CANADA-NEWFOUNDLAND & LABRADOR
C-NLOPB
OFFSHORE PETROLEUM BOARD

Well Integrity Life Cycle Management for Subsea Field Development - A Regulator's Perspective

John Kennedy, P. Eng., CRSP
Director of Operations
C-NLOPB

Who

C-NLOPB - Regulator for the Canada – Newfoundland and Labrador Offshore Area

- Established in 1985 under the *Atlantic Accord* to provide regulatory oversight in four areas:
  - Safety
  - Environment
  - Resource Management (includes Exploration)
  - Industrial Benefits

- One of three Canadian offshore regulators, along with CNSOPB and NEB

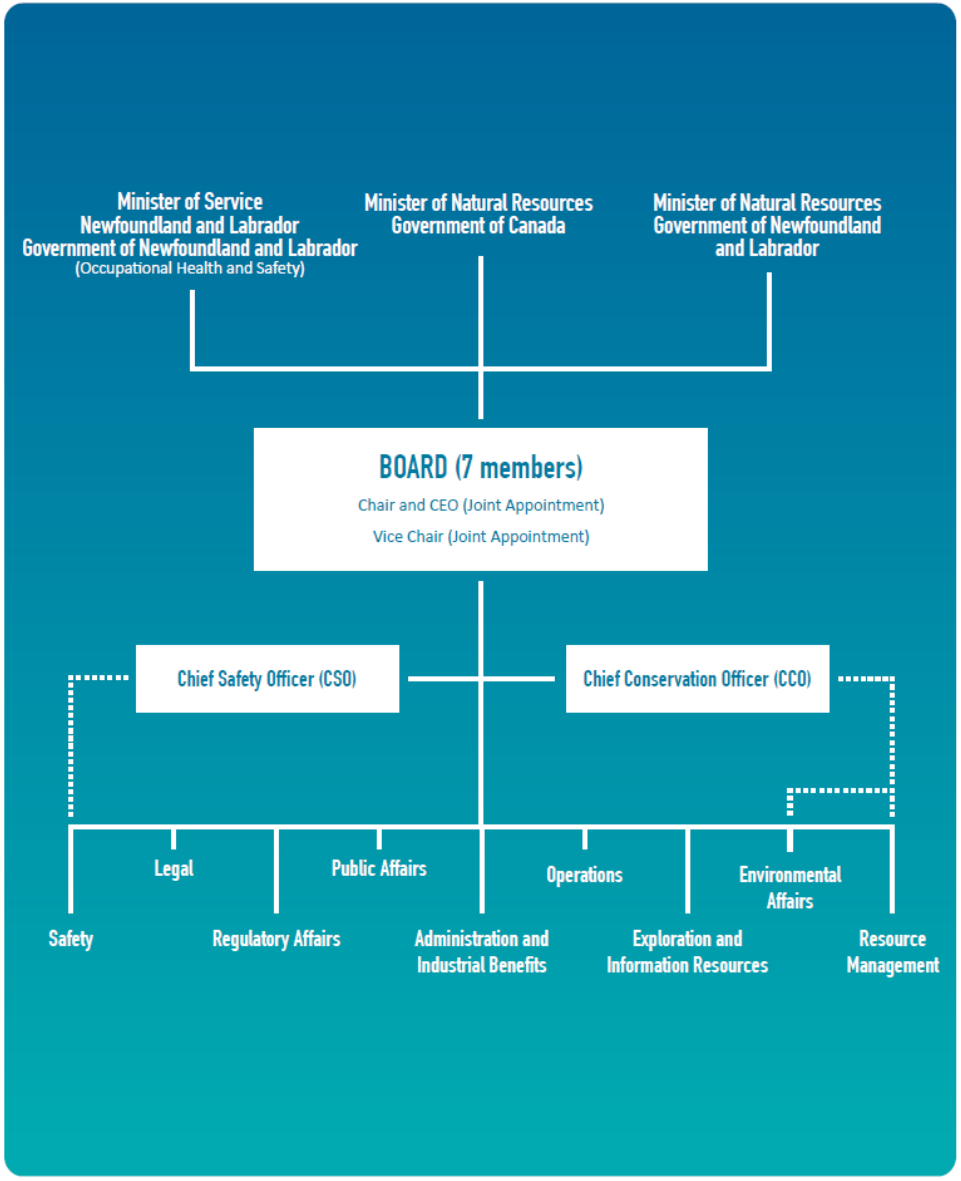
- Board reports to federal and provincial Ministers of Natural Resources, plus Minister of Service NL

- *Accord Acts* dictate a permissive regulatory regime but place ultimate responsibility for safety and environmental protection on operators, who are required to mitigate risk to a level as low as is reasonably practicable ("ALARP")

- Regulatory tools include legislation, regulations, guidance, codes of practice and conditions

- Enforcement and compliance tools include notices of non-compliance, orders, revocation of authorizations, prosecution and administrative monetary penalties

C-NLOPB Organization Structure



THE BOARD

Chair and CEO – *Scott Tessier*
Jointly Appointed by Government of NL and Government of Canada

Vice Chair – *Ed Williams*
Appointed by Government of NL, Endorsed by Government of Canada

6 Board Members
3 Appointed by Government of Canada - *Lidija Cicnjak-Chubbs, Cynthia Hickman* and ***One Vacancy***
3 Appointed by Government of NL – *Ed Williams, Ted O'Keefe* and ***One Vacancy***

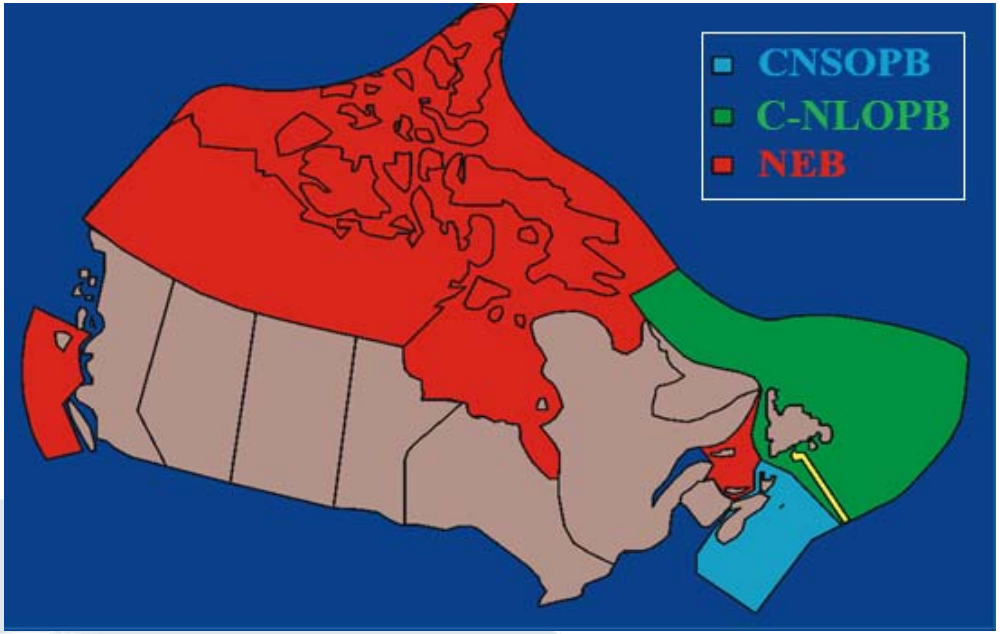
Canada - Newfoundland and Labrador Offshore Area

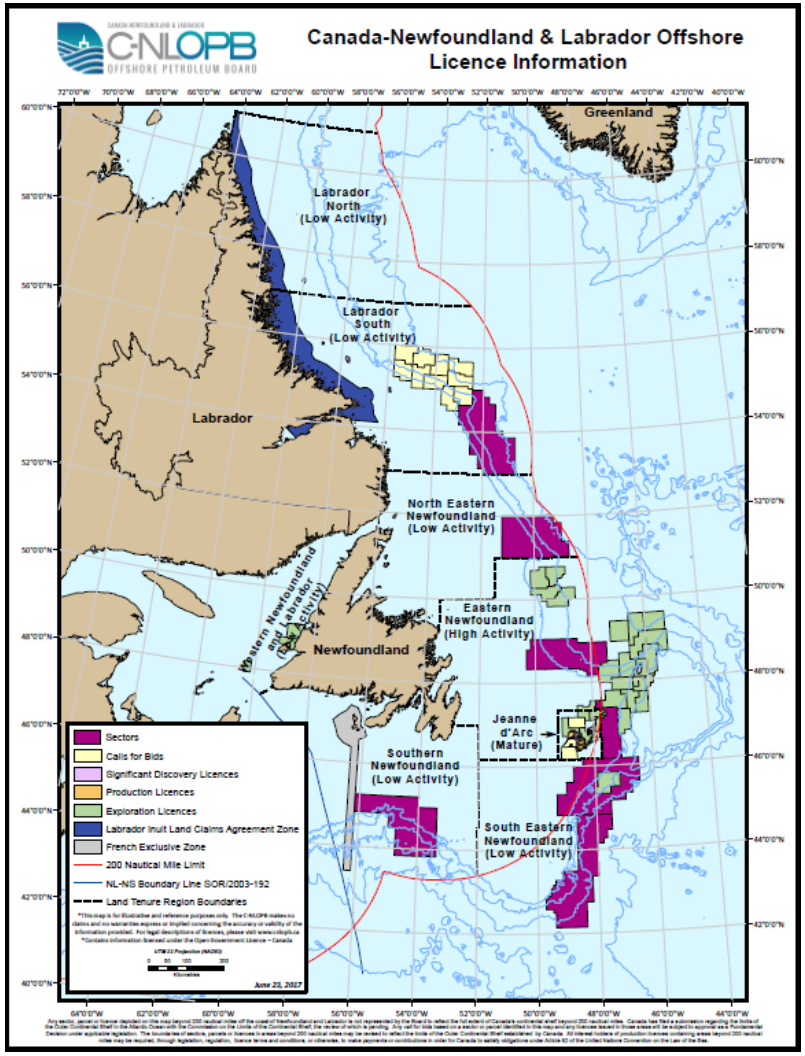
All maps used in this presentation are subject to the following disclaimer:

"Any sector, parcel or licence depicted on this map beyond 200 nautical miles off the coast of Newfoundland and Labrador is not represented by the Board to reflect the full extent of Canada's continental shelf beyond 200 nautical miles. Canada has filed a submission regarding the limits of the Outer Continental Shelf in the Atlantic Ocean with the Commission on the Limits of the Continental Shelf, the review of which is pending. Any call for bids based on a sector or parcel identified in this map and any licences issued in those areas will be subject to approval as a Fundamental Decision under applicable legislation. The boundaries of sectors, parcels or licences in areas beyond 200 nautical miles may be revised to reflect the limits of the Outer Continental Shelf established by Canada. All interest holders of production licences containing areas beyond 200 nautical miles may be required, through legislation, regulation, licence terms and conditions, or otherwise, to make payments or contributions in order for Canada to satisfy obligations under Article 82 of the United Nations Convention on the Law of the Sea."

Canada - Newfoundland and Labrador Offshore Area

- The current active fields are located in the Jeanne d'Arc Basin, about 350 km southeast of St. John's, NL
- Other active areas include the Flemish Pass which is +450km northeast of St. John's, NL





Current Operating Facilities and Rig Locations

Hibernia Platform

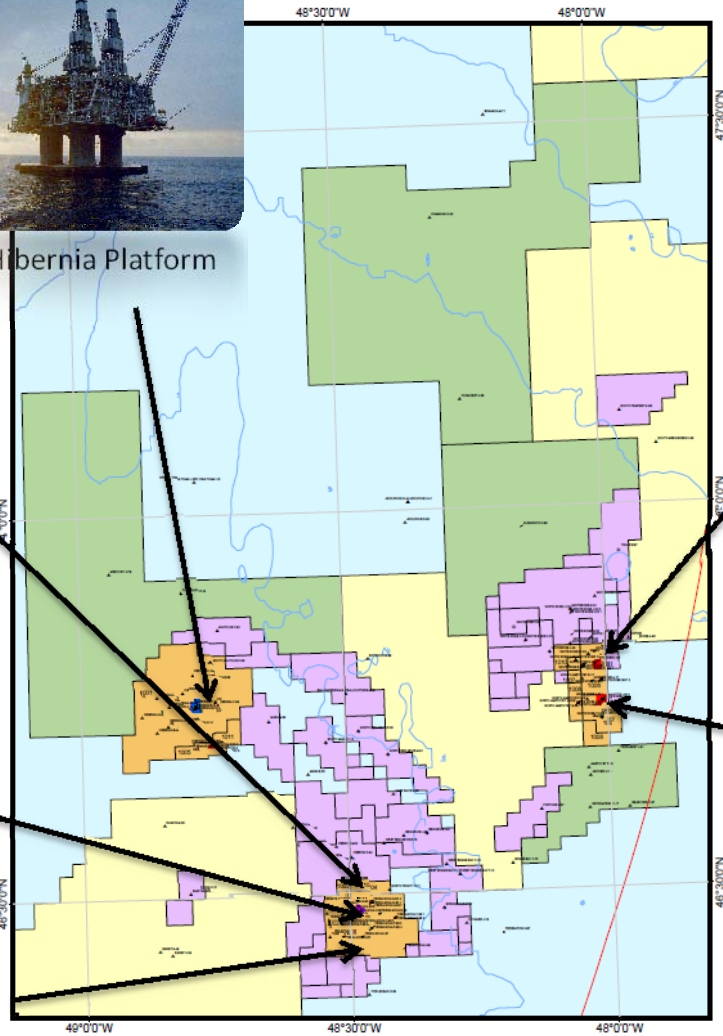
Hebron Platform

SeaRose FPSO

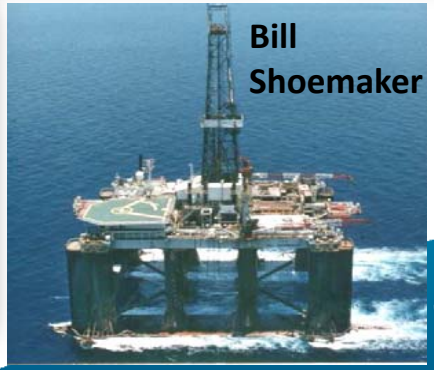
TerraNova FPSO

Henry Goodrich

Transocean Barents



Other Rigs Include…..



Environment

Harsh Environment

- Local environment referred to as “Hostile”
- Severity and frequency of storm conditions
- Harsh environment demands rigid adherence to a comprehensive Asset Integrity Management program (taking into consideration design, quality, operation, maintenance, competency, etc.)

High Sea States

- Regional **mean** wave heights range from 3 m in the western region to 4.5m in the east across February*
- Maximum wave heights can reach up to **16+** m

*Data from Strategic Environmental Assessment study of Eastern Newfoundland

Harsh Environment

High Winds

- We have had Maximum wind speeds reported above:
  - 148 km/h, gusting to 167 km/h, at a height of 50 m
  - 157 km/h, gusting to 175 km/h, at a height of 139 m

Icebergs, Pack ice

- In the last 15 years, there have been several occasions where the offshore production facilities undertook precautionary production shutdowns (in preparation for possible disconnect) due to pack ice and icebergs encroaching within safety zone

Fog

- The offshore NL region has some of the highest occurrence rates of fog in North America
- These conditions impact visibility and awareness and vary geographically and seasonally
  - The Flemish Cap region sees poor or very poor conditions (< 2 km) for 40% of some months*
  - The Flemish Cap region sees less than good visibility (< 10 km) for 57% of the year*
- On average in the last five years, installations reported cancelations to all flights 79 days annually, due to weather conditions such as fog, wave heights, and wind conditions

*Data from Strategic Environmental Assessment study of Eastern Newfoundland

Remote Environment

- Production platforms and MODUs are operating more than 350+ km from shore
- In comparison to other jurisdictions the infrastructure in this region is relatively small - currently we have 4 production facilities and 2 MODUs operating in the offshore NL region; with some additional seismic and construction vessels during the summer months
- Typically includes standby vessels for each facility unless operating in the same field
- Travel can take 90 to 180 minutes by helicopter or up to 18-24 hrs by vessel under normal conditions

MANAGING WELL INTEGRITY IS CHALLENGING IN THIS HARSH, REMOTE ENVIRONMENT

Regulations

Definition of Installation

INSTALLATION REGULATIONS

Definitions:

Installation – diving installation , drilling installation, production installation or accommodation installation;

Diving installation – diving system and any associated vessel that function independently of an accommodation installation, production installation or drilling installation;

Drilling installation – drilling unit or a drilling rig and its associated drilling base and includes any associated dependent diving system;

Production installation – production facility and any associated platform, artificial island, subsea production system, offshore loading system, drilling equipment, facilities related to marine activities and dependent diving system.

Drilling and Production Regulations

5 Management System

(2) The management system shall include

(c) the processes for identifying hazards and for evaluating and managing the associated risks;

(d) the processes for ensuring that personnel are trained and competent to perform their duties;

(e) the processes for ensuring and maintaining the integrity of all facilities, structures, *installations, support craft and equipment necessary to ensure safety, environmental protection and waste prevention;*

(g) the documents describing all management system processes and the processes for making personnel aware of their roles and responsibilities with respect to them

8 Safety Plan

The *safety plan shall set out the procedures, practices, resources, sequence of key safety-related activities and monitoring measures necessary to ensure the safety of the proposed work or activity and shall include*

(c) a description of the hazards that were identified and the results of the risk evaluation;

(d) a summary of the measures to avoid, prevent, reduce and manage safety risks;

(e) a list of all structures, facilities, equipment and systems critical to safety and a summary of the system in place for their inspection, testing and maintenance

Drilling and Production Regulations

19 Safety and Environmental Protection

The *operator shall take all reasonable precautions to ensure safety and environmental protection, including ensuring that*

(f) any drilling or *well operation is conducted in a manner that maintains full control of the well at all times;*

(g) if there is loss of control of a well at an *installation, all other wells at that installation are shut in until the well that is out of control is secured;*

(i) all equipment required for safety and environmental protection is available and in an operable condition;

(j) the inventory of all equipment identified in the *safety plan and the environmental protection plan is updated after the completion of any significant modification or repair to any major component of the equipment;*

(l) a sufficient number of trained and competent individuals are available to complete the authorized work or activities and to carry out any work or activity safely and without *pollution;*

Drilling and Production Regulations

25 Wells, Installations, Equipment, Facilities, and Support Craft

The *operator shall ensure that*

(a) all wells, *installations, equipment and facilities are designed, constructed, tested, maintained and operated to prevent incidents and waste under the maximum load conditions that may be reasonably anticipated during any operations*

Drilling and Production Regulations

Other key sections of the regulations that speak to well integrity include:

Regulation 26 - Installation Components & Sour Service Environments
Regulation 30 - Drilling Practices
Regulation 36 – Well Control Equipment
Regulation 39 – Casing Design
Regulation 40 – Depth of Well & Casing
Regulation 41 – Cementing Programs
Regulation 42 – Waiting on Cement Time
Regulation 43 – Casing Pressure Testing
Regulation 44 – Production Tubing
Regulation 46 – Well Completion
Regulation 47 – Subsurface Safety Valve
Regulation 48 – Wellhead & Christmas Tree Equipment
Regulation 56 – Suspension and Abandonment
Regulation 58 – Seafloor Clearing on Abandonment
Regulation 59 – Installation Removal

Drilling and Production Regulations

27 Rectification of Defects

(1) The *operator shall ensure that any defect in the installation, equipment, facilities and support craft that may be a hazard to safety or the environment is rectified without delay.*

(2) If it is not possible to rectify the defect without delay, the operator shall ensure that it is rectified as soon as circumstances permit and that mitigation measures are put in place to minimize the hazards while the defect is being rectified.

72 Experience, Training and Qualifications

The *operator shall ensure that*

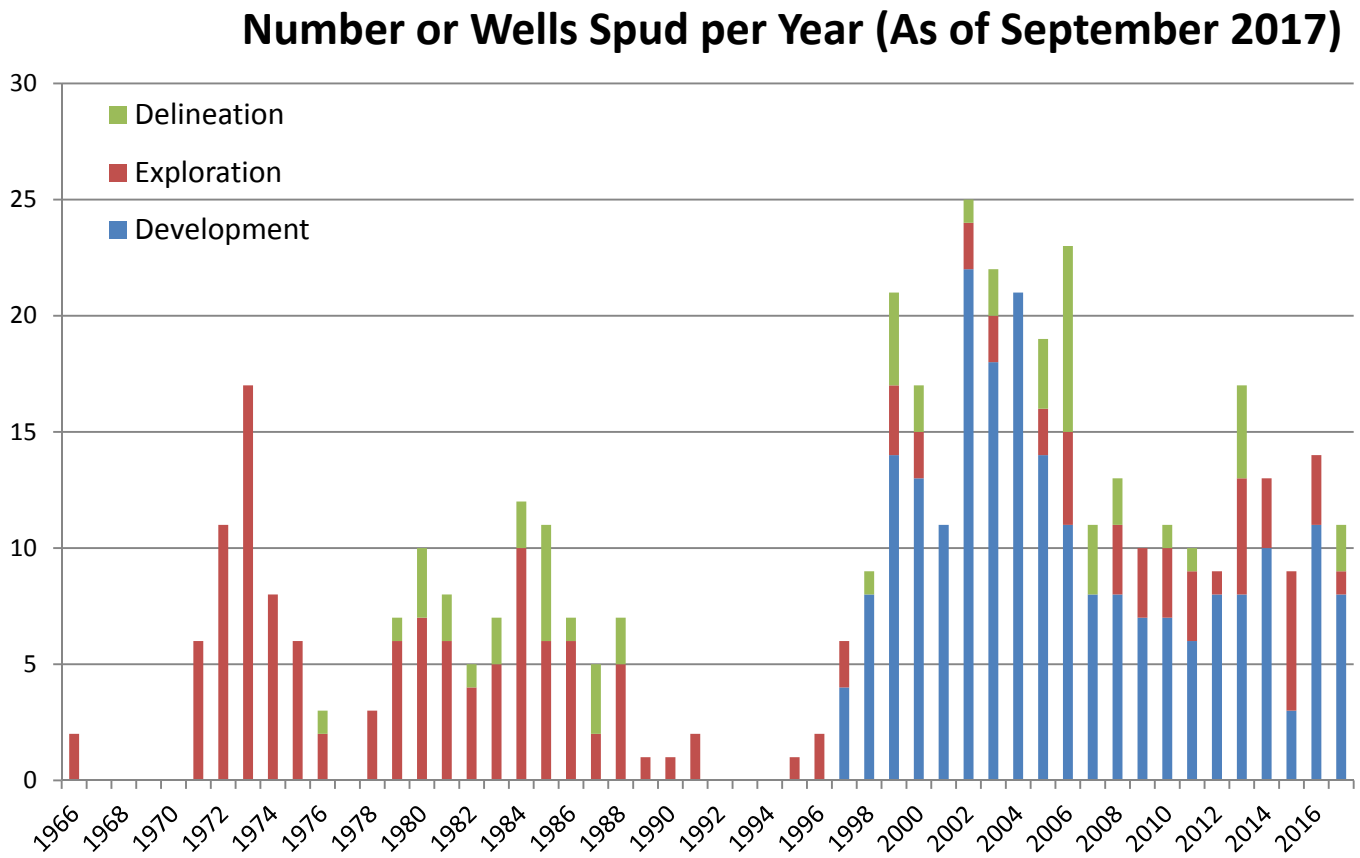
(a) all personnel have, before assuming their duties, the necessary experience, training and qualifications and are able to conduct their duties safely, competently and in compliance with these Regulations

Regulatory Compliance

- *Drilling & Production Regulations*
- *Installation Regulations*
- *Certificate of Fitness Regulations*
- *Codes and Standards*
- *Codes of Practice*
- *Good/Best Industry Practice*

Life Cycle Stages and Challenges

Offshore Activity



Total Well Status	
Completed	162
Abandoned	260
Suspended	20
Drilling	3
Total	**445**

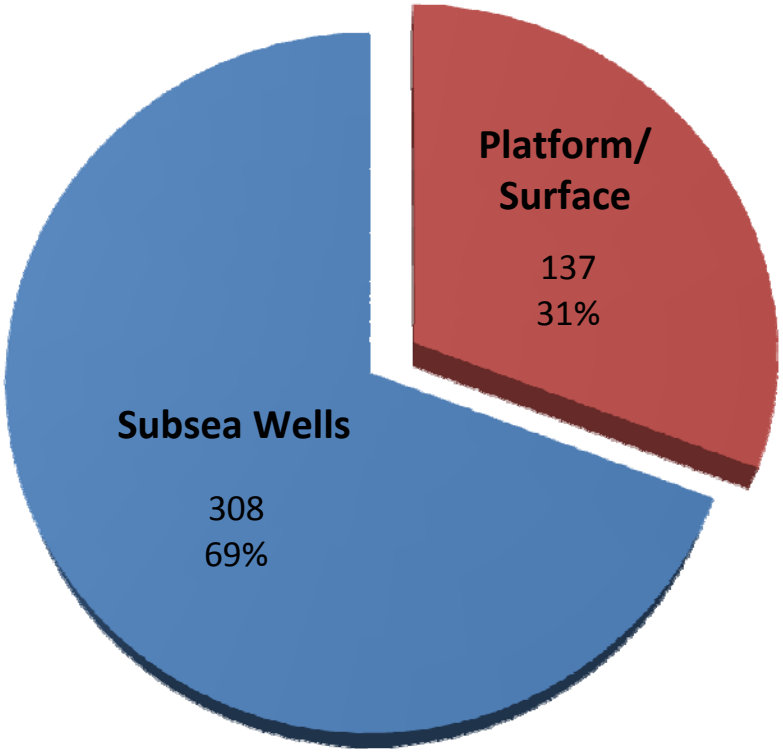
Total Number of Wells	
Development	220
Delineation	57
Exploration	169
Total	**446**

**As of September 30, 2017

NOTE: The Schedule of Wells shows a Total of 445 wells as of September 30, 2017. The second table above indicates 446 because we have one well that has the dual classification of exploration and delineation

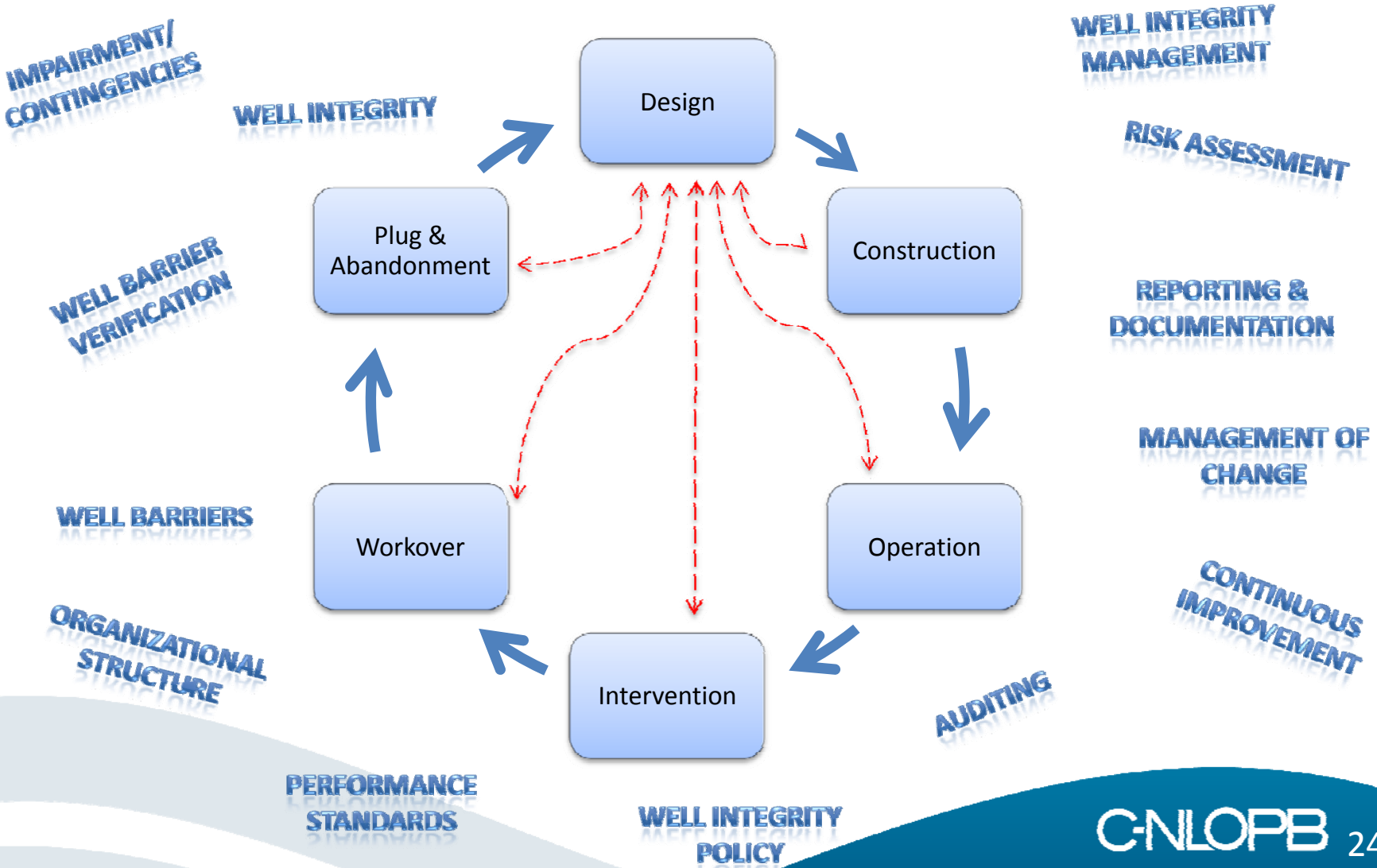
Offshore Activity

Platform VS. Subsea Wells as of September 2017



Note: *A Platform/Surface well refers to a well drilled with a dry BOP (onshore/jack-up/GBS)*

Lifecycle of a Well - Design to Plug and Abandonment



Well Integrity at the Design Stage

PART 4—EQUIPMENT AND OPERATIONS

25 Wells, Installations, Equipment, Facilities, and Support Craft

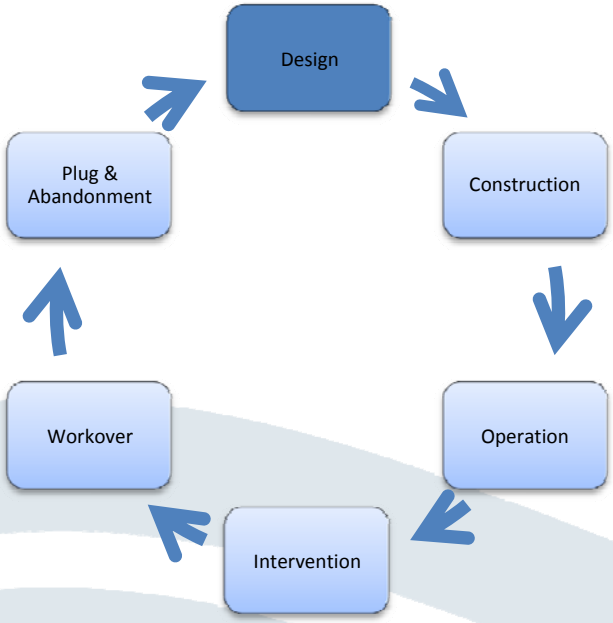
The *operator* shall ensure that

(a) all wells, *installations*, equipment and facilities are designed, constructed, tested, maintained and operated to prevent *incidents* and *waste* under the maximum load conditions that may be reasonably anticipated during any operations;

(b) a comprehensive inspection that includes a non-destructive examination of critical joints and structural members of an *installation* and any critical drilling or production equipment is made at an interval to ensure continued safe operation of the *installation* or equipment and in any case, at least once in every five-year period; and

(c) records of maintenance, tests and inspections are kept.

Regulation 25: Drilling and Production Regulations

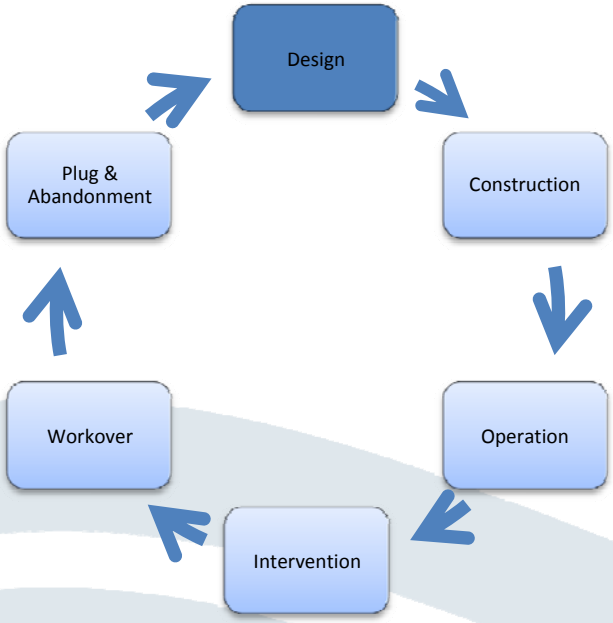


- Clear defined objectives for the life of the well to maximum load conditions
- Wells are designed with 2 barrier envelopes
- Plan for potential impairments, upset conditions, contingencies
- Equipment should be barrier qualified and appropriately certified

Well Integrity at the Design Stage

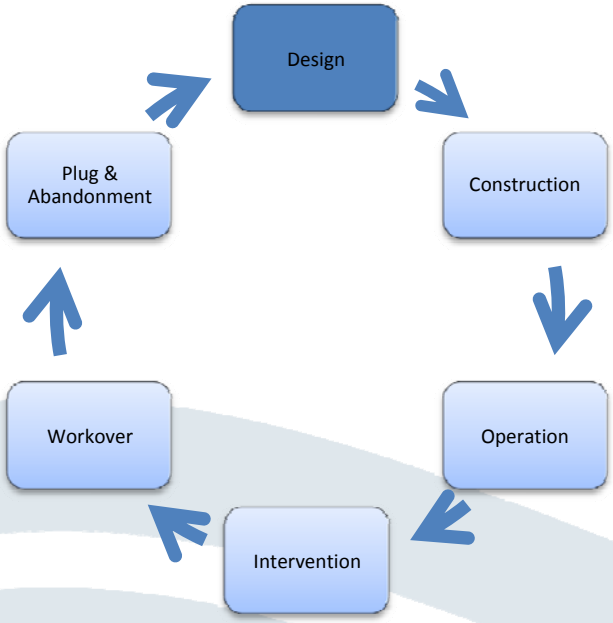
Well Design Considerations - Designing for the full lifecycle

- Change in reservoir conditions, e.g. sweet to sour
- Change in well objectives, e.g. water injection, to gas injection, WAG, etc…
- Converting an exploration well to a development well
- Validation of barriers (testing in the direction of flow - depleted reservoirs)
- Barrier impairments (tubing leak), does the design allow for re-defining the barrier envelopes



Challenges – Design Stage

- Critical casing cement and common well barrier elements
- Testing in the direction of flow (Production tubing, SCSSVs, etc…)
- The extent and timing of a low and high pressure test
- A wells "capability to flow"
- Formation integrity as a barrier
- Designing for worst case scenarios – Max anticipated surface pressure



- Well integrity for gas lifted wells
- Operator NOT engaging the Board early in the design stage for new or unique concepts/designs
- Clear in-house rules/procedures for drilling and completion engineers

Well Integrity at the Construction Stage

PART 4—EQUIPMENT AND OPERATIONS

25 Wells, Installations, Equipment, Facilities, and Support Craft

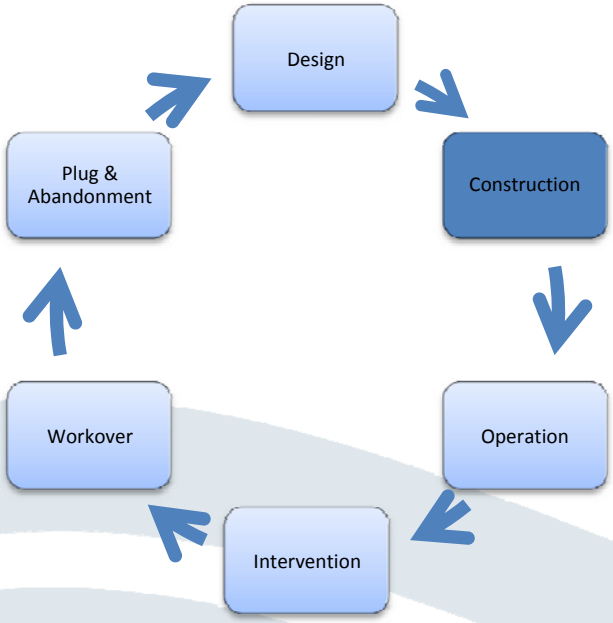
The *operator* shall ensure that

(a) all wells, *installations*, equipment and facilities are designed, constructed, tested, maintained and operated to prevent *incidents* and *waste* under the maximum load conditions that may be reasonably anticipated during any operations;

(b) a comprehensive inspection that includes a non-destructive examination of critical joints and structural members of an *installation* and any critical drilling or production equipment is made at an interval to ensure continued safe operation of the *installation* or equipment and in any case, at least once in every five-year period; and

(c) records of maintenance, tests and inspections are kept.

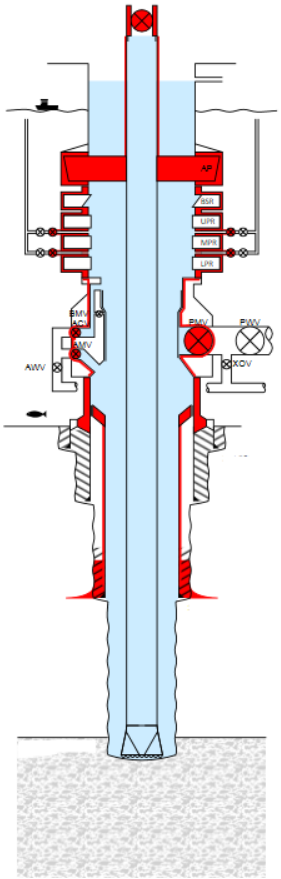
Regulation 25: Drilling and Production Regulations



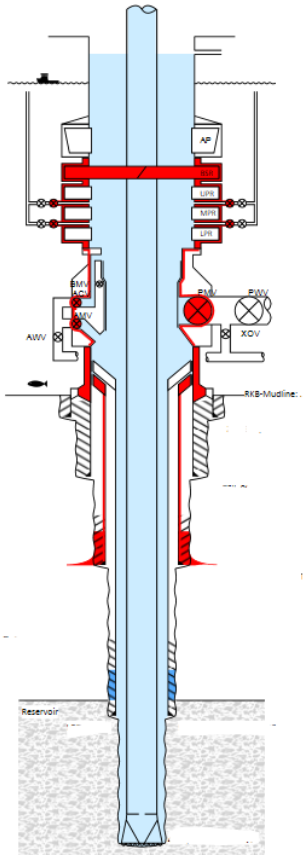
- Drilling and Completion phase
- Maintaining two well barrier envelopes
- Adequate validation of barrier elements
  - Casing cement and formation integrity
  - Tubing and other completion components
- Re-establish barriers if lost during testing

Well Integrity at the Construction Stage

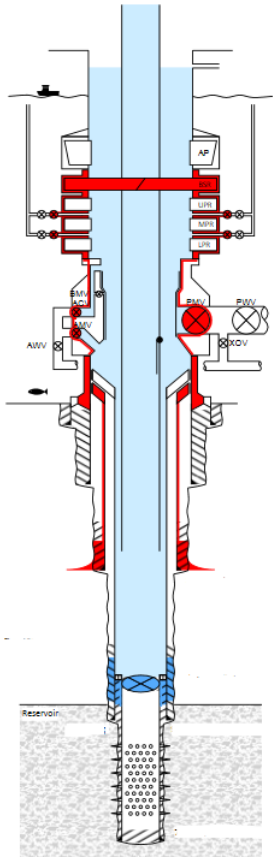
- Well barrier envelopes are very dynamic during the construction phase



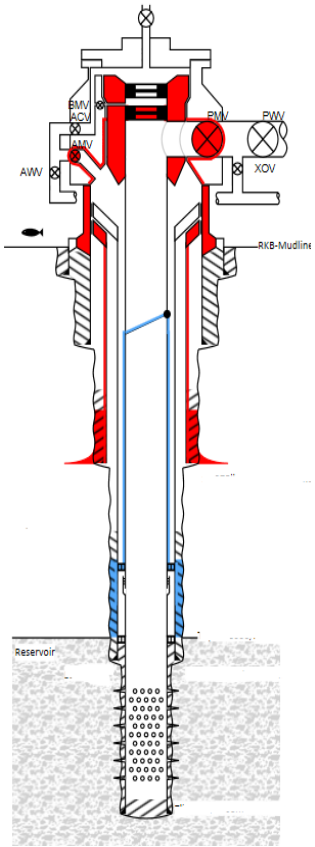
Drilling Production Hole Section



Drilling Reservoir Hole Section



Running Completions

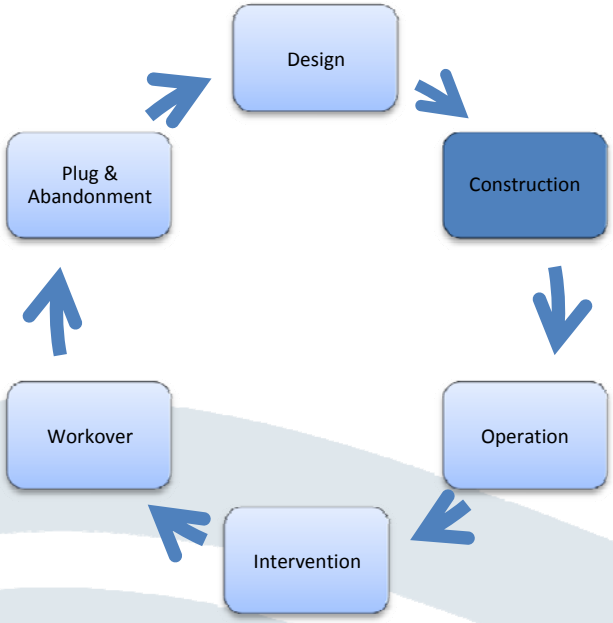


Hand-over to Production

- Having a clear understanding of the changing barrier envelopes is key in maintaining well security and integrity throughout the construction phase.

Challenges – Construction Stage

- Changes during the construction phase not based on issues encountered while drilling (different drivers than well condition)
- Cement bond log capabilities
- Clarity on pass/fail criteria during commissioning/testing of well barriers
- Not testing in the direction of flow (SCSSVs, production tubing, etc…)
- Definition of "ALARP" – What is as low as reasonably practicable?



- Capability to flow?
- Inconsistencies in application of Pressure Control Equipment

Well Integrity at the Operational Stage

PART 4—EQUIPMENT AND OPERATIONS

25 Wells, Installations, Equipment, Facilities, and Support Craft

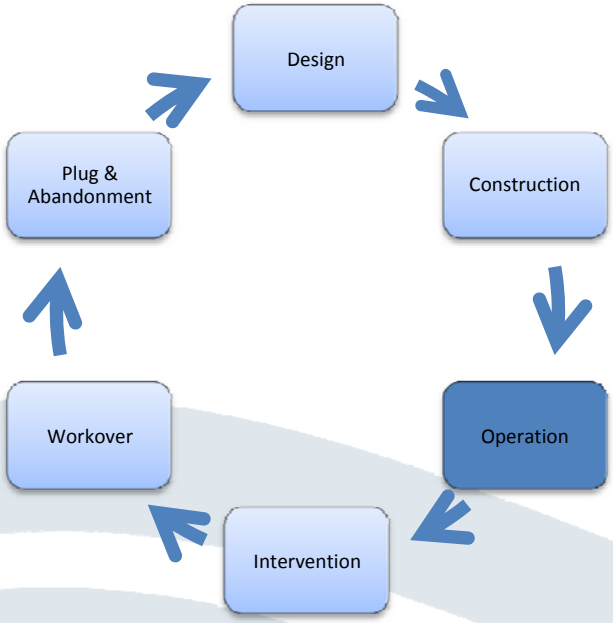
The *operator* shall ensure that

(a) all wells, *installations,* equipment and facilities are designed, constructed, tested, maintained and operated to prevent *incidents* and *waste* under the maximum load conditions that may be reasonably anticipated during any operations;

(b) a comprehensive inspection that includes a non-destructive examination of critical joints and structural members of an *installation* and any critical drilling or production equipment is made at an interval to ensure continued safe operation of the *installation* or equipment and in any case, at least once in every five-year period; and

(c) records of maintenance, tests and inspections are kept.

Regulation 25: Drilling and Production Regulations



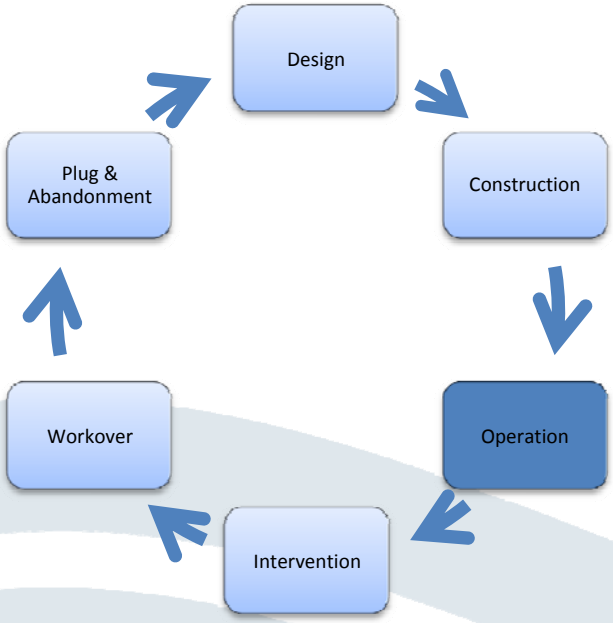
Achieving and Maintaining Well Integrity

- Ongoing Barrier verification
- The ability of testing barriers (depleted reservoirs – injectors)
- Basis of design
- Consistent means for evaluating the severity of an impairment
- Having clear strategies for addressing impairments

Well Integrity at the Operational Stage

Considerations for Maintaining Well Integrity

- Subsea vs. Dry Tree wells
- Recognizing changing operating conditions (eg going from sweet to sour)
- Dealing with impairments
- Clarity on impairment decision processes – Simplifying decisions
- Ongoing monitoring of barrier health status



36 Well Control Equipment

(1) The *operator* shall ensure that, during all *well operations*, reliably operating well control equipment is installed to control kicks, prevent blow-outs and safely carry out all *well* activities and operations, including drilling, completion and work-over operations.

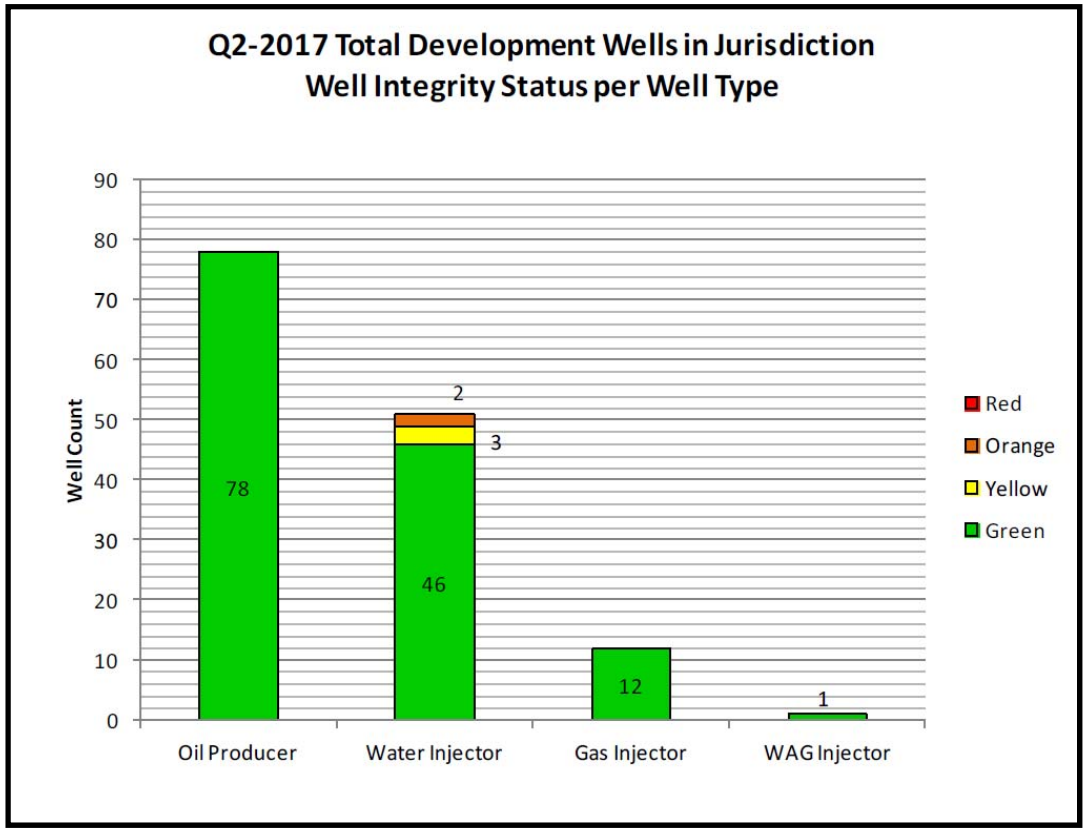
(2) After setting the *surface casing*, the *operator* shall ensure that at least two independent and tested well *barriers* are in place during all *well operations*.

(3) If a *barrier* fails, the *operator* shall ensure that no other activities, other than those intended to restore or replace the barrier, take place in the *well*.

(4) The operator shall ensure that, during drilling, except when drilling underbalanced, one of the two *barriers* to be maintained is the drilling fluid column.

Regulation 36: Drilling and Production Regulations

Well Integrity Monitoring Initiative

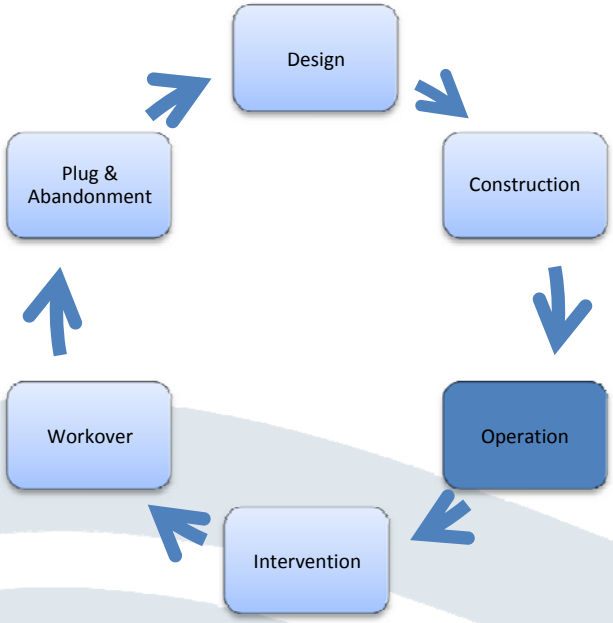


- Quarterly Reporting
- NORSOK D-010 and Norwegian Oil and Gas Association Recommended Guidelines for Well Integrity – No. 117
- Ongoing monitoring
- Barrier Impairments (orange category = shut-in)
- Subsea vs. Dry Tree wells
- Changing operating conditions

	Healthy well - no or minor issue
	One barrier degraded, the other is intact
	One barrier failure and the other is intact, or a single failure may lead to leak to surface.
	One barrier failure and the other is degraded/not verified, or leak to surface.

Challenges – Operations Stage

- Monitoring and ongoing validation of barrier elements
- Consistency in classifying the degree of severity of impairments amongst industry, operators, and Regulator
- The desire to continue operating with an impairment……"Risk Assessed", "ALARP" (Risk assessment is not the sole basis to proceed)
- Determining an adequate timeframe to address impairments



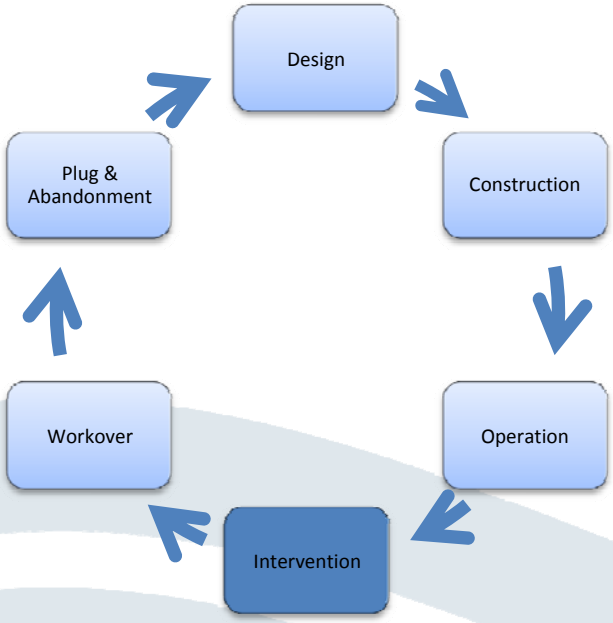
- Intent to return to original design state ("I don't need to do anything…..")
- Changes in well type vs. original design intent
- Definition of "ALARP" – What is as low as reasonably practicable?

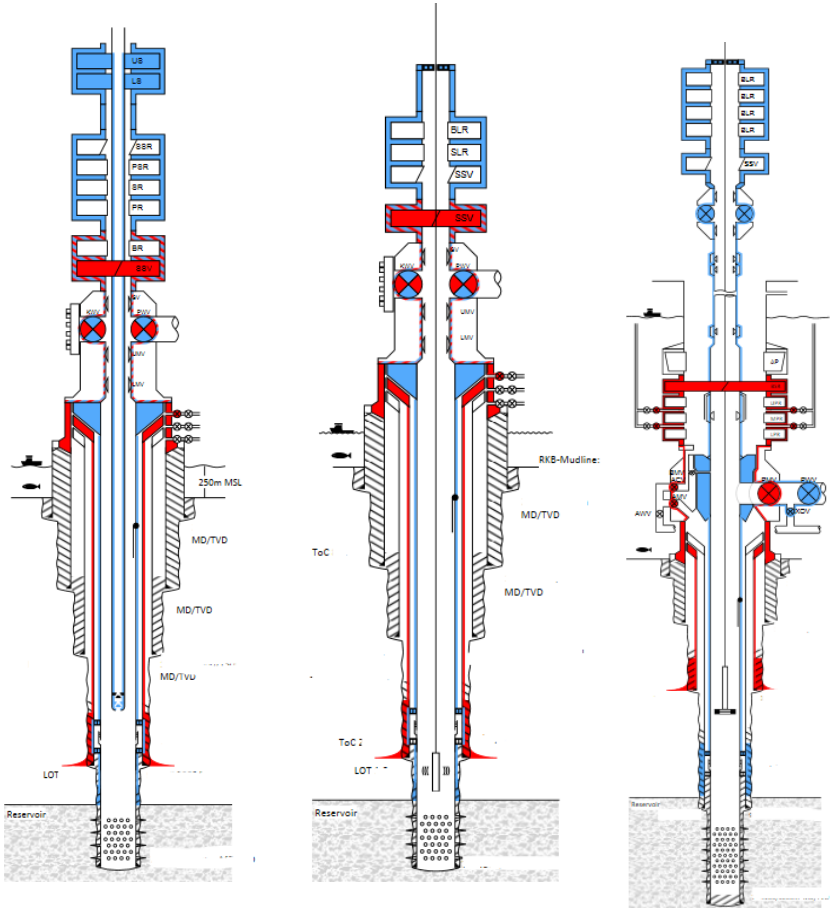
Well Integrity at the Intervention Stage

Intervention - *Operation to enter the well which requires breaking containment of an existing well barrier.*

**ISO 16530-1: 2017 Definition of Intervention*

- Wireline/Slickline/Coiled Tubing
- Re-defined well barrier envelopes
- Common barrier elements



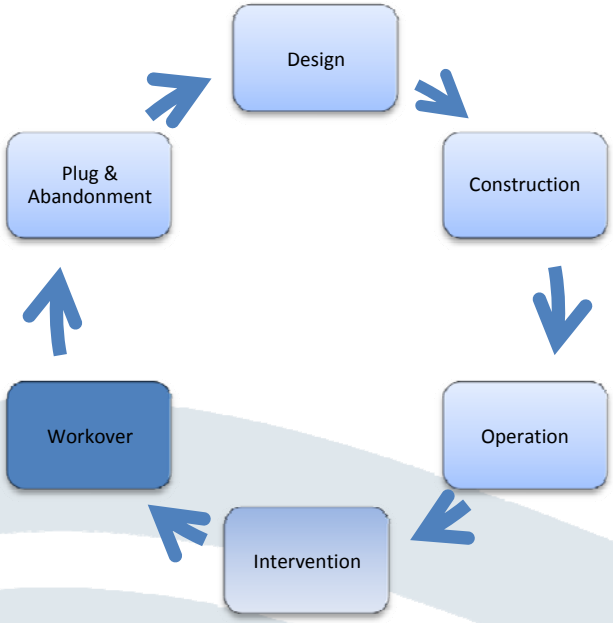


Well Integrity at the Workover Stage

Workover - *an operation on a completed well that requires removal of the Christmas tree or the tubing.*

**Drilling and Production Guideline Definition*

- Significant Intervention
- Significant impact to well barrier elements and envelopes
- Converting existing wells or re-completing
- Involves rig based work, wireline, coiled tubing, etc..

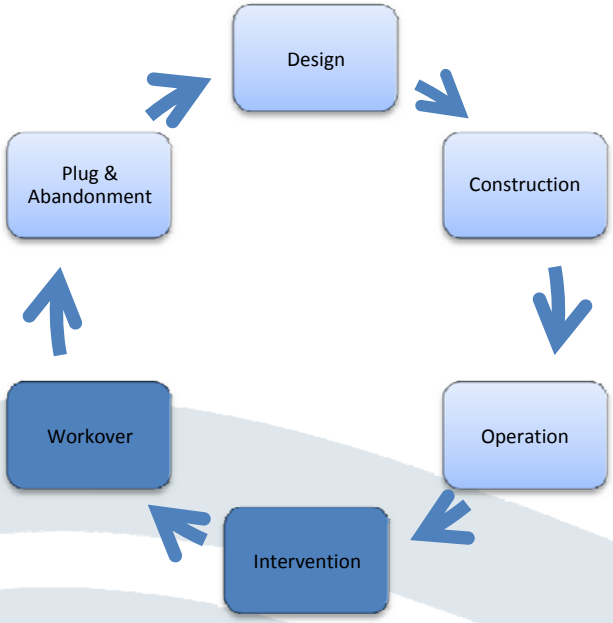


Drilling and Production Guidelines….

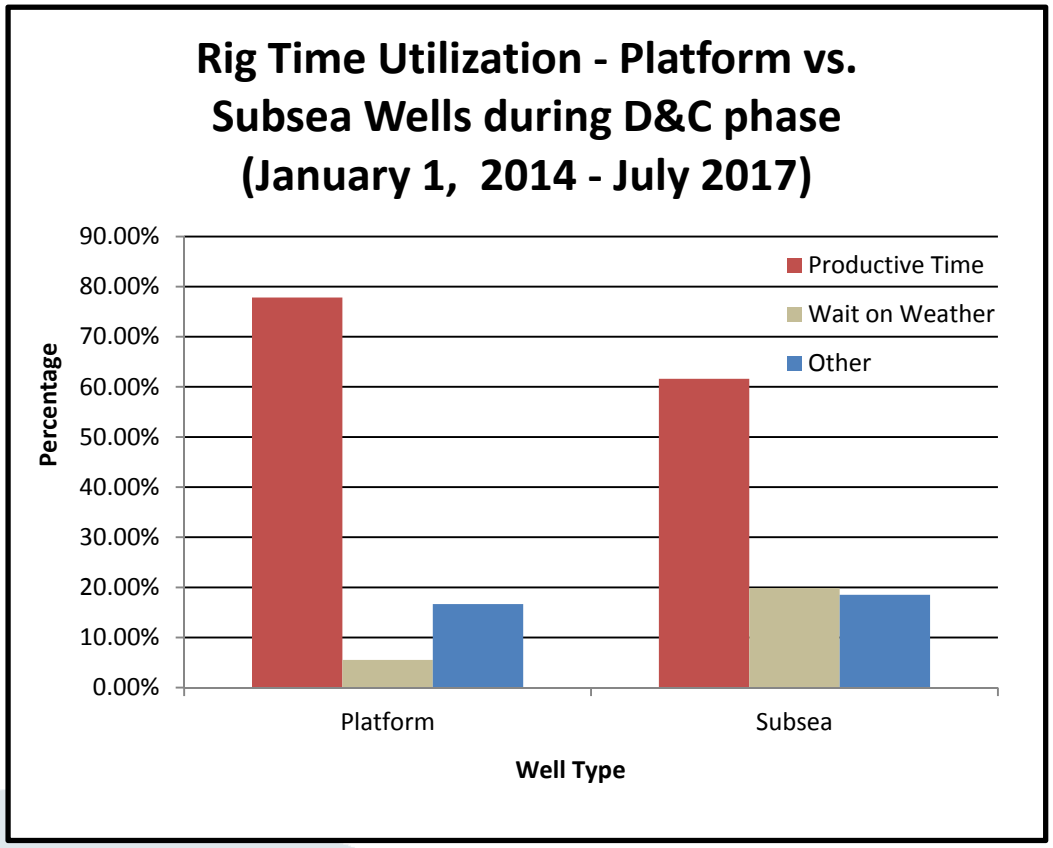
"…With reference to sub-sections 36(2), (3) and (4), operators should ensure that policies, procedures, equipment and methods respecting well operations provide adequate well barriers at all times. This requirement also applies when operating the well for production purposes."

Challenges – Workover & Intervention

- Requirement for PCE when two barriers are already in place
- Well control drills during Intervention/WO operations
- Well intervention strategy documents
- Availability of necessary inventory for timely intervention (landing string)
- Frequency of intervention and workovers



Maintaining Well Integrity - Subsea vs. Platform Wells



Subsea wells

- Require MODU or LIV
- Fatigue life issues
- Higher cost

Platforms Wells

- More efficient
- Easier to intervene
- More upfront cost (infrastructure)
- Higher volume of ACW related work

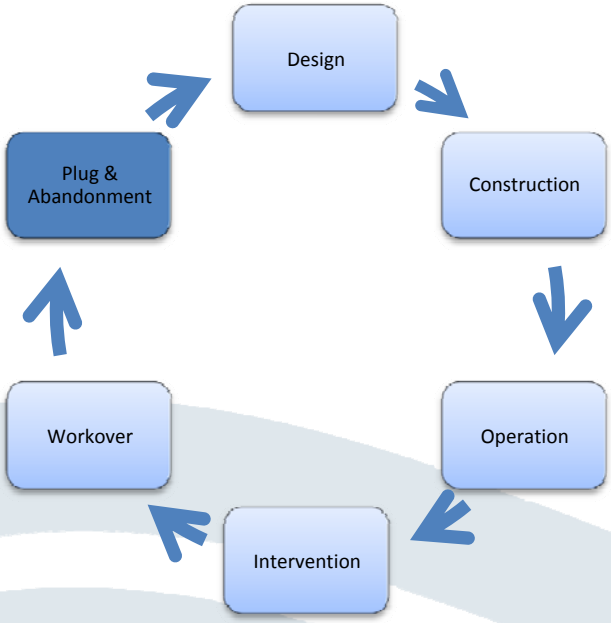
Well Integrity at the P & A Stage

56 Suspension or Abandonment

The *operator* shall ensure that every well that is *suspended* or *abandoned* can be readily located and left in a condition that

(a) provides for isolation of all hydrocarbon bearing *zones* and discrete pressure *zones*; and

(b) prevents any formation fluid from flowing through or escaping from the *well-bore*.

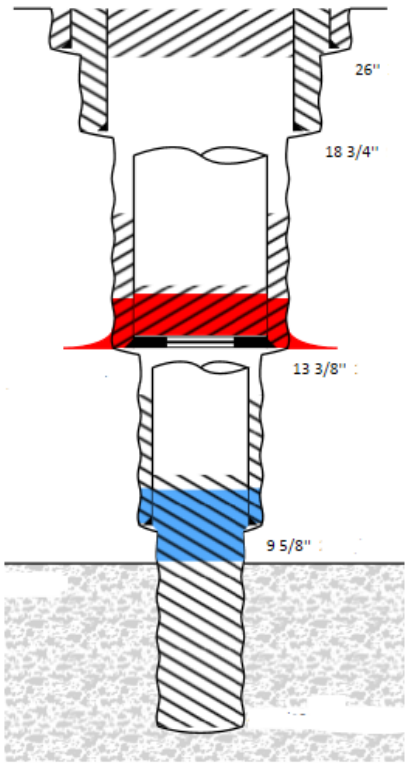


- Abandonment from the "eternal" perspective
- Objective is to Isolate flow to surface and cross flow within a well
- Ultimate goal is to re-instate environmental conditions to original state
- Section 59.3 of Drilling & Production Guidelines outlines one way to meet the Regulations 56-59

Well Integrity at the P & A Stage

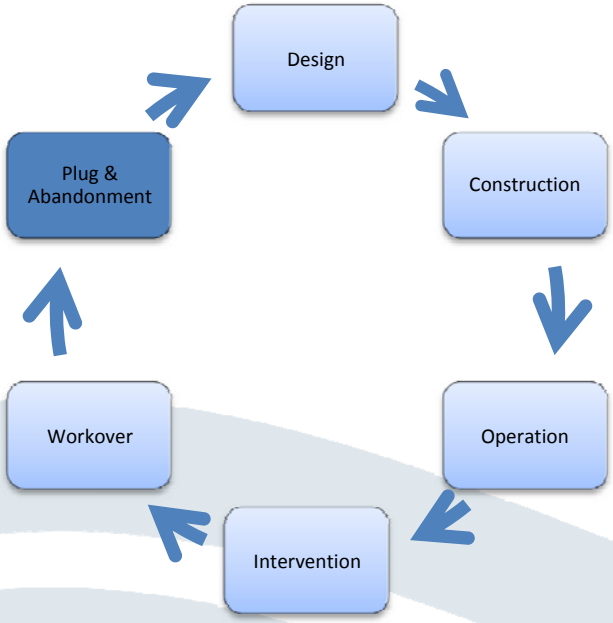
Considerations for Compliance

- Minimum lengths of cement plugs for isolation of open hole and of cased hole
    - 50m, 100m……. ??
- Cementing across casing stubs
- Full cross-sectional abandonments
- Restoring the cap rock
- Verifying casing cement
- Verifying plugs
- Wellhead removal/ Seafloor clean-up



Challenges – P&A Stage

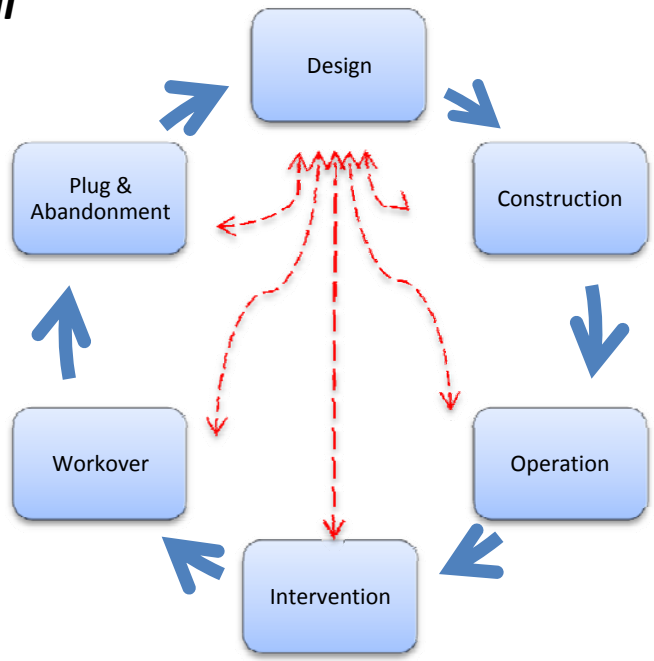
- Verification of annular barriers (CBL, pressure match, original cement job success indicators)
- Cement plug length
- Tagging weight



- Old well designs vs. new abandonment philosophies
- New abandonment technologies such as : through-tubing abandonments or alternative materials (other than cement)
- Isolation of non-hydrocarbon bearing zones
- Cement plug on bottom of well

In Conclusion……

- The main related regulation is ***Goal-based***
- Well Integrity must be considered throughout the ***full well life cycle*** .
- Understanding the changing ***well barrier envelopes*** throughout the life-cycle of a well is paramount .
- Develop pre-determined ***well impairment categorization*** processes to consistently rank severity.
- Implement a ***well intervention strategy*** to build and maintain well integrity throughout a well's life.
- Have **pre-defined pass/fail criteria** for barrier validation and qualification.
- Undertake **comprehensive, thorough design and planning** and then **Execute the plan** → High probability for success
- ***"Comply*** with regulations and ***Conform*** with industry best practice "



CANADA-NEWFOUNDLAND & LABRADOR
C-NLOPB
OFFSHORE PETROLEUM BOARD

THANK YOU

WEBSITE: **CNLOPB.CA**

@CNLOPB

C-NLOPB Channel

INFORMATION@CNLOPB.CA