 days under the following conditions:

Pressure: 10,000 psi (689 bars)
Temperature: 135°C (275 F)

During the test, once a day, and at after the test, the following measurements shall be taken/recorded and verified to be within specification:

Proof voltage test at 1,000 Vdc.
Acceptance criteria: maximum leakage current ≤ 0.005 mA

Insulation Resistance
Electrical Continuity
Acceptance criteria: no evidence of leakage into connector body or backshell. (Only after the test)

4.1.7 Temperature Limit Test

The connectors shall be placed in a pressure vessel filled with water. The connectors shall be mated and then placed under the following conditions:

Pressure: 10,000 psi (689 bars)
The following measurements shall be taken/recorded and verified to be within specification:

Proof voltage test at 1,000 Vdc.
Acceptance criteria: maximum leakage current ≤ 0.001 mA

Insulation Resistance
Electrical Continuity
Acceptance criteria: there shall be no evidence of leakage into connector body or backshell.

The temperature shall be raised to the maximum operating temperature and the measurements repeated/recorded and verified to be within specification.
The temperature shall be lowered to the minimum operating temperature and the measurements repeated/recorded and verified to be within specification.
Acceptance criteria: electrical properties within specification.



PETROBRAS

TITLE:

WET ELECTRICAL CONNECTOR FOR PERMANENT DOWNHOLE GAUGE

4.1.8 Vibration Test

The connectors must be submitted to a vibration test in a vibration table to allow no less than 6.0 g (7.5 g peak), 10 to 60 Hz vibration test in time period no less than 15 minutes.

Acceptance criteria: electrical properties within specification. No damage to the connector.

4.1.9 Shock (Drop) Test

The connectors must be submitted to a drop test. The connectors shall be dropped onto a bench, from a specified height. The bench and height shall be designed to provide a drop test of no less than class 5, 200 g equivalent. This procedure shall be repeated, at least, five times.

Acceptance criteria: electrical properties within specification. No damage to the connector

4.1.10 Gas Seal Test

The TH connector must be submitted to a gas seal test. The connector shall be installed in a special device, simulating the TH body. The Gas (helium) Test will be performed at 10,000 psi for 1 hour

Acceptance criteria: no leakage must be observed.

4.2 FACTORY ACCEPTANCE TESTING

Listed below are minimum factory acceptance test requirements, which shall be completed on each production connector prior to delivery to Petrobras.

4.2.1 Visual Inspection

A visual inspection shall be performed on the connectors to verify the following:

The connectors shall be free from knocks, burrs, scratches, or other obvious defects

The insulators shall be free from holes, fissures or cracks

The marking of the connectors shall be correct and legible


4.2.2 Dimensional Inspection

The dimensions of the connectors shall be verified to be within the tolerances specified on the applicable drawings.

4.2.3 Proof Voltage Test

A voltage of 1000 Vdc shall be applied between each contact and the connector body (shell) for one minute.

Acceptance criteria: the leakage current must be ≤ 0.005 mA. No breakdown or evidence of flashover

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|---|--|----------------------------------|---------------|
|  | TECHNICAL SPECIFICATION | Nº I-ET-3000.00-1516-823-PEK-058 | REV. 0 |
| | TITLE: WET ELECTRICAL CONNECTOR FOR PERMANENT DOWNHOLE GAUGE | | PAGE 11 of 15 |

4.2.4 Insulation Resistance

The insulation resistance shall be measured and verified to be within specification between the contact and the connector body (shell) with a test voltage of 500 ± 50 Vdc. Acceptance criteria: Insulation Resistance: $\geq 10 \text{ G}\Omega$ @ 1 min. No breakdown or evidence of flashover.

4.2.5 Contact Resistance

The insulation resistance shall be measured and verified to be within the design specification through the contacts and through the connector body (shell). Acceptance criteria: Contact Resistance: $\leq 0.025 \text{ m}\Omega$. No breakdown or evidence of flashover.

4.2.6 Pressure Test

The connectors shall be submitted to a pressure tested of 1.5 times the maximum working pressure. The connector shall be tested such that the pressure is applied in a similar manner to what the connector will actually experience during use. Acceptance criteria: there shall be no leakage into the connector backshell or change in electrical properties.

4.2.7 Operational Test

The connectors shall be placed in a pressure vessel filled with tap water under a pressure sufficient to simulate 2500 m (8200 ft) seawater depth. Mate and de-mate the connectors 5 times. At every mating cycle, the following measurements shall be taken and verified within specification:

Proof voltage test at 1000 Vdc.

Acceptance criteria: Maximum leakage current $\leq 0.005 \text{ mA}$

Insulation Resistance


Electrical Continuity

Acceptance criteria: no externally visual or measurable evidence of leakage into connector body or backshell.

4.3 Certificate of Compliance (C.O.C)

Each connector shall be shipped with a Certificate of Compliance (C.O.C) stating that the part complies with this specification and test data from quality inspection tests listed in section 4.

A supply history of at least 2 (two) connectors that meets all the items specified in this document must be submitted to complete the registration.

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|---|-------------------------|----------------------------------|---------------|
|  | TECHNICAL SPECIFICATION | Nº I-ET-3000.00-1516-823-PEK-058 | REV. 0 |
| | TITLE: | | PAGE 12 of 15 |
| WET ELECTRICAL CONNECTOR FOR PERMANENT DOWNHOLE GAUGE | | | |

5 SITE INTEGRATION TEST

The connector vendor will provide technical support during the site integration test, which will be held in Brazil, related to assembling and testing the connectors onto the tubing hanger and Xmas Tree.

6 DOCUMENTATION

During a bidding process, it may be required to supply all documentation in both written and digital formats. In this case, all drawings must be furnished as a .dwg or .dxf file and all documents must be furnished in MS Word or .pdf format.

Copies of design and development documents such as drawings and calculations will be provided for review and approval for Petrobras.

Copies of all test reports and data taken during testing will be provided to Petrobras. It includes assembly and disassembly procedures, technical illustrations and/or instructions, dimensional data, maintenance, Care/Storage and handling, Safety, Special tools or fixtures required.


6.1 THE TECHNICAL PROPOSAL FOR BID

6.1.1 When required in a bid, the proposal must be made in such a way to comply integrally with requirement in this technical specification and the applicable drawings.

6.1.2 The proposal must include, at least, the following documents:

- a) general arrangement drawings;
- b) assembly drawings, with views, sections, main dimensions and materials;
- c) mating drawing (the connectors in mating position);
- d) complete literature describing how the connectors (male and female) work;
- e) documents list;
- f) deviations list;
- g) quality plan;
- h) spare parts list;
- i) components and equipments list manufacture and model;
- j) a track record showing the sales of the type of connector to be furnished shall be presented. It is required, at least, 2 (two) connectors have been supplied.

6.1.3 The suppliers drawing and documents, submitted for PETROBRAS or its representatives approval, will not release the supplier of any responsibility for detailing, dimensions, equipment construction or specifications deviations.

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|---|-------------------------|----------------------------------|---------------|
|  | TECHNICAL SPECIFICATION | Nº I-ET-3000.00-1516-823-PEK-058 | REV. 0 |
| | TITLE: | | PAGE 13 of 15 |
| WET ELECTRICAL CONNECTOR FOR PERMANENT DOWNHOLE GAUGE | | | |

6.2 MANUAL

When all the final drawings and documents are issued and certified, the supplier must present them under the form of “MANUAL” bound and duly identified (PCM, AFM, etc) containing the requested information and applicable norms.

The manual shall include, at least:

- a) Drawings
 - arrangements;
 - assembling drawings with views, cross sections, main dimensions and materials;
 - parts list;
 - interconnection diagram;
- b) complete literature describing how the connectors (male and female) work;
- c) assembling procedure;
- d) FAT procedures.

The drawing and applied documentation shall be presented for PETROBRAS approval before the manufacturing. The MANUAL shall be presented for PETROBRAS approval 30 days before the connectors delivery, afterwards, one digital copy in “.pdf” . format in a CD or DVD shall be provided.

7 APPLICABLE DRAWINGS

7.1 Electric Cable

The attached drawing is as follow:

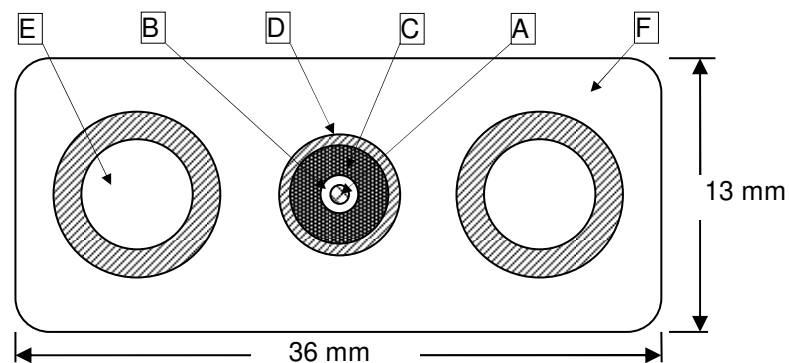


Figure 1 - Typical PDG Electrical cable

- A. # 18 AWG or # 16 AWG, solid tinned copper conductor.
- B. Insulation
- C. Jacket
- D. Type Incolloy or 316SS tube, 0.71 mm (nominal or higher) wall thickness, 6.35 mm (1/4") diameter.
- E. 2 x 5/16", 7 x 2.64 mm, 7.94 mm diameter, stranded galvanized steel ropes.
- F. Polimer compound encapsulation

7.2 Preparation for Downhole Pressure Gauge electrical connector in the Tubing Hanger

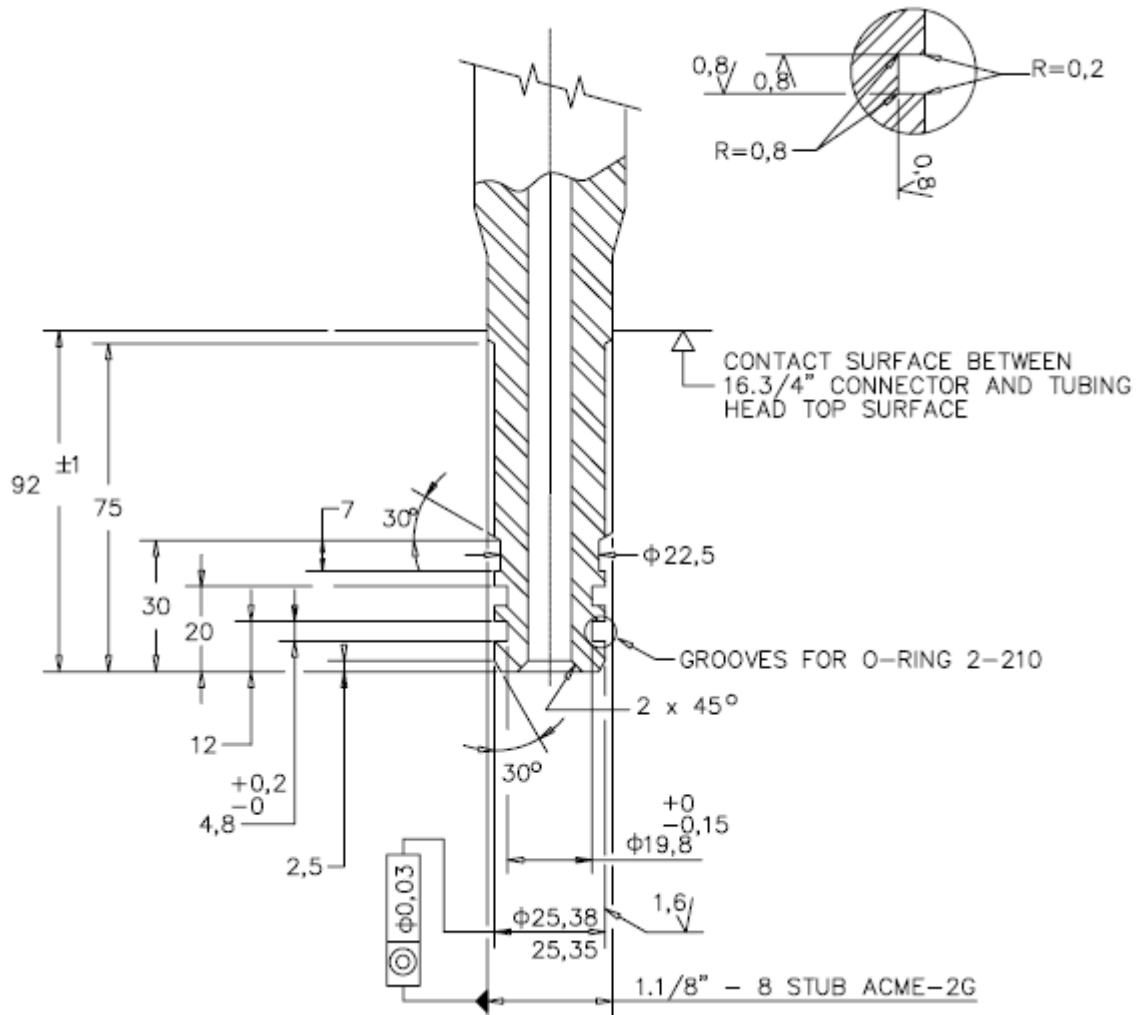
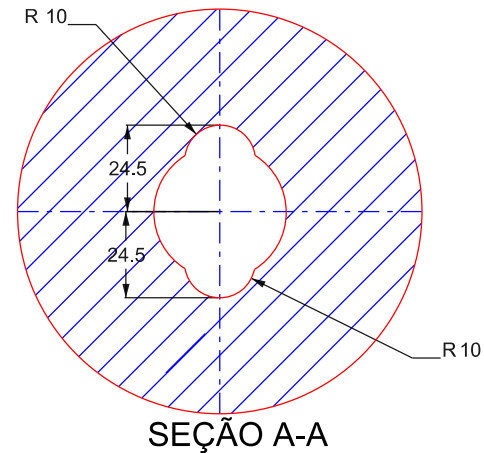
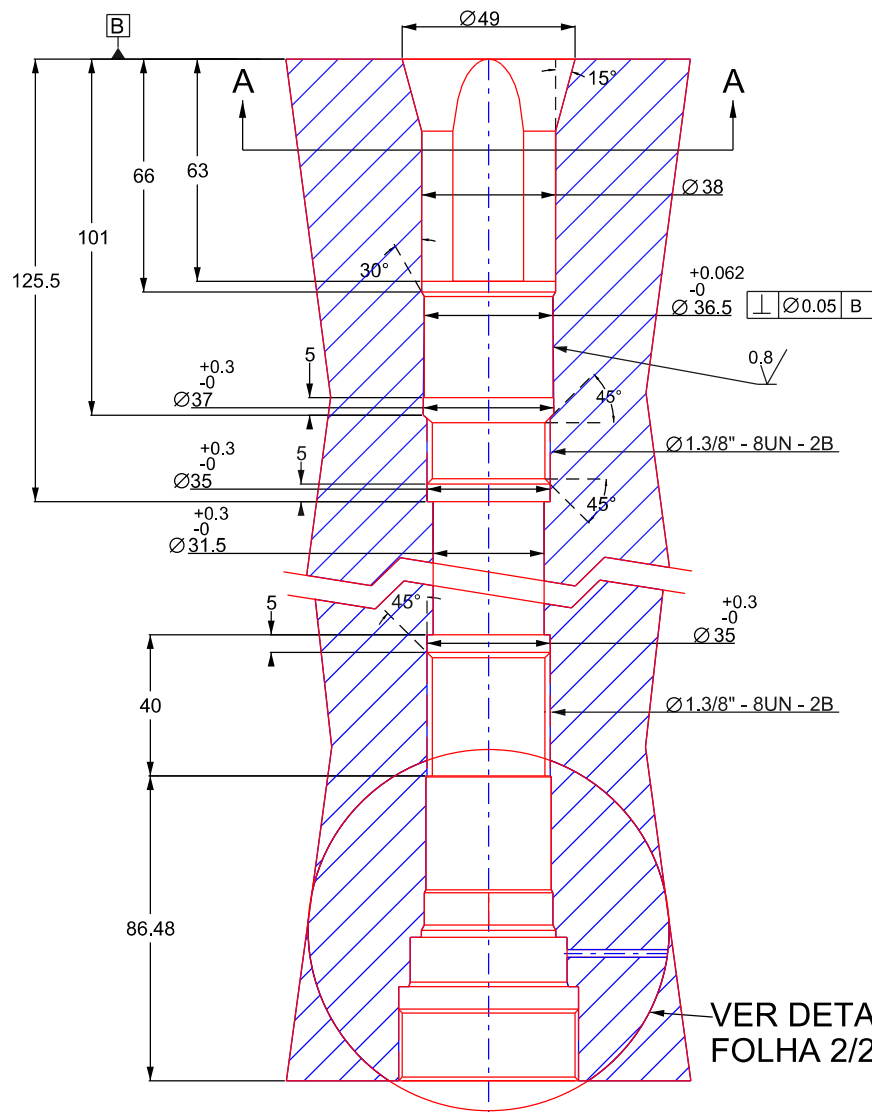


Figure 2 – Preparation for PDG electrical connector.

Refer to drawing DE-3000.00-1500-823-SRP-001.



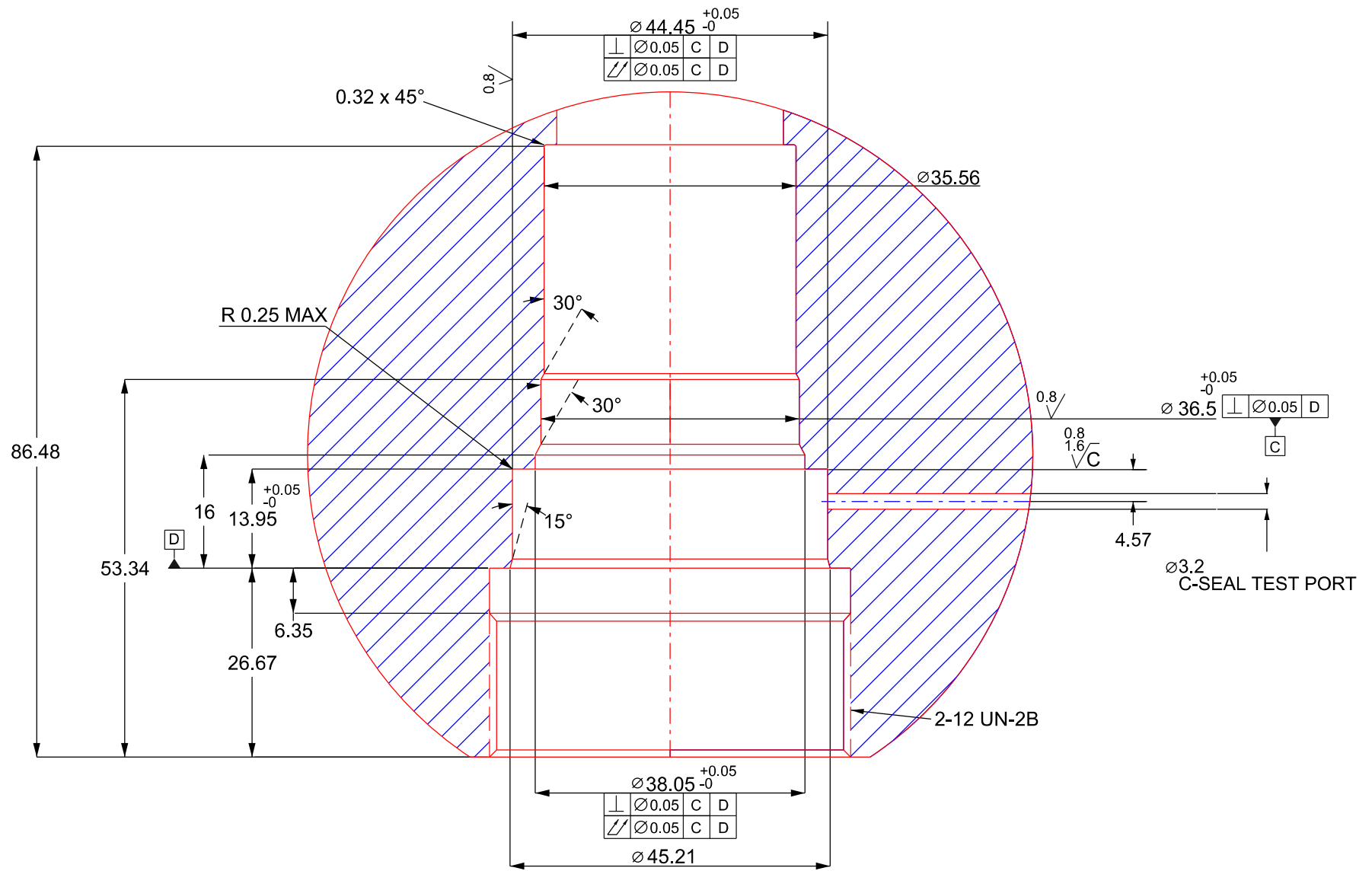
REFERÊNCIA:
 1- I-ET-3000.00-1516-823-PEK-003=C - WET ELECTRICAL CONNECTOR FOR PDG
 2- SST-P4170010 - GENESIS OIL & GAS BRASIL ENGENHARIA LTDA (CONTRATO 5125.0108113.18.2).

NOTAS:
 1- TODAS AS COTAS ESTÃO EM MILÍMETRO, EXCETO ONDE INDICADO.

| | REV. 0 | REV. A | REV. B | REV. C | REV. D | REV. E | REV. F | REV. G | REV. H | REV. I | REV. J |
|-------------|----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| DATA | 10/04/19 | | | | | | | | | | |
| PROJETO | GENESIS | | | | | | | | | | |
| EXECUÇÃO | F.SILVA | | | | | | | | | | |
| VERIFICAÇÃO | E.LIMA | | | | | | | | | | |
| APROVAÇÃO | M.DIAS | | | | | | | | | | |

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|----------------|---|------------------|-------------------------------|-------------|--------|
| CONTRATADA: | GENESIS OIL & GAS BRASIL ENGENHARIA LTDA. | CONTRATO Nº: | 5125.0108113.18.2 | PROJETO Nº: | 18.001 |
| RESP. TÉCNICO: | LUIZ OCTAVIO NASCIMENTO BANDEIRA | APLICATIVO: | MICROSTATION/V8i | | |
| CREA Nº: | 1993100738 | NOME DO ARQUIVO: | DE-3000.00-1500-823-SRP-001=0 | | |

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| | DESENHO Nº: | DE-3000.00-1500-823-SRP-001 | |
| | CLIENTE: | PETROBRAS | |
| | PROGRAMA: | GERAL | |
| | AREA: | GERAL | |
| TÍTULO: | PREPARAÇÃO PARA MONTAGEM DO CONECTOR PDG NO SUSPENSOR DE COLUNA. | | FOLHA 01 de 02 |
| | | SEM ESCALA | |



DETALHE A

REFERÊNCIA:
 1- I-ET-3000.00-1516-823-PEK-003=C - WET ELECTRICAL CONNECTOR FOR PDG.
 2- SST-P4170010 - GENESIS OIL & GAS BRASIL ENGENHARIA LTDA (CONTRATO 5125.0108113.18.2).

NOTAS:
 1- TODAS AS COTAS ESTÃO EM MILÍMETRO, EXCETO ONDE INDICADO.

| | REV. 0 | REV. A | REV. B | REV. C | REV. D | REV. E | REV. F | REV. G | REV. H | REV. I | REV. J |
|-------------|----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| DATA | 10/04/19 | | | | | | | | | | |
| PROJETO | GENESIS | | | | | | | | | | |
| EXECUÇÃO | F.SILVA | | | | | | | | | | |
| VERIFICAÇÃO | E.LIMA | | | | | | | | | | |
| APROVAÇÃO | M.DIAS | | | | | | | | | | |

FORMULÁRIO PERTENCENTE A PETROBRAS N-381 REV. L.

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|----------------|---|------------------|-------------------------------|-------------|--------|
| CONTRATADA: | GENESIS OIL & GAS BRASIL ENGENHARIA LTDA. | CONTRATO Nº: | 5125.0108113.18.2 | PROJETO Nº: | 18.001 |
| RESP. TÉCNICO: | LUIZ OCTAVIO NASCIMENTO BANDEIRA | APLICATIVO: | MICROSTATION/V8i | | |
| CREA Nº: | 1993100738 | NOME DO ARQUIVO: | DE-3000.00-1500-823-SRP-001=0 | | |

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| | DESENHO Nº: | DE-3000.00-1500-823-SRP-001 | |
| | CLIENTE: | PETROBRAS | |
| | PROGRAMA: | GERAL | |
| | AREA: | GERAL | |
| | TÍTULO: | PREPARAÇÃO PARA MONTAGEM DO CONECTOR PDG NO SUSPENSOR DE COLUNA. | FOLHA |
| | | | SEM ESCALA |

AS INFORMAÇÕES DESTES DOCUMENTOS SÃO PROPRIEDADE DA PETROBRAS, SENDO PROIBIDA A UTILIZAÇÃO FORA DA SUA FINALIDADE.