REVISION INDEX

REV.	DESCRIPTION AND/OR PAGES MODIFIED
0	First edition that incorporates and replaces the following documents: ET-2000.00-1140-610-PW7-001, ET-2000.00-1144-610-PW7-001, Technical Specification on MPD Rigs and PE-2POC-00046-A - Annex 7 - Section I - ET MPD/MCD (Annex 1a to Annex 1s)

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	08/08/2018								
PROJECT	POCOS/CTPS /QC								
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SUMMARY

1 INTRODUCTION

The application of the Managed Pressure System is related to the construction and intervention of offshore wells in narrow or inexistent operational windows, severe losses of circulation, exploratory and development wells. The MPD technique (by using the SBP and MCD variants) minimizes the volume of fluid loss to the formation through the management of the well annulus pressure and, in case of total loss of circulation, resumes well intervention, with safety, simultaneously to the occurrence of circulation losses. Managed pressure drilling has potential to make feasible the technically and economically unviable wells with conventional drilling technique.

2 SCOPE

Technical Specification of the Managed Pressure System – Managed Pressure Drilling (MPD) – applicable to MPD operations and their derivative techniques, as defined by the IADC - MPD and UBO Committee, during offshore well interventions with floating rigs.

The scenarios where the equipment listed in this ET are prone to being used:
• Shallow, deep, ultra-deep waters and deep drilling environments;
• Uncertainty of pore pressure;
• Occurrence of Ballooning / Breathing Formation;
• HPHT wells;
• Wells with narrow or non-existent operational window;
• Exploratory wells;
• Depleted reservoirs;
• Fractured formations;
• Karstfied and vugular formations;
• Environments with presence of H2S, to be defined in the specific TS-GSA.
• Environments with presence of CO2, to be defined in the specific TS-GSA.

This specification contains requirements covering the following system components / interfaces:

- Surface equipment
  - Rigid and flexible lines, valves, control panel;
  - Buffer manifold;
  - MPD Manifold;
  - Meters (flow, pressure, temperature, etc.);
  - Control system;
  - Data Acquisition.
- Riser equipment
  - RCD BTR (body and seal assembly);
  - Sub-surface annular BOP;
  - Flow spool;
  - Flexible hoses;
  - Valves;
  - By-pass for auxiliary lines of the drilling riser system;
  - Termination joint;
  - Adapters for riser system flange;
  - Split Ring and spider adapter;
  - Seal assembly installation tools;

- Equipment running tools.
- Drillstring Accessories
  - Crossover;
  - NRVs;
- Necessary adaptations / adjustments in the intervention unit
  - Circulation system;
  - Handling system;
  - Sea water intake system;
  - Drilling system;
  - Well control system;
  - Monitoring system;
  - Riser system.

3 REFERENCE DOCUMENTS

3.1 **ANSI/NACE MR 0175/ISO 15156: 2015** – Petroleum and Natural Gas Industries – Materials for use in H2S-containing Environments in Oil and Gas Production.
3.2 **API SPEC 5L: 2012 (45th edition)** – Specification for Line Pipe.
3.3 **API SPEC 6A: 2010 (20th edition)** – Specification for Wellhead and Christmas Tree Equipment.
3.4 **API SPEC 7NRV: 2012 -** Specification for Drill String Valves**.**
3.5 **API RP 7K: 2015 (6th edition)** – Drilling and Well Servicing Equipment.
3.6 **API SPEC 16A: 2017 (4th edition)** – Specification for Drill-through Equipment.
3.7 **API SPEC 16C: 2015 (2nd edition)** - Choke and Kill Equipment.
3.8 **API SPEC 16D: 2004 (2nd edition)** – Specification for Control Systems for Drilling Well Control Equipment and Control Systems for Diverter Equipment.
3.9 **API SPEC 16F: 2017 (2nd edition)** – Specification for Marine Drilling Riser Equipment.
3.10 **API RP 16Q: 2017 (2nd edition)** – Design, Selection, Operation and Maintenance of Marine Drilling Riser Systems.
3.11 **API SPEC 16R: 1996 (1st edition) –** Specification for Marine Drilling Riser Couplings.
3.12 **API SPEC 16RCD: 2015 (2nd edition)** – Specification for Rotating Control Devices.
3.13 **API RP 17B: 2017 (5th edition)** – Recommended Practice for Flexible Pipe.
3.14 **API SPEC 17K: 2017 (3rd edition)** – Specification for Bonded Flexible Pipe.
3.15 **API STD 53: 2012 (4th edition)** – Blowout Prevention Equipment Systems for Drilling Wells.
3.16 **ASME B31.3: 2015** – Process Piping.
3.17 **API RP 92M: 2017 (1st edition)** – Managed Pressure Drilling Operations with Surface Back-Pressure.
3.18 **API SPEC Q1:2013, addendum 2016 (9th edition)** - Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry.
3.19 **API SPEC Q2:2011, addendum 2016 (1st edition)** - Specification for Quality Management System Requirements for Service Supply Organizations for the Petroleum and Natural Gas Industries.

4 TERMS AND DEFINITIONS

4.1 Anchor Point

The depth at which the annular pressure must be kept constant using the MPD system, for all possible flow paths.

4.2 Flow anomaly

Anticipated or planned invasion of formation fluid into the well. Occurs due to planned operations, such as DPPT, fluid sampling, or others.

4.3 Ballooning / Breathing Formation

Phenomena occurring in the well characterized by the apparent loss of fluid to the formation during drilling (increased pressure due to ECD) and gain of fluid during the connection (stopping friction pressure losses) without, however, configuring an inflow.

4.4 Buffer Manifold

Distribution manifold that allows to direct the flow to different flow paths necessary for the MPD (SBP and MCD) operations. It is responsible for routing flow to other circulation systems in the rig, like choke manifold, standpipe manifold, mud gas separator, trip tank, among others.

4.5 Work String

String used by the intervention unit to perform well activity, it can be drilling, landing, completion, workover or conditioning string.

4.6 RCD Seal Assembly

Assembly consisting of the sealing elements and bearing, if present.

4.7 Well Barrier

A set of elements or practices intended to prevent the unintentional flow of fluid from a permeable formation into the wellbore or in the environment along a specific path.

4.8 Dynamic Formation Integrity Test

Formation Integrity Test performed while keeping circulation thru the well and Managed Pressure System. The formation of the open hole is subjected to a pressure by the combination of surface pressure, friction pressure losses and the fluid column hydrostatic pressure to verify the resistance of the formation to a planned pressure.

4.9 Dynamic Leak Off Test

Leak-off performed while keeping circulation thru the well and Managed Pressure System. The formation of the open hole is subjected to a pressure by the combination of surface pressure, friction pressure losses and the hydrostatic pressure to determine the pressure at which the formation absorbs the mud.

4.10 Dynamic Pore Pressure Test

Test performed while keeping circulation thru the well and Managed Pressure System, which aims to determine the pore pressure by reducing the pressure applied at the surface until to the confirmation of a flow anomaly.

4.11 Well Barrier Element

Element or practices that constitute the envelope of a set of barriers.

4.12 RCD Seal Element

RCD element that promotes sealing against the work string. The sealing element promotes pressure exertion to the well annulus.

4.13 Equivalent Circulation Density

Equivalent circulation density is the effective density of the circulating fluid thru the well resulting from the sum of the pressure imposed by the hydrostatic column of fluid, friction pressure losses and back pressure applied at the surface.

4.14 Technical Specification for Goods and Services Acquisition (TS-GSA)

Document that contains specific technical requirements and complementary guidelines required to define procurement scope of equipment, material and/or service.

4.15 Floating Mud Cap Drilling

It is a MCD technique in which the fluid level remains below the rotary table.

4.16 Hydrostatic Underbalanced Fluid

Fluid used in the intervention, whose pressure exerted by its hydrostatic column is lower than the pressure of a certain formation communicated to the openhole.

4.17 Karstified Formations

Formations that underwent dissolution of part of their matrix by groundwater, resulting in cavities of diverse shapes and sizes.

4.18 Formation Integrity Test

Integrity test with application of additional surface pressure in a fluid column (hydrostatic pressure) to verify the strength of the formation to a determined pressure. (Determine the ability of an underground zone to withstand a planned pressure).

4.19 HAZID

HAZID (Hazard Identification) are risk identification studies. Hazard identification process to plan, avoid or mitigate its impacts.

4.20 HAZOP

HAZOP (Hazard Operability study) is a structured and systematic examination of processes

(existing or planned) to identify and evaluate potential hazards to personnel, the environment or equipment, or to avoid poor operations.

4.21 Influx

Unpredicted and unwanted invasion of fluid from the formation to the wellbore.

4.22 Operational Window

Represents the smallest difference between the highest pore / collapse gradient and the lowest fracture gradient / loss of circulation gradient in the open hole.

4.23 Leak Off Test

Test that aims to determine the pressure at which the mud leak-off through, or is absorbed by, a permeable formation. The pressure is applied at surface and transmitted through the mud hydrostatic column until the indication of absorption.

4.24 Mud Cap Drilling

It is an MPD technique that enables the operation to safely continue while occurring total loss of fluid to the formation. The loss is not controlled and the produced cuttings during drilling are pumped back to the formation.

4.25 NRV

NRV (Non Return Valve) is a flapper type valve, installed inside the work string that prevents the upward flow in case of imbalance between work string and well annulus.

4.26 Pressurized Mud Cap Drilling

It is a MCD technique in which the total loss are managed by the application of surface back pressure.

4.27 Rotating Control Device

RCD (Rotating Control Device), equipment that allows the pass-through of work string (with or without rotation) through its interior while providing the sealing against the string and, consequently, keeping the pressure in the well annulus at desired level. It is an integral part of the well barrier envelope.

4.28 Backpressure System

System that generates back pressure by restricting the flow by chokes, maintaining the surface or annulus pressure at the desired level. It is comprised of MPD manifold and a control system.

4.29 Flow Diversion System

System comprised by equipment installed in the riser that diverts the flow from the well to the surface system.

4.30 Managed Pressure System

All the required apparatus to the application of MPD techniques and their variants.

4.31 Surface Back Pressure

Surface Back Pressure (SBP) is an MPD technique in which surface back pressure is actively applied during operation (drilling, connections, tripping, among others) in order to maintain pressure at the desired value at the Anchor Point.

4.32 Intervention Unit

Unit contracted by PETROBRAS to carry out the intervention in the well, in drilling, completion, well testing, workover or abandonment operations.

5 ACRONYMS AND ABBREVIATIONS

AP – Anchor Point
BOP – Blowout Preventer
BTR – Bellow Tensioner Ring
DFIT – Dynamic Formation Integrity Test
DLOT – Dynamic Leak Off Test
DPPT – Dynamic Pore Pressure Test
ECD – Equivalent Circulation Density
EKD – Early Kick Detection
FMEA – Failure Module and Effect Analysis
FMCD – Floating Mud Cap Drilling
HMI – Human Machine Interface
HPHT – High Pressure and High Temperature
INMETRO – Instituto Nacional de Metrologia, Qualidade e Tecnologia
LAM – Light Annular Mud
LWD – Logging while Drilling
MCD – Mud Cap Drilling
MGS – Mud Gas Separator (atmospheric separator)
MPD – Managed Pressure Drilling
MTTF – Mean Time to Failure
MWD – Measuring while Drilling
NRV – Non-return Valve
P&ID – Piping and Instrumentation Diagram
PMCD –Pressurized Mud Cap Drilling
PRV –Pressure Relief Valve
PS – Protective Sleeve
PWD – Pressure while Drilling
RCD – Rotating Control Device
SAC – Sacrificial fluid
SBP – Surface Back Pressure
WB – Well Barrier

6 FUNCTIONAL AND TECHNICAL REQUIREMENTS DESCRIPTION

6.1 Intervention Unit

6.1.1 Surface System

6.1.1.1 The surface system is comprised by rigid pipes, manual and remote valves, connectors, adapters, sensors, flexible hoses and their respective installations that connect the flow diversion system and the MPD manifold to other equipment (shakers, trip tank, standpipe, choke manifold, MGS, buffer manifold, etc.), allowing direct flow through different paths.

6.1.1.2 The surface system shall allow all possible alignments according to PETROBRAS operations and procedures involving the SBP and MCD techniques (FMCD and PMCD variants) for all well intervention cycles, as exemplified in item 6.4, but not restricted to them.

6.1.1.3 The surface system shall allow the installation of all sensors described in item 6.3.1.13 which are part of the back pressure system.

6.1.1.4 The P & ID has to be submitted and approved by PETROBRAS as an integral act of the intervention unit procurement or contract amendment process, regardless of having been already used by other operators in well interventions. Therefore, unrestricted access to the arrangement of lines and valves and documentation of the unit should be allowed.

6.1.1.5 All elements of the system (rigid lines, valves, elbows, blocks, adapters, etc.) shall comply with NACE MR-01-75: 2015 specifications and, in addition, rigid lines shall comply with ASME B31. 3: 2015.

6.1.1.6 The following lines (Table 1), but not limited to them, shall be installed on the surface system of the intervention unit:

Table 1 - Minimum specification of surface lines (minimum scope of delivery).

#	Tubular	Minimum nominal diameter	Minimum internal diameter	Work pressure
1	*standpipe* to *buffer manifold*	6”	5,761”	3000 psi
2	*choke manifold* to *buffer manifold*	6”	5,761”	3000 psi
3	*moonpool* to *buffer manifold*	6”	5,761”	3000 psi
4	*moonpool* to *buffer manifold*	6”	5,761”	3000 psi
5	*moonpool* to *buffer manifold*	2”	1,939”	3000 psi
6	*buffer manifold* to *manifold MPD*	6”	5,761”	3000 psi
7	*trip tank* to *buffer manifold*	2”	1,939”	300 psi (Grade B or higher)
8	*bypass manifold MPD* (*buffer manifold* to *flow line* / *degasser*)	6”	5,761”	300 psi (Grade B or higher)
9	*manifold MPD* to *flow line* / *trip tank*	6”	5,761”	300 psi (Grade B or higher)
10	*manifold MPD* to *degasser*	6”	5,761”	300 psi (Grade B or higher

6.1.1.7 Any change of direction or curves of short radius (R / d <10, where "R" is the radius of the curve and "d" is the internal diameter of the piping) shall be protected with a "target flange" or fluid cushion (minimum length equal to pipe diameter or 4" whichever is greater) in both directions of flow.

6.1.1.8 All permanent crossover subs shall have safety slings.

6.1.1.9 The maximum pressure drop between the moonpool and the MPD manifold, considering the total flow through only one line, from the moonpool to the buffer manifold and from the buffer manifold to the MPD manifold, at a rate of 1500 gpm with seawater, should be at maximum of 85 psi.

NOTE: This pressure drop will be calculated by subtracting the pressure read at the MPD manifold inlet from the pressure read on the flow spool, the hydrostatic pressure difference due to the difference in height between the MPD manifold and the flow spool and the pressure drop in the hose (estimated at 60 psi for a flexible hose 200 feet long and 6 inches internal diameter at a flow rate of 1500 gpm of seawater).

6.1.1.10 Pressure relief valves (PRVs) shall be installed to protect the equipment, including sections with pressure class change, plus the buffer manifold and / or well return flow lines, as exemplified by the global P&ID showed in Figure 1 of this TS.

6.1.1.11 The PRVs shall be automatic, programmable and self-restorable, with pressure class compatible with other surface system equipment which is intended to protect and be gas tight.

6.1.1.12 Redundant blocking valves shall be installed at the interconnection points of (a) buffer manifold with standpipe manifold and (b) of the buffer manifold with choke manifold, being pressure class compatible with the respective manifolds.

6.1.1.13 There shall be no sections with diameter reductions along the pipe, except for connections, with the reduction limited to the diameter of the connection.

6.1.1.14 A hydrodynamic study of the use of swivel for all flexible hoses shall be presented, assuring compliance to heading adjustments requirements for the intervention unit.

6.1.1.15 The control system of the remote actuation valves and sensors must have HMI for actuation and monitoring, as well means of logging the opening and closing maneuvers and allow the recovery of the registry by digital means, as well as being available in the data system of the intervention unit.

6.1.1.16 All remote operated valves should have mechanism for manual drive as a backup.

6.1.1.17 The valves at the lines that direct the flow to the MGS and the valves that direct the flow to the flow line / trip tank, should have remote operation, as well as having interlocking system.

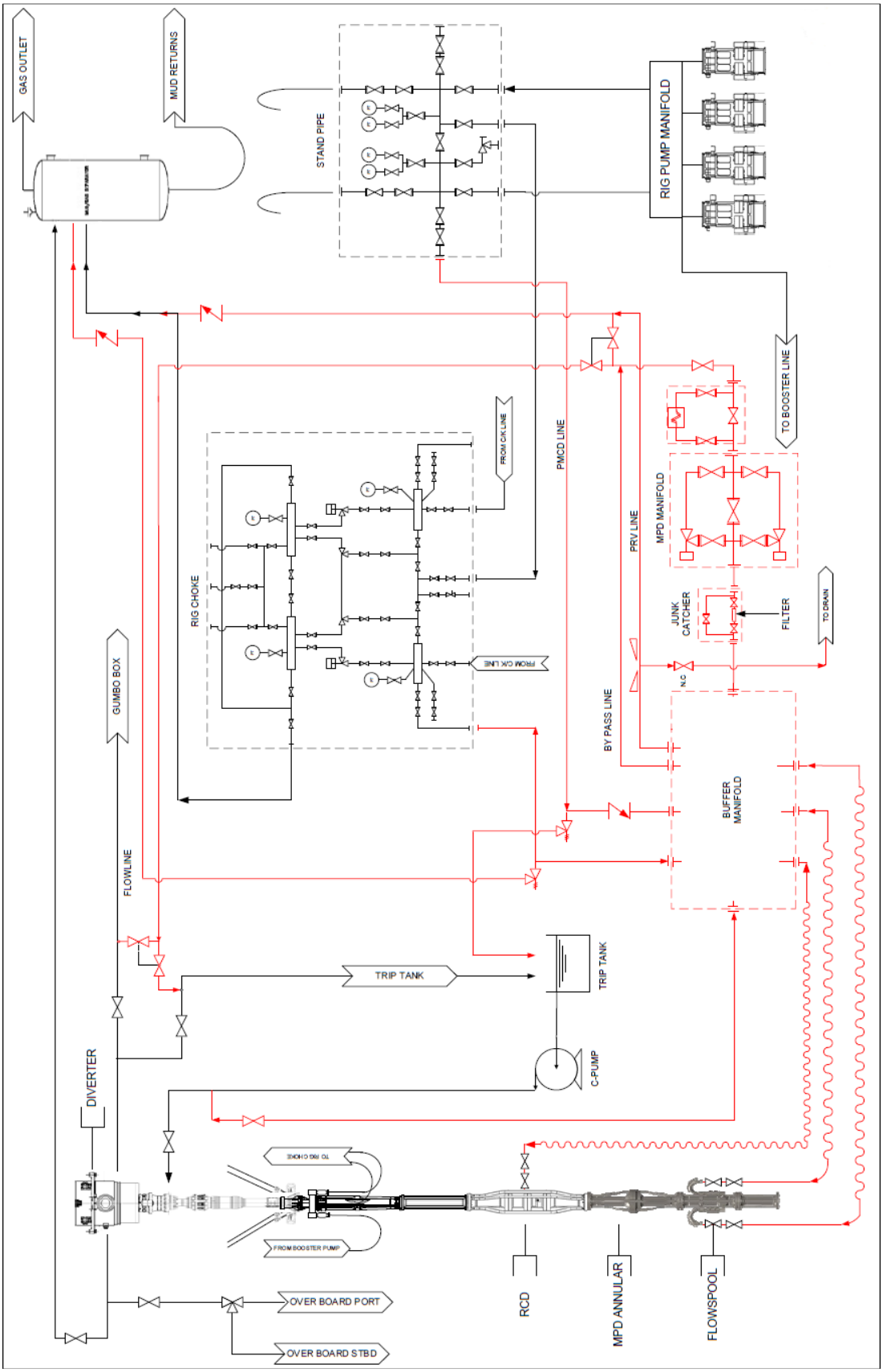

Figure 1 - Global P&ID (reference for supplier-specific P&ID elaboration).

6.1.1.18 The driller's cabin should have an area for the accommodation of MPD operators, MPD control, monitoring panels and computers from the team responsible for the Backpressure System.

6.1.1.19 The intervention unit shall be capable of rotating up to 175 degrees in both directions without causing interference from the Flexible hoses of the Flow Diversion System to the drilling riser or moonpool equipment.

6.1.2 Buffer manifold (Distribution manifold)

6.1.2.1 The buffer manifold shall allow alignment to the flow spool, trip tank, standpipe manifold, flow line, choke manifold, atmospheric separator, MPD manifold and drain tank, and shall allow all possible alignments according to PETROBRAS operations and procedures involving the SBP and MCD techniques (FMCD and PMCD variants) for all well intervention cycles, according to the operations listed in item 6.4, but not restricted to them.

6.1.2.1.1 The minimum scope, but not limited to, for the design of the buffer manifold, where the RCD bleed off is to a 2-inch flexible hose is depicted in Figure 2a.

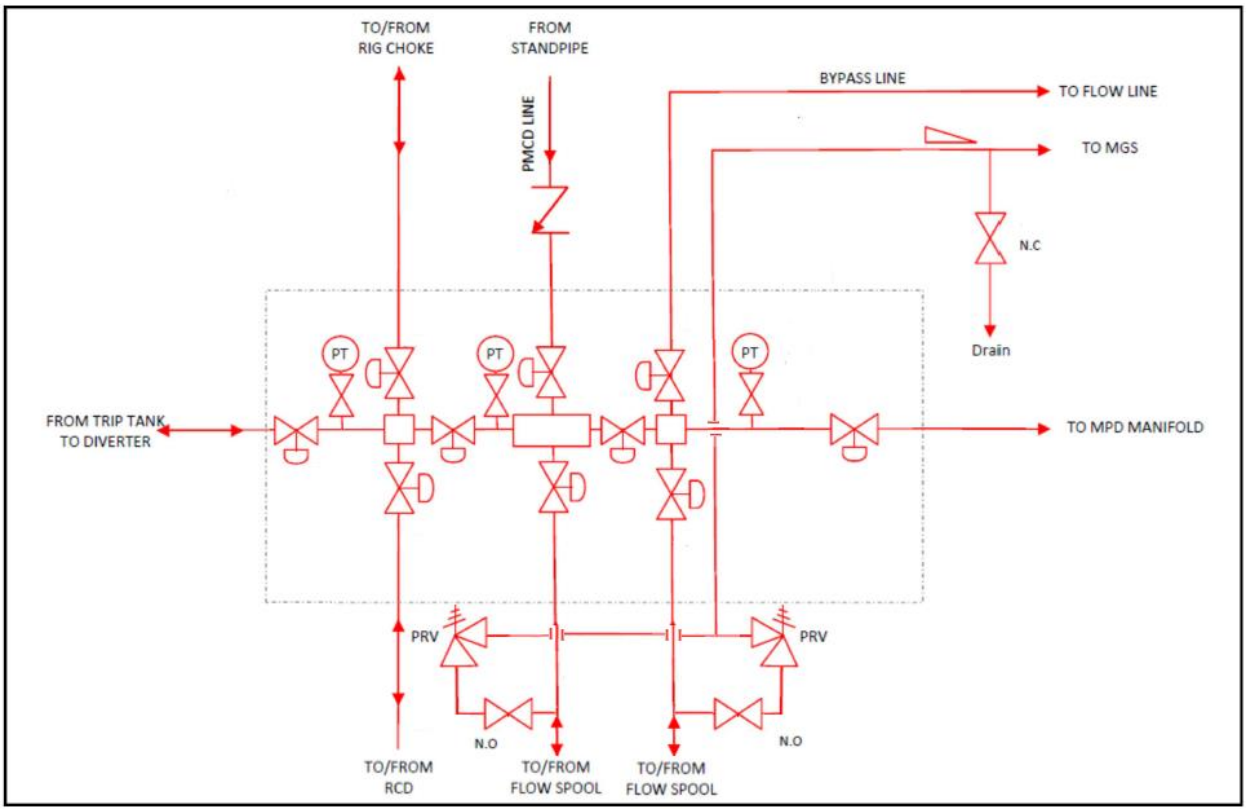

Figure 2a – Detail of buffer manifold (reference to support elaboration of specific P&ID by the supplier).

6.1.2.1.2 The minimum scope, but not limited to, for the design of the buffer manifold, where the RCD bleed off is to the flow spool is depicted in Figure 2b**.**

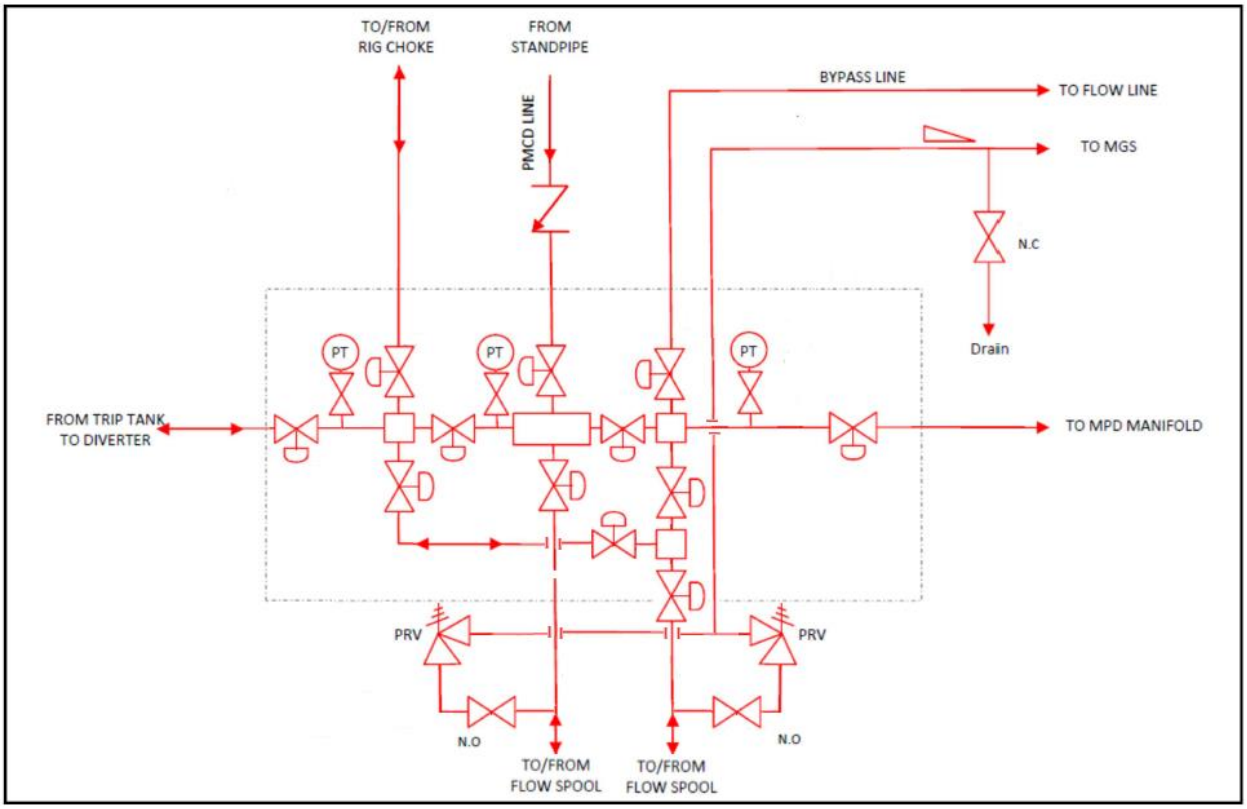

Figure 2b – Detail of buffer manifold (reference to support elaboration of specific P&ID by the supplier).

6.1.2.2 The pressure class of the buffer manifold should be 3000 psi or greater (nominal diameter 6 ", minimum internal diameter 5.761").

6.1.2.3 It must have at least three pressure sensors to allow pressure monitoring for all different alignments during PETROBRAS operations and procedures.

6.1.2.4 All pressure sensors should have local indicators in addition to the remote transmission capability to the intervention unit data system.

6.1.2.5 The pressure sensors shall be installed horizontally.

6.1.2.6 All valves shall be remotely commanded as per global P&ID showed in Figure 1 and be capable of being actuated while submitted to differential pressure.

6.1.3 P&ID

6.1.3.1 The interconnecting pipe between the buffer manifold and the Choke manifold must allow flow to both sides of the choke manifold while being isolated from the side that is not being used for MPD Operations.

6.1.3.2 The interconnection line between the Standpipe manifold and the Buffer manifold shall allow alignment of both sides of the Standpipe manifold while being isolated from the side that is not being used for MPD Operations.

6.1.3.3 There should be a line connecting the buffer manifold directly to the MGS.

6.1.3.4 The lines to the MGS, coming from the MPD manifold, buffer manifold and the PRVs should have check valves installed close to the separator.

6.1.3.5 The MPD manifold and the buffer manifold shall be connected by pipelines to the flow line (gumbo box) and the trip tank, being linked downstream of interlocking valves, in accordance with figure 3.

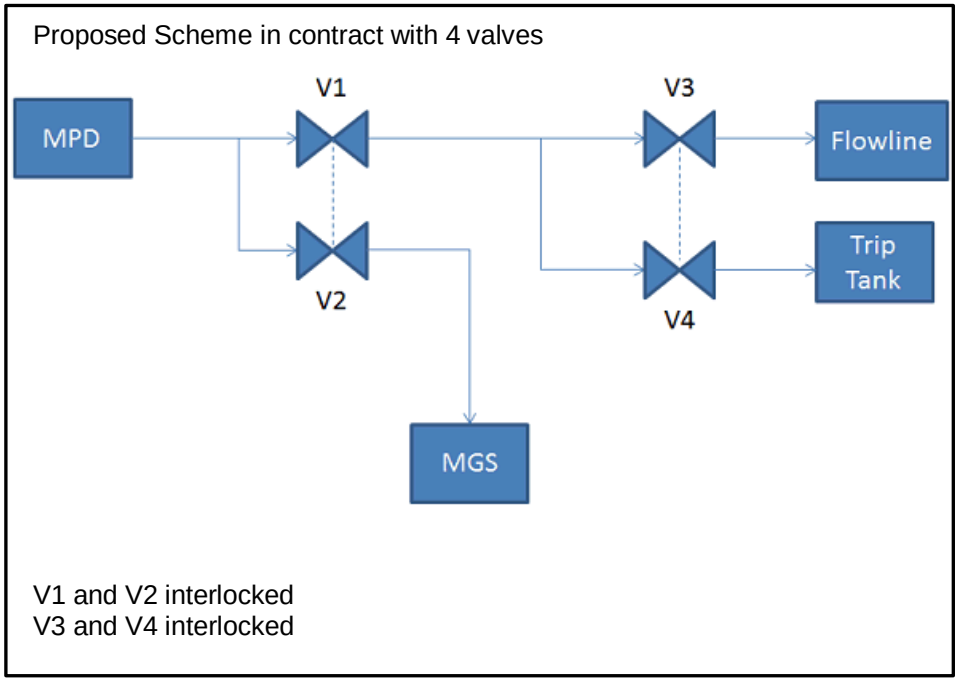

Figure 3 – Interlocking scheme of surface valves.

Note 1: The valves V1 and V2 are interlocked so that when one is open the other is closed. Both should be located as close as possible to the MPD manifold in order to prevent gas from accumulating in the other surface lines, in the event of gas circulation to the MGS.

Note 2: The valves V3 and V4 are interlocked so that when one is open the other is closed. The V4 should be located as close as possible to the trip tank so that, when it is necessary to perform flow-check through the trip tank, the line to the trip tank is filled with fluid.

Note 3: Normal operation occurs with V1 and V3 open.

6.1.3.6 Lines from the MPD and buffer manifolds should intercept the flowline upstream of the flowline gas sensor (item 6.1.6.2).

6.1.3.7 Lines from the MPD and buffer manifolds shall intercept the flowline without impact to the flow diverter to the shakers.

6.1.3.8 Provision should be made for the installation of a large-diameter junk catcher system (greater than or equal to 2" in diameter) upstream of the back pressure system. This junk catcher must have bypass that allows its cleaning without interruption to the operation.

6.1.4 Drilling accessories

6.1.4.1 Split bushing

According to TS-GSA of the intervention unit.

6.1.4.2 Pipe racking in the intervention unit

The intervention unit shall provide transition subs (crossovers) and pup joints, according to intervention unit TS-GSA, sufficient to maintain 3 (three) stands racked up simultaneously, one with setting / unsetting tools of the sealing assembly, one with a assembly connected to the tool and one with protecting sleeve (PS), with the PS suspended by the tool, without prejudice to the quantities already stablished in the TS-GSA of the intervention unit.

6.1.4.3 Special non-return valve (NRV)

6.1.4.3.1 Flapper type, non-ported, gas tight NRVs shall be made available for use in SBP / MCD operations.

6.1.4.3.2 Special NRVs must be certified to work at up to 400° F and 10,000 psi with H2S resistant elastomer.

6.1.4.3.3 All NRVs must be non-ported, flapper style, without pressure relief mechanisms and allow for passage of ball and dart of at least 2 1/2" diameter.

6.1.4.3.4 NRVs will be coupled into subs specially designated for MPD / MCD operations, in order to mechanically lock the NRVs and provide a seal between them.

6.1.4.3.5 Such subs for coupling of NRVs shall be available.

6.1.4.3.6 The equipment necessary for the installation and removal of the NRVS from subs shall be provided by intervention unit.

6.1.4.3.7 The diameters of the NRVs and subs to be made available must be compatible with all the working strings of the unit for the various types of intervention, such as drilling, completion, well testing, workover and abandonment.

6.1.4.3.8 There must be at least two NRVs available for each work string as well as backup NRVs.

6.1.4.3.9 NRVs and subs should meet the specifications and recommendations of API SPEC 7NRV: 2012.

6.1.4.3.10 NRVs and subs shall be compatible with drilling and completion fluid used in PETROBRAS operations and procedures involving SBP and MCD techniques as defined in item 6.4.3 (FMCD and PMCD variants) for all well intervention cycles. Fluids characteristic shall be stablished in the TS-GSA.

6.1.5 Load Handling System

6.1.5.1 The riser crane should have sufficient load capacity to move the MPD riser joint as an integral part from the deck to the drilling platform, positioning it on the riser catwalk. If the MPD riser joint is provisioned by 3rd party contracted by PETROBRAS, the required capacity will be informed in the TS-GSA of the intervention unit.

6.1.5.2 The riser catwalk should allow the MPD riser joint to be fitted as a single piece, with sufficient load capacity. In addition, it must have adequate geometry to

position the MPD riser joint so as not to damage it´s encapsulation. If the MPD riser joint is supplied by 3rd party contracted by PETROBRAS, the required capacity will be informed in the TS-GSA of the intervention unit.

6.1.6 Well control system

6.1.6.1 The MPD system shall be capable to be aligned directly to an MGS with capacity at least equal to the riser MGS as per the TS-GSA of the intervention unit.

6.1.6.2 The gas sensor shall be positioned in such a way as to permit measurement with any flow alignment to the flowline.

6.1.7 Subsea System

6.1.7.1 Subsea equipment exposed to well pressure, ie all components of the drilling riser and the subsea BOP system - LMRP and BOP stack (riser joints, flex joint, connectors, valves, annular preventers and rams) shall have the capacity to operate with an external differential pressure equivalent to the maximum water depth defined in the TS-GSA of the intervention unit, proven by submission of an engineering study by the manufacturer and / or drilling contractor.

6.1.7.2 Riser analysis shall be performed as defined in section G in the TS-GSA of the intervention unit considering flow diversion equipment for SBP, FMCD and PMCD scenarios, with 2000 psi applied at the top of the drilling riser, up to the maximum fluid weight and the maximum water depth defined in the TS-GSA of the intervention unit. Sensitivity analysis for water depth, riser pressure and static fluid level shall also be presented, indicating new limits and operating envelope in SBP, FMCD and PMCD mode.

6.1.7.3 The riser analysis shall consider the scenario of FMCD with empty riser in the emergency disconnection. The BOP ram should support the differential pressure in this scenario.

6.1.7.4 The riser recoil system should be able to handle situations with partially or totally empty riser and also situations where the riser is pressurized as defined in section G in the TS-GSA of the intervention unit.

6.1.7.5 The intervention unit shall be capable of operating with the following riser stack-up configuration from top to bottom:

i. Diverter with 19-1 / 4" minimum ID;
ii. Upper flex joint 19-1 / 4" minimum ID;
iii. Telescopic joint 19-1 / 4" minimum ID;
iv. Spool Adapter - Riser Flange to MPD riser joint flange;
v. MPD riser joint;
vi. Spool Adapter – MPD Riser joint flange to riser flange;
vii. Drilling riser

6.1.7.6 Accommodation of the auxiliary lines of the drilling riser system shall be specified in the TS-GSA of the intervention unit and may be:

a) By-pass for the auxiliary lines of the drilling riser system to be installed for items 6.1.7.5 (iv), (v), (vi) and (vii). The by-pass shall not interfere with the maximum diameters of pass-through of the rotary table and the tensioning ring of the intervention unit;

Or

b) Termination joint for riser system auxiliary lines, interconnecting items 6.1.7.5 (vi) and (vii).

6.1.7.7 The connection of the MPD riser joint shall be compatible with the riser column, being possible to use spool adapters. If spool adapters were used, the following requirements must be met:

6.1.7.7.1 Spool Adapter - Riser Flange to MPD Riser Joint Flange

- Upper flange compatible with riser connector of the intervention unit.
- Lower Flange compatible with MPD riser joint connector.
- Working load of 3,500,000 lbf
- Manufactured in accordance with API RP 16Q, API SPEC 16R and API SPEC 16F.
- Minimum internal diameter of 19 ¼ ".

6.1.7.7.2 Spool Adapter - MPD Riser Joint Flange to Riser Flange

- Upper flange compatible with MPD riser joint connector.
- Lower flange compatible with intervention unit riser connector.
- Working pressure 2000 psi.
- Workload of 3,500,000 lbf (with 2000 psi internal pressure applied).
- Suitable for H2S services, according to ANSI/NACE MR0175 / ISO 15156 all parts.
- Manufactured in accordance with API RP 16Q, API SPEC 16R and API SPEC 16F;
- Minimum drift of 18-3/4".

6.1.7.7.3 The connector type of the MPD riser joint shall be informed in the TS-GSA of the intervention unit.

6.1.7.7.4 It shall be informed in the TS-GSA of the intervention unit that requirement to consider by-pass for the auxiliary lines of the drilling riser (choke, kill, booster, supply, etc.).

6.1.8 Termination joint

6.1.8.1 A riser joint with riser auxiliary lines termination (choke, kill, booster, supply) shall be provided when there is no by-pass for the auxiliary lines on the MPD riser joint.

6.1.8.2 The upper and lower flanges of the termination joint must be compatible with the riser connector;

6.2 Flow Diversion system

6.2.1 General requirements

6.2.1.1 The entire system, described in items 6.2.1to 6.2.5, shall withstand a workload of 3,500,000 lbf (with 2000 psi applied of internal pressure) and bending moment equivalent to or greater than that of the drilling riser.

6.2.1.2 The equipment and its interfaces, described in items 6.2.1 to 6.2.5, shall be designed so as to allow the intervention unit to rotate at least 175 degrees to each side.

6.2.1.3 The equipment and its interfaces described in items 6.2.1 to 6.2.5shall meet the working pressure of 2000 psi. For the RCD this working pressure is in static conditions.

6.2.1.4 Working temperature for the equipment ranges from 35 ° F to 250 ° F.

6.2.2 MPD riser joint

6.2.2.1 The MPD riser joint is composed of at least (top to bottom):

- RCD
- Annular preventer
- Flow Spool

6.2.2.2 Supplied with all necessary accessories for operations including, but not limited to, adapters, split rings and running tools.

6.2.2.3 The running tool should be hydraulic, with at least one back-up installation tool, which may be mechanical.

6.2.2.4 Accommodation of the auxiliary lines of the drilling riser system shall be specified in the TS-GSA that provisions the supply of the MPD riser joint, which may be:

a) By-pass for the auxiliary lines of the drilling riser system to be installed for the components of the MPD riser joint. The by-pass shall not interfere with the maximum diameters of pass-through of the rotary table and the tensioning ring of the intervention unit;

Or

b) Riser system auxiliary lines termination joint, to be provided by the intervention unit, interconnecting items 6.1.7.5 (vi) and (vii).

6.2.2.5 The MPD riser joint must have a maximum OD that allows it to pass through the rotary table and tensioning ring of the intervention unit, even if it is with the flow spool valve actuators or encapsulated. It should have bumpers to prevent damage to its elements during descent.

6.2.2.6 The MPD riser joint shall comply with the manufacturing requirements of API SPEC

16A: 2017, API SPEC 16D: 2004, API RP 16Q: 2017, API SPEC 16R: 1996 and API SPEC 16F: 2017.

6.2.2.7 There shall be a pressure sensor installed in the MPD riser joint, below the annular preventer, and at the RCD, with the capability of sending this information to the rig data system and to the back pressure system data system.

6.2.2.8 The MPD riser joint shall have a minimum drift of 18-3/4" when the sealing assembly is not installed.

6.2.2.9 Provide a remote-actuated, redundant block valve, with position visual indicator and metal-to-metal seal, manufactured to the requirements of API SPEC 6A: 2010 - PSL-3, EE-0.5, U, for installation at the RCD pressure equalization and well access outlet (see section 6.2.3.8). This valve shall be monitored, have position indication and remotely controlled remotely at:

a) Hydraulic surface control panel.

b) Electronic control panel in the driller's cabin.

6.2.2.10 Provide a flexible hose for connection to the block valve (item 6.2.2.9), fire-resistant, abrasive fluids, solids, and operation stresses, for connection to the surface system with compatible connections, considering the heading adjustments requirements of the rig in the case of dynamic positioning rigs, according to item 6.2.1.2of this specification.

6.2.2.11 The hose must have quick coupling type connection for interlocking to the block valve (item 6.2.2.9).

6.2.2.12 It is allowed to adopt alternative solution to the flexible hose that interconnects the locking valve (item 6.2.2.9) to the surface system upon acceptance of PETROBRAS.

6.2.3 RCD

6.2.3.1 It shall withstand, with sealing assembly installed, hydrostatic pressure applied per fluid column above the installation point in the drilling riser, considering atmospheric pressure below.

6.2.3.2 It shall have components and connections designed for submerged operation, as the RCD may be installed in the riser up to 40 meters below sea level.

6.2.3.3 It must have sensors that allow well pressure measurement.

6.2.3.4 The housing (RCD body) for the sealing assembly shall have a minimum drift of 18 ¾" for subsea wellhead tools pass-through.

6.2.3.5 It must have a locking and unlocking system with actuation and remote operation, besides having back up system for unlocking.

6.2.3.6 The locking system of the seal assembly shall be "Fail Safe As Is". In this way, in case of operational failure or leakage of the locking trigger umbilical, the seal assembly must remain installed, even if the well is pressurized.

6.2.3.7 It shall have a monitoring system (with indication) and alarm for the functions of locking and unlocking the elements to be installed in the RCD, in addition to pressure sensors:

a) Locally on the HMI / RCD control panel,

b) Remotely in the driller's cabin, and

c) Available to the rig data system and the back pressure service company via communication protocol.

6.2.3.8 Provide at least 2 1/16" outlet for pressure equalization and well access.

6.2.3.9 The sealing assembly shall have an external diameter compatible with the drift of the elements above the installation point

6.2.3.10 During MPD operation, back-up sealing assemblies shall be on board, in addition to the required sealing elements and spares.

6.2.3.11 The RCD seal assembly shall have at least a double seal, having a sensor with transmission of the readings to the monitoring and control system of the RCD, in order to identify the failure of the lower or upper seal.

6.2.3.12 A protective sleeve shall be installed on the RCD, having a minimum internal diameter of 17 3/4".

6.2.3.13 The RCD shall allow for minimum dynamic operating pressure at 100 RPM of 1000 psi, at 50 RPM of 1500 psi and rotation limit of at least 200 RPM.

6.2.3.14 The running/pulling tools of the seal assembly and protective sleeve, with mechanical (preferably), hydraulic or pneumatic actuation, shall have the same tensile strength of the working string of the intervention unit.

6.2.3.15 All accessories required for operations shall be available including, but not limited to, adapters and running tools, with 4 ½ "IF, 5 ½" FH or 6 5/8 "REG connections and connections compatible with all work string defined in the TS-GSA of the intervention unit. It is necessary to be capable of mounting at least one section with protective sleeve and two with the sealing set.

6.2.3.16 The available seal elements shall allow the operation with working strings with OD 6-5/8”, 5-7/8”, 5-1/2”, 5”, 4-1/2”, 4”, 3-1/2”, 2-7/8” e 2-3/8”.

6.2.3.17 Equipment for MPD wireline logging shall be available to be installed on the RCD, with the same capacity as the other elements. This equipment, together with other wireline logging equipment specific to the MPD scenario, should allow the cable to be lowered by keeping the well pressurized.

6.2.3.18 It is acceptable the use of adapters in the RCD bore that connect to casing provided by PETROBRAS and promote the annular seal of the casing.

6.2.3.19 The sealing elements shall be resistant to the fluids, temperatures and operations used in PETROBRAS, according to item 6.4, but not restricted to.

6.2.3.20 The RCD sealing elements shall be able to operate without interruption for a

minimum period of 120 hours, within the operating ranges of the equipment.

6.2.3.21 It shall have a monitoring and control system of the RCD, which may be the same unit used by the other elements of the MPD riser joint.

6.2.3.22 The RCD shall comply with the requirements of the API SPEC 16RCD: 2015 and an API monogram shall be provided attesting to compliance with that specification.

6.2.3.23 The RCD bearing, when used, shall be able to operate without interruption for a minimum period of 360 hours under normal operating conditions.

6.2.3.24 Maintenance and repairs shall be carried out in installations in the Brazilian territory.

6.2.4 Annular surface BOP

6.2.4.1 The annular preventer has the primary function of allowing the pressure maintenance in the well during the replacement of the RCD seal assembly, ensuring the isolation of drilling riser from the atmosphere.

6.2.4.2 It shall allow closing pressure adjustment to perform a stripping operation. To do this, it shall have a dedicated accumulator for stripping operation, able to regulate the pressure in increments of 50 psi, with response time according to API STD 53: 2012.

6.2.4.3 Provided with bumpers to prevent damage to its elements during installation and removal.

6.2.4.4 The surface BOP sealing element shall permit stripping with tool joints of all provided working strings required in the TS-GSA of the intervention unit.

6.2.5 Flow Spool

6.2.5.1 Direct the return flow of the well through flexible hoses to the surface system.

6.2.5.2 It shall have two side outlets with redundant, remote-actuated block valves, with position visual indicator and metal-to-metal seal, manufactured to the requirements of API SPEC 6A: 2010 - PSL-3, EE-0.5, U. This valve shall be monitored, It shall have position indication and be remotely controlled at:

a) Hydraulic surface control panel.

b) Electronic control panel in the driller's cabin.

6.2.5.3 Provided with goose neck type connection for flow hoses.

6.2.5.4 Provide flexible hoses, fire resistant, unaffected by abrasive fluids and solids. They shall withstand handling and operational loads for interconnecting with drilling equipment and surface system, having also compatible connections.

6.2.5.5 Two hoses shall be connected to the Flow Spool, taking into account the

requirements for the rig heading adjustment in case of dealing with a dynamic positioning rig, according to item 6.2.1.2 of this specification.

6.2.5.6 Hoses shall have a quick coupling type connection for linking to the Flow Spool goose necks.

6.2.5.7 The diameter for pass-through the rotary table and tensioner ring should consider Flow Spool valves with their actuators.

6.3 Backpressure system (MPD manifold)

6.3.1 General requirements

6.3.1.1 The Back Pressure System shall analyze the available drilling data and automatically control the pressure at a desired depth using the hydraulic model and the MPD manifold, keeping the well permanently under control.

6.3.1.2 The system includes the wellbore pressure management by application of surface pressure (SBP) with automatic downstream well control, anticipated inflow detection (EKD) and other well events, and non-return drilling with or MudCap Drilling (MCD).

6.3.1.3 The back pressure system shall:

- Monitor well parameters including pore pressure, fracture / absorption pressure, equivalent circulation density, and surge / swab pressures during drilling and connections through measurements or tests.
- Detect and control influxes and losses in manual and automatic mode.
- Maintain constant pressure at predefined depths, with or without fluid circulation through the working column, without affecting the ability to detect and control inflows and losses.
- Indicate when there is a need to change from SBP mode to MCD mode, and enable the return to SBP mode.
- Allow DPPT, DFIT and DLOT to be performed through the choke control software with an integrated hydraulic model.

6.3.1.4 A software, based on control algorithms and system programming logic, should be made available for well design, simulation of MPD operations and problem diagnostics. Licenses must be made available for use in the PETROBRAS system, in addition to the licenses for equipment provided for operations in the drilling units.

6.3.1.5 Technical information should be provided to PETROBRAS with detailed and proven method for detection and control of flow anomalies.

6.3.1.6 The system shall perform the circulation of flow anomalies by the driller's method, manual and automatically.

6.3.1.7 The system shall allow all possible alignments and planned or contingent

operations in accordance with the PETROBRAS procedures, according to item 6.4.1, but not limited to these procedures.

6.3.1.8 If the method for calculating or measuring surface pressure loss is based on direct pressure measurements, the system shall provide an alternative in case of failure or absence of pressure transmitter, ensuring redundancy.

6.3.1.9 A study and / or MPD project shall be carried out for each operation to be performed, in accordance with specific TS-GSA requirements, taking into account the deadline stipulated in that TS-GSA, upon PETROBRAS request.

6.3.1.10 The system shall have the possibility of being operated remotely by the operator of the Back Pressure System, and shall be monitored by the remote driller panels and the PETROBRAS company man. The system shall also have the capability of transmitting operational data via the WITSML protocol to a Petrobras server in the intervention unit.

6.3.1.11 The MPD Manifold shall be able to work with the flow through the Coriolis meter while drilling at any rate of penetration, with the exception of drilling of cement, accessories or casing.

6.3.1.12 The necessary equipment that composes the Backpressure System must have the minimum required certifications, arranged in Certification bodies accredited by INMETRO, ensuring their total operation.

6.3.1.13 The system shall be composed of at least the following equipment and functionalities:

- 2 (two) drilling chokes, which can be used independently and in parallel;
- Coriolis type flow meter with a minimum working pressure of 2000 psi;
- Strokes counter for installation in the mud pumps of the intervention unit, in quantitative compatible with the number of pumps of the unit; **NOTE:** If the intervention unit has Coriolis type flow meters for inlet flow, the Back Pressure System shall be capable of receiving data from that meter.
- 2 (two) pressure transmitters with local display for installation in the standpipe manifold;
- 2 (two) pressure transmitters with local display for installation on the MPD manifold;
- Bypass line for MPD manifold chokes;
- Bypass line for the Coriolis type flowmeter;
- Gate type block valves that allow maintenance and / or isolation of MPD chokes while maintaining operation by the other MPD choke (s);
- Remote control and actuation unit;

- Real-time data transmission system;
- System for recording and transferring operational data that can be used at any operation time;
- 4 (four) monitors to follow the operations in the intervention unit with adaptive interface according to user;
- Ability to operate the chokes without power or pressurized air, in order to allow at least a complete opening and closing of the chokes.

6.3.1.14 The Coriolis type flow measurement system shall allow diagnosis and verification to establish reliability of meter performance without interruption of operation, being programmable and used on demand.

6.3.1.15 The Coriolis flow meter shall be capable of operating in a specific mass and fluid flow range compatible with PETROBRAS operations, with no discrepancies greater than ± 0.15 ppg in relation to the density measured with a pressurized scale.

6.3.1.16 The system for calculating the background pressure by the MPD software, when compared to the data of the PWD tool, previously checked in the Shallow Test or in the cased well fingerprint step, cannot present discrepancies greater than 50 psi (plus or minus).

6.3.1.17 All sensors that are provided with the system shall have independent redundancy and a real-time diagnostic function.

6.3.1.18 The MPD Manifold should be modularized, facilitating installation and configuration / arrangement. The interconnection between the modules must be carried out by rigid line or flexible hose, at the discretion of PETROBRAS.

6.3.1.19 The MPD manifold shall meet items 6.1.1.5, 6.1.1.6 and 6.1.1.7 of this specification.

6.3.2 System Characteristics

6.3.2.1 MPD Manifold Specification	
Characteristic	**Specification**
Type	MPD (electronic equipment for Zone 1)
Minimum working pressure	3 000 psi
Flanges	Minimum ID of 7 1/16 "3000 psi.
Work temperature	Class V: 35°F to 250°F (2 °C to 121°C)
Material class	Class EE (Sour Service)
Adjustable hydraulic choke	Minimum ID of 3 "
Rigid Lines, Connections and Locking Valves	PSL-3, minimum ID of 6 "
Flexible interconnection hose	Minimum ID of 5 ", fire resistant, abrasive fluid
Manufacturing	API SPEC 5L:2012, API SPEC 6A:2010, API SPEC 16C: 2015, API SPEC 17K: 2017, ASME B31.3: 2015

6.3.2.2 Coriolis Flow Meter Specification	
Pressure Category	At least 2000 psi
Nominal diameter	Minimum of 6 "
Process Fluid	Liquid, mud and Gas
Process Variables	Mass, Volume, Density and Temperature
Flow tube material	Super Duplex (working with H2S) or Nickel Alloy C22 (working with H2S)
Maximum Flow rate	Equal to or greater than 1500 gpm with seawater or equivalent mass flow
Location	Upstream or downstream of chokes

6.3.3 Data Acquisition and Transmission System

6.3.3.1 The Back Pressure System shall be capable of receiving data from the intervention unit and the providers of drilling service, such as mud logging, directional drilling service, PWD / MWD, Petron, among others, through the WITSML protocol.

6.3.3.2 All data shall be stored on the Backpressure System server on the rig and transmitted to the server in the PETROBRAS corporate Environment, according to PETROBRAS Information Safety Standards.

6.3.3.3 From this server, the data must be made available, in real time, through the website hosted on the Internal Network of PETROBRAS, through the access authorization for each operation.

6.3.3.4 Access to the website shall be made available to users authorized by PETROBRAS, including supervisors or decision support centers through the use of a personal and non-transferable login and password.

6.3.3.5 The system shall have control and monitoring panels with dimensions appropriate to the installation in the driller's cabin.

6.4 Operations in the scope of the Technical Specification

6.4.1 The following operations in MPD mode and their derivative techniques are planned in the scope of service provision, but not restricted to them:

- Drilling, connection and tripping
- Running casing or liner
- Cement job
- Wireline Logging
- Dynamic Pore Pressure Test
- Dynamic Formation Integrity Test
- Dynamic Leak Off Test
- Circulation of flow anomaly by the pressure management system.
- Circulation of inflow by the pressure management system, through specific risk

analysis

- Tripping with any tubular element in the drilling riser with closed BOP
- Lower completion
- Heavy workover

6.4.2 The above operations may be performed with the use of hydrostatically overbalance, nearbalance or underbalance fluid.

6.4.3 Fluids may be water base, synthetic, organic or aerated. They may be abrasive by the addition of thickening solids, incorporation of solids from the well or addition of other solids required for the operation.

7 DOCUMENTATION

7.1 The company or supplier shall prove by means of technical reports, simulations, API monogram, certifications and other technical documentation that meets the whole functional, technical and complementary requirements defined in this technical specification,

7.1.1 All documents must be made available electronically in PDF format.

7.1.2 The documents described below are scope of delivery and must be available for technical analysis and approval:

a) API SPEC 16RCD monogram with license scope for RCD - manufacturing and testing according to normative specification;

b) API SPEC 16A monogram with license scope for annular prevention - manufacturing and testing according to normative specification;

c) API SPEC 6A monogram with license scope for the flanges - manufacturing and testing according to normative specification

d) API SPEC 16R and API SPEC 16F monogram and API RP 16Q service certificate with license scope for MPD riser joint and termination joint - manufacturing and testing according to normative specification.

e) API SPEC 16D monogram with license scope for Valve Control System.

f) API SPEC 17K monogram and API RP 7K and API RP 17B compliant certificate for hoses.

g) API SPEC 6A and API SPEC 5L monogram and ASME B31.3 certificate of service with license scope for rigid pipes.

h) Certificates and proof of calibration of all pressure sensors.

i) Operational and emergency procedures of the MPD system.

j) Surface system P & ID (reference item 6.1.1.4).

k) Hydrodynamic study report evaluating the use of swivel of all flexible hoses (reference item 6.1.1.14).

l) Technical material to PETROBRAS with details and proof of methodology for the detection and control of flow anomaly (reference item 6.3.1.5).

m) Engineering study of the manufacturer and / or drilling contractor proving that subsea equipment exposed to well pressure, ie all components of the drilling riser and the subsea BOP system - LMRP and BOP stack (riser joints, flex joint, connectors, valves, annular preventers, BOP rams) are capable of operating with an external pressure differential equivalent to the maximum water depth provided in the operations considered for the hiring step (reference item 6.1.7.1).

n) Riser analysis report considering the MPD riser joint, for SBP and FMCD scenarios, presenting sensitivity analysis for water depth, riser pressure and static fluid level, with appropriate operating envelopes (reference item 6.1.7.2).

o) FMEA and system reliability study. FMEA shall comprise analysis up to component level with failure mode and assignment of associated failure probability and severity. The conclusions and recommendations shall include planned actions to reduce failure probability or mitigate their effects. Additionally, the following reliability metric shall be provided: MTTF and the model utilized to proceed calculationl. The input data used for the aforementioned analysis shall be related to the technology described in this technical specification. Technical report with calculation memory and other related information shall be provided.

7.2 Operational and emergency procedures shall be affixed to main equipment in such a way that access to them is readily available if necessary.

7.3 Specific procedures should be provided for each operation contemplated in PETROBRAS 'scope of work, in accordance with its procedures.

7.4 For the purpose of contracting suppliers, a valid certificate of API SPEC Q1 and API SPEC Q2 must be submitted. The manufacturing of system components must meet the requirements stablished in the SPEC Q1 API, 9th edition. The service delivery must meet the requirements established in the API SPEC Q2, 1st edition.

8 SUPPLY CATEGORIES

8.1 The supply items contained in this technical specification may be made available to PETROBRAS by procurement of services in accordance with the categories listed below.

Categories	Object	Enabled Suppliers
1	Modifications to the intervention unit (6.1)	Intervention unit Not allowed to supply to managed pressure service providers
2	Supply of RCD (6.2.1 and 6.2.3)	Intervention unit Managed pressure service providers
3	Supply of surface annular and flow spool (6.2.1, 6.2.4 and 6.2.5)	Intervention unit Managed pressure service providers
4	Supply of backpressure system (6.3)	Not allowed by the intervention unit
5	Supply of accessories for MPD riser joint composition (6.2.1 and 6.2.2)	Intervention unit Managed pressure service providers

8.2 The respective TS-GSA shall reference the items of this technical specification according to the object of services intended for procurement.

8.3 Every MPD service demand treatment shall mandatorily have an intervention unit that meets category 1, an MPD service provider that meets category 4 and a clear definition of the provisioning strategy for categories 2 and 3.

8.4 Shall be defined during the procurement strategy process, when elaborating the TS-GSA, which supplier will be responsible to provision item 6.2.2.

(END OF THE ANNEX)