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Ministry of National Infrastructure, Energy and Water Resources
Natural Resources Administration

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ג' בטבת התשע"ו

הנחיות לסידוק הידראולי

הנחיות אלו מפרטות את דרישות משרד התשתיות הלאומיות, האנרגיה והמים באשר לביצוע סידוק הידראולי. ההנחיות מבוססות בחלקן על מסמך ההנחיות הקנדי:

Directive 083: Hydraulic Fracturing – Subsurface Integrity

<https://www.aer.ca/documents/directives/Directive083.pdf>

בנוסף המסמך מבוסס אף על אזכורים של תקני API הרלוונטיים להנחיות:

http://www.api.org/~media/files/policy/exploration/hydraulic_fracturing_infosheet.pdf

ההנחיות נועדו למספר מטרות:

- א. לקבוע מדדים להליכי תכנון של פעולת הסידוק ההידראולי, אופן הגשת תכניות ודו"ח סופי לאחר הפעולה.
- ב. לייעל את תוצאת הסידוק על ידי תכנון מיטבי.
- ג. לבחון את תוצאת הסידוק על ידי בדיקות שלאחר פעולה הסידוק על ידי ניטור.
- ד. לוודא כי פעולות הסידוק לא גורמות לנוק של הקידוח.
- ה. להקטין את הסיכוי של חדירה נוזלים בין קידוח בו מבצעים פעולת סידוק לבין קידוחים סמוכים.
- ו. לשלוט במצב בו התרחשה חדירה בין הקידוחים לעיל.
- ז. לוודא כי אין תופעות לוואי שליליות מפעולות הסידוק לאקוויפר.
- ח. לוודא כי אין השפעות שליליות מפעולות הסידוק לקידוחי מים.
- ט. לוודא כי לא קיימת השפעה שלילית של פעולת הסידוק בפני הקרקע.

ההנחיות כוללות:

- א. מבוא (סעיף 1).
- ב. דרישות לתכן הסידוק (סעיף 2).
- ג. דרישות דיווח ואישור טרם פעולת סידוק, במהלכה ולאחר פעולת הסידוק (סעיף 2).
- ד. פעולות הנדרשות על מנת לוודא את שלמות הקידוח (סעיף 3).
- ה. דרישות לביצוע הערכה וניהול הסיכונים בפעולת הסידוק בנוגע לקידוחים סמוכים (סעיף 4).

- ו. דרישות יידוע בעלי קידוחים הסמוכים בדבר הסיכונים הקשורים לפעילות סידוק הידראולי (סעיף 4.3).
- ז. דרישות להגנה על אקוויפרים שפירים מפעולות סידוק הידראולי הנערכות בעומקים הפחותים מ-100 מטרים משכבת האקוויפר (סעיף 5).
- ח. דרישות למרחקים מינימאליים (אופקיים ואנכיים) של פעולות הסידוק מבארות מים (סעיף 6).
- ט. דרישות לעומק מינימאלי לפעילות סידוק הידראולי מתחתית סלע השֵׁתִית (סעיף 7).
- י. דרישות לביצוע סידוק בקרקע המכילה הידרוקרבונים מוצקים (סעיף 8).
- יא. דרישות בעניין העברת מידע למשרד התשתיות הלאומיות, האנרגיה והמים בדבר פעולות הסידוק ההידראולי (סעיף 9).

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1. Introduction

1.1 Purpose of These Guidelines

These guidelines set out the Ministry of National Infrastructures, Energy, and Water Resources (MНИЕWR) requirements for Hydraulic fracturing design and operations. These guidelines do not apply to thermal wells. All the requirements and assigned limits described below shall be applied while design and operations of wells tests with injection pressure higher than formation pressure.

1.1.1 These requirements are intended to

- a) standardize of procedures of hydrofrac operation planning, submission of Hydrofrac Program, operations' result and End Operation report to MНИЕWR,
- b) optimize result of hydrofrac by accurate design,
- c) investigation of result of hydrofrac by post hydrofrac tests and/or monitoring,
- d) prevent the loss of well integrity at a subject well (a well at which a licensee proposes to conduct hydraulic fracturing operations),
- e) reduce the likelihood of unintentional inter-wellbore communication between a subject well and an offset well,
- f) manage well control at an offset well in the event of inter-wellbore communication with a subject well,
- g) prevent adverse effects to non-saline aquifers,
- h) prevent impacts to water wells, and
- i) prevent surface impacts.

1.1.2 These guidelines include

- a) introduction (section 1),
- b) requirements to hydrofrac design (section 2),
- c) requirements to pre/post job reporting and raw data supply (section 2),
- d) requirements to prevent the loss of well integrity at a subject well (section 3),
- e) requirements for licensees to assess, plan for, and mitigate the risks of interwellbore communication with offset wells (section 4),
- f) requirements to notify licensees of at-risk offset wells related to hydraulic fracturing operations (section 4.3),
- g) forbiddance of hydraulic fracturing operations if the distance between induced fractures zone multiplied on factor 2 till top of waterbearing formation less than 100 m (section 2 and 5),
- h) increased vertical depth restriction for hydraulic fracturing operations near water wells (section 6),
- i) increased vertical depth restriction for hydraulic fracturing operations near the top of the bedrock surface (section 7),
- j) pumping-volume restrictions and provisions to setback distances for nitrogen fracturing operations for coalbed methane (section 8), and
- k) requirements to notify the MНИЕWR about hydraulic fracturing operations (section 9).

1.2 Implementation Date for Guidelines Requirements

The requirements of these guidelines are effective **December 15, 2015**.

1.3 Compliance Assurance

The term "must"/"shall" indicates MNIWR requirements for which compliance is required and is subject to MNIWR enforcement. The terms "recommends" or "expects" indicate recommended practices and are not subject to enforcement action.

In its assessment of licensees' compliance with the requirements of these guidelines, the MNIWR may at any time request licensees to produce those documents, records, or plans required to be completed by these guidelines, and licensees must provide them to the MNIWR. If the MNIWR determines that the documentation is incomplete, insufficient, or that additional documentation is needed to support licensees' compliance with the regulatory objectives in these guidelines, licensees may be required to provide additional documentation prior to conducting its hydraulic fracturing operation. The MNIWR recommends that all documentation be kept on file for the life of the well.

2. Major requirements

Hydraulic fracture treatments are used to increase the productivity index of a producing well or the injectivity index of an injection well. The productivity index defines the rate at which oil or gas can be produced at a given pressure differential between the reservoir and the wellbore, while the injectivity index refers to the rate at which fluid can be injected into a well at a given pressure differential. Hydraulic fracturing is a process in which pressure is applied to a reservoir rock on purpose in order to break or crack it. These cracks are called hydraulic fractures. Most hydraulic and natural fractures are near vertical and increase well productivity significantly.

2.1 Applications for hydraulic fracturing:

- Increase the flow rate of oil and/or gas from low-permeability reservoirs
- Increase the flow rate of oil and/or gas from wells that have been damaged
- Connect the natural fractures and/or cleats in a formation to the wellbore
- Decrease the pressure drop around the well to minimize sand production
- Enhance gravel-packing sand placement
- Decrease the pressure drop around the well to minimize problems with asphaltine and/or paraffin deposition
- Increase the area of drainage or the amount of formation in contact with the wellbore
- Connect the full vertical extent of a reservoir to a slanted or horizontal well.

2.2 General requirements for right holders.

- Hydrofrac operation shall not be implemented by Right Holder till written permit of MNIWR will not be received based on Hydrofrac Program done in accordance with on present Guidelines requirements. Hydrofrac Program shall be submitted to MNIWR min 30 days before the operation. MNIWR has right to revoke the program, to request to change conditions.

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- FDP, Drilling programs on low permeability formation (lower than 10 mD for oil wells and 1mD for gas well) will not be accepted by MNIWR without plan on operations on increasing productivity index.
- Hydrofracturing should be considered for increasing production rates not only on low permeability formations but when it is feasible, efficient (like drainage of laminated formation, sands control etc.) and not risky. Other methods of productivity index increase shall also be considered by Right Holder to maximize recovery factor while limitation of risks.
- Hydrofrac design, hydrofrac operations, post-frac formation testing and result monitoring and analysis shall be inline with the descriptions below and made based on qualified data set, described below as well. Hydrofrac design shall include risk and uncertainty analysis.
- Decision about hydrofrac operation (and variant of design) shall be taken by Right Holder on the base of it production/commercial efficiency and minimization of the risks and it shall be presented to MNIWR.
- MNIWR may to request Right Holder to plan hydrofrac operations and decision about hydrofrac operation will be taken on the base of production/commercial efficiency and risks.
- Together with Hydrofrac Program Right Holder must submit to MNIWR the report of quality of well casing.
- After receiving of written permit on Hydrofrac Operation from MNIWR, Right Holder could start the treatment and all the details shall be reported daily and the process and the result, plan –fact analysis of Hydrofrac shall be send to MNIWR not later than 30 days after finalization of hydrofrac operation. Specific requirements to operations described at Clause 3 and below.
- End Operational report shall include details of Hydrofrac operation and plan-fact analysis, result of hydrofrac analysis based on post-frac well test or monitoring of frac and after-frac well activity. Result of the measurements and tests shall be accompanied with raw data in Excel format and the result of data interpretation shall be added to End of Operational report and send to MNIWR not later then 90 days after finalization of hydrofrac operation and post-frac test.

2.3 Procedure of hydraulic fracturing:

2.3.1 Decision of hydraulic fracturing shall be taken based on prediction of production incremental rate after operation and economical efficiency evaluation. Evaluation conducting for all wells-candidates for hydrofrac based on at least sector geological, dynamic and geomechanical reservoir models and on the information listed below, so accurate core analysis, logging, RCI, well test and their interpretation shall be done prior. All raw data, result of their interpretation and modeling with illustration of following parameters shall be presented to MNIWR in (together and as the part) with Hydrofrac program:

- a) Geological vision,
- b) Topographical maps with all cultural elements and water wells locations (with aquifer depth). If the distance between well –candidate for Hydrofrac and water well less then 1000 meters in depth and by lateraly, detail geological description of whole section lower than seal layer of waterbearing horizon, or if waterbearing horizon is below interval for hydraulic fracturing then the description shall cover whole section below 100 m of waterbearing horizon.

Geological description shall include lithofacial and petrophysical properties of each of formation, structural features of the area, including tectonic history, quality of the seals which separate target interval for hydrofrac from water bearing horizon. Independently on distance to waterbearing formation, structural and lithofacial models shall be presented (structural maps with faults, lithological boundary, lithofacial description) till target horizon +100 m.

- c) Target Formation permeability and porosity,
- d) Target Formation compressibility,
- e) Elastic modules,
- f) Reservoir fluid viscosity,
- g) Skin factor at target interval,
- h) Reservoir pressure (initial and current),
- i) Reservoir depth,
- j) Reservoir thickness,
- k) The condition of the wellbore,
- l) Formation water properties,
- m) Oil (gas) water contact,
- n) Reservoir seal and caprock properties,
- o) Production and workover history, production analysis,
- p) Well casing design and quality of casing,
- q) Geological sector model,
- r) Dynamic sector model,
- s) Induced and natural fractures description & characteristic (observed from image logs, core, drilling data, well test result, seismic attributes etc) and geomechanical reservoir models, including overburden pressure, horizontal stress and anisotropy, expected fracture pressure gradient, pressure of fracture creation at target formations.

2.3.2 Hydrofrac program shall describe: design of Hydrofrac, prefrac casing tests, frac operations, post-frac test and hydrofrac monitoring (if it is applicable), answers on QHSE questions:

2.3.3 Design of Hydrofrac. The goal of every fracture treatment design includes optimization of propped fractures geometry and conductivity: length, width, height, permeability and the drainage area. While geomechanical modeling, the quality of seals should be taken into account to predict radius of hydrofrac distribution.

Options of stimulation shall be prepared and each should include:

- a) Composition and properties of pumping fluid, rate and volume of pumping fluid; expected value of fracture half-length, width, height, direction, also, fluid transportation and expected leaking. Four considerations govern fluid selection and choice of properties of fluid and pumping pressure: creation of planned fractures; minimization of damage as low as possible; protection from fluid loss; low friction pressure drop. Most fracture treatments should be pumped with suitable water-base fracture fluids. Acid-base fluids can be used in some case (concentration and content shall be chosen and approved ONLY after proper acidation test based on core data); Oil-base fluids should be used only in oil reservoirs when water-base fluids have proved conclusively do not work. Because of pumping oil-base fluids and acid are more dangerous than pumping water-base fluids, special care should be taken while planning and during the operation. The necessity of usage of such fluids, including chemicals for

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"breaking" fluid and possible negative impact while usage of such fluids should be demonstrated in Hydrofrac Program.

- a) Propped fractures width, height and length/radius of distribution, permeability and concentration of proppant in fractures, physical properties of the proppants (strength, grain size, density etc.) and proppant volume, closure stress, expected fracture conductivity, contaminants. And, expectation of reduction of fractures conductivity in future related to propping agent properties. Modelled vertical distance from induced fractures zone multiplied by a factor of two till waterbearing layer shall be more than 100m (for min case).
- b) Gravel pack. At many reasons of treatment application of gravel pack is preferable or needed (gives lower average skin values, the high production rates and sand control). But this method could not be applied at all the situations, so, should be considered it is appropriate solution at each particular case.
- c) Production forecast.

2.3.4 Uncertainty and risk analysis. Uncertainty should be included into Hydrofrac program to prove chosen variant of hydrofrac treatment. Uncertainty should be evaluated with taking account of uncertainty of input parameters to the models, like uncertainty of in-situ stress, Poisson and Young's modulus, permeability or fluid-loss. The design should acknowledge these uncertainties and make sensitivity runs with the fracture-propagation model to determine the effect of these uncertainties on the design process. Permit holder should evaluate risks such as:

- a) Mechanical risks - mechanical problems with the well or the surface equipment cause the treatment to fail.
- b) Product price risks - risk of the situation that hydraulic fracturing is executed and paid for (i.e., the money is spent), but the well does not produce at the desired flow rates nor achieve the expected cumulative recovery.
- c) Geologic risks - uncertainty of geological data should be counted as main reason of lost of efficiency of operations.
- d) Environment damage and other similar risks. Important to understand penetration of the liquid outside the reservoir.

2.3.5 Cost and economic efficiency evaluation. Economical evaluation determines the optimum fracture treatment design. Decision of frac design will be taken based on comparison of the variants of costs of the treatment with benefit came from increase of hydrocarbon volume at the result of the treatment with minimal risks.

2.3.6 All operation aspect of Hydrofrac described at all the details below (at item 3 and below).

2.3.7 Hydrofrac operation should be checked at on-line regime. The data should be reported.

2.3.8 Post frac operations:

- a) Post frac wells test/measurements into the wells. Raw data of post-frac well tests result, result of data interpretation and final report of conducted tests or other measurements should be included in End Operational report.
- b) Microseismic monitoring of hydrofracturing operations. In some case it could be required activity. At this case monitoring technology, design and details of monitoring process should be presented in Hydrofrac program. Raw data of hydrofrac monitoring and their interpretation should be included in End Operational report.

- c) End Operational report. The report of done hydrofrac job with plan-fact hydrofrac parameters and analysis should be given within 90 days after completion of the operation.

3. Well Integrity – Subject Well

3.1 Issue

During hydraulic fracturing operations, subject wells can incur significant stresses, which may lead to a loss of well integrity. A loss of well integrity may result in subsurface impacts or result in a release of fluids to the surface, placing the public and the environment at risk.

3.2 Regulatory Objective

To prevent the loss of well integrity at a subject well.

3.3 Requirements

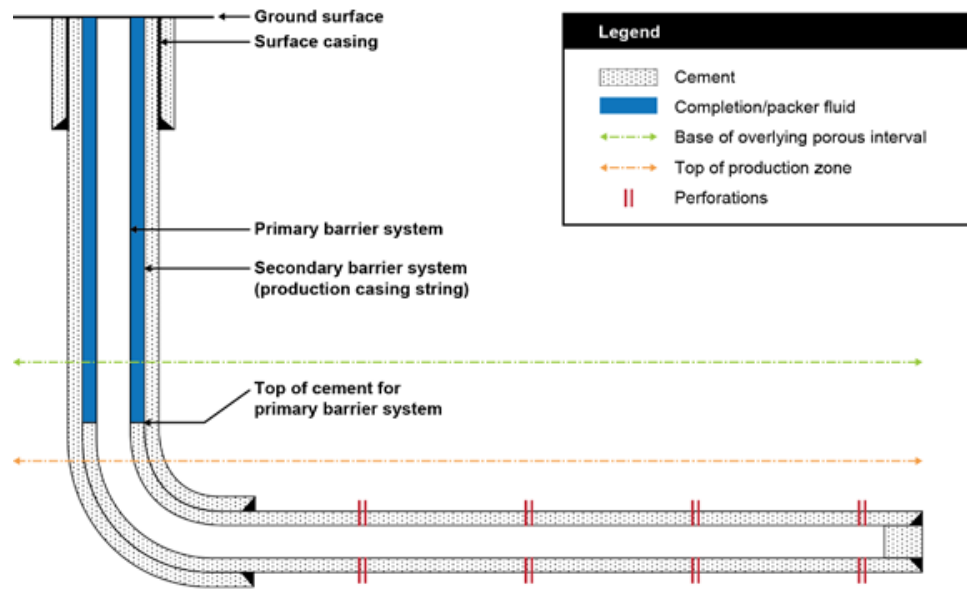
3.3.1 General

- a) Licensees must design, construct, and operate its well to provide well integrity during hydraulic fracturing operations.
- b) Licensees must obtain MNIEWR approval if using a single- or dual-barrier system as described below, or a barrier system other than a single- or dual-barrier system. Licensees are expected to manage well integrity throughout the life of the well, from construction to post abandonment.

3.3.2 Dual-barrier System

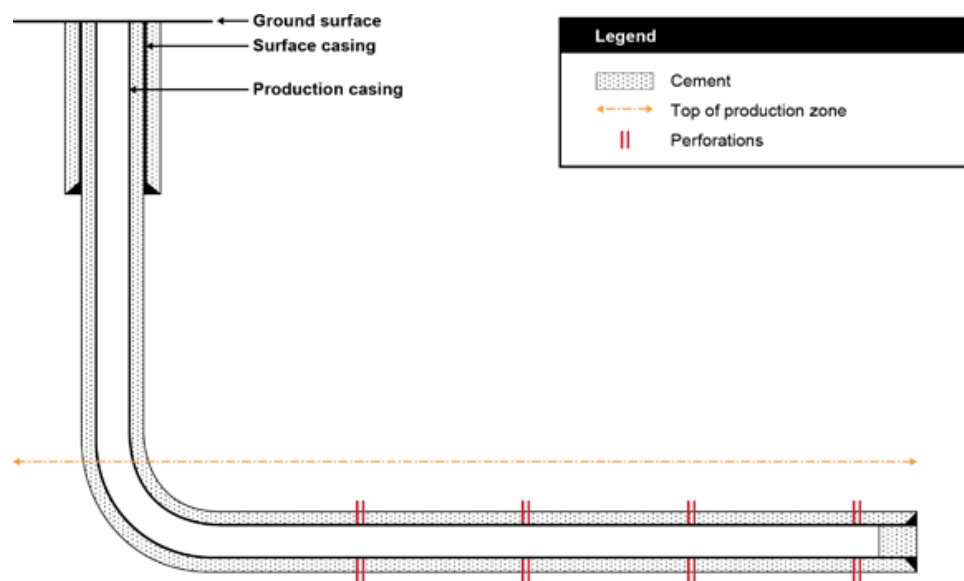
- a) If a dual-barrier system (see **Figure 1**) is used, it must consist of
 - a primary barrier system capable of containing and isolating the fracture fluids,
 - a secondary barrier system capable of providing well control in the event of a failure of the primary barrier, and
 - a monitoring system to detect and allow for a response to a primary barrier failure.
- b) To be classified as a dual-barrier system, the cement of the primary barrier system must not extend above the base of the overlying porous interval.

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Figure 1 - Example of a simplified dual-barrier system.



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Figure 2 - Example of a single-barrier system.

3.3.3 Single-barrier System

The MNEWR expects licensees to apply increased diligence in designing a single-barrier system (see **Figure 2**). When using a single-barrier system, surface casing must be set in accordance with the current requirements of [Directive 008: Surface Casing Depth Requirements](#).

- If surface casing is not set to the BGWP, licensees must
 - not use hydraulic fracturing fluids that may cause an adverse effect on non-saline aquifers and
 - cement the next casing string to surface.

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- b) If a single-barrier system is used, licensees must
- document the load capacity and safety factors used in the design of its casing relative to the loads and the well environment that the casing will be exposed to,
 - document the adjusted maximum pressure,
 - use an operating practice, such as the Primary and Remedial Cementing Guidelines (Drilling and Completions Committee) or a technically equivalent standard, when planning and executing its cementing program,
 - be able to demonstrate integrity of both casing and cement prior to initial fracture operations,
 - be able to demonstrate integrity of casing during fracture operations,
 - be able to demonstrate integrity of casing with final completion operations or within 90 days of the fracture operation,
 - test the production casing to a pressure that is adequate to meet the well's operational objectives (which should include potential pressures during fracturing operations) prior to perforating and hydraulic fracturing operations and
 - conduct a surface casing vent flow / gas migration test (as per [Interim Directive 2003-01: Isolation Packer Testing, Reporting, and Repair Requirements; Surface Casing Vent Flow/Gas Migration Testing, Reporting, and Repair Requirements; Casing Failure Reporting and Repair Requirements](#), or a surface casing annulus flow test (as per the attachment to [Bulletin 2011-35: Surface Casing Vent Requirements for Wells](#))
 - prior to initial fracturing operations and
 - between 60 and 90 days after completing fracturing operations.

4. Inter-wellbore Communication

4.1 Issue

Inter-wellbore communication occurs when a communication pathway has been established between a subject well and an offset well. A communication pathway may cause a well control event at an offset well, which may result in subsurface impacts or a release of fluids to the surface, placing the public and the environment at risk.

4.2 Regulatory Objective

To reduce the likelihood of unintentional inter-wellbore communication between a subject well and an offset well.

To manage well control at an offset well in the event of inter-wellbore communication with a subject well.

4.3 Requirements

4.3.1 General

- a) Licensees must manage the risks of inter-wellbore communication between a subject well and an offset well.

4.3.2 Hydraulic Fracturing Risk Planning

- a) Licensees must have a documented hydraulic fracturing program.
- b) The hydraulic fracturing program must include the following elements:
- determination of a fracture planning zone (FPZ),
 - identification of all offset wells within the FPZ,

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- an assessment of well integrity for each offset well,
 - a risk assessment for each offset well, using a methodology such as that described in Interim Industry Recommended Practice 24: Fracture Stimulation: Inter-wellbore Communication (IRP 24) (Drilling and Completions Committee),
 - determination of at-risk offset wells within the FPZ,
 - identification and assessment of special-consideration wells for possible inclusion in the well control plan, and
 - identification of energizing gas(es) used in fracture fluids.
- c) Licensees must maintain a copy of its hydraulic fracturing program at the subject well site for the duration of the operation.

The use of high vapour pressure hydrocarbons requires prior approval by the MNIWR.

Licensees should be aware of any subsurface features such as those described, for example, in *IRP 24* Hazard Register.

4.3.3 At-risk Offset Well Control Plans

- a) Licensees must have a documented well control plan for each at-risk offset well that includes
- the method(s) of detection of inter-wellbore communication,
 - how information will be relayed from an at-risk offset well back to the hydraulic,
 - fracturing operations should an inter-wellbore communication event occur,
 - the adjusted maximum pressure for each at-risk offset well, and
 - how the licensee will ensure well control at each at-risk offset well.
- b) Licensees must maintain a copy of its at-risk offset well control plan at the subject well site for the duration of the hydraulic fracturing operation.

4.3.4 Subject Well / At-risk Offset Well Licensee Engagement

- a) Licensees must notify licensees of at-risk offset wells of its planned hydraulic fracturing program.
Upon notification of a planned hydraulic fracturing program, licensees of at-risk offset wells are expected to engage and work cooperatively with licensees of subject wells in the development of well control plans.
- b) Licensees must engage licensees of at-risk offset wells and make all reasonable efforts to develop mutually acceptable well control plans.
- c) Licensees of both offset and subject wells are responsible for maintaining control of its licensed wells at all times.
- d) If the at-risk offset well does not have an active licensee, and it is not an orphan well, licensees must contact the MNIWR representative.
- e) Upon becoming aware of any communication event with an offset well, licensees must immediately notify the licensee of the offset well.

Additional MNIWR notification requirements are found in section 9.

5 Nonsaline Aquifer Protection

5.1 Issue

Communication between the subject well and a nonsaline aquifer as a result of hydraulic fracturing operations may cause adverse effects.

5.2 Regulatory Objective

To prevent adverse effects to nonsaline aquifers.

5.3 Requirements

5.3.1 General

- a) Licensees' hydraulic fracturing operations must not have an adverse effect on a nonsaline aquifer.

5.3.2 Nonsaline Aquifer Risk Assessment

- b) **Licensees must not use hydraulic fracturing within 100 m above of the top of any nonsaline aquifers, or within 100 m below the BGWP.**
- c) A risk assessment must be prepared if conducting hydraulic fracturing operations above 500 m of the top of any nonsaline aquifers, or within 500 m below, the BGWP.
- d) Licensees' risk assessment must include the following:
 - an evaluation of the potential for direct fracture communication from the subject well to a nonsaline aquifer,
 - the true vertical depth (TVD) of the top and base of any nonsaline aquifers above the BGWP,
 - the TVD of the fracture interval(s) within the wellbore,
 - the modelled vertical fracture distance (i.e., vertical half length),
 - the minimum distance between vertical fracture propagation and the adjacent nonsaline aquifers along the entire fracture interval,
 - documentation of the procedure used to determine whether or not fracture fluid components may cause an adverse effect on nonsaline aquifers,
 - any geological feature or other pathways that may allow or facilitate communication to a nonsaline aquifer, and
 - mitigation measures to minimize the risk of adverse effects on nonsaline aquifers.
- e) **If the modelled vertical fracture distance multiplied by a factor of two is within 100 m below the BGWP, or is within 100 m above of the top of any nonsaline aquifers, licensees must not use hydraulic fracturing.**

6 Hydraulic Fracturing Near Water Wells

6.1 Issue

Communication between the subject well and water wells as a result of hydraulic fracturing operations may cause adverse effects.

6.2 Regulatory Objective

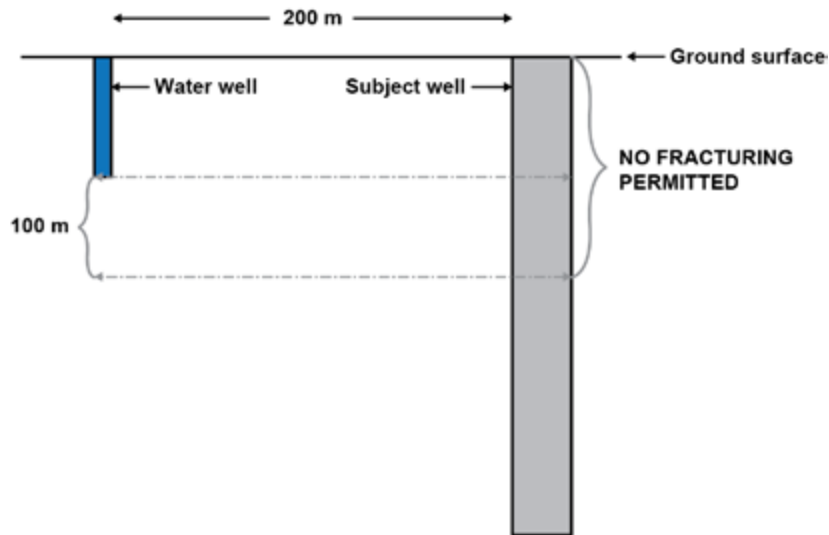
To prevent impacts to water wells.

6.3 Requirements

- a) Licensees' hydraulic fracturing operations must not have an adverse effect on the water well's water quality or quantity.

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- b) Licensees must not initiate hydraulic fracturing operations within a zone that extends 200 m horizontally from the surface location of a water well and 100 m vertically from the total depth of the water well (see **Figure 3**), except when using nitrogen as the fracturing fluid for coalbed methane completions (see section 8).
- c) Licensees must not initiate hydraulic fracturing operations within a zone that extends 100 m horizontally from the surface location of a water well and 200 m vertically from the total depth of the water well.



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Figure 3 - Hydraulic fracturing near water wells.

7 Hydraulic Fracturing Near Top of Bedrock

7.1 Issue

Fracture propagation during hydraulic fracturing operations may result in a release of fluids to the surface, placing the public and the environment at risk.

7.2 Regulatory Objective

To prevent surface impacts.

7.3 Requirements

- a) Licensees' hydraulic fracturing operations must not cause surface impacts.
- b) Licensees must not hydraulically fracture within 100 vertical m of the top of the bedrock surface (see **Figure 4**), except when using nitrogen as the fracturing fluid for coalbed methane completions (see section 8).

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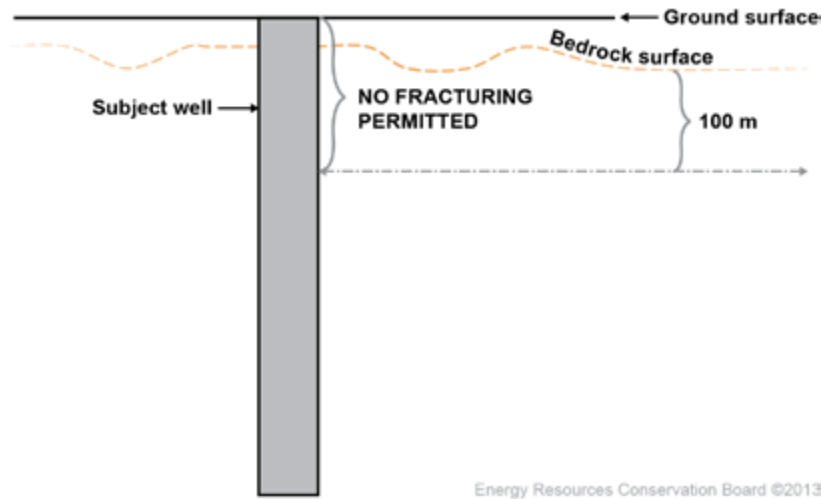


Figure 4 - Hydraulic fracturing near top of bedrock.

8 Special Provisions for Coalbed Methane Fracturing

The requirements below are derived from an independent study with respect to using nitrogen as the fracturing fluid for coalbed methane completions (The report, Shallow Nitrogen Fracturing Dimensions and Groundwater Protection, outlining the findings of the study can be found on the landing page for Directive 027: Shallow Fracturing Operations-Restricted Operations on the ERCB website, www.ercb.ca).

8.1 Coalbed Methane Fracturing Near Water Wells

- a) Licensees must not initiate nitrogen fracturing operations within a zone that extends 200 m horizontally from the surface location of a water well to 50 m vertically from the total depth of the water well.

8.2 Coalbed Methane Fracturing Near Top of Bedrock

- a) Licensees must not initiate nitrogen fracturing operations within 50 vertical m of the top of the bedrock surface.

8.3 Nitrogen Pumping Volume Limitations in Coals

- a) Licensees must not use more than 15 000 standard cubic metres of nitrogen per vertical metre of coal.

9 MNIEWR Notification Requirements

- a) Licensees must notify the MNIEWR a minimum of **five days** prior to the pressure test of surface equipment for hydraulic fracturing operations as per the Hydraulic Fracturing Notification Submission procedure found on the MNIEWR website at www.energy.gov.il. Notification is for one well licence or for a pad (multi-well) with continuous hydraulic fracturing operations.
- b) If an operation is demobilized and remobilized at a later date, licensees must re-notify the MNIEWR via the Hydraulic Fracturing Notification Submission procedure a minimum of **five days** prior to the pressure test of surface equipment for hydraulic fracturing operations. Notification is for one well licence or for a pad (multi-well) with continuous hydraulic fracturing operations.

- c) Licensees must immediately notify the MNIWR if well integrity fails.
- d) Licensees of the subject well must immediately notify the MNIWR upon becoming aware of any communication event with an offset well, a nonsaline aquifer, or a water well.

10 Continual Improvement

It is recommended that all licensees continually improve the planning and execution of its hydraulic fracturing operations by evaluating the effectiveness of its operations in meeting the regulatory objectives of these guidelines and by revising the planning and execution of its subsequent hydraulic fracturing operations accordingly.

Licensees are encouraged to document its continual improvement process using an appropriate procedure.

11 Environmental**11.1 Water Management**

Water management associated with hydraulic fracturing shall be in accordance with "API GUIDANCE DOCUMENT HF2" and requirements of Israeli Water Authority.

11.2 Mitigating Surface Impacts

Practices for mitigating surface impacts associated with hydraulic fracturing shall be in accordance with "API GUIDANCE DOCUMENT HF3" and requirements of Israeli Ministry of Environmental Protection.

12 Safety and Fire protection

Process and occupational safety and fire protection measures associated with hydraulic fracturing shall be **at least** in accordance with API standards (appendix 4 on p.25), safety guidelines of MNIEWR, which published on the MNIEWR website, and requirements of District Fire Services.

Appendix 1 – Definitions of Terms as used in These Guidelines

Adjusted maximum pressure	Operating pressure limits at the subject well and the offset wells, including a safety margin that will not be exceeded.
Adverse effect	Impairment of or damage to the environment, human health or safety or property.
At-risk offset well	An offset well that may be adversely affected by a hydraulic fracturing operation.
Barrier	Individual components that collectively make up a barrier system.
Base of groundwater protection (BGWP)	A modelled depth at which saline groundwater is likely to occur. It is calculated as the base of the deepest protected (nonsaline groundwater-bearing) formation plus a 15 m buffer.
Bedrock	Consolidated rock underlying unconsolidated glacial or drift material, or Solid rock either exposed at the surface or situated below surface soil, unconsolidated sediments and weathered rock.
Dual-barrier system	A well system designed for hydraulic fracturing operations made up of both primary and secondary barrier systems.
Energizing gas	A gas used to improve the effectiveness of the hydraulic fracture.
Fracture planning zone (FPZ)	An area that may be impacted by hydraulic fracturing operations (FPZ defines a screening area around the Subject Well, making it possible to identify all offset wells proximal to the Subject Well that require risk assessment).
High vapour pressure hydrocarbon	any hydrocarbon and stabilized hydrocarbon mixture with a Reid vapour pressure greater than 14 kilopascals.
Licensees	For the purposes of these guidelines, the term "licensees" is used to designate the responsible duty holder (e.g., licensee, operator, company, applicant, approval holder, right holder) as specified in legislation, and refers to subject well licensees unless otherwise stated.
Nonsaline aquifer	An aquifer above the BGWP that contains water with a total dissolved solids content of less than or equal to 4000 milligrams per liter
Offset well	Any well that is within the FPZ of a subject well, excluding water wells.
Orphan well	A well that has been designated by the MNIWR as an orphan well.
Primary barrier system	A well system designed to contain and isolate fracture fluids within the well.
Risk assessment	Systematic analysis of the risks from activities and a rational evaluation of their significance by comparison against predetermined standards, target risk levels, or other risk criteria.

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Secondary barrier system	The backup well system that provides well control in the event of a failure of the primary barrier system.
Single-barrier system	A well system designed for hydraulic fracturing operations comprised of a primary barrier system only.
Special-consideration well	A well beyond the FPZ that may have characteristics of unique concern which justifies further scrutiny.
Subject well	A well at which a licensee proposes to conduct hydraulic fracturing operations.
Thermal well	A well that is completed in a reservoir that is, was, or has the potential to be artificially heated.
Water well	A well with the primary purpose of nonsaline groundwater production or well that is connected to a public water system.
Well control event	A flow of wellbore fluids in the subsurface from one formation to another formation, a flow of wellbore fluids at surface that can be controlled by existing wellhead or blowout prevention equipment, or a blowout.
Well integrity	Prevention of the escape of fluids (i.e., liquids or gases) to subsurface formations or surface.

Appendix 2 – Chemicals are used within fracture fluids

Chemical additives perform many functions within fracture fluids. A Chemical Abstracts Service (CAS) Number is a unique identifier for chemical substances. The CAS is a division of the American Chemical Society that is responsible for the administration, quality assurance and maintenance of the CAS registry. A CAS Number itself has no inherent chemical significance but provides an unambiguous way to identify a chemical substance or molecular structure when there are many possible systematic, generic, proprietary or trade names. The number of chemical additives used in a typical fracture treatment depends on the conditions, such as depth or location, of the specific well being fractured and the characteristics of the formation, such as thickness and type of rock. A typical fracture treatment will use very low concentrations of between 3 and 12 additive chemicals, depending on the characteristics of the water and the rock formation being fractured. Each component serves a specific, engineered purpose.

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Product Function	Chemical Name	CAS	Chemical Purpose
Acid	Hydrochloric Acid	007647-01-0	Helps dissolve minerals and initiate cracks in the rock
Biocide	Glutaraldehyde	000111-30-8	Eliminates bacteria in the water that produces corrosive by-products
	Ammonium Chloride	012125-02-9	Eliminates bacteria in the water that produces corrosive by-products
	Quaternary Ammonium Chloride	061789-71-1	Eliminates bacteria in the water that produces corrosive by-products
	Tetrakis Hydroxymethyl-Phosphonium Sulphate	055566-30-8	Eliminates bacteria in the water that produces corrosive by-products
Breaker	Ammonium Persulphate	007727-54-0	Allows a delayed break down of the gel
	Sodium Chloride	007647-14-5	Product Stabilizer
	Magnesium Peroxide	014452-57-4	Allows a delayed break down of the gel
	Magnesium Oxide	001309-48-4	Allows a delayed break down of the gel
	Calcium Chloride	010043-52-4	Product Stabilizer
Clay Stabilizer	Choline Chloride	000067-48-1	Prevents clays from swelling or shifting
	Tetramethyl ammonium chloride	000075-57-0	Prevents clays from swelling or shifting
	Sodium Chloride	007647-14-5	Prevents clays from swelling or shifting
Corrosion Inhibitor	Isopropanol	000067-63-0	Product stabilizer and / or winterizing agent
	Methanol	000067-56-1	Product stabilizer and / or winterizing agent
	Formic Acid	000064-18-6	Prevents the corrosion of the pipe
	Acetaldehyde	000075-07-0	Prevents the corrosion of the pipe
Crosslinker	Petroleum Distillate	064741-85-1	Carrier fluid for borate or zirconate crosslinker
	Hydrotreated Light Petroleum Distillate	064742-47-8	Carrier fluid for borate or zirconate crosslinker
	Potassium Metaborate	013709-94-9	Maintains fluid viscosity as temperature increases
	Triethanolamine Zirconate	101033-44-7	Maintains fluid viscosity as temperature increases
	Sodium Tetraborate	001303-96-4	Maintains fluid viscosity as temperature increases

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	Boric Acid	001333-73-9	Maintains fluid viscosity as temperature increases
	Zirconium Complex	113184-20-6	Maintains fluid viscosity as temperature increases
	Borate Salts	N/A	Maintains fluid viscosity as temperature increases
	Ethylene Glycol	000107-21-1	Product stabilizer and / or winterizing agent.
	Methanol	000067-56-1	Product stabilizer and / or winterizing agent.
Friction Reducer	Polyacrylamide	009003-05-8	"Slicks" the water to minimize friction
	Petroleum Distillate	064741-85-1	Carrier fluid for polyacrylamide friction reducer
	Hydrotreated Light Petroleum Distillate	064742-47-8	Carrier fluid for polyacrylamide friction reducer
	Methanol	000067-56-1	Product stabilizer and / or winterizing agent.
	Ethylene Glycol	000107-21-1	Product stabilizer and / or winterizing agent.
Gelling Agent	Guar Gum	009000-30-0	Thickens the water in order to suspend the sand
	Petroleum Distillate	064741-85-1	Carrier fluid for guar gum in liquid gels
	Hydrotreated Light Petroleum Distillate	064742-47-8	Carrier fluid for guar gum in liquid gels
	Methanol	000067-56-1	Product stabilizer and / or winterizing agent.
	Polysaccharide Blend	068130-15-4	Thickens the water in order to suspend the sand
	Ethylene Glycol	000107-21-1	Product stabilizer and / or winterizing agent.
Iron Control	Citric Acid	000077-92-9	Prevents precipitation of metal oxides
	Acetic Acid	000064-19-7	Prevents precipitation of metal oxides
	Thioglycolic Acid	000068-11-1	Prevents precipitation of metal oxides
	Sodium Erythorbate	006381-77-7	Prevents precipitation of metal oxides
Non-Emulsifier	Lauryl Sulphate	000151-21-3	Used to prevent the formation of emulsions in the fracture fluid
	Isopropanol	000067-63-0	Product stabilizer and / or winterizing agent.
	Ethylene Glycol	000107-21-1	Product stabilizer and / or winterizing agent.

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pH Adjusting Agent	Sodium Hydroxide	001310-73-2	Adjusts the pH of fluid to maintains the effectiveness of other components, such as crosslinkers
	Potassium Hydroxide	001310-58-3	Adjusts the pH of fluid to maintains the effectiveness of other components, such as crosslinkers
	Acetic Acid	000064-19-7	Adjusts the pH of fluid to maintains the effectiveness of other components, such as crosslinkers
	Sodium Carbonate	000497-19-8	Adjusts the pH of fluid to maintains the effectiveness of other components, such as crosslinkers
	Potassium Carbonate	000584-08-7	Adjusts the pH of fluid to maintains the effectiveness of other components, such as crosslinkers
Scale Inhibitor	Copolymer of Acrylamide and Sodium Acrylate	025987-30-8	Prevents scale deposits in the pipe
	Sodium Polycarboxylate	N/A	Prevents scale deposits in the pipe
	Phosphonic Acid Salt	N/A	Prevents scale deposits in the pipe
Surfactant	Lauryl Sulphate	000151-21-3	Used to increase the viscosity of the fracture fluid
	Ethanol	000064-17-5	Product stabilizer and / or winterizing agent.
	Naphthalene	000091-20-3	Carrier fluid for the active surfactant ingredients
	Methanol	000067-56-1	Product stabilizer and / or winterizing agent.
	Isopropyl Alcohol	000067-63-0	Product stabilizer and / or winterizing agent.
	2-Butoxyethanol	000111-76-2	Product stabilizer

Appendix 3 – API Standards supporting HF

<http://www.api.org/policy-and-issues/policy-items/hf/hydraulic-fracturing-best-practices>
http://www.api.org/~media/files/policy/exploration/hydraulic_fracturing_infosheet.pdf

Overview of Industry | Guidance/Best Practices Supporting Hydraulic Fracturing (HF)

<p>API Spec 4F API RP 46 API Spec 9A API RP 74 API RP 88 API Spec 8C API Spec 16A API Spec 16C API RP 185T API SM 53 API RP 92U API SM 689 API Spec Q2 API Spec 12B API Spec 12D API Spec 12F API Spec 12J API Spec 12K API Spec 12L API RP 12N</p>	<p>Drilling and Well Servicing Structures Wellhead and Christmas Tree Equipment Hoisting Equipment Hoisting Equipment Hoisting Equipment Drift-through Equipment Coke and KIL Systems Control Systems for Drilling Well Control Equipment Coiled Tubing Well Control Equipment Systems Blowout Prevention Equipment Systems Underbalanced Drilling Operations Reliability/Maintenance Data OHS Requirements for Service Organizations for the Petroleum and Natural Gas Industry Production Storage Tanks (Bolted) Production Liquid Storage Tanks (Shop welded) Oil and Gas Separators Indirect Type Oilfield Heaters Vertical and Horizontal Emulsion Treaters Flame Arresters, Operations, Testing and Maintenance</p>	<p>API Spec 12P API RP 12B1 API RP 289B API RP 693 API Bull 016 API RP 49 API RP 54 API RP 55 API RP 59 API RP 64 API RP 67 API RP 68 API RP 74 API RP 74L API RP 76 API Spec 65-2 API RP 90-2 API RP 100-1 API RP 100-2 API RP 50 API RP 51R</p> <p>Fiberglass Reinforced Plastic Tanks Production Service Tanks (Inspection and Maintenance) Storage Tanks Overfill Protection Remediation of Self-Healed Soils Soil Remediation Comprehensive Plan Drilling and Servicing Involving Hydrogen Sulfide Drilling and Servicing Operations Occupational Safety Gas Processing Involving Hydrogen Sulfide Well Control Operations Diverter Systems Equipment and Operations Oilfield Exposures Safety Oil and Well Servicing and Workover Operations Involving Hydrogen Sulfide Production Operations Occupational Safety Safety and Environmental Management Systems Construction Safety Incident Investigation Annular Casing Pressure for Onshore Wells Well Integrity and Fracture Containment Environmental Aspects Related to Onshore Operations Environmental Protection Natural Gas Processing Plant Practices Environmental Protection for Operations</p>	<p>API RP 52 API Bull E2 API Bull E3 API Bull E4 API Bull HE4 API Spec 5L API Spec 6D API RP 6DR API 6FA API SM 1104 API RP 1110 API RP 1133 API RP 1169 API RP 1162 API RP 1163 API RP 1172 API Spec 11B API Spec 11E API RP 11ER</p> <p>Environmental Protection Land Drilling Practices NORM Management Wear Abatement and Inactive Wells Waste Management Community Engagement Line Pipe Pipeline Valves Repair and Remanufacture of Pipeline Valves Fire Testing for Valves Pipeline Welding Steel Pipeline Pressure Testing Guidelines for Onshore Hydrocarbon Pipelines Affecting High Consequence Floodplains Managing System Integrity Public Awareness Programs Pipeline Construction – New Construction Pipeline SMS Stacker Rods Pumping Units Guarding Pumping Units</p>
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<p>API RP 543 API Spec 6B API Spec 6B1 API RP 561 API RP 565 API RP 566 API Spec 6CRA API Spec 6C API Spec 6D API Spec 7-1 API Spec 7-2 API RP 76 API RP 76-2 API Spec 10A API RP 10B-2 API RP 10B-5 API RP 10B-6 API Spec 10D API RP 10D-2 API RP 10F API TR 10TR1 API TR 10TR2</p>	<p>Thread Compounds Wellhead Inspection Threading, Gauges and Thread Inspection Practices Threading, Gauges and Thread Inspection Practices Casing and Tubing Care and Use Tubular Performance property calculations Casing and Tubing Connections Testing Welding Connections to Pipe Corrosion Resistant Alloy Pipe Casing and Tubing Drill Pipe Drill Stem Elements Rotary Shouldered Connection Threading and Gauges Drill Stem Design Drill Stem Elements (Inspection and Classification) Well Cements Well Cement Testing Well Cement Testing Well Cement Shrinkage and Expansion Determination Well Cement Shrinkage and Expansion Determination Bow Spring Casing Centralizers Centralizer Placement and Stop-Collar Testing Cement Float Equipment Cement Sheath Evaluation Cement Shrinkage and Expansion</p>	<p>API TR 10TR3 API TR 10TR4 API TR 10TR5 API Spec 13A API RP 13B-1 API RP 13B-2 API RP 13C API RP 13D API RP 131 API RP 132 API RP 13M API RP 13M-4 API RP 198 API RP 19C API RP 19D API Spec 110H API Spec 110Z API Spec 110Z API Spec 14A API Spec 14B API Spec 14L API Spec 18E1 API Spec 18E2 API Spec 18E3 API RP 18E4 API Spec 18V</p> <p>Concentric Threading Time Tests Solid and Ditch Centralizer Testing Drilling Fluids Water-based Drilling Fluids Testing Oil-based Drilling Fluids Testing Drilling Fluids Processing System Evaluation Drilling Fluids Rheology Drilling Fluids Lub Testing Completion Fluids Viscous Properties Gravel-pack Fluid Leak-off Well Performer Evaluation Proppants Properties Long-term Conductivity of Proppants Packers and Bridge Plugs Progressing Cavity Pump Systems Progressing Cavity Pump Systems Subsurface Safety Valves Subsurface Safety Valves (Inspection and Maintenance) Lock, Mandrels and Landing Nipples Slide-Pocket Mandrels Slide-Pocket Mandrel Flow Control Devices Slide-Pocket Mandrel Latches and Seals Slide-Pocket Mandrel Related Equipment Banner Valves</p>
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