REVISION INDEX

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1 SUBJECT

This specification presents technical information and requirements for the Permanent Downhole Gauge (PDG) and gauge carrier to be installed in Low Pressure and Low Temperature (LPLT) oil or gas wells, up to 10,000 psi and 125 °C or in a High Pressure and High Temperature (HPHT) oil or gas wells, up to 15,000 psi and 150 ºC, to monitor simultaneously the tubing and annulus "A" of the well. It is also presented the technical information and requirements for the Surface Data Acquisition System (SAS), Portable Surface Data Acquisition System (PSAS), and accessories.

1.1 DEFINITIONS, SYMBOLS AND ACRONYMS

The definitions used within this document are as follows:

I.D.	Inside or Inner Diameter.
IPT	Quality / Inspection and Test Plan.
IWIS	Intelligent Well Interface Standardization.
O.D.	Outside or Outer Diameter.
OPC UA	OLE (object linking and embedding) for Process Control Unified Achitecture.
OPC DA	OPC Data Access.
PDG	Permanent Downhole Gauge.
PSAS	Portable Surface Data Acquisition System.
SAS	Surface Data Acquisition System.
SOAP	Simple Object Access Protocol.
"Shall" or "Must"	Indicates a mandatory requirement.
"Should"	Indicates a requirement for the good engineering practice.
SIT	System Integration Test.

2 REFERENCES

API 17F - Standard for Subsea Production Control Systems.

AWES RP 3362-36 - Recommended Practice For the Qualification of Downhole Instrumentation.

I-ET-3000.00-1516-823-PEK-002 - Full Redundant Pressure and Temperature Gauge for Permanent Downhole Instalation – PDG in HPHT Wells.

I-ET-3500.00-1516-273-PSE-032 - Full Redundant Electronic Pressure and Temperature Gauge For Permanent Downhole Installation - PDG.**IEC 60529** - Degrees of protection provided by enclosures (IP Code).

3 GENERAL DESCRIPTION AND REQUIREMENTS

3.1 The PDG system consists of a pressure and temperature gauge, a gauge carrier, accessories and topside equipment for monitoring in real time the downhole pressure and temperature of the reservoir.

3.2 The PDG must monitor simultaneously pressure and temperature inside the tubing and in the annulus “A”, which is shown at Figure 1 as an example.

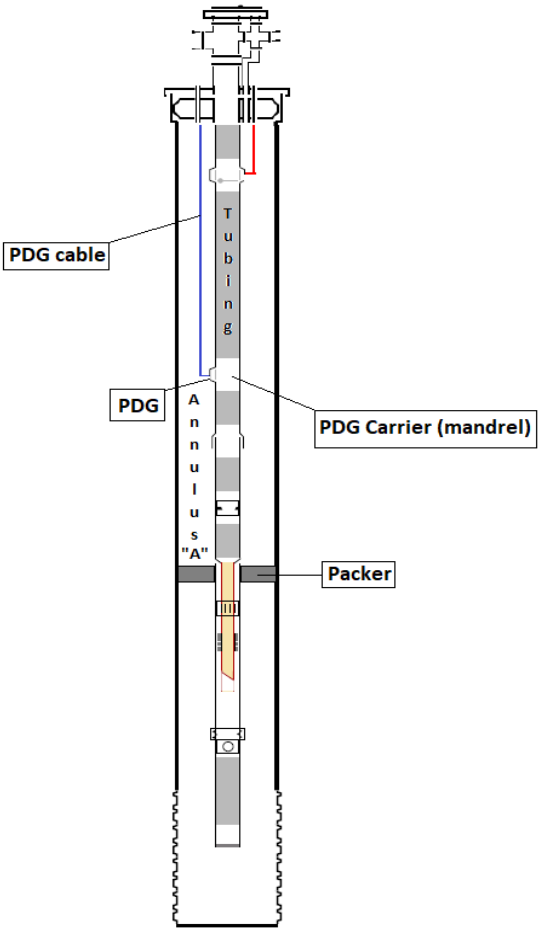

Figure 1 - Scheme of the well.

3.3 The supplier must have qualified the low power (24 W) IWIS electronic card compatible with the PDG supplied. Refer to API 17F for information concerning IWIS standard.

3.4 SCOPE OF SUPPLY

The scope of supply for each PDG set includes all material needed for its installation, as presented in Table 1. The items presented in Table 2, Table 3, items **Erro! Fonte de referência não encontrada.**, 5, 6.1.9.1, **Erro! Fonte de referência não encontrada.**, and item 10.8, are also included in the scope of supply.

Table 1 – PDG set.

Sensor (downhole gauge)
Mandrel
Special Tools (non commercial tools)
Pressure test adapters
Spare parts for two installations

Table 2 – Documents.

Installation procedure – to be written in Brazilian Portuguese language
Maintenance procedure – to be written in Brazilian Portuguese language
Drawings
Datasheets

Table 3 – Topside.

SAS panel for 19'' rack
Portable SAS for installation
Installation procedure – in Brazilian Portuguese
Maintenance procedure – in Brazilian Portuguese
Electrical interconnection diagram
OPC map

3.4.1 Eventually, PETROBRAS may order the IWIS electronic card.

4 DOWNHOLE INSTRUMENTATION AND EQUIPMENT REQUIREMENTS

4.1 PDG GAUGES

4.1.1 GENERAL CHARACTERISTICS AND REQUIREMENTS

4.1.1.1 The PDG system shall be designed to operate in a bottom well installation (harsh environment) and must withstand shocks, vibration, chemical attack, corrosion, working pressure and temperature without any electronic failure and necessity of recalibration.

4.1.1.2 The PDG system shall be designed to a minimum service life of 10 (ten) years without any electronic failure and necessity of recalibration.

4.1.1.3 The components and parts of the PDG system shall be individually selected and extensively tested and qualified in order to provide a very robust (rugged) and high reliable system.

4.1.1.4 The PDG shall be **Type 1** or **Type 2**, as described bellow:

PDG Type 1 (double sensor)

- single sensor to monitor pressure and temperature inside the tubing;
- single sensor to monitor pressure and temperature in annulus “A”.

PDG Type 2 (triple sensor)

- full redundant sensor, e.g., two sensors (quartz) with two electronics, one for each sensor, to monitor pressure and temperature inside the tubing;
- single sensor to monitor pressure and temperature in annulus “A”.

PETROBRAS will define which type of PDG must be supplied.

4.1.1.5 Each sensor and its electronic circuitry shall be completely independent from one to another.

4.1.1.6 The PDG system and its components shall be designed considering the possibility of, at least, two PDG being connected on the same installation line and at the same depth.

4.1.1.7 The pressure test gantry and adaptors or any equipment scope of this Technical Specification must be designed to withstand a working pressure of 10,000 (for LPLT) or 15,000 psi (for HPHT). Adaptors for a “JIC 4” and “NPT” male, shall also be provided.

4.1.1.8 The elements of the pressure and temperature sensors and their electronics must be assembled in the same single housing.

4.1.1.9 The electronics must be encased within a permanently sealed and welded single housing. The housing must be filled with an atmospheric inert gas without any contamination.

4.1.1.10 The output signals (pressure and temperature) shall be transmitted trough a single wire downhole cable, type: 18 AWG, 1/4” metal encased cable through two ways (positive and ground).

4.1.1.11 The electronic components shall be individually selected and extensively tested (temperature, vibration, shock, etc.). The electronics gauge shall be designed to withstand harsh offshore electrical conditions as power line variations, noises, electromagnetic interference, electrostatic discharge, voltage and current surges.

4.1.1.12 Each sensor and electronic shall be able to provide a minimum sample rate of 1 second at the surface acquisition system (SAS/PSAS) and, if one sensor or electronic fails, the PDG Type 1 and Type 2 shall be capable to keep the 1 second sample rate.

4.1.1.13 The electronics shall be designed to allow the communication of each sensor and its corresponding electronic with the SAS, in an independent way from one to another.

4.1.1.14 The electronics shall be designed to allow the independent operation of the transducers in case of failures.

4.1.1.15 The PDG shall operate without any loss considering that its subsea electrical cable length has at least 12 km plus 3 km of well cable. The supplier shall carry out a simulation to identify how far-reaching is the PDG/SAS communication, according to the electrical cable characteristics as following:

Well cable (1/4” metal encased cable):
DC resistance of the central conductor: 22 Ω/km (@ 20°C);
Assumed ground resistance into well: 10 Ω;
Capacitance from center conductor to steel tube: 90 pF/m (@1 kHz);
Length to be considered: 2 km and 3 km.

Subsea electrical cable:
DC resistance: 7.6 Ω/km/wire (@ 20°C);
Capacitance (maximum): 168 nF/km;
Length to be considered: 2 km, 5 km, 10 km, 12 km, 15 km.

The supplier shall provide a report with the results of this simulation in the BID to be approved by PETROBRAS.

4.1.1.16 The sensor shall be provided according to the folowing characteriscts: Crystal of Quartz, sealed and with compensation of temperature.

4.1.2 PRESSURE GAUGE

4.1.2.1 Working pressure range: 0 to 10,000 psi (LPLT) or 15,000 psi (HPHT).

4.1.2.2 Calibration range: 14.7 psi to 10,000 psi (LPLT) or 15,000 psi (HPHT).

4.1.2.3 Over pressure capability: 1.2 times the working pressure range.

4.1.2.4 Accuracy: 0.02 % of the full scale.

4.1.2.5 Pressure resolution: minimum of 0.01 psi for a scanning rate of 1 sec.

4.1.2.6 Repeatability: minimum of 0.01 % full scale.

4.1.2.7 Long term stability: maximum drift of 2.0 psi/year at 100°C, 5,000 psi.

4.1.2.8 The bellows shall be rugged, protected and sealed in order to avoid the risk of damage during installation.

4.1.3 TEMPERATURE GAUGE:

4.1.3.1 Working range: 0 °C to 125 °C (LPLT) 150 °C (HPHT).

4.1.3.2 Calibration range: 25 °C to 125 °C (LPLT) 150 °C (HPHT).

4.1.3.3 Accuracy: minimum of 1 °C full scale.

4.1.3.4 Resolution: minimum of 0.01 °C.

4.1.3.5 Repeatability: minimum of 0.5 % full scale.

4.1.3.6 Temperature stability: maximum drift of 0.05 °C/year.

4.1.4 HOUSING

4.1.4.1 Outside diameter: It shall be as minimum as possible. The maximum O.D. shall be 1.25”.

4.1.4.2 Material: 17- 4 PH, Inconel 718 or similar.

4.1.4.3 It shall withstand the over pressure specified on item 4.1.2.3 for internal and external pressure.

4.1.4.4 The upper housing shall include a cable head to fitting the ¼” metal encased cable with the features described on section 4.1.5.

4.1.4.5 The bottom housing shall include a connection to be connected on the bottom of gauge carrier to allow the penetration of well fluid in the measurement interface.

4.1.4.6 All the fittings of the housings shall be metal-to-metal seal with dual elastomer backup.

4.1.5 HOUSING CABLE HEAD

4.1.5.1 It shall be reliable and easy to test and assembly in field.

4.1.5.2 It shall fit (fittings and boot seal) the ¼" metal encased cable (drawings attached).

4.1.5.3 The fittings shall be compatible with the cables described on section 13.

4.1.5.4 It shall have the same O.D. of PDG housing.

4.1.5.5 It shall provide, at least, two mechanical barriers against fluid ingress in the rear of gauge electrical connector insert. The barriers shall be tested during the installation phase.

4.1.5.6 It will only be accepted one electrical connection between the cable head ceramic feedthrough and the ¼" metal encased cable. This connector shall be manufactured in one piece. It will not be accepted welded connectors.

4.1.5.7 It shall be designed to withstand the same working pressure and temperature of the gauge.

4.1.6 GAUGE CARRIER (MANDREL)

4.1.6.1 It shall be designed to carrying and protecting the gauge over its whole length. The external profile and its ends shall be proper to run down and pulling out of well without the risk of internal shocking and holding into the well casing.

4.1.6.2 It shall allow the installation of the gauge outside of the production string (e.g. the installation of the gauge shall be performed without the need of introducing the gauge inside the mandrel).

4.1.6.3 It shall be an open type mandrel, manufacturing in one piece and non-welded assembly. The external profile shall also be proper to being easily fished whether necessary.

4.1.6.4 The bottom section of mandrel shall have an interface to permit sensing the downhole pressure and temperature inside the string. This interface shall fit a gland connector from the bottom gauge section and it shall allow a metal-to-metal seal with a dual elastometer back up. That seal shall be tested during the installation phase.

4.1.6.5 The interface of the bottom section of mandrel must be PIN and the interface of the upper section of mandrel must be BOX.

4.1.6.6 The use of screws shall be reduced to a minimum. If it's necessary, bolt locking systems must be provided.

4.1.6.7 The outside diameter, material composition and others specifications of mandrels will be provided opportunely by PETROBRAS for quotation.

4.1.6.8 Mandrels with tubing O.D. of 4 ½" and 5 ½" must be compatible to be installed in wells with casing drift I.D. of 8 ½".

4.1.6.9 The mandrel must have the fish neck of at least 12 inches long for tong use purpose.

4.1.6.10 The mandrel shall be designed to carry one PDG as well as to allow the connection (stack) of another PDG downhole.

4.1.6.11 The PDG gauge and its gauge carrier (mandrel) shall be installed above the Packer.

5 SPARE PARTS

It is scope of supply spare parts to be used during installation whether necessary. It is required two sets of spare parts for each PDG installation. The participants of the bidding shall propose a list of spare parts for this purpose. The minimum shall be the following:

5.1 Gauge: O'rings and screws.

5.2 Cable head: O'rings, fittings, ferrules, pressure test adapter, pressure test tube and plugs.

5.3 Gauge carrier / gland seal: O'rings, pressure test adapter, pressure test tube, screws and plugs.

5.4 Surface interfaces (for the SAS): at least three sets of fuses, screws and cage nuts, terminals type needle, fork and ring for 1 mm to 2.5 mm.

5.5 Portable SAS: at least three sets of fuses and cables.

6 SURFACE DATA ACQUISITION SYSTEM (SAS)

It can be scope of supply two types of topside interfaces as following:

6.1 PORTABLE SURFACE ACQUISITION SYSTEM (PSAS)

6.1.1 Electrical characteristics:

- Input AC voltage: automatic 110 - 240 VAC, 50/60 Hz.
- Rechargeable battery operated, 12 hours minimum of autonomy.
- Short circuit, overvoltage and overcharge circuitry protection.
- It shall incorporate a battery charger inside.

6.1.2 It shall have a LCD display to show all the parameters as “pressure”, “temperature”, power consumption (voltage and current) and “error messages” and etc.

6.1.3 It shall have an internal memory with the capability of record up to 100,000 data sets.

6.1.3.1 It shall have options to record values in Engineering Units per 1 second, 5 seconds multiply, minutes and even hours.

6.1.3.2 It shall allow the operator to Create/export files in TXT and/or CSV format.

6.1.4 It shall have a RS-232, RS-485, Ethernet 10/100/1000, and USB interface to allow the reading of data from memory by a laptop.

6.1.5 It shall be able to power and read only one line of PDG. It means that it shall be able to read at least two PDG connected on the same line.

6.1.6 The electronics and components of PSAS shall be packed into a small carrying case proper to offshore operation and transportation. The weight of the PSAS shall not exceed 35 lb (aprox. 16 Kg).

6.1.7 The SOFTWARE to operate the PSAS is scope of supply and it must be compatible with Windows 7, Windows 8, and Windows 10.

6.1.8 The HMI (Human-Machine Interface) shall be all written in Brazilian Portuguese language.

6.1.9 The PSAS can be integrated on industrial laptop.

6.1.9.1 The data acquired by the PSAS must also be available to the platform control system via OPC UA. For this purpose, it is scope of supply one industrial laptop with the following hardware specifications and software functionalities:

Laptop minimum hardware specification:

- 110 to 240 VAC, 50 to 60 Hz, auto switch.
- At least 1 TB Hard Disk storage capacity.
- At least one Solid State Unit SATA M.2, 256 GB.
- At least 14” screen, resolution 1024 x 768 or superior, touchscreen.
- At least 16 GB RAM memory, 2133 MHz, DDR4.
- Processor Dual Core, 2.4 GHz or faster, 64 bit (x64).
- At least three USB ports, version 3.0.
- At least two USB ports, version 2.0.
- Wireless board (dual band).
- Two RS-232 serial ports.
- Two RJ-45 ethernet ports.
- One integrated microphone.
- One integrated camera.

- Internal DVD Read / Write drive.
- At least ten hours of battery autonomy.
- Laptop charger.
- Certified for extreme environment (rugged) according to the standard MIL-STD-810G - Environmental Engineering Considerations and Laboratory Tests.
- Certified for Ingress Protection IP65.

Laptop software functionalities

- OPC UA server, compatible with OPC UA and OPC DA clients.
- OPC UA client, compatible with OPC UA and OPC DA servers.
- The Operational System must be Windows 7 or an later version.
- The OPC UA client and server must have the following modules: UA Alarms&Condition, UA Historical Trend View, UA DI Information Model, UA Performance Evaluates.
- The OPC UA client and server must use both the binary protocol (opctcp://server) and the SOAP protocol (http://server). The user shall be able to select which one will be used.

6.1.9.2 It is scope of supply the bag proper to transport the laptop and its charger.

6.1.9.3 The softwares must be installed on the laptop and tested before delivery to PETROBRAS.

6.1.9.4 All the softwares must be compatible with Windows 7 and later versions.

6.1.10 The communications protocols of the PSAS must be Modbus RTU in serial ports and Modbus TCP/IP.

6.1.11 The Modbus (RTU and TCP/IP) communication drive is scope of supply of PSAS system. It is also scope of supply a CD-ROM containing the software installed on the PSAS, firmware, software required to operate the PSAS, software installed on the industrial laptop, drivers, and passwords.

6.2 RACK MOUNTED SURFACE ACQUISITION SYSTEM (SAS)

6.2.1 It shall be supplied a rack mounted Surface Acquisition System (SAS) to be installed on the platform control room (no classified area);

6.2.2 Electrical characteristics:

- Input CC voltage: 24 VCC.
- Input AC voltage: automatic 110 - 240 VAC, 50/60 Hz.
- Rechargeable battery operated, 12 hours minimum of autonomy.
- Short-circuity, overvoltage and overcharge circuitry protection.
- It shall incorporate a battery charger inside.
- AC Plug type NEMA 5-15p and NBR 14136.
- Earth protection connections.

6.2.3 It shall have a LCD display to show all the parameters as “pressure”, “temperature”, power consumption (voltage and current), “error messages” and etc.

6.2.4 It shall have an internal memory capable of recording the acquired data for a period of not less than 180 days.

6.2.4.1 It shall have options to record values in Engineering Units per 1 second, 5 seconds multiply, minutes and even hours.

6.2.4.2 It shall allow the operator to Create/export files in TXT and/or CSV format.

6.2.5 It shall have a RS-232, a RS-485 and ethernet network interface selectable by software to allow the reading of data from memory by a platform control system.

6.2.6 It shall be able to power and read at least (10) lines of PDG, e.g., it means that it shall be able to read at least thirty (30) sensors connected to the same panel.

6.2.7 The electronics and components of SAS shall be packed into a standard 19 inch rack mounted.

6.2.8 The software to operate the SAS is scope of supply. It shall be windows architecture compatible, and must be able to be accessed and monitored via local area network from remote terminal onshore. Once accessed, the system must allow the operator to reprogram, to alter log rates, to set alarms and retrieve the data log.

6.2.9 The HMI (Human-Machine Interface) shall be all written in Brazilian Portuguese language.

6.2.10 An industrial computer standard 19 inch rack mounted shall be supplied as part of SAS system with minimum following characteristics and devices: clock of 1 gigahertz (GHz) or faster, 64-bit (x64) processor, at least 16 GB memory RAM, rewritable DVD, USB ports, HDMI port, two hard disks each one with at least 1 TB of capacity (mirror back-up RAID 1), two RS-232, two RS-485 and two ethernet port devices.

6.2.11 The LCD monitor of the industrial computer shall be compatible with the standard 19 inch rack mounted with the size of the screen at least 15 inch and minimum resolution of 1024 x 768.

6.2.12 The software to configurate the SAS, required on item 6.2.8 must be installed in the industrial computer and the SAS configuration must be done through the industrial computer.

6.2.13 The Modbus RTU communication drive is scope of supply of SAS system. It is also scope of supply a CD-ROM containing the software installed on the SAS, firmware, software required to operate the SAS and passwords.

6.2.14 The data acquired by the SAS must also be available to the platform control system via OPC UA. It must be installed on the SAS computer the OPC client and server, with the following functionalities:

- OPC UA server, compatible with OPC UA and OPC DA clients.
- OPC UA client, compatible with OPC UA and OPC DA servers.
- The Operational System must be Windows 7 or an later version.
- The OPC UA client and server must have the following modules: UA Alarms&Condition, UA Historical Trend View, UA DI Information Model, UA Performance Evaluates.
- The OPC UA client and server must use both the binary protocol (opctcp://server) and the SOAP protocol (http://server). The user shall be able to select which one will be used.

6.2.15 For the supply of LPLT PDGs, the SAS must be compatible with the IWIS protocol as detailed below:

6.2.15.1 The SAS software must be prepared to support 8 different types (PN - Part Numbers) of IWIS cards. During the detailing of the project, PETROBRAS will indicate which are the PNs and the information needed for software development.

6.2.15.2 The configuration of which IWIS card will be used must be performed with engineering level access on the SAS.

6.2.15.3 The SAS must be delivered only with the SUPPLIER'S IWIS cards.

7 DOCUMENTATION

7.1 TECHNICAL PROPOSAL

7.1.1 Technical proposal shall comply integrally with this technical specification and the others applicable specification and drawings presented on item 13. If it is not possible, the supplier must clearly indicate the deviations and exceptions in a specific list. The omission of such list indicates that the proposal complies integrally with this technical specification and its enclosures.

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

7.1.2.1 Pressure/temperature sensors and electronics functional characteristics.

7.1.2.2 PDG general conception and description.

7.1.2.3 Pressure/temperature element sensors specifications.

7.1.2.4 Cable head specifications.

7.1.2.5 Mandrel specifications.

7.1.2.6 List of spare parts for PDG, cable head, mandrel and surface interfaces (according to item 5).

7.1.2.7 Portable SAS and rack mounted SAS conception and description.

7.1.2.8 List of tools for installation (commercial and non-commercial use).

7.1.2.9 A complete list and description of the manufacturing tests carried out prior the PDG system delivery.

7.1.2.10 Deviations list.

7.1.2.11 Long term quartz sensors and electronics stability test report and historical data.

7.1.2.12 Simulation Report (according to item 4.1.1.15).

7.1.2.13 Project schedule.

7.1.2.14 Realiability report, including accelerated ageing test.

7.1.2.15 It shall be presented the track record according to the item **Erro! Fonte de referência não encontrada.**.

7.1.2.16 Sensor signal acquisition using a digital scope showing the waveform at 1 sample/second of each sensor in postscript format (pdf).

7.1.3 The drawings and documents submitted by the supplier for PETROBRAS approval, will not release the supplier of any responsibility for detailing, dimensions, and equipment construction, performance or specification deviations during the PDG development.

7.1.4 The drawings and documents must be verified, approved, signed and dated by the supplier, prior to be sent to PETROBRAS. This requirement must also be applied to the sub suppliers drawings and documents.

7.2 DEVELOPMENT/BUILDING DOCUMENTATION

7.2.1 The documents to be commented by PETROBRAS during the development and manufacturing process must include, at least, the following:

7.2.1.1 Quality/surveillance plan.

7.2.1.2 PDG detailed drawings, electronic schemes and list of material.

7.2.1.3 Cable head detailed drawings and list of material.

7.2.1.4 Mandrel detailed drawings and list of material.

7.2.1.5 Portable SAS and rack mounted SAS detailed drawings, electronic schemes and list of material.

7.2.1.6 All the manufacturing procedure tests and associated documents (test reports, etc.).

7.2.1.7 Assembling and installation procedures for the cable head, mandrel and PDG itself.

7.2.1.8 System reliability prediction analysis.

7.2.1.9 Simulation to show how far-reaching is the PDG/SAS communication.

7.2.1.10 Meeting reports.

7.2.1.11 Pending action list.

7.2.1.12 Maintenance plan for portable SAS (PSAS) and rack mounted SAS.

8 INSPECTION AND TESTING

The purpose of this section is to identify basic requirements for testing components and subsystems of the PDG system. The tests shall be divided in the following types:

A) Components, before system assembly, for example: quartz sensors, electronics, housing, housing cable head, gland seal of the sensor and mandrel.

B) Factory Acceptance Test, with the PDG and mandrel fully assembled.

These tests should not be considered as substitute of the manufacturer’s test procedures, but must be used only to provide a guide of the minimum requirements.

8.1 COMPONENTS BEFORE SYSTEM ASSEMBLY

8.1.1 PETROBRAS shall have the opportunity to witness the test of the following components, but not limited to, quartz sensors, electronics, housing, housing cable head, gauge gland seal, mandrel and SAS/interface board.

8.1.2 The tests of the components shall be, at least, the following:

8.1.2.1 Quartz sensor test: functional and pressure/temperature testing.

8.1.2.2 Electronics: functional and burn in test, and long term stability test.

8.1.2.3 Housing: pressure test of the seals.

8.1.2.4 Housing cable head: electrical tests (continuity and insulation) and barriers pressure test.

8.1.2.5 Gauge gland seal: pressure test of the seals.

8.1.2.6 Mandrel: internal pressure test and pressure test of the seals.

8.1.2.7 Portable SAS/rack mounted SAS: functional tests.

8.2 FACTORY ACCEPTANCE TEST (FAT)

8.2.1 The supplier shall develop and implement an inspection and test program. The program shall demonstrate to PETROBRAS that all PDG system and components of its scope of supply will perform without any fail in service and meet or exceed all requirements of this technical specification.

8.2.2 PETROBRAS shall have the opportunity to witness, inspect and approval, at least, all tests/assembly of the complete set of PDG system. The supplier shall give, at least, 30 days notice prior to the PDG system's test schedule.

8.2.3 PETROBRAS will witness and sign for the total acceptability of all tests accordingly with the previously agreed Quality / Inspection and Test Plan (ITP).

8.2.4 The FAT program shall cover the following:

8.2.4.1 To demonstrate that the functional capability of the PDG/components meet the requirements of this technical specification.

8.2.4.2 To demonstrate that the interfaces configurations are correct.

8.2.4.3 To demonstrate that the item is as defined by the approved assembly drawings.

8.2.4.4 To demonstrate that PETROBRAS has previously approved the acceptance procedure.

8.2.5 The FAT shall include, at least, the following tests:

8.2.5.1 PDG pressure and temperature calibration check.

8.2.5.2 PDG/cable head/Downhole cable assembled on the mandrel applying internal pressure aftter finishing the assembly steps.

8.2.5.3 Portable SAS/rack mounted SAS functional tests.

8.2.5.4 Communication test PDG/SAS using electrical cable simulator according to item 4.1.1.15.

9 GUIDELINE TEST REQUIREMENTS

The purpose of this section is to present the guidelines for the test requirements. This guideline does not cancel or change manufacturer's test procedures. Some of tests must be carried out during FAT whereas others must be carried out only for qualification purposes. The standard AWES RP 3362-36 is recommended as a guideline for the qualification program.

9.1 CALIBRATION

The PDG shall be audited and calibrated over the range specified in items 4.1.2.2 and 4.1.3.2 prior to be delivered. It shall be provided two copies of CD and a calibration book with the calibration data, calibration certificate, calibration traceability and manufacturing test results.

9.2 BURN IN TESTING

The PDG (sensors and electronics) must be submitted to a burn in test. The burn in test shall be carried out to avoid the possibility of failure caused by "infant mortality". The burn in temperature and associated time shall be set to achieve the objective above.

9.3 VIBRATION TEST

The PDG (sensors and electronics) must be submitted to a vibration test (in a vibration table) to allow no less than 10.0 g (15.0 g peak), 10 Hz to 1 kHz vibration test in period of the time no less than 30 minutes. The vibration tests shall be carried out with the PDG powered and with full and continuous monitoring of all functions. PETROBRAS reserves the right to accept or refuse the qualification using others parameters that do not comply with the minimum required.

The maximum sweep rate is one octave per minute. The sweep rate shall be low enough to allow any resonance to build-up amplitude.

Acceptance criteria: The PDG must be functional after the test.

9.4 SHOCK TEST

The PDG (sensor and electronics) must be submitted to a drop test. The PDG shall be dropped while running, onto a bench, from a specified height. The bench and height shall be set to provide a drop test no less than class 5, 200 g equivalent. This test shall be repeated, at least, five times. The PDG shall maintain all functionalities and no damage shall be verified. PETROBRAS reserves the right to accept or refuse the qualification using any alternative parameters that do not comply with the minimum required.

Acceptance criteria: The PDG must be functional after the test.

9.5 PRESSURE TESTS

Pressure tests shall be carried out to check the quality of metal-to-metal seals, elastomers seals and electrical boot seal on the PDG housing, cable head and gland seal of PDG/mandrel.

The pressure tests shall be carried out according to the following requirements:

9.5.1 PDG housing:

9.5.1.1 It shall be applied 12,000 psi (LPLT) or 20,000 psi (HPHT) water pressure during internal and external pressure test in a period of time no less than 30 minutes.

9.5.1.2 It shall be applied 150 psi Helium pressure during internal pressure test with the housing under water or in presence of an Helium sensor to identify any leakage in a period of time no less than 30 minutes.

9.5.1.3 Acceptance criteria: No liquid or gas leakage must be observed during testing.

9.5.2 PDG cable head:

9.5.2.1 It shall be applied 12,000 psi (LPLT) or 20,000 psi (HPHT) water during external pressure test in a period of time no less than 30 minutes.

9.5.2.2 Acceptance criteria: No damage must be observed during testing.

9.5.2.3 It shall be applied 10,000 psi (LPLT) or 15,000 psi (HPHT) water internal pressure in each port in order to test the barriers, including the boot seal.

9.5.2.4 It shall be applied 150 psi Helium pressure during internal pressure test with the housing under water or in presence of an Helium sensor to identify any leakage in a period of time no less than 30 minutes.

9.5.2.5 Acceptance criteria: No liquid or gas leakage must be observed during testing.

9.5.3 Gland seal PDG/mandrel:

9.5.3.1 It shall be applied 10,000 psi (LPLT) or 20,000 psi (HPHT) water pressure between the gland metal-to-metal seal and elastometer seal in a period of time no less than 30 minutes.

9.5.3.2 It shall be applied 150 psi Helium pressure between the gland metal-to-metal seal and elastomers with the mandrel under water in a period of time no less than 30 minutes.

9.5.3.3 Acceptance criteria: No liquid or gas leakage must be observed during testing.

9.5.4 Mandrel:

9.5.4.1 It shall be applied 10,000 psi (LPLT) or 15,000 psi (HPHT) water internal pressure in a period of time no less than 30 minutes with the PDG assembled.

9.5.4.2 Acceptance criteria: No liquid or gas leakage must be observed during testing.

9.6 LONG TERM STABILITY TEST

The supplier shall carry out a LONG TERM STABILITY TEST to the QUARTZ sensors up to being observed the growing drift trends.

9.7 ACCELERATED AGING TEST

Two sets of PDG (electronics and sensor) shall be submitted to accelerated ageing test at temperature of 150 °C (LPLT) or 200 °C (HPHT), with desired real lifetime of 120 months, to evaluate the lifetime and profile of grown uncertainty.

9.8 PORTABLE SAS AND INTERFACE BOARD FOR EXISTED SAS TESTS

Functional tests shall be carried out to demonstrate the ability of the surface interfaces, for example:

9.8.1 Three sensors can be monitored on one single cable.

9.8.2 Three sensors can be monitored on various cable lengths using a cable simulator.

9.8.3 To communicate with the existed SAS.

9.8.4 Operation with a failed gauge in the line does not affect the other gauges.

9.8.5 To communicate with a laptop.

9.8.6 To operate in temperatures up to 70 °C.

9.8.7 Shock test, 100 g, at least 10 times.

9.8.8 Vibration test, 7.5 g (peak) at 10 to 60 Hz.

9.8.9 Acceptance criteria: All abilities must have been demonstrated, evidencing the equipment functionality during and after each test.

9.9 QUALIFICATION TEST OF BOOT SLEEVE FROM THE CABLE HEAD

Two samples of the boot sleeve from the cable head shall be tested to verify the following:

9.9.1 Compatibility and sealability considering seawater under 10,000 psi during 24 hours. The continuity and insulation shall be monitored during the time test. The insulation shall be greater than 1,000 MΩ/500 VCC.

9.9.2 Acceptance criteria: The insulation after testing must be greater than 1,000 Mohms/500 Vcc/1 min @ 20 °C.

9.9.3 Chemical compatibility with oil (petroleum) at 150 °C during 24 hours.

9.9.4 Acceptance criteria: The insulation after testing must be greater than 1,000 Mohms/500 Vcc/1 min @ 20 °C.

9.10 SOFTWARES TESTING

The softwares must be tested according to IEEE-Std-829 - Standard for Software Test Documentation.

10 IDENTIFICATION AND PACKAGING

10.1 The PDG shall be delivered in a case with protection index IP65 as per IEC 60529.

10.1.1 The case must be proper to allow the offshore transportation by helicopter.

10.1.2 Each case must contain only one PDG, the parts needed to assembly the PDG in the cable/mandrel and the spare parts for one PDG.

10.2 The SAS shall be delivered in resistant boxes with protection index IP65.

10.2.1 The box must be easily opened/closed for inspection purposes, proper to allow offshore transportation, and compatible to be lifted using forklift.

10.2.2 The boxes shall have cover and locking mechanism.

10.2.3 Each box must contain only one SAS and its spare parts.

10.3 The PSAS shall be delivered in a plastic carrying case (pelican case type) proper to allow the offshore transportation by helicopter.

10.4 The gauge carriers (mandrels) shall be delivered in resistant boxes with protection index IP65.

10.4.1 Each box must contain only one mandrel and must meet the requirements of item 10.2.1.

10.5 All the boxes/cases supplied for PDG, SAS and mandrel must withstand the ambient conditions (rain, dust, sun exposure) and protect its contents for a minimum period of five years exposed to those harsh conditions. Boxes made of wood will not be accepted.

10.6 The PDG, mandrels and components shall have their serial numbers printed on their own bodies.

10.7 The calibration coefficients of PDG shall be provided on CD inside the carrying case of the PDG.

10.8 A photographic checklist of items shall be provided in each package.

11 MANUFACTURE DATA BOOK AND MANUAL

All the documentation referring to the manufacturing process must be grouped. It must contain, at least:

11.1 All drawings and lists of materials.

11.2 Raw material certificates.

11.3 Executed tests and essays, including procedures.

11.4 Executed tests reports.

11.5 Calibration certificates and calibration traceability.

11.6 Field assembly, installation and configuration procedures.

11.7 Details of SAS as maximum power consumption, voltage, maximum current, etc.

11.8 The Manual must be in Brazilian Portuguese Language, with all technical data and procedures of gauge, mandrel, SAS, PSAS and the industrial laptop.

11.9 Sketch of the PDG equivalent electrical circuit diagram.

11.10 Troubleshooting procedures.

11.11 Two copies of the MANUFACTURE DATA BOOK and of the manual shall be provided together with the delivered systems (in CD or DVD).

12 ALTERNATIVE PROPOSALS

The suppliers may present alternative technical proposals for the specified in this spec but PETROBRAS reserves the right to refuse any alternative proposal that does not comply with the minimum requirements according to this spec.

13 ATTACHED DOCUMENTATION

13.1 Typical PDG electrical cable for production wells:

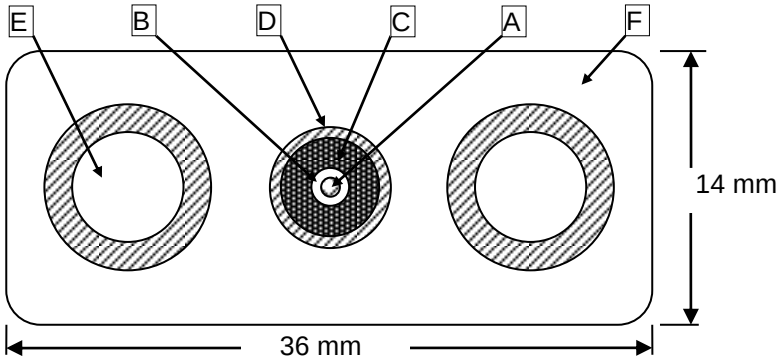

Figure 2 - Typical PDG Electrical cable for production wells.

A. Wire 18 AWG, solid tinned copper conductor.
B. Tefzel insulation, 2.60 ± 0.08 mm diameter.
C. Dielectric filler.
D. Type Inconel 825 or 316SS tube, wall thickness enough to stand 15,000 psi of internal pressure (0.71 mm (0.028") or 0.89 mm (0.035")), OD = 6.35 mm (1/4").
E. Two hydraulic tube, Type 316SS (LP) or Inconel 825 (HP), wall thickness enough to stand 10,000 psi (LP) or 15,000 psi (HP) of internal pressure, OD = 9.52 mm (3/8").
F. Polymer compound encapsulation.

Typical PDG electrical cable for injection wells

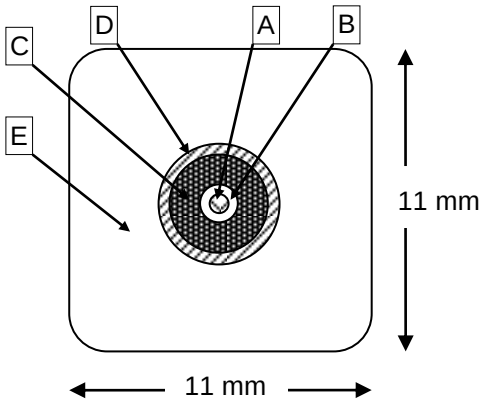

Figure 3 - Typical PDG Electrical cable for injection wells.

A. Wire 18 AWG, solid tinned copper.
B. Tefzel insulation, 2.60 ± 0.08 mm diameter.
C. Dielectric filler.
D. Type 316SS, wall thickness = 0.71 mm (0.028”) or 0.89 mm (0.035”), O.D = 6.35 mm (1/4”).
E. Polymer compound encapsulation 11x11 mm.

End of the document