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Report

Temporary abandoned wells on NCS

Subtitle

Author(s)
Nils Totland

SINTEF Petroleum Research
Well Integrity
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SINTEF Petroleumsforskning AS
SINTEF Petroleum Research

Address:
Thormøhlensgt. 53 C
NO-5006 Bergen
NORWAY

Telephone:+47 73591100
Telefax:+47 55314255

petroleum@sintef.no
www.sintef.no/petroleum
Enterprise /VAT No:
NO 936 882 331 MVA

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Nils Totland

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ABSTRACT

Summary

SINTEF Petroleum research has been requested by Petroleumstilsynet (PTIL) to perform a review of the information received from operators on the Norwegian Continental Shelf (NCS) describing the well barrier status of temporary abandoned wells.

The work has been undertaken to review the answers from a questionnaire and well barrier schematics, as requested by PTIL.

The background for this review is compliance to the Norsok D-010, rev. 3, August 2004, standard.
In addition to this standard, the OLF 117"Recommended practice for well integrity", rev. 3, dated 29.11.2010, has been used to check the various operators internal practices with respect to the categorization of well barriers as recommended in the OLF 117..

Included in the report, the sub contractor WellBarrier has reported their findings and comments to a selection of well barrier schematics representing all of the operators. This report is found in Appendix A.

PREPARED BY
Nils Totland

SIGNATURE

CHECKED BY
Inge M. Carlsen

SIGNATURE

APPROVED BY
Jostein Mårdalen

SIGNATURE

Jostein Mårdalen Digitally signed by Jostein Mårdalen CN=Jostein Mårdalen Date: 2011.08.31 10:54:53 +02'00'

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APPENDICES

1 Background

During the fall of 2010, Petroleum Safety Authority of Norway / Petroleumstilsynet (PSA / PTIL) requested documentation from all operators on the Norwegian Continental Shelf (NCS) describing the state of their temporary abandoned wells. The request included a pre-made spreadsheet to be filled in, in addition to well barrier schematics of all their temporary abandoned wells.
PTIL has received the requested documentation from 8 operators covering 193 wells on the NCS. The documentation has been given in a format as specified by PTIL in the initial request.

This report contains SINTEF Petroleum Research's evaluation of the received data.

Temporary abandoned wells are defined as all wells / all wellbores except all active wells and wells that are permanently plugged and abandoned according to the regulations.

- Active wells are defined as production / injection wells that are currently producing or injecting.
- This should include both platform and subsea wells.

The sub contractor WellBarrier has done a separate review of a selection of the well barrier schematic and well data received. This report, describing and commenting the well barrier schematics on 11 temporary abandoned wells, is presented in Appendix A of this report.

2 Objective

The objective of this report is to review the documentation received regarding the various operators' use of well barrier schematics, well integrity categorization and verification / monitoring of the various well barrier elements, - as described in the OLF 117 "Recommended Guidelines for Well Integrity", rev. 3, date revised 29.11.2010.

In addition to the use of this recommended guideline, some attention has also been made to the marking and seabed protection of subsea wells, as well as marking/identification and inspection routines.

A common understanding of the OLF 117 well integrity guidelines between operators, and the operator's use of the recommended colour coding system for well integrity categorisation, has also been checked.

Comments are made to some observations found on some well barrier schematics.
This is comments that may improve the amount of information displayed on these schematics and there by improve these schematics to become a tool better suited for use in well operations planning.

Finally, some statistics has been run on the received data to try to give a broader overall view of the state of the temporary abandoned wells on the NCS with respect to Norsok D-010 and OLF 117 recommended guidelines for well integrity.

3 Findings

3.1 Compliance to OLF 117- Recommended Guideline for Well Integrity

When reviewing the received data package covering the barrier status of temporary abandoned wells on the NCS, it appears that much of the information that is found on the well barrier schematics vary between the various operators.

However, the OLF 117 states a list of data that the Well Integrity Forum (WIF) has recommended to be a minimum of data to be submitted on these Well Barrier Schematics.
This guideline of minimum data is listed in Chapter 3.3 of the OLF 117.
The following minimum data has been agreed upon:

- Formation strength should be indicated for formation within the barrier envelopes.
- Reservoir(s) should be shown on the drawing.
- Each barrier element in both barrier envelopes should be presented in a table along with its initial integrity-verification test.
- Depths should be shown relatively correct according to each barrier element on the drawing.
- All casing and cement, including the surface casing, should be on the drawing and labelled with its size.
- There should be separate fields for the following well information: installation, well name, well type, well status, rev. no and date, “Prepared by:” and “Verified/Approved by:”.
- Include a “Note” field for important well integrity information.

3.2 Abandonment duration related to temporary abandoned wells.

There are several temporary abandoned wells that have been abandoned for several decades. Figure 3.2.1, show the time of abandonment for the wells covered in this survey.

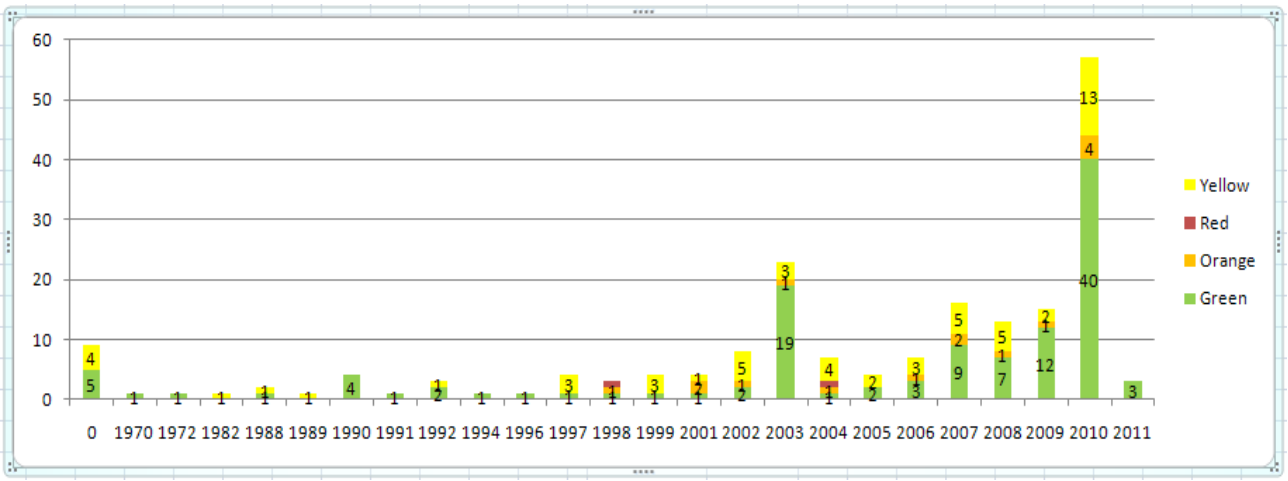


Figure 3.2.1 Time of abandonment for temporary abandoned wells on the NCS

As shown on Figure 3.2.1, the oldest wells were temporary abandoned back in the early 1970’s. These oldest wells should be permanently plugged and abandoned as soon as possible.

Some concern has been raised regarding potential deterioration of mechanical packers/plugs used for temporary abandonment when wells are "temporary" abandoned for decades.
The oldest wells in this survey were reviewed with respect to the type of barrier element being used. The result of this exercise was as follows:

- 27 wells that has been temporary abandoned prior to year 2000 are still "temporary" abandoned
- Of these 27 wells, 2 wells use mechanical plugs as primary and secondary barrier.
- One of these 27 wells was abandoned with mechanical plug as barrier between reservoirs.

A majority of the wells temporary abandoned prior to year 2000 have primary and secondary barriers that fulfil the requirements for permanent P&A.

3.3 Inspection, marking and identification of subsea well structures

The number of subsea wells represents 84 wells out of the total number of 193 temporary abandoned wells on the NCS.

This number includes wells under construction, former producers and injectors in addition to temporary abandoned exploration and appraisal wells. Some wells are also defined to be waste fluid injectors, produced water injection wells etc.

The split between the various well integrity colour coding categories for the subsea wells are 59 wells in green category, 18 in yellow, 6 in orange and one well in red category.

The operators state that they plan to perform inspections of subsea structures, wellheads, etc with varying frequency.
This inspection frequency varies from "no planned inspection", via every second year to yearly inspections for the various operators.
Some operators plan for ROV inspection of sub sea structures and wellheads every 6 months initially, with yearly inspections after initial stable conditions has been verified.

Most of the subsea wells are reported to be left with an over-trawl able well protection structure and with corrosion caps with corrosion inhibitor fluid.

3.4 Comments on some observed well barrier schematics practices

It seems like the various operating companies most likely have adopted some field specific needs into their well barrier schematics. But some of the information that is frequently requested in some fields / licenses may be of less importance to others.

In the next sub sections of this chapter, some operator specific additions to the list of minimum data will be presented to indicate ways of exceeding the amount of information being made available on these schematics.

3.4.1 Formation strength

The OLF 117 guideline of minimum data states that the formation strength should be included for formation within the barrier envelope.

A few comments can be made to this:

- Formation strength is usually presented in SG units on the well barrier schematics. Without knowing the reservoir pressure and reservoir fluid, the formation strength adds little value to the schematic. However, formation strength data presented as pressure at a TVD depth, together with reservoir fluid and pressure data, would improve the value of the well barrier schematics.

- In addition to information about reservoir pressure and fluid, maximum gas/water injection pressure should be added to the schematics for injection wells. This is also the case for gas lifted wells, the max expected gas lift pressure needs to be known in order to make use of the presented formation strength data.

Figure 3.4.1 show an extract of a well barrier schematic, which show how one operator have included reservoir pressure and fluid data to their well barrier schematics.

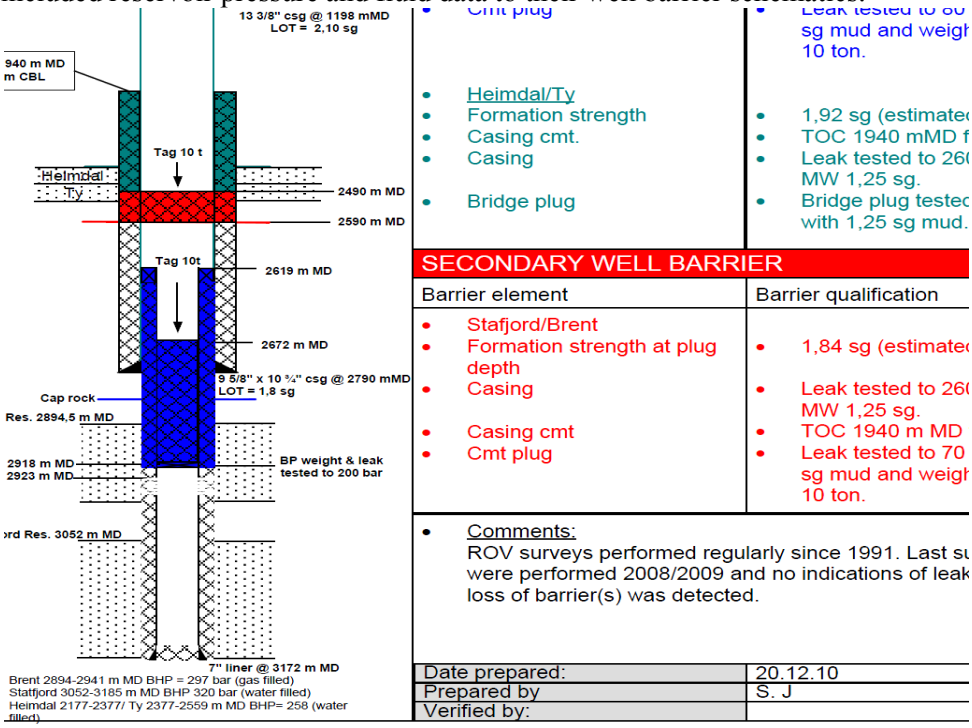


Figure 3.4.1 Extract of Well Barrier Schematic

3.4.2 Standardizing Well Barrier Schematics

When reviewing the received information regarding the temporary abandoned wells, it appeared that one of the operators had not standardized the format of their well barrier schematics. This made the review of the various well barrier schematics covering different licences a bit more challenging.

It is expected that an operator will benefit from having one system available and stick to this format when presenting well barrier schematics for the wells covering different fields / licences.

3.4.3 Potential /observed leak paths

Some operators have implemented use of symbols to indicate potential or observed leak paths on their well barrier schematics.

One approach has been to indicate a leak path by adding a symbol (black droplet) to the right column of the Well Barrier Element Test Pressure/ Date table on the well barrier schematic. An example of this is shown on Figure 3.4.2.

Well integrity problem(s)		*If any, indicated by ⇨*	♦
Annuli	**MAASP, psi**	**MOP, psi**	
A, 5 ½" x 9 5/8"	1586	1000	
B, 9 5/8" x 13 3/8"	1312	1000	
C, 13 3/8" x 20"	300	200	
Well barrier elements	**Table ref. Norsok D-010 Rev3**	**Test Pressure(PSI)/Date**	
Primary barrier			
9-5/8" Casing Cement	22	3,1% returns	♦
9-5/8" Casing below Production packer	2	4500 w/1,78sg/05.06.1995	
Tieback Liner Top Packer	43	4500 w/1,52sg/10.08.1995	
Seal Assembly		4500/12.08.1995 - From above	♦
Gauge Carrier	29	4500/12.08.1995 - From A-Annulus side	
Tubing	25	4500/12.08.1995 - From A-Annulus side	
TRSCSSV	8	Inflow test	
Comments			
Secondary barrier			
9-5/8" Casing Cement	22	3,1% returns	♦
9-5/8" Casing	2	4500/05.06.1995	♦
Wellhead	5	4500/12.08.1995	
Tubing Hanger	10	5000/12.08.1995	
Annulus Valve	12	A-Annulus	
X-mas tree	33	5000/12.08.1995	
Comments			

Figure 3.4.2, Example of indicating potential / observed leak paths.

Another operator has implemented a similar approach, but has marked their schematics with a sign (red circle with an arrow) that indicate the point of anticipated or observed leak path.

Figure 3.4.3 shows how the operator uses this symbol on their schematics.

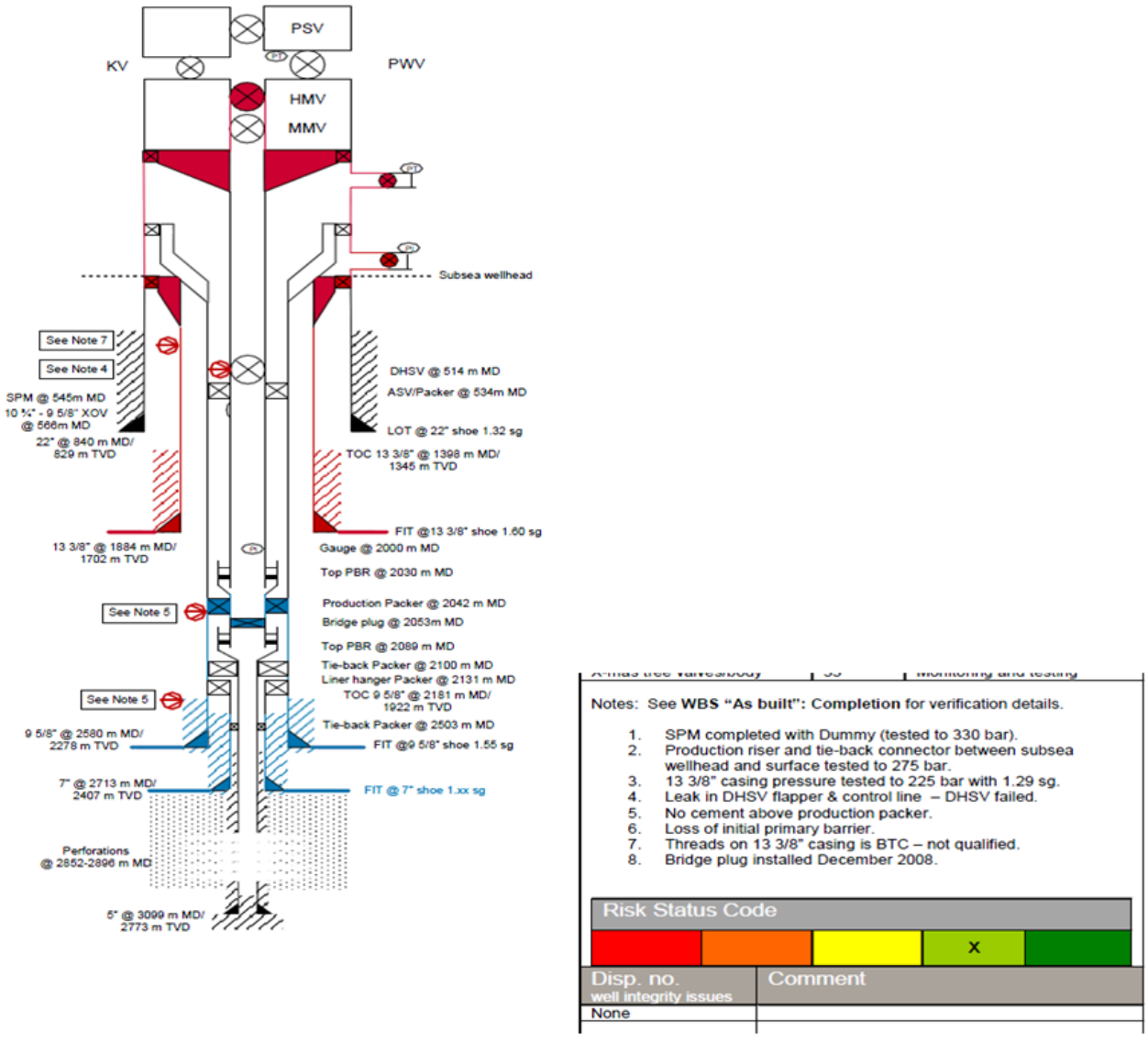
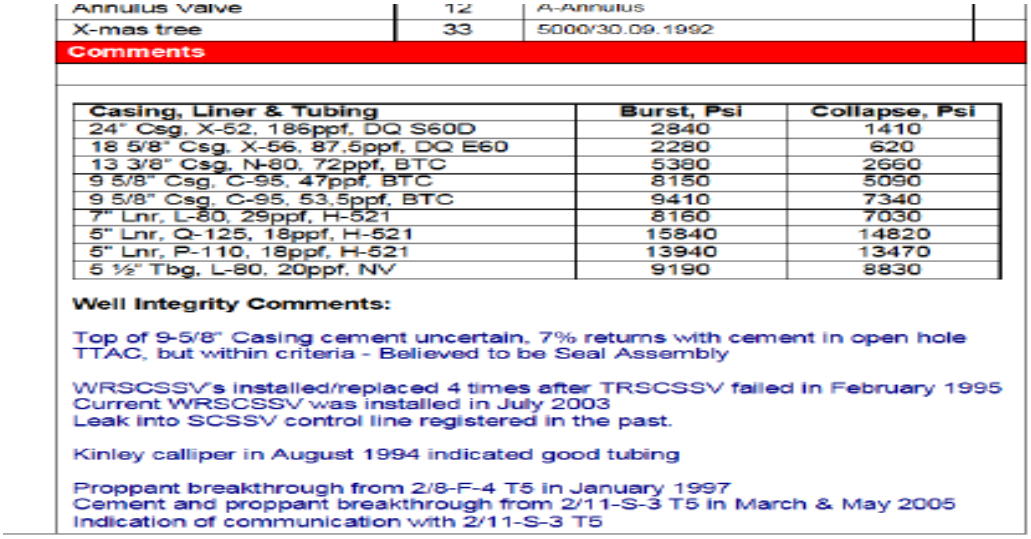


Figure 3.4.3, Extract of well barrier schematic

The schematic shown above indicate how the combined use of signs and the Notes/Comments field can be applied to give an improved picture of the potential well barrier challenges for a specific well.

Note also that this operator has added the well integrity colour coding category to their well barrier schematics (but using 5 in stead of 4 colours, as suggested in the OLF 117).

Another operator has implemented extensive use of the Note/Comments field on their schematics to add well barrier related information and casing / tubing strength data. This is shown on the example below.



Annulus Valve	12	A-Annulus
X-mas tree	33	5000/30.09.1992

Comments

Casing, Liner & Tubing	Burst, Psi	Collapse, Psi
24" Csg, X-52, 186ppf, DQ S60D	2840	1410
18 5/8" Csg, X-56, 87.5ppf, DQ E60	2280	620
13 3/8" Csg, N-80, 72ppf, BTC	5380	2660
9 5/8" Csg, C-95, 47ppf, BTC	8150	5090
9 5/8" Csg, C-95, 53.5ppf, BTC	9410	7340
7" Lnr, L-80, 29ppf, H-521	8160	7030
5" Lnr, Q-125, 18ppf, H-521	15840	14820
5" Lnr, P-110, 18ppf, H-521	13940	13470
5 ½" Tbg, L-80, 20ppf, NV	9190	8830

Well Integrity Comments:

Top of 9-5/8" Casing cement uncertain, 7% returns with cement in open hole TTAC, but within criteria - Believed to be Seal Assembly

WRSCSSV's installed/replaced 4 times after TRSCSSV failed in February 1995
Current WRSCSSV was installed in July 2003
Leak into SCSSV control line registered in the past.

Kinley calliper in August 1994 indicated good tubing

Proppant breakthrough from 2/8-F-4 T5 in January 1997
Cement and proppant breakthrough from 2/11-S-3 T5 in March & May 2005
Indication of communication with 2/11-S-3 T5

Figure 3.4.4 Extract of well barrier schematic

3.4.4 Reported Top of Cement

The reported "Top of cement" is usually identified through cement evaluation logs, estimated by volume pumped and/or returned, - or by other means.
Below are some comments/suggestions related to the term "Top of cement":

- If "Top of Cement" (TOC) has been verified through cement evaluation logs, it is suggested to add a few lines on the Notes/Comments field of the well barrier schematic if there is additional well barrier related information that can be interpreted from the logs. The TOC depth does not necessarily mean that there is good cement bonding from the casing shoe to TOC, and this information can be valuable at some time after the well construction phase (this has been implemented of some schematics on one of the operator's fields).

- In some fields, there exists some "weak zones" that is believed to take return fluid during cement jobs. Some comments in the note/comments field regarding the existence of such zones may add value to the creditability of "estimated TOC" depths in cases with very little or no returns during the cement jobs.

- Also, in fields where there exists swelling formations that has proven to pack off the open hole-casing annulus with time, this kind of information may be useful to add to the note field of the well barrier schematic.

3.4.5 Additional information displayed

Some of the operators use tables and the comments field to add valuable well integrity related information to their well barrier schematics.

Several operators include the MAASP (maximum allowable annulus surface pressure) on their schematics, one operator include the MOP (maximum operating pressure) on the schematic.

Also, one operator use coloured typing when describing barrier elements on their schematics. This simplifies the reading of the text on schematic in cases where primary (blue typing) and secondary (red typing) barriers overlap.

One operator use the table "Verification of barrier elements" on their schematic to refer to dates for drilling report to ease a search for more detailed information regarding cement tops, pressure tests, etc.
The same operator has also included a field for well integrity related dispensations on their well barrier schematics.

With such an amount of information to be displayed on the well barrier schematics, abbreviations are frequently used. This can from time to time make the full understanding of the well barrier schematics a bit complicated. Consequently, access to a list of abbreviations (preferably standardized between the operators) should ease this problem.

3.5 Statistics

The OLF 117 well integrity colour coding system is defined as shown below:

Category	Principle
Red	One barrier failure and the other is degraded/not verified, or leak to surface
Orange	One barrier failure and the other is intact, or a single failure may lead to leak to surface
Yellow	One barrier degraded, the other is intact
Green	Healthy well - no or minor issue

Figure 3.5.1 Colour Code Categorisation of Well Integrity

On Figure 3.5.2, the type of well was determined from the well barrier schematics and other info supplied. As some of the operators did not specify the type of the well, these wells together with observation well (only 4) and batch drilled wells, are categorised as other wells.

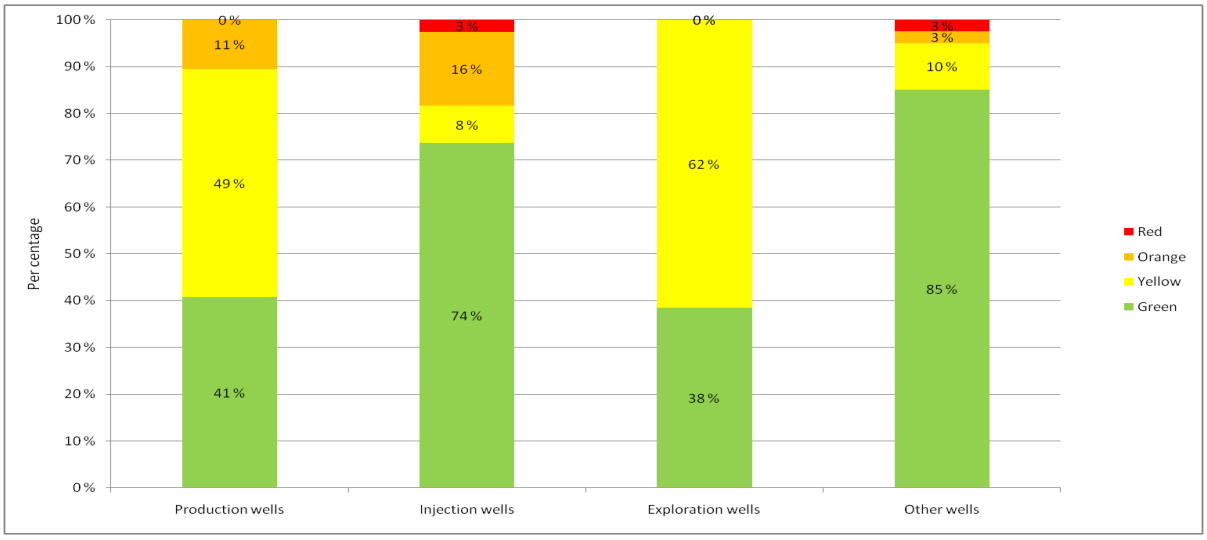


Figure 3.5.2: Well risk category for different well types.

"Other wells" include monitoring wells, pre-drilled wells, wells where utilisation information is missing. The number of wells for the categories displayed on the graph above is 78, 37, and 13 for production, injection and exploration wells, respectively.

The split between the numbers of temporary abandoned wells been made available for this study is:

- Red: 2 wells
- Orange: 15 wells
- Yellow: 57 wells
- Green: 119 wells

Presented in a pie diagram, this indicates that 38 % of the temporary abandoned wells have some degree of integrity problems.

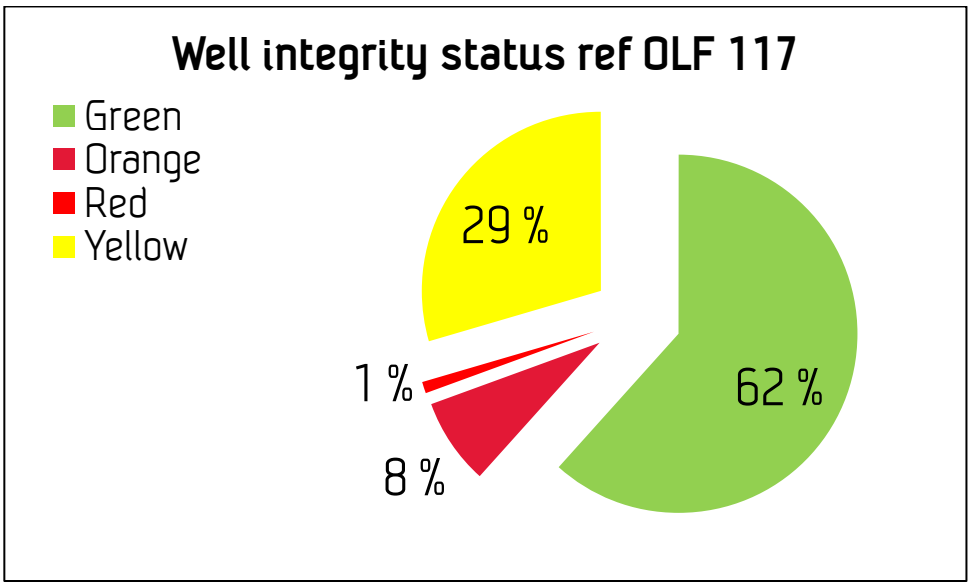


Figure 3.5.3 shows the percentage split between temporary abandoned wells of the different colour codes.

In this context it may appropriate to refer to the regulations and standards, which states that:

- **Activities Regulations Section 88, securing wells:**
  "All wells shall be secured before they are abandoned so that well integrity is safeguarded during the time they are abandoned".

- **Facilities Regulations Section 48, Well barriers:**
  "When a well is temporarily or permanently abandoned, the barriers shall be designed such that they take into account well integrity for the longest period of time the well is expected to be abandoned".

- **Activities Regulations Section 85, Well barriers:**
  "If a barrier fails, activities shall not be carried out in the well other than those intended to restore the barrier".

Finally, the **NORSOK D-010 Standard - Temporary abandonment states that:**

- A mechanical barrier may be acceptable for temporary abandonment
- The integrity of the material should be ensured for the planned abandoned period times two.
- Degradation of casing body should be considered for longer temporary abandonment scenarios

When wells have been "temporary abandoned" for about 40 years, it appears that it may be a challenge to document that the temporary abandonment of a well does comply with all regulations and standards.

It is suggested that the operators speed up on their decision making process, take decisions regarding permanent or temporary abandonment, inform about their decisions, and stick to the presented plans.

The planned future use of the temporarily abandoned wells can be divided into about 3 main groups, where 1/3 are decided to be P&A'd, almost 1/3 has no current plans regarding future use and the remaining 1/3 is either under construction, are planned worked over or will be sidetracked for new reservoir targets.

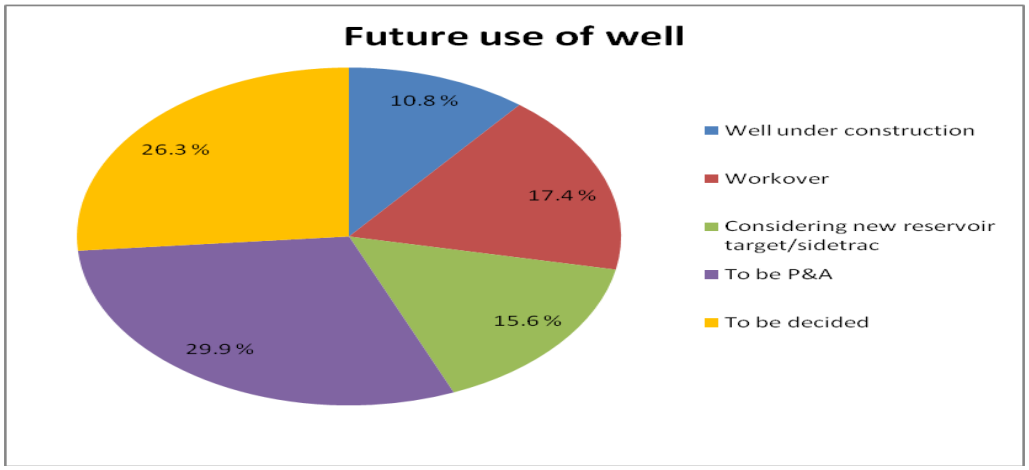


Figure 3.5.4: Planned future use of wells

4 Summary and conclusion

A total of 193 temporary abandoned wells on the NCS have been reviewed in this study. The wells cover exploration / appraisal wells, production and injection wells in addition to wells currently under construction.

The overall impression after the review of the information received can be summarized as follows:

- About 1/3 of all the temporary abandoned wells have some kind of integrity problems
- It has been identified temporary abandoned well(s) with long abandonment time, mechanical plugs as barrier elements of primary and secondary barriers, and no/limited monitoring of the barrier status. Such wells should be given priority to be permanently plugged and abandoned.
- It should be considered to request operators to give time estimates to when they plan to transfer temporary abandoned wells to permanently abandonment status.
- The operators use the colour coding system suggested used in the OLF 117 according to this recommended practice.
- There are room for improvements; all operators could improve their well barrier schematics in order to comply with the OLF 117 recommended guidelines of minimum data presented on these schematics.

A Appendix: WellBarrier Report: Evaluation of well barriers in Temporary abandoned wells

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