



Statoil

Plug & Abandonment

An introduction





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- Permanent vs. temporary

GENERAL

– definitions

Permanent abandonment

well status, where the well or part of the well, will be plugged and abandoned permanently, and with the intention of never being used or re-entered again

Temporary abandonment

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)

Potential source of inflow

formation with permeability, but not necessarily a reservoir

Reservoir

permeable formation or group of formation zones originally within the same pressure regime, with a flow potential and/or hydrocarbons present or likely to be present in the future

GENERAL

– barrier requirements P&A

Drilling and well activities	Formation
Two barriers	Permeable or impermeable formation with overpressure or reservoir exposed (HC present)
One barrier	Permeable or impermeable formation with normal pressure (or less)

Temp. P&A	Formation
Two barriers	Permeable or impermeable formation with overpressure or reservoir exposed (HC present)
One barrier	Permeable or impermeable formation with normal pressure (or less)

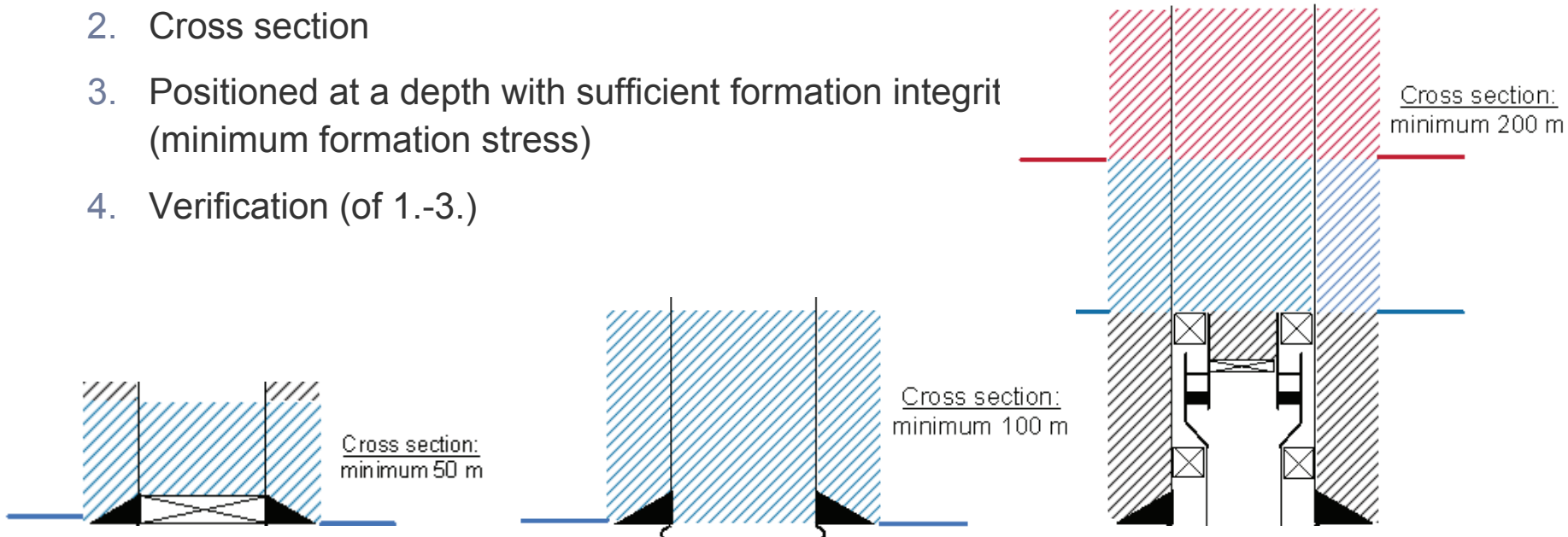
Permanent P&A	Formation
Two barriers	Permeable formation with overpressure or reservoir exposed (HC present)
One barrier	Impermeable formation with overpressure
One barrier	Permeable formation with normal pressure (or less)
Applicable for wells where no continued operations are planned	

PERMANENT P&A

– barrier requirements

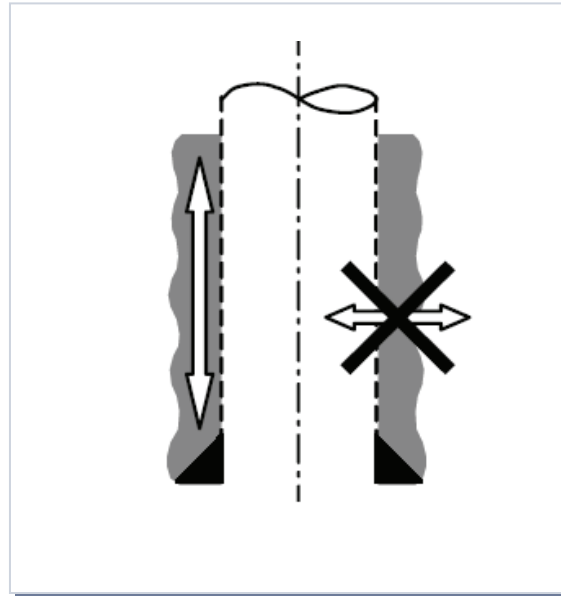
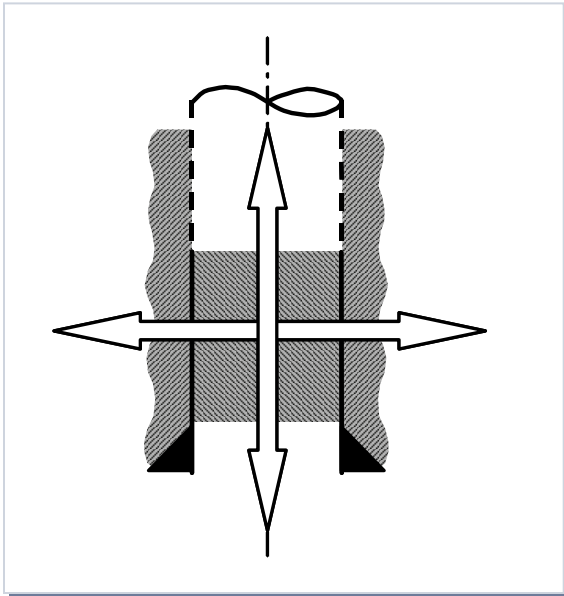
Criteria to be fulfilled for a permanent barrier element:

1. Length
 - 50 m, 100 m or 200 m
2. Cross section
3. Positioned at a depth with sufficient formation integrity (minimum formation stress)
4. Verification (of 1.-3.)



PERMANENT P&A

– barrier requirements



PERMANENT P&A

– well barriers

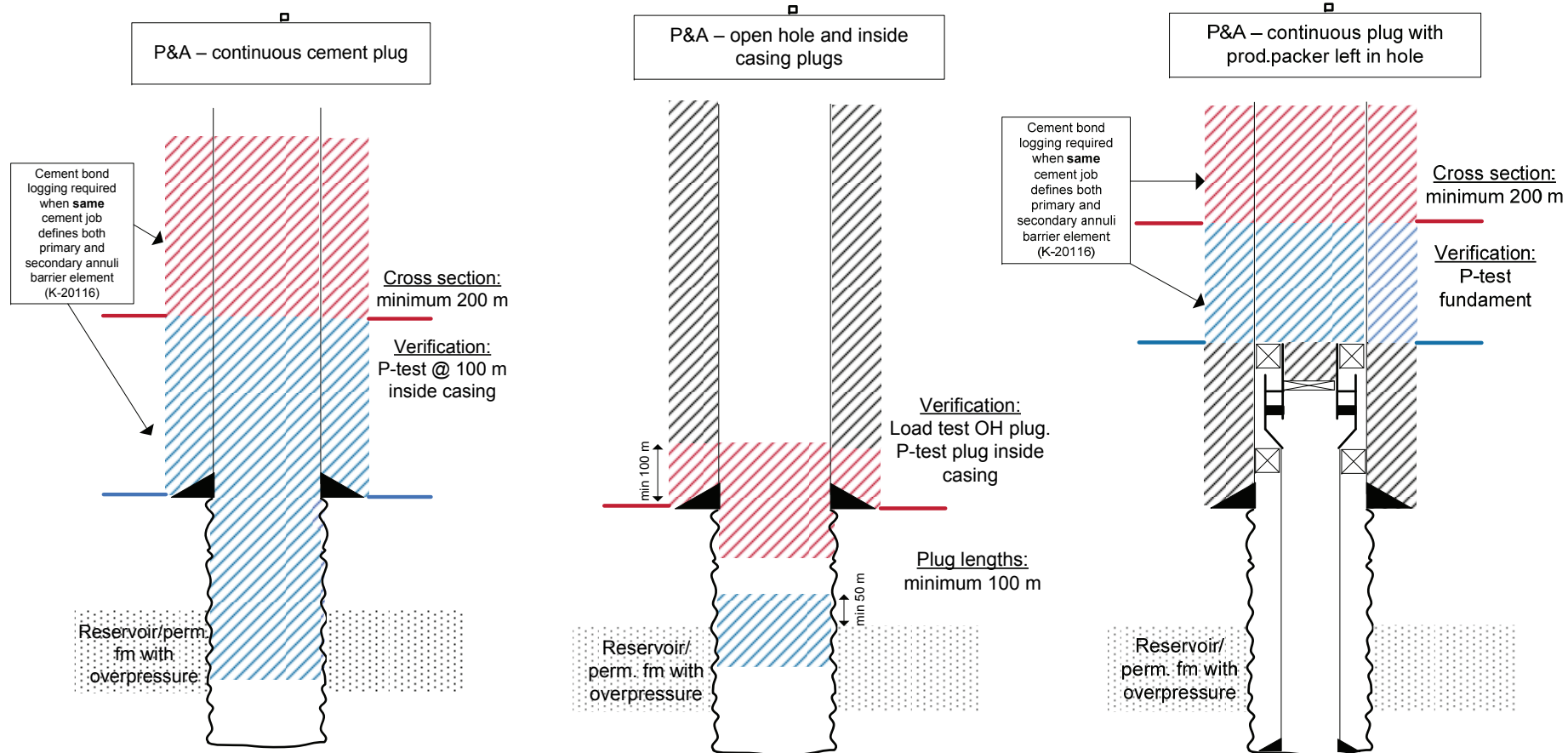
Name	Function	Requirement to depth position
Primary well barrier	First well barrier against a potential source of inflow.	Minimum formation stress at the base of the barrier shall be in excess of the potential pressure below.
Secondary well barrier, reservoir	Back-up to the primary well barrier, and applies where the potential source of inflow is also a reservoir.	As above.
Well barrier between reservoirs	To permanent isolate reservoirs from each other. Can also function as primary barrier for the reservoir below.	As above.
Open hole to surface well barrier	To permanent isolate an open hole from surface exposed after casing cut. (This formation can be i) impermeable* or ii) permeable with no HC and less/equal to normal pressure).	As deep as possible in the surface casing and with the top minimum 50 m above the shallowest permeable zone.

(*): For impermeable formation with overpressure, it shall be documented that no permeable zone is exposed (e.g. thin sand lenses in the shale etc.).

Minimum formation stress: is the fracture closing pressure

PERMANENT P&A

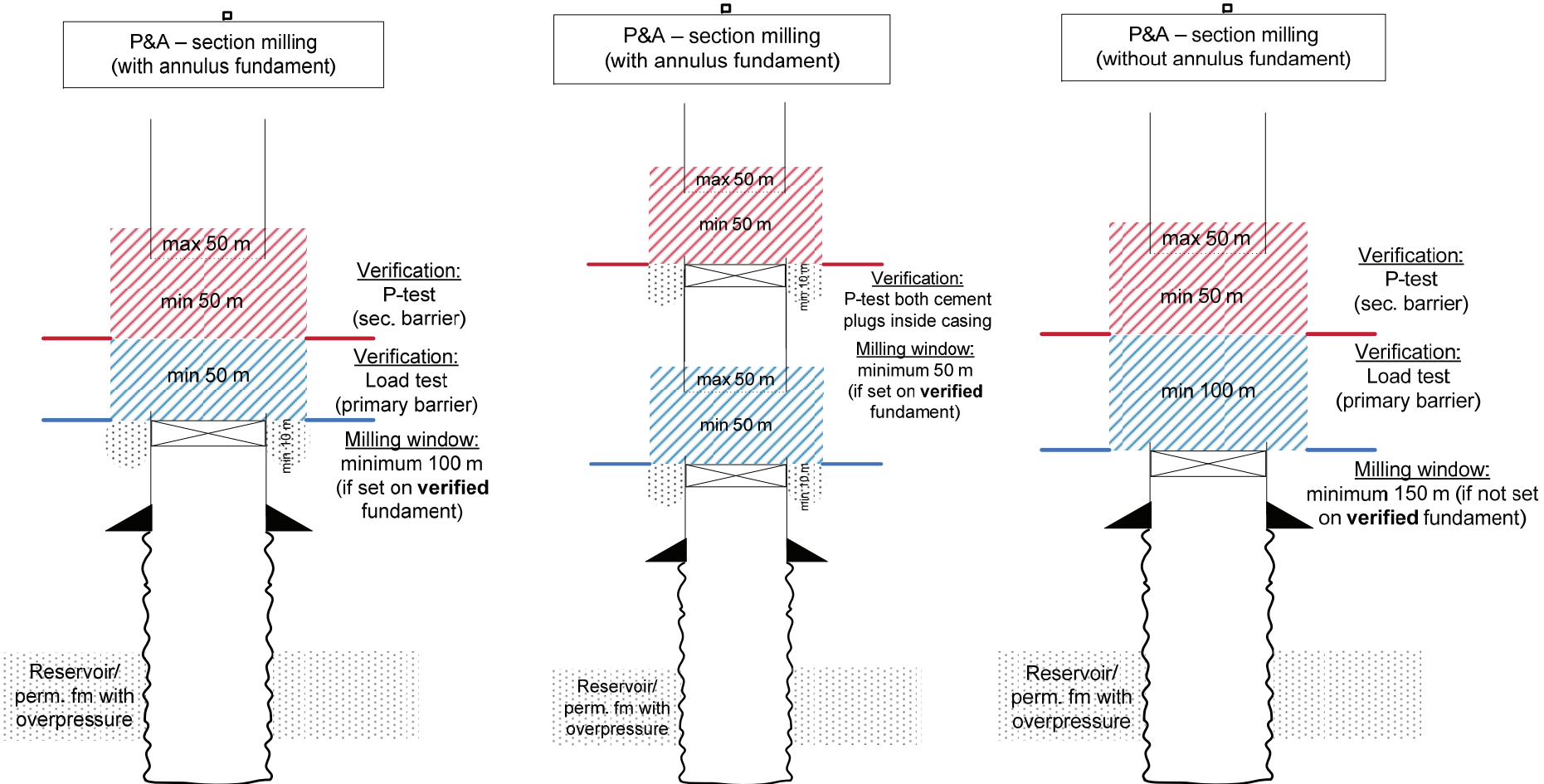
– examples



**RECOMMENDED/
PREFERRED METHOD!**

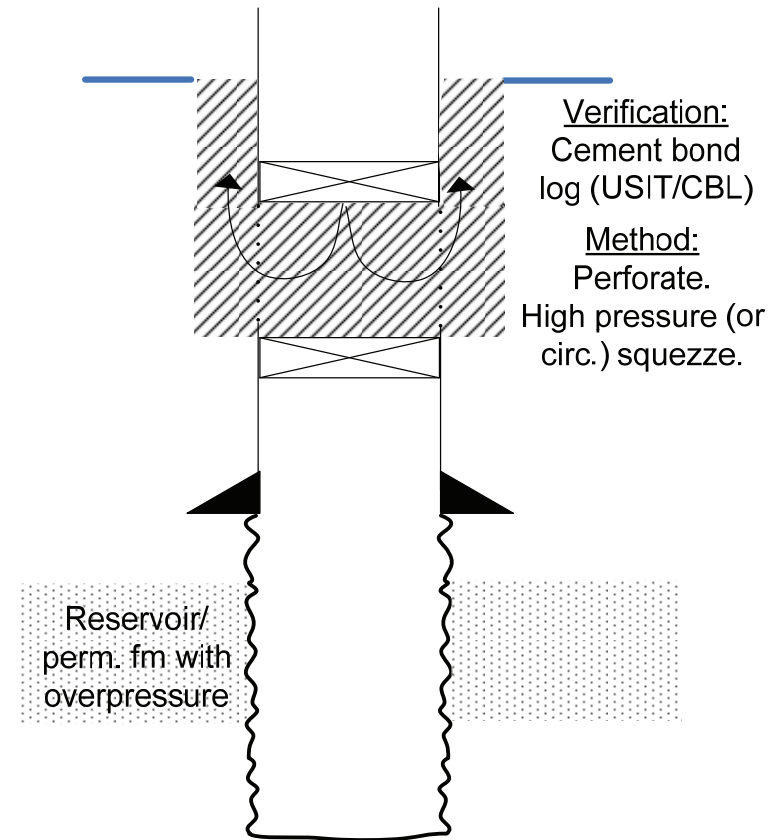
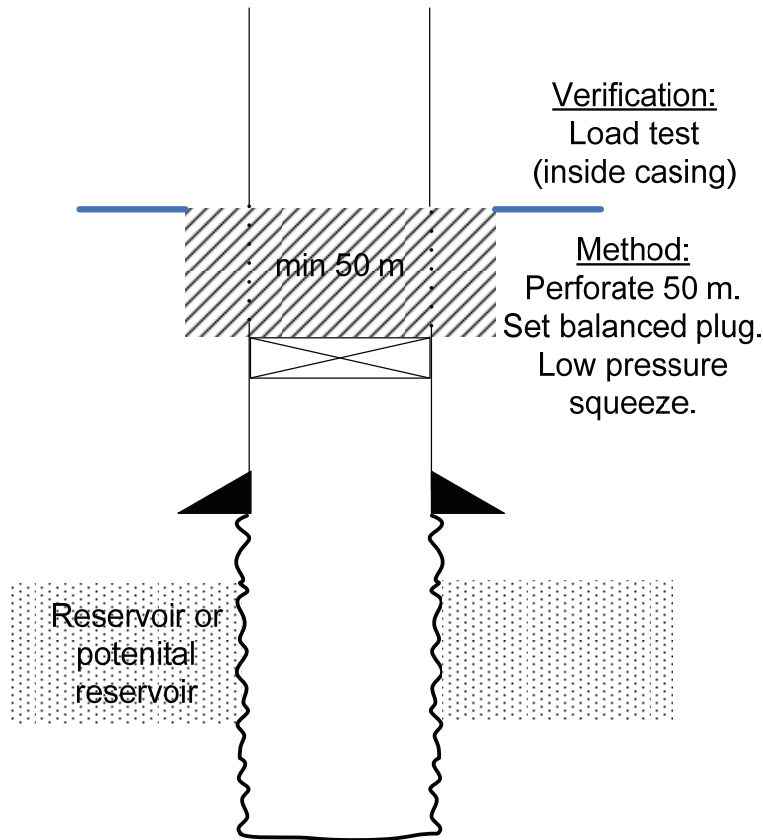
PERMANENT P&A

– section milling examples



PERMANENT P&A

– methods to establish annulus fundament



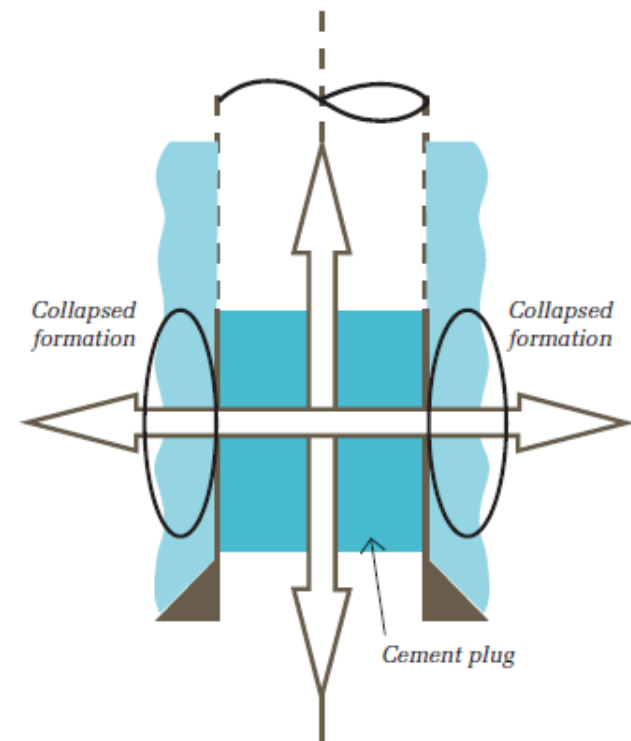
PERMANENT P&A

– bonded shale as barrier element

The most important requirements:

- If bonded shale formation is to be used as a barrier element, its location shall be identified and sealing ability verified by logging and leak testing respectively.
- Bonded shale formation can not be predicted. Therefore during any planning phase (construction, production, P&A, etc), it shall be planned for using cement as barrier element outside casings. However, once collapsed formation is proven in place and qualified it can be used, and is preferred used in permanent

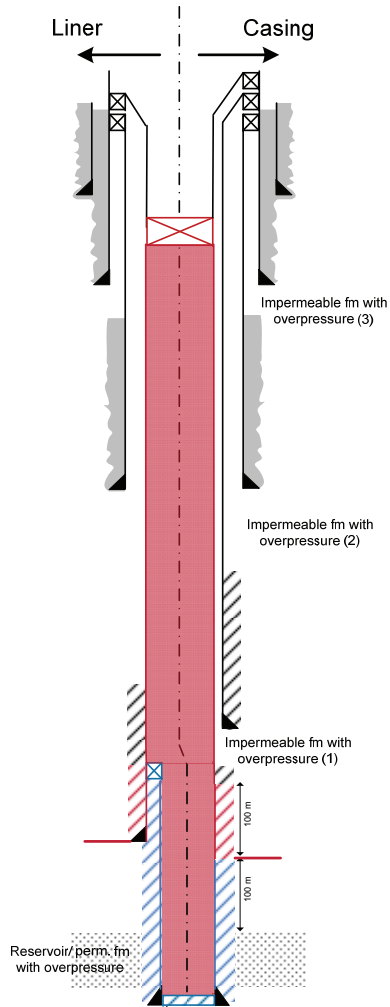
Qualified shale formation (collapsed) as annuli barrier element





PERMANENT P&A

– non perforated well

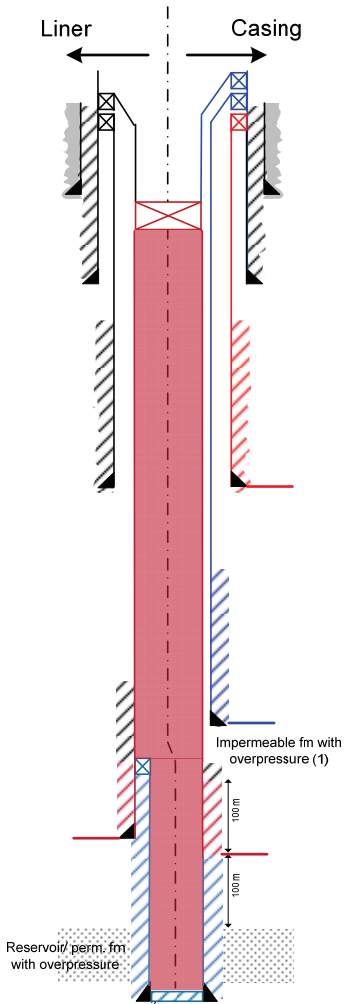


Well barrier elements	Ref. WBEAC tables	Verification of barrier elements
PRIMARY – reservoir		
1. Cement plug	24	Shoetrack
2. Casing float valves	41	
3. Casing/liner cement	22	Minimum 100 m > top res.
4. Casing/liner	2	
5. Liner top packer	43	Grade V1
SECONDARY – reservoir		
1. Casing cement	22	Minimum 100 m > primary casing cement barrier element
2. Casing	2	
3. Formation	na	
4. Fluid column	1	The well shall be secured with both a fluid barrier (time limited) plus an additional shallow set plug. For new wells where the last casing is inflow tested, the fluid barrier is not required (shallow plug is sufficient).
5. Mechanical plug	28	Shallow plug

Barriers towards reservoir

PERMANENT P&A

– non perforated well



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5. Mechanical plug	28	Shallow plug
PRIMARY – impermeable formations with overpressure (1)		
1. Casing cement	22	Minimum 100 m
2. Casing (production)	2	
3. Seal assembly (csg hanger)	5	Only one barrier possible when BOP is removed
4. Formation at shoe	na	
SECONDARY – imperm. formations with overpressure (1)		
1. Casing cement	22	Minimum 100 m
2. Casing (intermediate)	2	
3. Seal assembly (csg hanger)	5	
4. Formation at shoe	na	
5. Mechanical plug*	28	Shared with secondary barrier element for reservoir

Barriers also towards **impermeable formation with overpressure**



PERMANENT P&A

– barrier requirements

Temp. P&A	Special situations	Comments
Two barriers	Last casing string not perforated/drilled out or sealed off by a cement/mech. plug at bottom. Reservoir exposed behind casing.	The well shall be secured with both a fluid barrier (time limited) plus an additional shallow set plug. For new wells where the last casing is inflow tested, the fluid barrier is not required (shallow plug is sufficient).
Two barriers	Last casing string not perforated/drilled out or sealed off by a cement/mech. plug at bottom. No reservoir – only impermeable formation with overpressure exposed behind casing.	In case it can be documented that only impermeable formations are exposed (less than one percent probability), a dispensation might be given for Having only one barrier for a shorter period of time.
Two barriers	Hang-off/disconnect of marine riser. Reservoir exposed.	The well shall not be secured with fluid as primary barrier for a longer period of time.
Two barriers	Hang-off/disconnect of marine riser. No reservoir – only impermeable formation with overpressure exposed.	
Two barriers	Reservoir is plugged according to requirement for permanent P&A with two barriers. However, the overburden/impermeable formation with overpressure are exposed behind shallower casings to be reused – and for this reason the well is temporary abandoned.	In case it can be documented that only impermeable formations are exposed (less than one percent probability), a dispensation might be given for having only one barrier for a shorter period of time.

PERMANENT P&A

– VXT removal

For wells that have been in operation

Fluid	Possible to monitor primary barrier?	Primary barrier element	Secondary barrier element	Compensating measures ("third" element)
Light fluid	Yes (downhole pressure gauge or tubing to annulus communication)	<ul style="list-style-type: none"> Deep set mechanical bridge plug 	<ul style="list-style-type: none"> 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 barrier to be monitored at all times on DHPG or a-annulus pressure
	No	<ul style="list-style-type: none"> Deep set mechanical bridge plug 	<ul style="list-style-type: none"> 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	Yes (tubing to annulus communication)	<ul style="list-style-type: none"> Deep set bridge plug and brine/mud above plug, or Kill pill and brine or kill mud from perforations/screen to surface 	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Deep set bridge plug and brine/mud above plug 	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Kill pill and brine or kill mud from perforations/screen to surface 	<ul style="list-style-type: none"> 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



Thank you