

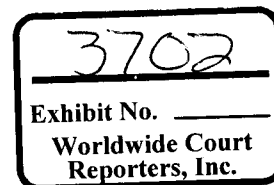
Document No.	GP 10-16
Applicability	Group
Date	9 July 2008

GP 10-16

Pore Pressure Detection During Well Operations

Group Practice

**BP GROUP
ENGINEERING TECHNICAL PRACTICES**



Introduction

The introduction to this ETP mirrors section 16 of the revised DWOP.

All Pore Pressure Detection activity shall conform to Engineering Technical Practice GP10-16 – Pore Pressure Detection

1. A Single Point of Accountability (SPA) shall be defined for the delivery of a real-time pore and fracture gradient analysis for any given well.
2. The SPA shall be responsible to insure that all contractors and employees involved in the real-time detection of pressure meet the minimum requirements set out in this Engineering Technical Practice.
3. The real-time analysis of pressure for a BP well shall be prepared by a qualified individual who has been trained on BP practices, workflows, and relevant tools and applications to be used at the wellsite.
4. All individuals preparing real-time pressure analysis for BP wells shall have been appropriately trained on the use of the software used in the analysis.
5. Every well operated by BP shall have an ongoing assessment of the pore and fracture pressures during drilling operations.
6. Real-time pressure analysis prepared by contractors shall be monitored on a periodic basis using BP approved software to ensure that results are consistent with BP methodologies.
7. Personnel preparing real-time pressure analysis at the wellsite shall have a copy of the pre-drill pressure prediction for the well.
8. Personnel preparing real-time pressure analysis at the wellsite shall participate in a pre-operational meeting with the relevant BP personnel designated as the SPA for the pressure prediction to discuss the pre-drill prediction, methods planned for usage in detecting pressure, lines of communication, and responsibilities.
9. The SPA shall assure that all equipment used for pressure detection at the wellsite is available, in good working order, and calibrated as necessary.

In addition, the following related minimum requirements are presented in the "Health, Safety and the Environment – working hours at the wellsite" section (section 3) and the "Safety Critical Software" section (section 12) of the BP Drilling and Well Operations Practice (BPA-D-001):

10. Excessive working hours leads to fatigue and impairment of mental awareness. Personnel engaged in BP's drilling and well operations shall not work in excess of 16 hours during a 24 hour period nor 28 days at the wellsite during a 42 day period without written authority of the designated company representative.
11. Real-time pressure detection software and tools (whether provided by BP or a contractor) is defined as safety critical. The SPA shall require that contractors ensure that appropriate standards are maintained for installation, operation and disaster recovery.



Foreword

This is the first issue of Engineering Technical Practice (ETP) BP GP 10-16 dealing with Pore Pressure Detection. This Group Practice (GP) replaces the relevant parts of the Drilling and Well Operations Policy BPA-D-01.

Description of Risk

The real-time detection of pore and fracture pressures in wells is considered a zero tolerance activity within BP. Errors associated with the detection of pore and fracture pressures could lead to the harm to people, damage to the environment, and undermine BP's operational reputation. For these reasons pressure detection requires a definition of practices that establish the minimum requirements for performing pressure detection.

The purpose of this document is to establish the minimum requirements in the real-time detection of pore and fracture pressures in BP operated wells. These requirements should be met by both employees and contractors acting on the behalf of BP in the execution of wells operated by BP.

Note: This Practice reflects the balanced judgment of the BP Group and is based on experience and inputs from a variety of sources. However, it should be recognised that risk can never be eliminated and, as we learn, the Group may have to adjust the acceptable risk envelope and the Minimum Requirements of this Practice. This would result in an updated edition of this Practice being issued by the relevant authority.

What is the Pore Pressure Detection Engineering Technical Practice (ETP)?

This PPD Practice is intended to ensure that there is a formal approach to managing the risks associated with detecting pore and fracture pressure in BP operated wells, that these risks are identified, assessed and controlled in a methodical way so that they can be removed or reduced to an acceptable level.

The primary aim of this Practice is to prevent safety incidents. However, the processes may be extended to include other aspects of performance.

Who is it for?

This Practice is intended for the use of following groups:

- Those involved in the real-time detection of pore and fracture pressure for BP operated wells
- Those directly involved in the selection and management of those employees and contractors who will conduct pressure detection on BP wells

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In the event of a conflict between this document and a relevant law or regulation, the relevant law or regulation shall be followed. If the document creates a higher obligation, it shall be followed as long as this also achieves full compliance with the law or regulation.



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1. Scope

This Practice applies to work on any BP operated well. A BP Company is a company in the BP Group or other legal entity where BP has operational control, is responsible for HSSE and has the right to impose these requirements. In situations where BP does not have control (i.e. a joint venture where BP is not the operator) we should endeavour to confirm that the operator implements processes that meet the minimum requirements in this document.

Applicability

For the purpose of this Group Practice, the workforce comprises BP employees and every employee of any other company or other legal entity that has been engaged to perform work on BP-operated reservoirs or production/injection infrastructure. A BP-operated reservoir for the purposes of this document includes any site or location used for the injection or extraction of fluids that is owned or operated by or for a BP Company.

In situations in which BP does not have control (i.e. a joint venture where BP is not the operator) BP should attempt to persuade the operator to employ practices at least meeting the Minimum Requirements in this document.

In the event of a conflict between this Group Practice and a relevant law or regulation, the relevant law or regulation will be followed. If the Group Practice creates a higher obligation, it should be followed as long as full compliance with the law or regulation is achieved.

Subject to the Group Practice's intent and subject to existing contractual constraints (to the extent that they cannot be renegotiated) this Group Practice shall be applied to all contractors and their associated subcontractors who perform work on BP-operated reservoirs or on behalf of BP and shall be incorporated in all tenders and contracts.

2. Normative references

The following normative documents contain requirements that, through reference in this text, constitute requirements of this technical practice. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this technical practice are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

BP

BPA-D-001

BP Drilling & Well operations Practice

3. Terms and definitions

For the purposes of this GP, the following terms and definitions apply:

Accountable Person

The person in the organization who has ultimate responsibility.



Activities

Specific actions or pursuits.

Assess

To consider and make a judgment upon.

Assurance

A guarantee, giving certainty.

Auditing

A formal or official examination and verification. The audit process should include monitoring, review, and reporting of the outcome of the audit to those people who can implement any changes needed.

Authority

Official permission.

A position that has the power to make a judgement; an individual cited or appealed to as an expert.

The power to influence or command.

BP Company

A company in the BP Group, or a company or other legal entity where BP has operational control, is responsible for HSSE and has the right to impose this Standard.

BP Employee

A person employed by a BP Company.

BP Operations

BP Business Units, projects, facilities sites and operations.

BP Premises

Any site, location or marine vessel that is owned or operated by or for a BP Company.

Competency

The ability to perform a task in the correct manner with the correct understanding and reasoning behind the task.

Competent Person

A person who has demonstrated that they have the knowledge, training and experience required to perform the defined role to the standard required.

Confirm

To support or establish the certainty or validity of; verify.

Contractors

A Company or individual who is under a contractual relationship to supply BP plc or one of its subsidiary companies with Goods and Services and is working solely for the benefit of BP.

A contractual relationship includes:

- All individuals contracted directly or sub-contracted.



- All employees of companies contracted directly or sub-contracted
- All situations where a contract has not been raised but BP's procurement policy would normally expect there to be a contract in place. This applies to all levels including sub-contracted relationships.

Note: For the purposes of HSSE reporting any sub-contractor should be treated as if they held a contract directly with BP plc or one of its subsidiary companies.

Control

- a) A mechanism used to regulate a physical process or activity
- b) An action to mitigate risk.
- c) The power to direct (usually through authority).

Document Control Management System

An established means of controlling the issue, use and updating of documents used in the management of a site. A full document control management system (DCMS) will include reference numbers on documents, means of tracking changes and updates and regular audits of the system to confirm compliance.

Eliminate

To remove or get rid of.

Formal

A formal process or agreement is one that is written, recorded and audited. It may also include tracking to confirm that work is following the process or agreement.

Minimum Requirements

The activities, tasks or deliverables that shall be completed to comply with this Practice.

Monitoring

The routine function of regular inspection carried out by a responsible and competent person.

Operational Control

Where BP has responsibility for the activity as owner or under a contractual obligation with the owners of the entity and, as a consequence, has appropriate authority to manage directly all HSSE aspects of the operational activities to meet BP policy and expectations.

Plan

The function of task (work) identification, interaction and sequencing including, preparation and completion requirements, to achieve an outcome.

Policy

Plan of action pursued by the Company (BP) with which all personnel shall comply.

Procedure

A detailed document either in paper or electronic form which sets out sequential or parallel actions which shall be followed by those engaged in carrying out an activity.

Process

A detailed description of a management system or a production operation.



Risk

Possibility of loss, injury, damage, or exposure to hazard or danger.

Risk Assessment

The process of hazard identification and the assessment of the potential for identified hazards to be realised in any given activity.

Roles

The documented description of personnel functions within a management structure.

Routine

A procedure that does not vary in its execution

Single Point Accountable

The person in the organization (site/Business Unit) who has been appointed as being accountable for the delivery and performance of an activity.

Training

The bringing of a person to a desired degree of proficiency in some activity or skill. Training should only be carried out by people who have been assessed as being competent to train.

Task

An activity in support of a piece of work.

Work

An activity made up of a number of different tasks.

Workflow

An activity made up of a sequence of different tasks designed to deliver a desired outcome

Workforce

BP employees and every employee of any other company (includes all contractors) or other legal entity that has been engaged to perform work on BP Premises.

Zero Tolerance Activity

A BP well planning activity that potentially places people or the environment at risk and requires a minimum set of requirements for performing those activities.

4. Symbols and abbreviations

For the purpose of this GP, the following symbols and abbreviations apply:

CoP	Community of Practice
DCMS	Document Control Management System
HSSE	Health, Safety, Security and Environment
PPFG	Pore Pressure Fracture Gradient
OMS	Operating Management System
SME	Subject Matter Expert



SPA	Single Point of Accountability
SPU	Strategic Performance Unit
TVP	Technology Vice President

5. Practice Structure

5.1. Requirements and Recommendations

Minimum Requirements and Operational Excellence

Minimum requirements describe the minimum processes and activities that shall be completed to deliver the intent of this Practice. These Minimum Requirements shall become the "benchmark" for acceptable operating within BP.

Recommendations provide details of good practice – both internal and external to BP – which go beyond the Minimum Requirements of this Practice. These are intended to provide options for continuous improvement that will take businesses beyond the "getting the basics right" and towards operational excellence. Adherence to recommendations will not be required to meet the intent of this Practice.

5.2. Language

"Shall" and "Should"

Throughout this document the following language is used:

- "Shall" is used where a provision is a Minimum Requirement of the Practice and is mandatory.
- "Should" is used where a provision is a Recommendation or is used to identify a preferred option.

5.3. References and Responsibilities

References

References, where appropriate, are made to other relevant guidelines, procedures and documents that may be used in order to support the application of this Practice. Any relevant Normative References will be made available at the technical practices portal:

http://technical_practices.bpweb.bp.com/

Responsibilities

Where appropriate, roles and responsibilities to deliver any process/activities required within this Practice are clearly defined. Delivery of these responsibilities will be locally assigned.

6. Accountability

Intent

BP Executives, Managers and Supervisors shall actively participate in and recognize that effective technical management of this zero tolerance activity is critical to our business success. Clearly identifying the roles, responsibilities, and competencies for both BP employees and contractors and holding them accountable for desired behaviors and performance is essential to effective pore pressure detection.



6.1. Minimum Requirements

- a. A Single Point of Accountability (SPA) shall be defined for the delivery of a real-time pore and fracture gradient analysis for any given well.
- b. The SPA shall be responsible to insure that all contractors and employees involved in the real-time detection of pressure meet the minimum requirements set out in this Engineering Technical Practice.

6.2. Recommendations

- a. The Segment Engineering Technical Authority should be consulted by the Single Point of Accountability (SPA) for clarification of pore pressure detection recommended practices as required.

7. Competence**Intent**

To ensure that those individuals conducting pore pressure detection have the necessary experience, capability and knowledge to undertake the work in a manner that meets BP's expectations.

7.1. Minimum Requirements

- a. The real-time analysis of pressure for a BP well shall be prepared by a qualified individual who has been trained on BP practices, workflows, and relevant tools and applications to be used at the wellsite.
- b. All individuals preparing real-time pressure analysis for BP wells shall have been appropriately trained on the use of the particular software used for pressure detection on the well.

8. Practices and Procedures**Intent**

To ensure that practices and procedures used by pressure detection practitioners meet all relevant technical requirements and are kept up-to-date and accessible.

8.1. Minimum Requirements

- a. Every well operated by BP shall have an ongoing assessment of the pore and fracture pressures during drilling operations.
- b. Real-time pressure analysis prepared by contractors shall be monitored on a periodic basis using BP approved software to ensure that results are consistent with BP methodologies.
- c. Excessive working hours leads to fatigue and impairment of mental awareness. Personnel engaged in BP's drilling and well operations shall not work in excess of 16 hours during a 24 hour period nor 28 days at the wellsite during a 42 day period without written authority of the designated company representative.
- d. Personnel preparing real-time pressure analysis at the wellsite shall have a copy of the pre-drill pressure prediction for the well.
- e. Personnel preparing real-time pressure analysis at the wellsite shall participate in a pre-operational meeting with the relevant BP personnel designated as the SPA for the pressure prediction to discuss the pre-drill detection, methods planned for usage in detecting pressure, lines of communication, and responsibilities.



8.2. Recommendations

- a. Key individuals with a supervisory role over a wellsite PPFG team should attend the 21st C PPFG School to ensure implementation of BP best practise

8.3. References

- a. Every well operated by BP shall have a detailed ongoing assessment of the pore and fracture pressures during drilling operations on exploration and appraisal wells. (BP Drilling and Well Operations Policy 10.1)
- b. Excessive working hours leads to fatigue and impairment of mental awareness. Personnel engaged in BP's drilling and well operations shall not work in excess of 16 hours during a 24 hour period nor 28 days at the wellsite during a 42 day period without written authority of the designated company representative. (BP Drilling and Well Operations Policy 3.4.3)

9. Software**Intent**

To assure that software used to prepare real-time pressure detection meets BP specifications, design, programme changes, fault tracking, documentation, implementation, testing, and acceptance requirements

9.1. Minimum Requirements

- a. Real-time pressure detection software and tools (whether provided by BP or a contractor) is defined as safety critical. The SPA shall require that contractors ensure that appropriate standards are maintained for installation, operation and disaster recovery.

9.2. Recommendations

- a. Currently, pressure detection software which has been confirmed to meet BP safety critical standards are:
 - Landmark version of Presgraf

9.3. References

- a. Approval of the Segment Engineering Technical Authority and the relevant applications domain expert shall be obtained in establishing that used software meets BP safety critical standards.
- b. Before the release and distribution of any new or revised safety critical software, a defined plan shall be in place addressing the business case and responsibilities for implementation. A system shall be in place to report, categorise, prioritise and resolve software bugs, as well as properly track critical faults. (BP Drilling and Well Operations Policy 3.2.3)

10. Assurance**Intent**

To insure BP recommended practices are utilized in preparing a pressure detection and to share lesson's learned in a rapid and timely manner.

10.1. Minimum Requirements

- a. The SPA shall assure that all equipment and software used for pressure detection at the wellsite is available, in good working order, and calibrated as necessary.



- b. Real-time pressure analysis prepared by contractors shall be monitored on a periodic basis using BP software to ensure that results are consistent with BP.

10.2. Recommendations

- a. SPA's for pressure detection should participate in PPFG community of practice (CoP) activities to maximize knowledge shared with other parts of the organization.
 - Be a member of the PPFG email distribution list.
 - Attend PPFG CoP meetings.



Annex A**Pore Pressure Detection Recommended Workflow**

There are a number of methods that are particularly useful in detecting pressure at the wellsite. It is important to establish the viability of the different methods in the area that a well is being drilled because not all methods are universally applicable. Where possible, use offset well information to establish which methods work in the area and within stratigraphic intervals expected. If the well is a rank wildcat, or drills new stratigraphy, all methods should be used. Methods to be considered:

Mudlogging:

- Gas level monitoring including drilled, connection and pump-off gases
- Dnc, ROP
- Torque, drag and hole fill
- Caving size, shape and volume
- Shale bulk density
- Mud weight in and out of the hole
- Mud salinity / chlorides / resistivity in and out of the hole
- Mud temperature in and out of the hole
- Active mud system and trip tank volume monitoring – for kick detection
- Standpipe Pressure – for early kick (or washout) detection
- Mud flow out and connection flow monitoring – for early kick detection

Down-hole parameters from MWD / LWD tools (if available)

- Weight on bit, torque, RPM if available
- Acoustic caliper data from Density LWD tools

LWD based methods:

- Shale resistivity
- Shale interval travel time
- Shale density

A.1. Mudlogging Procedures

- Identify relevant offset or analogue wells.
- Build a best estimate of pore pressure in geological analogue wells using all available data (mudlogging and petrophysical) using BP recommended practices.
- Gather relevant mudlogging information from analogue wells and compare observations to best BP pore pressure estimate to establish key real-time pressure indicators.
- Install, maintain, calibrate, and operate mudlogging equipment in accordance with BP Mudlogging Specifications
- Plot a True Vertical Depth (TVD) analysis of the following at a frequency suited to regional conditions:
 - Gas trends, particularly connection and pump-off gases, including chromatograph analysis
 - Corrected Drilling Exponent (Use down-hole WOB, RPM data where possible)
 - Torque, Drag and Hole Fill trends
 - Cavings Type and relative Volume. (Consider a continuous measurement of the volume of cuttings and cavings returned to surface)
 - Flow Line Mud Temperature, Differential Temperature, Mud Temperature In
 - Flow-line Resistivity (water-base muds only)
 - Mud Weight and Effective Circulating Density (ECD)



- Pore Pressure – the best estimate based on mudlogging indicators and petrophysical modelling if the latter is available
 - Shale and Sand Fracture Pressure
 - Overburden
 - When using oil-base mud, note the surface and equivalent down-hole mud weight if available
 - Note the down-hole as well as surface mud weight equivalents for Formation Integrity and Leak-Off Tests (FITs and LOTs) when using oil-base mud
 - Kicks
 - Mud Loss Pressures - where it is possible to determine the loss depth
 - Lithology
 - A separate report shall be prepared detailing the above and outlining the likely error associated with the best real time estimate of pore pressure
- Any re-calibration of trend lines should be annotated on plots with a justification noted in a separate report.
 - In intervals of rapid pore pressure transition, or intervals with relatively small pore pressure to fracture gradient margins, consider limiting the number of connection / pump-off gas events in the borehole at any time so as to enable timely response to ditch gas indicators.
 - The Mudloggers shall monitor Pit Volumes, Mud Flow Out and Standpipe Pressure and report any indication of formation fluid influx.
 - Those conducting real-time pressure analyses shall communicate to the BP Representative and Drilling Leadership any situation developing with safety or efficiency implications.
 - Those conducting real-time pressure analyses shall ensure that the BP Representative, Drilling Leadership and the Pore Pressure SPA are aware when pore pressure exceeds mud hydrostatic and / or Effective Circulating Density (ECD).

A.2. Petrophysical Procedures:

LWD Resistivity methods:

- Build an overburden curve, preferably using measured density measurements, supplemented with pseudo density data from acoustic measurements, and, if required, modelled density data.
- Validate overburden at casing points relative to leak-off measurements.
- Use offset best estimate of pore pressure to establish the temperature corrected resistivity normally pressured compaction trend. Use this trend as the basis for detection of pressure from resistivity in the operating well
- Correct resistivity trends and measurements to a common temperature.
- If necessary, recalibrate the resistivity compaction trend to direct measurements of pressure from the well.
- Select resistivity points in representative shale, using gamma ray and resistivity values to discriminate shale quality.

LWD acoustic methods:

- Build an overburden curve, preferably using measured density measurements, supplemented with pseudo density data from acoustic measurements, and, if required, modelled density data.
- Validate overburden at casing points relative to leak-off measurements.
- Use offset best estimate of pore pressure to establish the acoustic normally pressured compaction trend. Use this trend as the basis for detection of pressure from acoustic measurements in the operating well.



- If necessary, recalibrate the acoustic normally pressured compaction trend to direct measurements of pressure from the well.
- Select acoustic interval travel time (or velocity) points in representative shale, using gamma ray and resistivity values to discriminate shale quality.

A.3. General Practices

- Compare and reconcile all pressure indicators. Recalibrate where necessary. Use reconciled measurements to expressed uncertainty of pressure detection.
- Compute sand and shale fracture gradients using offset validated relationships. Include measured leak-off data in presentation.
- Communicate most likely and range of uncertainty to SPA for pore and fracture pressure detection.
- Plot ECD against pore and fracture pressures. Ensure the pore pressure SPA is aware when ECD is below pore pressure or above fracture pressure.
- Ensure that the detected pore and fracture pressure and encountered ECD do not deviate significantly from values used to formulate stress cage lost circulation prevention additives. If a significant deviation occurs, reformulate stress cage additives.
- When drilling in low kick tolerance, only have one connection in the hole at any given point in time.

A.4. References

More detailed description of pressure detection practices can be found in the 21st Century Pore Pressure Principles training materials which are posted at the PPFG website: <http://ppfg.bpweb.bp.com>

Additional material is contained in the BP Well Control Manual available at the BP drilling manual site.



Annex B

Administration

B.1. Administration and Authorisation

Administration and Authorisation

Administration and authorisation responsibilities for this Practice are:

Custodian:	The pore pressure Segment Engineering Technical Authority
Maintainer:	The pore pressure Segment Engineering Technical Authority
Adjudicator:	Head of Discipline Drilling & Completions under delegation from the TVP Drilling & Completions and endorsed by Head of Discipline, Appraisal and Pre-Development

The Custodian is responsible for confirming the accuracy and integrity of content and proposed changes to the Practice.

The Maintainer is responsible for the upkeep and continued integrity of the Practice, including regular reviews and audits.

The Adjudicator is responsible for authorising and approving changes to the Practice.

Interpretation

Questions of interpretation should be directed in writing to the custodian of this Practice for the purpose of clarification.

Changes and Amendments

Any suggested changes or amendments to this Practice should be forwarded to the document custodian along with the reasons for the change.

All suggestions should be acknowledged and, if rejected, the reasons given for their rejection.

Accepted changes should be administered through the document change control system employed by the Document Control Management System (DCMS).

Document Control and Review

The Practice shall be held and controlled on the DCMS.

This Practice is subject to regular review and also to review whenever circumstances dictate. All reviews, regular and otherwise, shall be initiated by the Custodian.

B.2 Auditing, Compliance and Deviation

Auditing and Compliance

Monitoring adoption of this Practice and reporting on implementation and progress on meeting targets shall be locally owned and included as part of the annual self verification process for each Business and Functional Unit.

BP businesses that are within the scope of this Practice shall adopt or modify their procedures and practices to conform to the Minimum Requirements described in this document.

In the event of a conflict between this Practice and a relevant law or regulation, the relevant law or regulation shall be followed. If this Practice creates a higher obligation, it should be followed as long as full compliance with the law or regulation is also achieved.



Deviation from Minimum Requirements

A decision not to implement these Practices by a Business Unit or for a given field requires that a risk assessment be conducted and formally peer reviewed.

Any risk assessment that results in the decision not to apply this Practice shall be formally justified, recorded and authorised by the relevant Business Unit leader or their delegated nominee.

