

Well Control Systems - Managed Pressure Drilling (MPD) Recommendations



Acknowledgements

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Executive summary

The Well Control Systems Subcommittee, under IOGP's Wells Expert Committee (WEC), has carried out a systematic review of managed pressure drilling systems and components to identify opportunities for further improvements to existing standards and references. For those areas where potential gaps were suspected, the subcommittee has provided relevant existing standards and subsequent recommendations for members of the industry – particularly IADC's Underbalanced Operations and Managed Pressure Drilling (UBO/MPD) Committee – to use as a guide for further discussion.

Introduction

Managed pressure drilling (MPD) has become increasingly common in narrow window environments (between Pore Pressure and Fracture Gradient (PPFG)). To accomplish MPD, additional equipment is required to apply back pressure to the well. These operations may require modifications to rig systems and a certain level of automation and integration with the rig – and can make the MPD system part of the primary well control barrier.

While many standards exist around the implementation of MPD, there are still some opportunities to further clarify how to best operate these systems safely and reliably. The IOGP Well Control Systems Subcommittee examined several aspects of the surface back pressure (SBP) MPD system to determine if further guidance would be beneficial to the industry, either from manufacturers, drilling contractors, or associated service companies.

The areas that were considered were:

- Rotating Control Devices (RCDs) and Integrated Riser Joints (IRJs)
- Chokes and pressure relief devices*
- Well monitoring and detection*
- Pipework and valving
- Hoses
- Integration with rig systems*
- Pumps
- Human factors
- Operating philosophies
- Control systems*

Ultimately, it was determined that although existing guidance is sufficient in many facets of MPD implementation, in the cases of the topics above denoted by an asterisk (*), the subcommittee should identify additional recommendations to allow for increased safety, efficiency, and reliability of this critical system.

In particular, the subcommittee recognized that many of the main references that are used were intended to specifically cover well control equipment do not adequately consider MPD applications. The ensuing gap around designing, operating, and maintaining some MPD components has historically been addressed through original equipment manufacturer (OEM) procedures, recommended practices (RPs), and operators' procedures.

The aim of this document is to provide a consolidated view from the Operator's perspective of the main challenges for MPD components taking into account existing references (RPs and standards). The recommendations presented provide topics to be considered in MPD operations and in any upcoming standards reviews. While this document focuses on subsea operations, some of the findings may be applicable to land or surface applications.

Chokes and pressure relief devices

MPD choke and pressure relief devices are important components in the MPD System. MPD chokes generate back pressure by restricting the flow to maintain the surface or annular pressure at the desired level. Pressure relief devices relieve the line pressure that is above the safe operating limit by automatically opening. The main challenges for these devices are related to the lack of standards or functional guidelines for MPD applications. Currently, the well control equipment standards are used as a reference, but they do not address the specific functions and operational needs of MPD applications.

Challenges

- Lack of industry standards or functional guidelines for adjustable chokes and pressure relief valves in MPD applications:
 - Choke Control System
 - Minimum data input and validation for using hydraulics model control
 - Minimum accuracy (trim) for chokes
 - Minimum Operating Modes (e.g., SBP, AP and manual mode)
 - Pressure transducer placement and redundancy
 - Minimum backup supply autonomy
 - Minimum alarms on HMI (e.g., loss of supply, choke position span, low supply so difficult to achieve)
 - Choke behavior option after of loss of supply
 - Log of events and commands
 - Standardize Choke indication
 - Pressure Relief Control System
 - Establish a clear functional definition of the PRV system
 - Standardize minimum response time for relief actuation
 - Minimum alarms and warning on HMI panels (e.g., loss of supply, choke position span, low supply) all panels capable of control
 - PRV behaviors option after of loss of supply
 - Guidelines to define setpoints
 - Recommended flow routes for relieving
 - Emergency backup supply
 - Establish minimum number of functions with backup supply
 - Minimum requirements for qualification tests.
 - Define which tests should be done during installation and subsequent tests during operations
 - Minimum requirements for operational tests
 - Define which tests should be done during installation and subsequent tests during operations

References

Chokes:

- API RP 92S - Managed Pressure Drilling Operations – Surface Back-pressure with a Subsea Blowout Preventer, 1st Edition, 2018
- API SPEC 6A: Specification for Wellhead and Tree Equipment, 21st Edition, 2018
- API SPEC 16C: Choke and Kill Equipment, 2nd edition, 2015
- API STD 16D: Control Systems for Drilling Well Control Equipment and Control Systems for Diverter Equipment, 3rd Edition, 2018
- NACE MR0175/ISO 15156-1 – Petroleum and natural gas industries – Materials for use in H₂S-containing Environments in oil and gas production, 1st Edition, 2015

Pressure Relief Devices:

- API RP 92P: Managed Pressure Drilling Operations – Pressurized Mud Cap Drilling with a Subsea Blowout Preventer, 1st Edition, 2019
- API RP 92S: Managed Pressure Drilling Operations – Surface Back-pressure with a Subsea Blowout Preventer, 1st Edition, 2018
- API SPEC 6A: Specification for Wellhead and Tree Equipment, 21st Edition, 2018
- API STD 520 - Sizing, Selection, and Installation of Pressure-relieving Devices, 10th Edition, 2020
- DACC IRP #22 RMD/MPD/UBD Operations – An Industry Recommended Practice (IRP) for the Canadian Oil and Gas Industry, 3rd Edition, 2021
- NACE MR0175/ISO 15156-1: Petroleum and natural gas industries – Materials for use in H₂S-containing Environments in oil and gas production, 1st Edition, 2015

Recommendations

- Define functional requirements design and performance standards for choke and PRV control system in MPD applications in API 92 Series with reference to API 16D where practical.
- Define safety functions and backup devices for choke and PRV control system in MPD applications in applicable standards (e.g., API RP 92 series).
- Establish guidelines and recommended practices for PRV settings (e.g., API RP 92).
- Create a section in API 92 Series with reference to API 16A to define qualification tests for choke and PRVs for MPD Applications
- Develop operational testing guidelines in API RP 92 series
- Provide guidance for the calibration of measurement devices used in choke control

Well monitoring and detection

The well monitoring and detection systems are critical components in the MPD System. These systems notify operators of early kicks and losses, which is a key well control function and introduces operational advantages. The primary element of this system is a flowmeter. Currently, most operations use a Coriolis flow meter installed downstream of the MPD choke (direct flow measurement) and a set of stroke counters installed on the rig pumps (calculated flow measurement). This data is analysed to determine the well behavior.

There is a lack of standards and guidelines to ensure that well monitoring equipment functions reliably, and the industry would benefit from the introduction of dedicated guidelines and recommendations addressing this topic.

Challenges

Lack of industry references for:

- Gas management guidelines including riser and surface gas
- High accuracy flowmeters, such as coriolis meter deployment and use
- Fluid type behavior through MPD choke especially related to OBM (Oil Base Mud)
- Virtual trip tank (data filtering required) guidance
- Well control procedures while circulating a potential influx through the riser
- Well control drills for influx detection
- Guidelines for flow measurements (in/out)

References

Coriolis Meters:

- API RP 92M: Managed Pressure Drilling Operations with Surface Back-pressure, 1st Edition, 2017
- API RP 92S: Managed Pressure Drilling Operations – Surface Back-pressure with a Subsea Blowout Preventer, 1st Edition, 2018
- API RP 551: Process Management, 2nd Edition, 2016
- API Manual of Petroleum Measurement Standards (MPMS), 2nd Edition, 2021
- ASME MFC-11-2006: Measurement of Fluid Flow by Means of Coriolis Mass Flowmeters, Reaffirmed 2014
- ASME B16.5: Pipe Flanges and Flanged Fittings NPS ½ Through NPS 24 Metric/Inch Standard, 2020 Edition
- ASME B31.3: Process Piping, 2020 Edition
- ATEX Directive/IEC 60079: Explosive Atmosphere, 2016

- ISO 10790: Measurement of fluid flow in closed conduits – Guidance to the selection, installation and use of Coriolis flowmeters (mass flow, density and volume flow measurements), 3rd Edition, 2015
- ISO/IEC 17025: General requirements for the competence of testing and calibration laboratories, 2017
- NACE MR0175/ISO 15156-1: Petroleum and natural gas industries – Materials for use in H₂S-containing Environments in oil and gas production, 1st Edition, 2015

General requirements:

- API RP 59: Recommended Practice for Well Control Operations (2018 reaffirmed)

Recommendations

- Survey operators, drilling contractors, and service companies about existing procedures and internal standards for the challenges mentioned above
- Encourage industry groups in conjunction with IADC's MPD UBO Committee to review the standards mentioned above and consider including general details around gas management guidelines, meter and flowline geometry requirements, the proper use of digital trip tanks, and enhanced well control procedures and drills, among other topics
- Evaluate the need for guidance for gas management, meter and flowline geometry and the proper use of virtual trip tanks
- Provide guidance on calibration and verification of flow detection devices
- Ensure existing rig detection is still available irrespective of Coriolis

Integration with rig systems

MPD operations require integration with and modifications to several rig equipment systems, both on surface and subsea. There is a lack of standards and guidelines for MPD integration with rig system equipment, and the industry would benefit from further clarifications.

Challenges

Additional guidelines could be supplied for:

- Requirements for interface points between systems (e.g., two gate valves between buffer manifold and rig's manifold).
- Mud gas separator (MGS) design requirements for MPD operation, including pressure and fluid level measurement
- Limits on the use of well control equipment when used during MPD operations.
- Mud gas separator maintenance (cuttings clean out, cement clean out, etc.)
- Pressure relief valve (PRV) requirements (position and specifications)
- Riser analysis for emergency disconnection during different MPD operations (e.g., FMCD). This should consider riser anti-recoil valve settings for FMCD operations where the riser may become underbalanced to seawater hydrostatic pressure and the proportional closing cannot work properly.

References

- API RP 16Q: Design, Selection, Operation, and Maintenance of Marine Drilling Riser Systems, 2nd Edition, 2017
- API RP 92M: Managed Pressure Drilling Operations with Surface Back-pressure, 1st Edition, 2017
- API RP 92P: Managed Pressure Drilling Operations – Pressurized Mud Cap Drilling with a Subsea Blowout Preventer, 1st Edition, 2019
- API RP 92S – Managed Pressure Drilling Operations – Surface Back-pressure with a Subsea Blowout Preventer, 1st Edition, 2018
- API STD 53: Well Control Equipment Systems for Drilling Wells, 5th Edition, 2018
- API SPEC 6A: Specification for Wellhead and Tree Equipment, 21st Edition, 2018
- API SPEC 16A: Specification for Drill-through Equipment, 4th Edition, 2017.
- API SPEC 16C: Choke and Kill Equipment, 3rd Edition, 2021
- API SPEC 16D: Control Systems for Drilling Well Control Equipment and Control Systems for Diverter Equipment, 3rd Edition, 2018
- API SPEC 16F: Specification for Marine Drilling Riser Equipment, 2nd Edition, 2017
- API SPEC 16RCD: Rotating Control Devices, 3rd Edition, 2022
- API SPEC 17K: Specification for Bonded Flexible Pipe, 3rd Edition, 2017.

- ABS. Guide for Classification and Certification of Managed Pressure Drilling Systems (MPD Guide), 2017
- DNV-OS-E101 – Drilling facilities, 2021
- IOGP Info Sheet: Key factors for training and competency in Managed Pressure Drilling (MPD) operations, 2022
- NORSOK. NORSOK STANDARD-010: Well integrity in drilling and well operations, 2021

Recommendations

- Review the “Equipment and Procedures” and “Guidance for MPD planning and risk assessment studies” sections of the IOGP Info Sheet “Key Factors for Training and Competency in Managed Pressure Drilling (MPD) Operations.”
- Review existing MPD references and encourage industry to consider at least the following:
 - Well control equipment:
 - Two gate valves installed in the interfaces between different systems (e.g., rig’s manifold and buffer manifold)
 - Recommendations for mud gas separator (MGS) design specifications
 - Safeguards to prevent backflowing from MPD system to MGS
 - Assessment for BOP and riser maximum external pressure capacity (including all seals where a failure can communicate the well with environment)
 - Assessment for BOP ram reverse pressure capacity (e.g., after an emergency disconnect, in a FMCD operation, the blind shear can be submitted to a water depth reverse pressure – top to bottom)
 - Riser analysis for MPD operation scenarios (e.g., FMCD with riser rapidly filling with seawater after an EDS).
 - Assessment and settings of riser anti-recoil valve for MPD operation.
 - Systems/equipment to be protected by PRV and its specification.
 - Rig floor monitors and controls:
 - Driller’s Cabin accommodation area for MPD operators, areas for MPD control, monitoring panels and computers from the team responsible for the back pressure system.
 - Safety interlocks between valves (e.g., lines to the MGS and lines to the flow line / trip tank).
 - Event log for remotely operated valves
 - Ability to operate remotely controlled valves in the MPD system by means of a local manual override
 - Local gages as backup for pressure transducer
 - Ensuring the gas monitoring system functions are unaffected by MPD integration.

Control systems

The MPD control systems in use today provide users various options and functionality. These systems may include fluid hydraulics models as one method of controlling the choke. Additionally, the various systems available provide multiple other control parameters such as:

- Surface Back Pressure
- Flow in and flow out
- Pump pressure

These system modes all have primary functions that are intended to perform, such as maintaining a constant pressure upstream of the choke, or managing the choke to maintain equal flow in and out. Beyond the primary functions, they also have secondary, contingency, and notification/alarm functions.

Challenges

The current level of MPD control system automation is quite advanced. As MPD control systems have increased in capability and complexity, the development and testing of these software packages has not changed since the MPD systems began to include automation. The drilling industry does not have guidance or requirements for the development, testing, and lifecycle version control of these complex software packages. As a result, it is common to encounter failures or “bugs”.

References

- API SPEC 16D: Control Systems for Drilling Well Control Equipment and Control Systems for Diverter Equipment, 3rd Edition, 2018
- IADC MPD Committee drafting Control System reliability document

Recommendations

- Review and consider the applicability of other industry control system standards to MPD systems until specific industry MPD control system standards are developed.
- Develop an MPD control system focused specification that incorporates other industry control system specification’s learnings, applicable to MPD, for manufacture, quality control and testing (factory acceptance and site-integration). This specification should also include software lifecycle requirements.
- Include MPD control system in-field maintenance and testing requirements within an existing standard.

Conclusions

The IOGP Well Control Systems Subcommittee has completed a comprehensive study of the existing references that govern Managed Pressure Drilling operations. While many references are available for operators, rig contractors, and service companies, some potential gaps have nonetheless been identified around industry standards, guidance, and RPs, for the components used in the MPD applications.

Specifically, recommendations have been provided in the areas of chokes and pressure relief devices, well monitoring and detection, integration with rig systems, and control systems. This document will hopefully assist in creating a dialogue amongst standards institutes and associations for a better understanding of any existing gaps for designing, operating, and maintaining MPD components to achieve improved reliability and safety.

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