

NORSOK D-010, Rev 4

Chapter 9 Abandonment activities

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The Journey

Milestones:

- ✓ Comments round 1 (24.08.11)
- ✓ Kick-off meeting (26.10.11)
- ✓ Comments round 2 (15.11.11)
- ✓ Mini-hearing EGD/DMF (15.8.12)
- ✓ EGD meeting (12.12.12)
- ✓ Industry Hearing (20.12.2012)
- ✓ Receive comments (15.2.13)
- ✓ Submit section draft for QA (12.4.13)
- ✓ All sections completed (14.5.13)
- ✓ Compiled draft submitted (27.5.13)
- ✓ Approved by EGD (27.5.13)
- ✓ Approved by Standard Norge (30.5.13)
- Issue (June 13)



Comments and time

Comments	15.11.2011	15.8.12 (DMF, WIF, PAF only)	20.12.12 (Industry hearing)	Total No. Of comments
1. Scope	1	4	0	5
2. Normative & Informative Ref.	1	8	0	9
3. Definitions and Abbreviations	38	7	147	192
4. General Principles	112	50	325	487
5. Drilling Activities	43	28	373	444
6. Testing Activities	16	3	99	118
7. Completion Activities	11	45	237	293
8. Production Activities	12	25	143	180
9. ST, Susp. & Aban. Activities	40	26	256	322
10. Wireline Operations	11	2	84	97
11. Coiled Tubing Operations	4	0	30	34
12. Snubbing Operations	5	0	26	31
13. Under Balanced D&C Ops.	3	2	60	65
14. Pumping Operations	3	0	37	40
Annex A	4	0	0	4
1. Correct english language				
	304	200	1817	2321

Estimate of work hrs per. 30.05.2013

Activity	Units	hrs/unit	Sub-total (hrs)
Project Leader			925
Editor / EGD / PSA meetings			903
Section review	16	50	800
Special topic meetings	32	16	512
Initial comments	305	1	305
PIF comments	3	50	150
PAF comments	3	50	150
Mini-hearing (DMF)	200	1	200
Hearing (20.12.12)	1817	1	1817
TOTAL EST.			5762

Overview of Changes

Added/Changed:

- Re-defined Suspension to only include wells under construction/intervention, Temporary Abandonment with monitoring (indefinite) and without monitoring (max 3 years)
- Examples on placement of plugs/casing cement (permanent P&A)
- Simplified the chapter with the use of examples to support text. The text in the document describes how to perform temporary or permanent P&A, not the examples
- Relevant EAC tables have been edited where necessary
- Decision support for section milling and placement of cement behind casing
- Cement plug verification, tagging or drilling
- Critical casing cement
- XMT removal requirements added

Deleted/moved :

- Well control actions procedures moved to chapter 4

Suspension and Permanent Abandonment

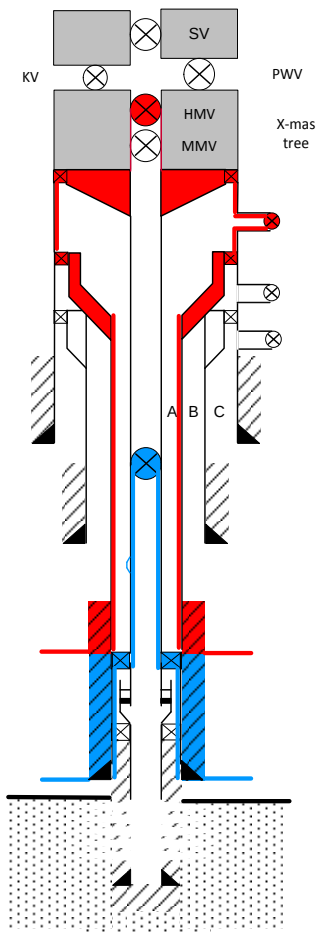
- **Rev 3**
 - **Suspension** is a well status, where the well operation is suspended without removing the well control equipment.
 - *Example - Rig skidded to do short term work on another well, strike, rough weather conditions, waiting on equipment, etc.*
 - **Permanent abandonment** is a well status, where the well or part of the well, will be abandoned with the intention of never being used or re-entered again.
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- **Rev 4**
 - **Suspension** well status, where the well operation is suspended without removing the well control equipment. Applies to wells under construction/intervention.
 - *Example - Rig skidded to do short term work on another well, strike, WOW, waiting on equipment, etc.*
 - **Permanent abandonment** well status, where the well is abandoned permanently and will not be used or re-entered again

Temporary Abandonment

- **Rev 3**
 - **Temporary abandonment** is a well status, where the well is abandoned and/or the well control equipment is removed, with the intention that the operation will be resumed within a specified time frame (from days up to several years).
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- **Rev 4**
 - **Temporary abandonment is defined as:**
 - a) temporary abandonment – with monitoring**
 - Well status where the well is abandoned and the primary and secondary well barriers are continuously monitored and routinely tested. If the criteria cannot be fulfilled, the well shall be categorized as a temporary abandoned well without monitoring.
 - There is no maximum abandonment period for wells with monitoring.
 - b) temporary abandonment – without monitoring**
 - Well status, where the well is abandoned and the primary and secondary well barriers are not continuously monitored and not routinely tested.
 - The maximum abandonment period shall be three years.

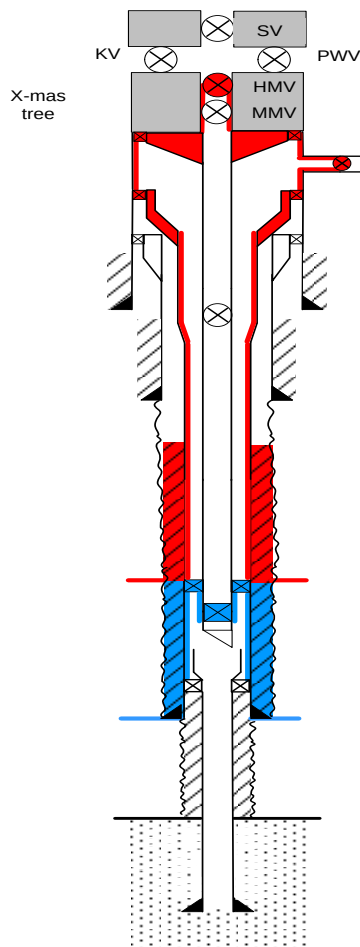
Temporary Abandonment

Production/Active

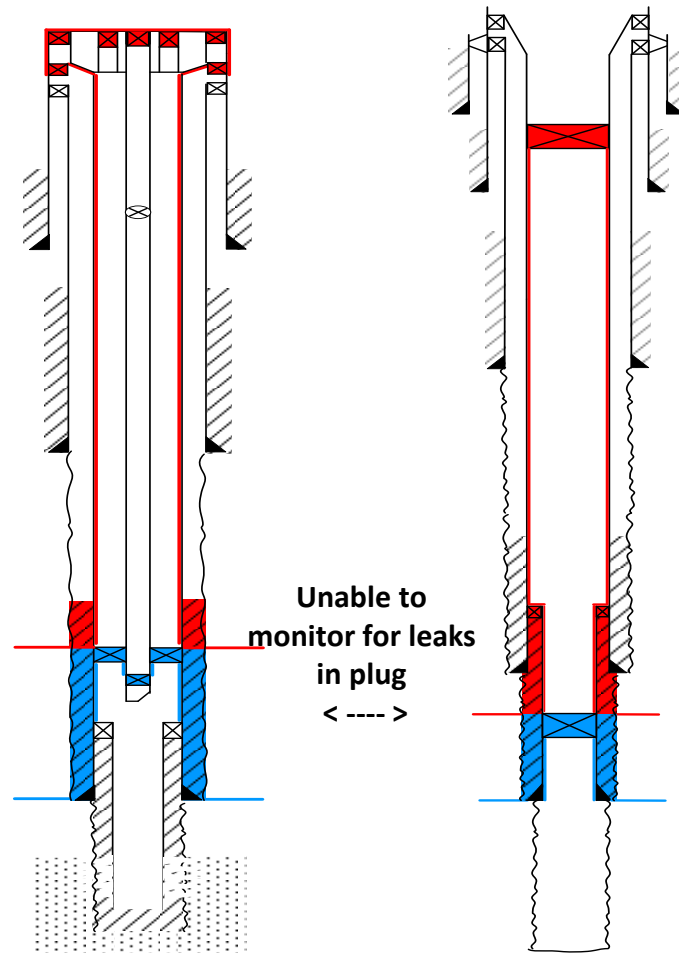


Monitored and routinely tested WBE's in the primary and secondary WB

Temporary abandoned with monitoring



Temporary abandoned without monitoring



Observe for leaks in secondary WB

Well Barriers

Minimum number of well barriers	Source of inflow
One well barrier	a) Undesirable cross flow between formation zones b) Normally pressured formation with no hydrocarbon and no potential to flow to surface c) Abnormally pressured hydrocarbon formation with no potential to flow to surface (e.g. tar formation without hydrocarbon vapour)
Two well barriers	a) Hydrocarbon bearing formations b) Abnormally pressured formation with potential to flow to surface

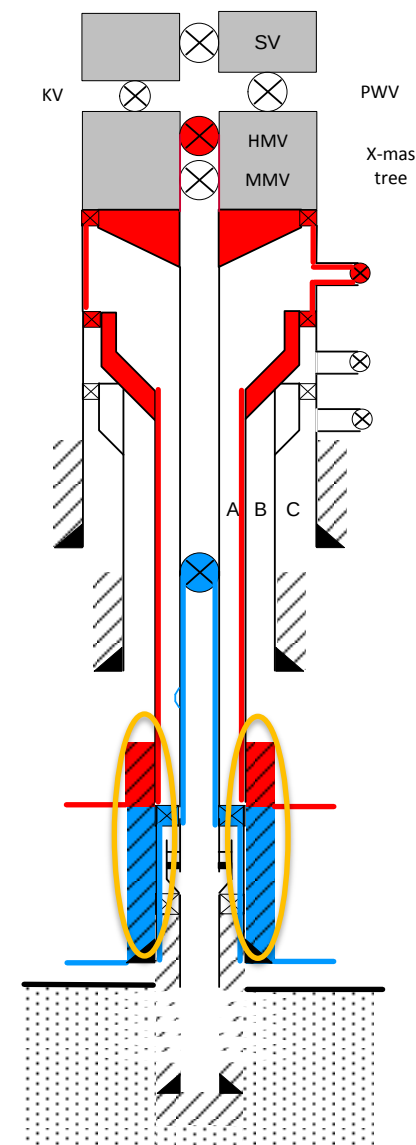
Well Barriers

Name	Function	Depth position
Primary well barrier	To isolate a potential source of inflow, formation with normal pressure or over-pressured/ impermeable formation from surface/seabed.	The base of the well barriers shall be positioned at a depth where formation integrity is higher than potential pressure below
Secondary well barrier	Back-up to the primary well barrier, against a potential source of inflow.	As above.
Crossflow well barrier	To prevent flow between formations (where crossflow is not acceptable). May also function as primary well barrier for the reservoir below.	As above.
Open hole to surface well barrier	To permanently isolate exposed formation to surface after casing(s) are cut and retrieved and contain environmental harmful fluids. The exposed formation can be over-pressured with no potential source of inflow. No hydrocarbons present.	No depth requirement with respect to formation integrity.

The overburden formation including shallow permeable zones shall be assessed with regards to abandonment requirements.

Critical casing cement

- **Critical casing cement shall be logged and is defined by the following scenarios:**
- The production casing/liner when set into/through the reservoir
- The production casing/liner when the same casing cement job is a part of the primary and secondary well barriers.
- Wells with injection pressure which exceeds the cap rock integrity

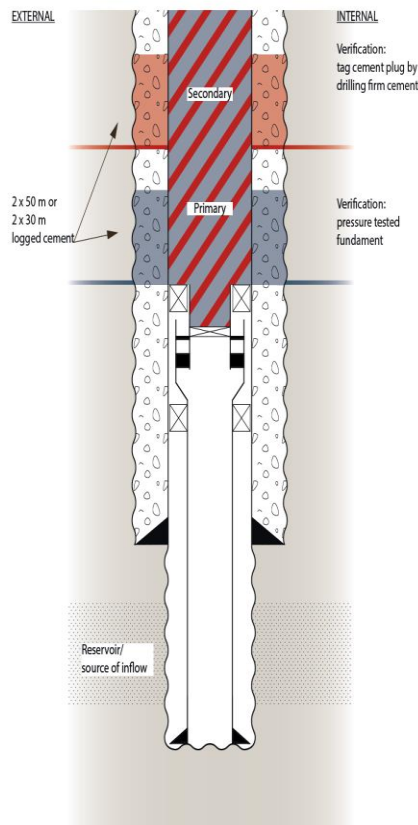


Casing cement

Verification method

The cement length shall be verified by one of the following:

1. Bonding logs: Fit for purpose, azimuthal /segmented data, verified by qualified personnel
2. 100 % displacement efficiency. Actual displacement pressure/volumes vs. simulations Losses, -> loss zone to be above planned TOC (ref. similar loss case(s) -> sufficient length verified by logging.)
3. Losses: PIT/FIT or LOT is OK only for drilling the next hole section.



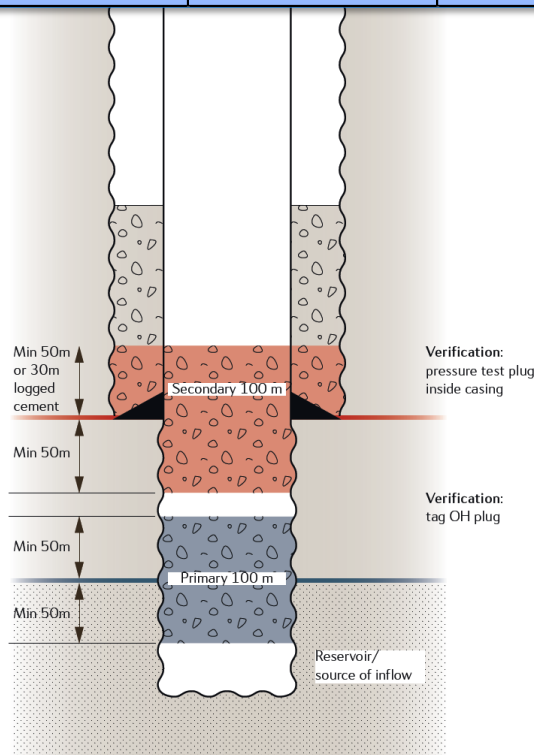
Acceptance criteria

Actual cement length shall be:

- above potential source of inflow/ reservoir
- 50 m MD verified by displacement calculations or 30 m MD when verified by bonding logs. Formation integrity shall exceed the maximum expected pressure at base of interval.
- 2 x 30m MD verified by bonding logs when the same casing cement will be a part of the primary and secondary well barrier.
- Formation integrity shall exceed the maximum expected pressure at the base of each interval.
- Injection pressure exceeding formation integrity at cap rock: Cemented from injection point to 30 m MD above top reservoir verified by bonding logs.

Cement plug

Open hole	Cased hole	In surface casing
100 m MD, min. 50 m MD above source of inflow/leakage point. In transition from open hole to casing should be min. 50 m MD above and below casing shoe.	50 m MD if set on a mechanical/cement plug as foundation, otherwise 100 m MD	50 m MD if set on a mechanical plug, otherwise 100 m MD.



Verification method

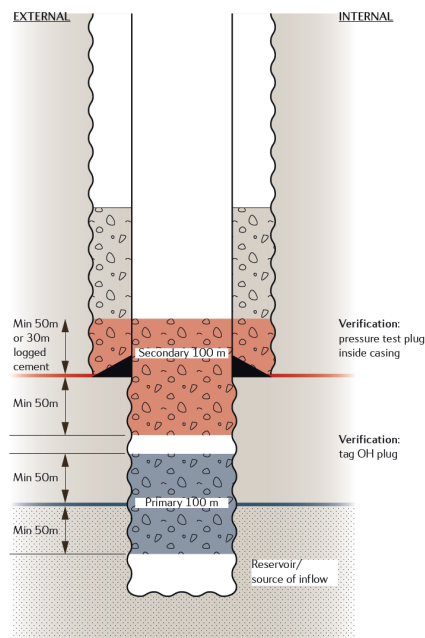
- Cased hole plugs tested either in the direction of flow or from above.
- Shoe track: bleed back volume = calculated volume; pressure tested + supported by overbalanced fluid or inflow tested.
- Check surface samples + cure at downhole temp. & pressure.
- Installation verified through evaluation of job execution
- Plug in open hole: Tag (no pressure test)
- Plug in cased hole: Tag + pressure test to 70 bar above LOT below casing/ potential leak path, or 35 bar for surface casing plugs. Exemption: If set on a pressure tested foundation, no pressure test is not required -> verify by tagging.
- If one continuous cement plug (same cement operation) is a common WBE, it shall be verified by drilling out until hard cement is confirmed.

Abandonment examples

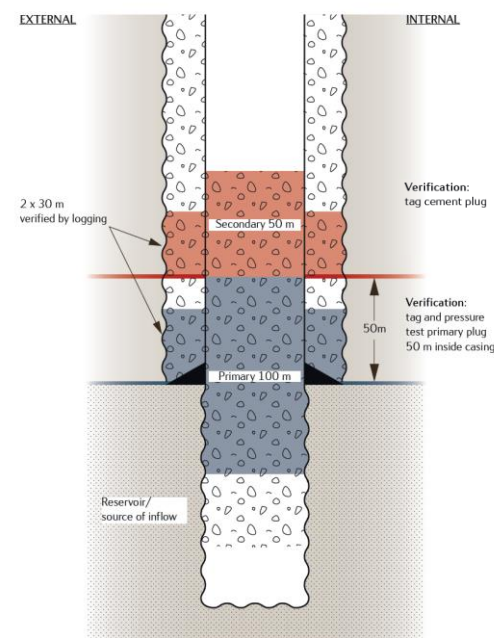
- Example, Abandonment of open hole with cement plugs.** The last open hole section of a wellbore is abandoned permanently by setting an open hole cement plug across/above the reservoir and with an additional cement plug from the open hole into the casing.

- Example, Back to back cement plugs and logged casing cement.** The last open hole section of a wellbore or a perforated casing/liner is abandoned permanently by setting two back to back cement plugs from the reservoir (or as close as possible to the reservoir), providing that the casing cement is verified in the annulus.

P&A -
open hole and inside casing plugs

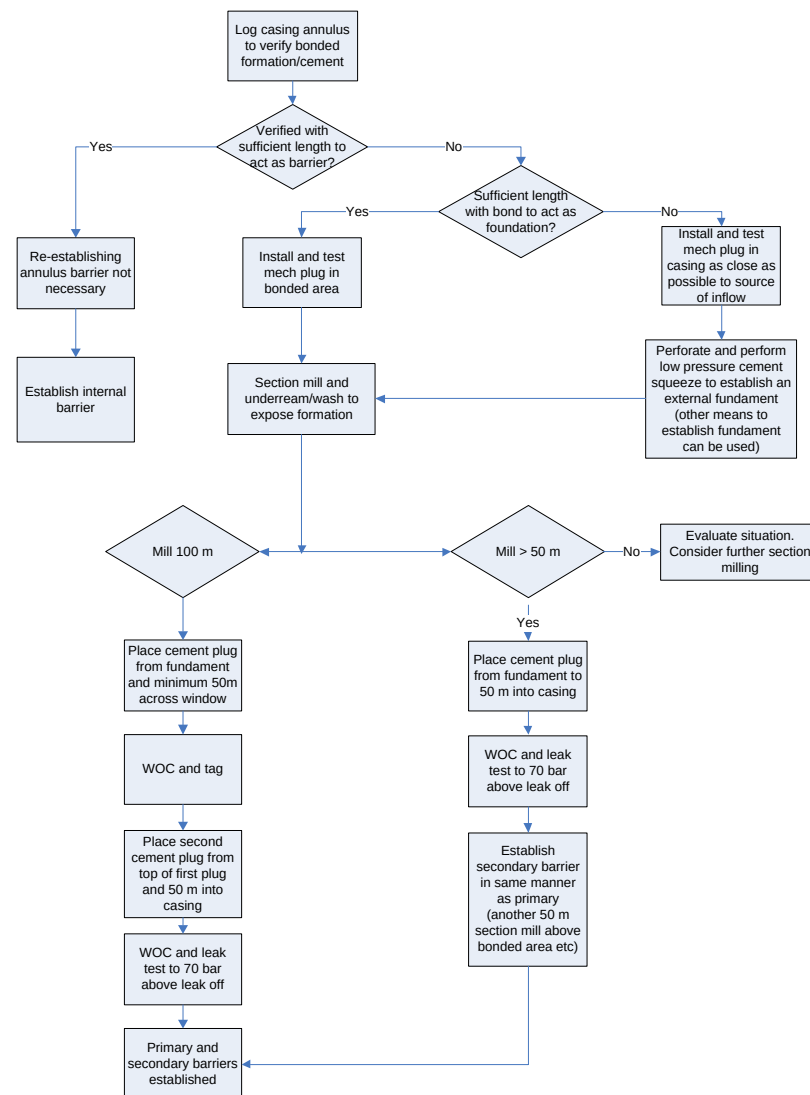
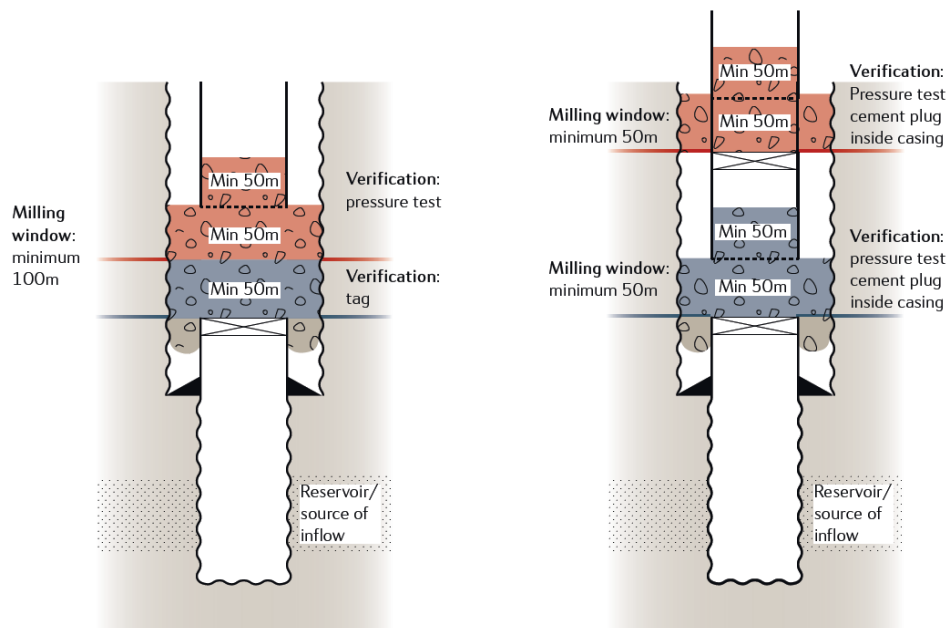


P&A -
two back to back cement plugs



Section milling example

- Section Milling Examples
- For wells with poor casing cement or no access to the last open hole section, section milling (removal of casing) is a method for placing cement in contact with formation to form permanent well barriers.



XMT removal barriers

Fluid	Possible to monitor primary well barrier?	Primary well barrier element	Secondary well barrier element	Compensating measures
Light fluid (under-balanced)	Yes (downhole pressure gauge or tubing to annulus communication)	Deep set mechanical bridge plug	Inflow tested DHSV and drop protection device – accepted if DHSV has zero leakage, or a BPV/tubing hanger plug, or a shallow set mechanical bridge plug	Status of primary well barrier to be monitored at all times on DHPG or A-annulus pressure
	No	Deep set mechanical bridge plug	a BPV/tubing hanger plug, or a shallow set mechanical bridge plug	Inflow tested DHSV as compensating measure due to not able to monitor primary barrier
Heavy fluid (over-balanced)	Yes (tubing to annulus communication)	Deep set mechanical bridge plug and brine/mud above plug, or Kill pill and brine or kill mud from perforations/screen to surface	Inflow tested DHSV and drop protection device – accepted if DHSV has zero leakage, or a BPV/tubing hanger plug, or a shallow set mechanical bridge plug	Fluid level or applied pressure to be monitored on A-annulus
	No	Deep set mechanical bridge plug and brine/mud above plug	Inflow tested DHSV and drop protection device – accepted if DHSV has zero leakage, or a BPV/tubing hanger plug, or a shallow set mechanical bridge plug	
	No	Kill pill and brine or kill mud from perforations/screen to surface	a BPV/tubing hanger plug, or a shallow set mechanical bridge plug	Inflow tested DHSV as compensating measure due to not able to monitor primary well barrier