

Investigation report

PDP DW

Internal accident investigation

Well Control Incident Troll Q-21

Classification:	Internal	Status:	Final
Report no.:	N/A	Date:	02.03.2026
Expiration date:	N/A	Synergi no.:	6445754

Brief subject description:

On September 23rd, 2025, Deepsea Bollsta was conducting PP&A on Troll well Q-21. After cutting 13 3/8" casing, water came up through rotary. The flow increased, and diverter sequence was activated and annular preventer closed. ESD1 and general alarm were activated. Before the diverter element was fully closed, 100% LEL was measured both in the shaker room and drill floor.

Investigation team:

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Date

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1 Summary

The main purpose with this investigation in retrospect of the incident is to contribute to a constructive learning effect to prevent recurrence and to achieve an improvement in the HSE-level. The investigation work has been carried out to the investigation team's best ability and is based upon the assessment of available knowledge and information. The investigation team has not undertaken any assessment of the legal aspects of the incident, i.e., related to incident causes, liability, or other similar issues.

1.1 The incident

In September 2025, during permanent plug and abandonment operations on the Q-21 well in the Troll field, a substantial release of trapped gas occurred. The rig was conducting P&A activities to seal the well when the incident happened.

At 03:57 in the morning on September 23rd, while cutting a 13 3/8" casing at 510 meters depth, gas unexpectedly escaped into the rig area. Gas alarms were immediately triggered, and emergency shutdown systems were activated. The crew engaged the diverter system and the Blowout Preventer (BOP) and diverted the gas away from the rig.

Shortly after the cut, gas concentrations reached high levels in several areas of the rig, up to 100% of the Lower Explosive Limit (LEL). One crew member experienced temporary difficulties evacuating the shaker room due to a pressure differential across a door, and a water column damaged HVAC ducts in the shaker room ceiling.

1.2 Consequences

Category	Actual degree of seriousness	Potential degree of seriousness
Injury	5	5
Uncontrolled discharge/emissions	5	5
Oil/gas/flammable liquids leakages	1	1
Fire/ explosion	Gas not ignited	No ignition of gas
Safety barriers	5	
Costs/ losses	4	4

Table 1-1: Consequences

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This well control incident severity has been classified as a Level 4 – non classified (grey) well control incident, according to GL0455.

1.3 Causes

The immediate cause of the well control incident was that the 13 3/8" casing was cut while the Blowout Preventer (BOP) was open, combined with the presence of gas behind the casing. This situation directly led to the release of gas into the atmosphere.

The Detailed Operations Procedure (DOP) contains the detailed plans for a specific operation. The DOP is prepared by the planning team and is reviewed and aligned with the rig and accepted and signed by the OC prior to operation start. According to the DOP, the plan was to cut the 13 3/8" casing with the BOP open. The planning team followed a commonly accepted interpretation of TR3507, which allowed shallow cutting with an open BOP when there was no risk of gas behind the casing. The assessment of no gas present behind casing was initially based on the fact there was no flow units identified in the overburden for the Q-21 wellbores. Cement logging results indicated that the cement was properly sealed providing adequate zonal isolation, which further supported this assessment. Before this incident, early gas migration through intervals later assessed as having quality cement bonding had not been viewed as a plausible risk.

Prior to the cutting of the 13 3/8" casing, a cement bond log verified that there was no gas behind the casing. This logging indicated that the annulus was liquid-filled. The cement bond logging tool was calibrated assuming liquid in the annulus in the interval 500 – 600 m MD RKB Deepsea Bollsta. However, recalculation of the logging data after the incident revealed that the annulus was in fact gas filled.

During calibration of the cement bond logging tool, acoustic impedance readings were outside the expected range for liquids. In accordance with the vendor's procedure, a constant in the algorithm was disabled, which caused gas-filled annulus readings to appear as liquid values.

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1.4 Actions

Recommended actions:

1. Revise TR3507 to clearly require BOP closure during shallow cuts and to ensure full alignment with requirement 4.1 in FR03, “*1- Well barriers and non-technical barriers related to well control and well integrity shall prevent that a single failure escalate into an unacceptable situation.*” As part of this revision, conduct evaluations of BOP response time and the effect of u-tubing on well control indicators. Company also sees to it that all Drilling Contractors involved in Company-operated activities review and update their Well Control Manuals based on learnings from this incident.
2. Ensure the logging tool technology used in the incident is fully qualified for risk and operational readiness, including see to it that the vendor has corrected internal procedures and instructions and removed error traps. In cooperation with vendors, eliminate error traps related to data acquisition and data interpretation, and review default free pipe calibration depths to ensure consistent and standardized depth references for both subsea and fixed installations.
3. Company must assess how to manage risk related to old well bores where barrier schematics are not available.
4. Company should strengthen integration of well integrity Information in risk management processes:
 - Clarify how well integrity tags are to be applied within the risk register in Wellcom.
 - Assess how to improve the linkage between the risk register, Well Barrier Status, and DOPs to ensure consistent and aligned barrier and risk management.
5. Company should evaluate how to strengthen learning loop:
 - Assess where to integrate lessons learned regarding the avoidance of activities such as hot work where risk of HC exists, e.g. during casing cutting or circulation in P&A operations.
 - Emphasis needs to gather relevant experiences from nearby area and similar activities in start of project, especially related to well control. Company must evaluate to register an IMP to change I-31811 to requirement element. Specify requirement text to include general area experiences and companywide well control and similar activity experiences. The requirement should be valid for all well planning processes
6. Company should assess to revise template on Emergency Bridging documents in D&W:
 - Include “*Notify EPN IMT 2nd line via Response and Support Centre (RSC, 51990002).*” This is the same wording as found in the WR1156 template.
 - Assess to include that a substitute for Appendix “Standard form for notifying / cooperating between Line 1 and Line 2” is to take photo of emergency board and send this to IMT.

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7. Company should evaluate whether the Mud Logging Units should be classified as “essential” or “non-essential” equipment for operations in hazardous areas and, if appropriate, escalate classification of mud logging units to Offshore Norge to support harmonization of requirements across operators on the NCS.
8. For Company-operated operations, the Company recommends that the Rig Operator assess the alarm sound levels for the various systems in the driller’s cabin and implement noise-reduction measures where necessary.
9. For Company-operated operations, the Company recommends that the Rig Operator assess evacuation from the shaker room and the shaker operator cabin, as well as the safety of personnel located in the shaker operator cabin during a gas leak or fire event.
10. The investigation team recommends that the Company assess whether to propose a revision of the well control incident classification in GL0455 and Offshore Norge GL135, to ensure that incidents involving the release of significant volumes of trapped fluid without potential for continuous flow, are properly captured in terms of seriousness and learning potential.

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2 Mandate for investigation

2.1 Mandate



L3 Mandated Investigation Doc. No. n/a
 D&W OCN NW 2
 Well Control Incident Troll Q-21 Valid from: 23/09/2025 Rev. no. 0

Mandate for Investigation: Well Control Incident Troll Q-21

Introduction:

Deepsea Bollsta was hired to complete Permanent Plug and Abandonment operations on the wells NO 31/3-Q-21 BY1H and NO 31/2-X-23 Y1H on the Troll field. The Q-21 is a gas producer for Troll C platform. The original well was drilled and completed in 2001. In 2007 a sidetrack was drilled and completed, abandoning the original wellbore. Q-21 has been shut in since 2011. On arrival it had a well integrity status of orange. During the second part of the operation plan on Q-21 well the rig a well control incident occurred whilst cutting the 13 3/8" casing.

Status of the well prior to the incident was that the reservoir was plugged back with an Archer oil tools Timelock plug that was placed and tested in the 10 3/4" casing. After cutting and pulling out the 10 3/4" casing above the Timelock plug, the 13 3/8" casing was cleaned out and logged with wireline to check the cement bond behind the casing. The log showed good intervals of cement bonding, sufficient to place both the primary and secondary barriers with a cement plug in the casing. Additionally, the logging result confirmed no gas behind the 13 3/8" casing which matched the expected state from planning of the PP&A which stated no risk of gas from the 17 1/2" section. A 200 meter cement plug was placed using the Timelock plug, in the 10 3/4" casing, as a fundament and up into the 13 3/8" casing with a theoretical top of cement at 1153 mMD. Prior to cutting the 13 3/8" the cement was tagged at 1174 mMD. Due to log results showing no gas behind the casing, the casing cut was planned without using a swivel and with an open BOP.

The string was moved to place the casing cutter to cut the well at 510m MD and started to cut the casing. On the 23rd September 03:57, immediately after cutting of the casing, water came up through rotary. U-tubing was expected given the fact that 1.31 sg Aquadrill was behind the casing and 1.00 drillwater was on the inside of the casing and in the string. However, backflow increased rapidly and the diverter was activated by the driller and the well was shut in on the annular. Gas was detected on several gas sensor activating both ESD1 and the general alarm. Fluid arriving at the shaker room caused an overpressure in the room resulting in equipment damage in the shaker room. One worker was in the shaker room at the time of the overpressure. When flow ceased from the diverter overboard line, the riser was re-filled with drillwater.

Synergy number	Title	Classification
6445754	Well control incident well NO 31/3-Q-21	TBD

Per DW901 (R-105428) an in-depth study is mandated to understand the causes of the event and to prevent re-occurrence. According to DW901, this investigation is mandated at an L3 level.

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L3 Mandated Investigation Doc. No. n/a
 D&W OCN NW 2
 Well Control Incident Troll Q-21 Valid from: 23/09/2025 Rev. no. 0

Mandate for the investigation:

The study shall be performed as aligned with best practice contained within DW901(I-105314) including but not limited to the following actions:

- Clarify the sequence of events and background for the incident
- Identify immediate causes and underlying causes wrt well control incident. Specifically identify source of gas.
- Identify immediate causes and underlying causes wrt damage observed in the shaker room and associated areas / systems.
- Assess impact on mudlogging shutdown and length of restart. Any changes needed to ESD logic.
- Assess the actual and potential severity of the incident according to DW9592 including: injury actual/potential, fire/explosion potential, gas leakage actual volumes (ref GL0131) and impairment to safety barriers actual/potential (ref 3.3.6)
- Assess and categorize well control incident severity according to GL0455
- Clarify the time and cost consequences associated with the incident.
- As is first incident with Deepsea Bollsta requiring line 2 – a review of how ER / notification system went.
- Check for similar incidents/conditions and any transfer of experience from them
- Identify broken and missing barriers, and also barriers that have functioned as intended
- Recommend preventive actions and changes to avoid repetition in the future

Expectations:

- The investigation team has the authority to define actions to meet the requirements of this mandate.
- The investigation team shall include other disciplines as required.
- The investigation team shall follow the Equinor Procedure SF103 and INV101.
- During the investigation the investigation team shall have this work as their priority.
- Deadline to present a draft of the investigation is by October 17th.

In-depth study team:

- Investigation Lead:
- Equinor D&W
 -
 -
 -
 -
- Odfjell Reps:
 -
 -
 -
 -
- Baker Reps:
 -
- Review and QC
 -
 -

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L3 Mandated Investigation

Doc. No. n/a

D&W OCN NW 2

Well Control Incident Troll Q-21

Valid from: 23/09/2025

Rev. no. 0

Commissioned by (subject to change):

VP D&W OCN

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2.2 Investigation work

The purpose of this investigation, following the incident, is to clarify the sequence of events, the causal factors, and to promote recommendations for learning and improvement. The investigation team has not made any assessment of civil or criminal liability and responsibility. The use of this report for purposes other than preventive safety work should be avoided.

The investigation team held its first meeting on September 25th, 2025. Parts of the investigation team were offshore on Deepsea Bollsta from September 26th to 28th. The investigation process has involved the collection and review of relevant documentation, as well as interviews. A total of 31 interviews has been conducted as part of the investigation. The Safety Technology discipline in Equinor has performed simulations of gas release on the drill floor and in the shaker room and been consulted to obtain an assessment of the incident's potential. The medical group has been consulted to assess the potential for injuries.

The investigation has been conducted in accordance with Equinor's investigation process as described in ARIS INV101. The investigation team has used the HOP principles in the investigation. The entire investigation team stands behind the content of the report.

2.3 Uncertainties and limitations

There is uncertainty associated with the assessments of the origin of the gas migration behind the casing. The technical discipline has performed an evaluation to identify the most likely migration pathway.

There is uncertainty regarding the significance of the heavy PS30 slips (5 tons) positioned in the rotary table and its potential contribution to the damage observed in the shaker room, as it may have caused a choke effect on the flow out. The investigation team has assessed this as a potential explanation for why the damage in the shaker room was more extensive than that observed during the Troll G-4 incident.

The investigation team has not been able to conclude whether overpressure or underpressure in the shaker room contributed to the difficulties in evacuating the area during the incident. Both conditions may explain why evacuation of the shaker room was difficult.

The uncertainties associated with the Memo Gas Hazard Analysis – Well control incident Deepsea Bollsta sept.25 are described in this report⁹.

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3 Background information

3.1 Troll field

The Troll field lies in the northern part of the North Sea, approximately 70 kilometres west of Bergen in water depths of 313 – 352 meters, see Figure 3-1.

The field comprises the main Troll East and Troll West structures in blocks 31/2, 31/3, 31/5 and 31/6. The gas reservoirs lie 1 500 – 1 600 meters below sea level. Troll also used to be one of the largest oil fields on the Norwegian continental shelf, producing from a thin oil layer below the gas. Many of these oil wells are now ready to be plugged permanently.

Equinor operates the Troll A, B and C platforms (Figure 3-2).

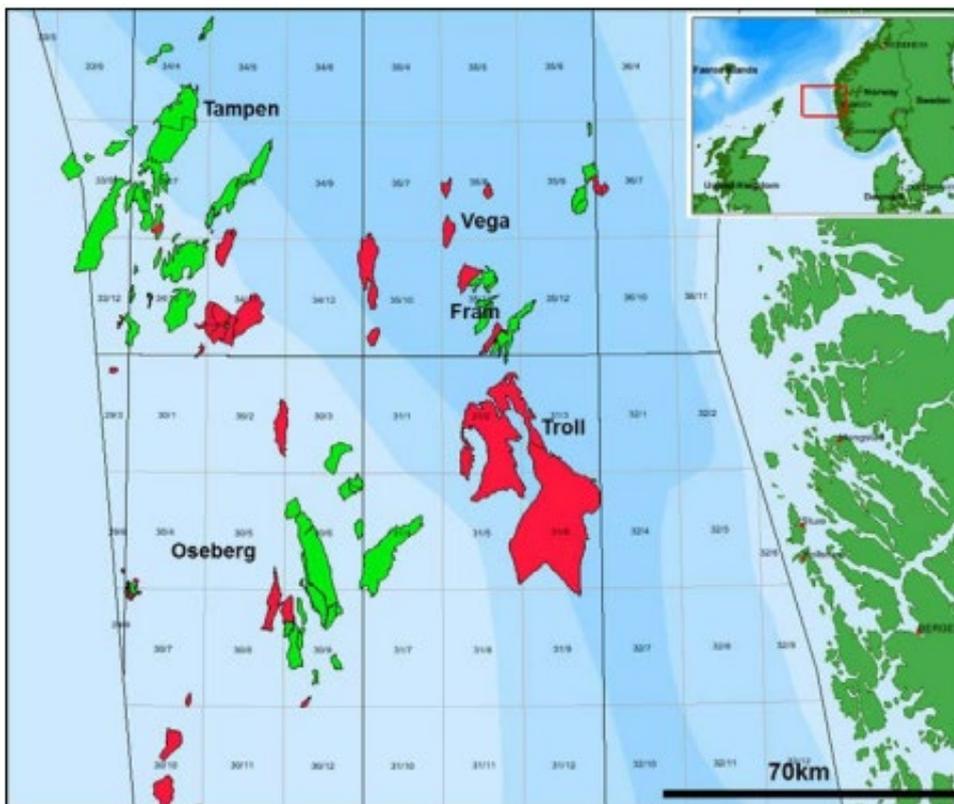


Figure 3-1: Location of the Troll field

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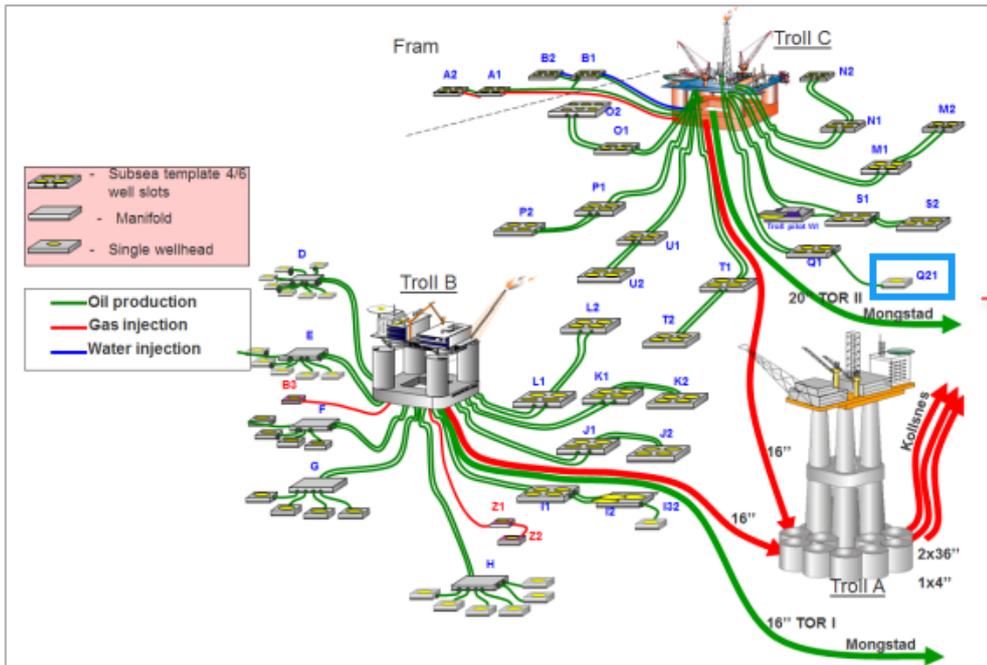


Figure 3–2: Illustration of wells, templates and oil, gas, and water pipelines in the Troll field. Q-21 indicated by blue frame is a single wellhead.

3.2 Deepsea Bollsta



Figure 3–3: Deepsea Bollsta¹

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DeepSea Bollsta is a semi-submersible drilling rig built in 2019. After completing the inshore part of an Acceptance Test Program (ATP) at Hanøytangen near Bergen during 2025, the rig and crew mobilized to the Troll field to carry out permanent plug and abandonment operations on two wells, Q-21 and X-23, in a batched campaign where the rig moves between the wells to optimize the sequence of operations. The rig arrived at the field on August 31, 2025. At the time of the well control incident on September 23, there were 114 persons onboard.

3.3 Organizational structures

Drilling operations, including Permanent Plug & Abandonment (PP&A) operations, are run by integrated teams with close collaboration between Rig Contractor, Service Provider(s), and Company (Subsurface and D&W) where the overall goals are safe and efficient planning and operation. D&W in Equinor is divided into Planning Centres (PC), planning the wells, and Operation Centres (OC), executing the operations.

3.4 Permanent Plug & Abandonment (PP&A)

The objective with permanent plug and abandonment is to establish cross-sectional barriers against any source of influx that can sustain the maximum anticipated pressure in an eternal perspective. Reservoirs require two cross-sectional barriers with sufficient formation integrity on both.

A cross-sectional barrier (Figure 3-4) will normally consist of the following elements (with verification method in brackets):

- Cement inside the casing (load testing with drill string)
- The casing itself (pressure tested at initial installation)
- Cement outside the casing (cement job data or cement bond log)
- Formation integrity at the base of the cross-sectional barrier (formation strength charts, based on modelling of seismic data, correlated with extended leak off tests and formation integrity tests)

To the extent possible the cross-sectional barriers should be independent. If that is not possible, extra measures are taken on the verification method. Example of such measure is requirement for logging of casing cement if the cement represents a common barrier element, i.e. primary and secondary barrier elements against a flow zone.

To set cross-sectional barriers, it is often required to cut and retrieve inner casings.

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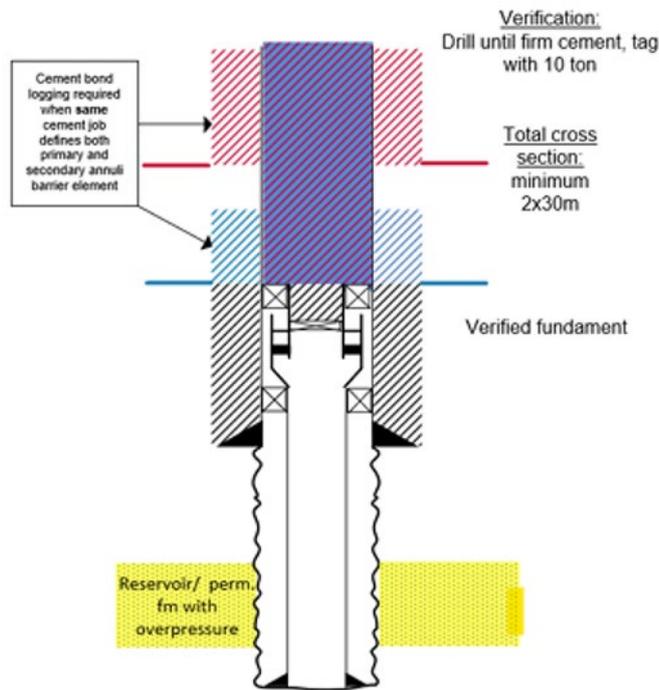


Figure 3–4: Illustration of permanent plugging of a reservoir using same casing cement job and internal cement plug as primary and secondary barrier elements².

3.4.1 Methods for cutting and retrieval of casings.

Casings are typically removed in the following sequence:

- Run into the well with a drill string containing a casing cutter, i.e. knife blades that extend laterally into the casing wall by pressure activation. When circulating is established, the knives are pushed into the casing wall and by applying rotation to the drill string the casing is cut. Once rotation is established, cutting of a casing is normally done within minutes.
 - Rotation of the drill string cannot be done with the BOP closed as this can cause damage unless the following equipment is included in the drill string.
 - Annular Swivel, allowing an annular preventer to be closed on the swivel prior to and during rotation of the drill string.
 - Mud motor, allowing the drill string to be stationary in the BOP area and rotate below the mud motor. A typical BHA setup would include a marine swivel to land off string weight and keep cutter at position.
- Pull the seal assembly in a separate run with drill string.

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- Pull the casing in a separate run using a spear and pack off assembly.
 - In this stage the normal practice is to circulate out old fluid in annulus with closed BOP prior to start pulling casing free.

There is variation in this sequence, i.e. use of combination runs has increased efficiency during plug and abandonment operations.

3.4.2 Gas behind casing

In P&A operations where gas is identified behind old casings, the most common type is hydrocarbon gas, i.e. Methane, but there are also examples of operations where Carbon monoxide (CO) and Hydrogen Sulphide (H₂S) have been measured.

Hydrocarbon gas can be separated into two types:

- Biogenic gas: This type of gas is primarily generated through anaerobic decomposition of organic matter by microorganisms, particularly in environments with low temperatures and pressures, such as shallow sediments. Methane (CH₄) is the main component.
- Thermogenic gas: Formed from the thermal cracking of organic materials under high temperatures and pressures (deeper formations). This process occurs during later stages of hydrocarbon maturation, resulting in a mixed gas composition, C₁-C₅+

When drilling a well, the term “overburden” is used for the layers above the reservoir, and in oil producer’s “reservoir” is used for the target zones containing hydrocarbons.

After drilling, the casing is cemented. Sometimes the casing passes through zones where gas was detected. If there is a risk of gas flow from these zones, chemicals are added to the cement to make it harden faster. This prevents gas from creating channels / leaking paths through the cement.

Once the cementing is done, a seal assembly is placed at the top of the casing annulus. The fluid inside the annulus stays still, and over time, heavy materials like barite settle. This lowers the fluid’s density and pressure, which may allow small amounts of gas to enter if gas is present in the formation.

Some wells (especially on fixed platforms) allow pressure readings from the casing annulus at the surface. This helps monitor well integrity and detect leaks. On Troll Q-21, the annulus pressure could not be read or released.

3.5 Well control equipment

On top of each subsea well there is a wellhead or valve tree (Christmas tree) which the rig is latched onto with the Blow Out Preventer (BOP stack). From the BOP up to the rig there is a Marine Riser and on top of the marine riser system there is a telescopic joint that allows the rig to heave with the sea without transferring compression/tension into the riser (Figure 3-5). A diverter system is placed just below rotary table to allow for diversion of gas away from the rig in case of gas entering the riser from the well below, either due to leak in the BOP or due to late activation of the BOP.

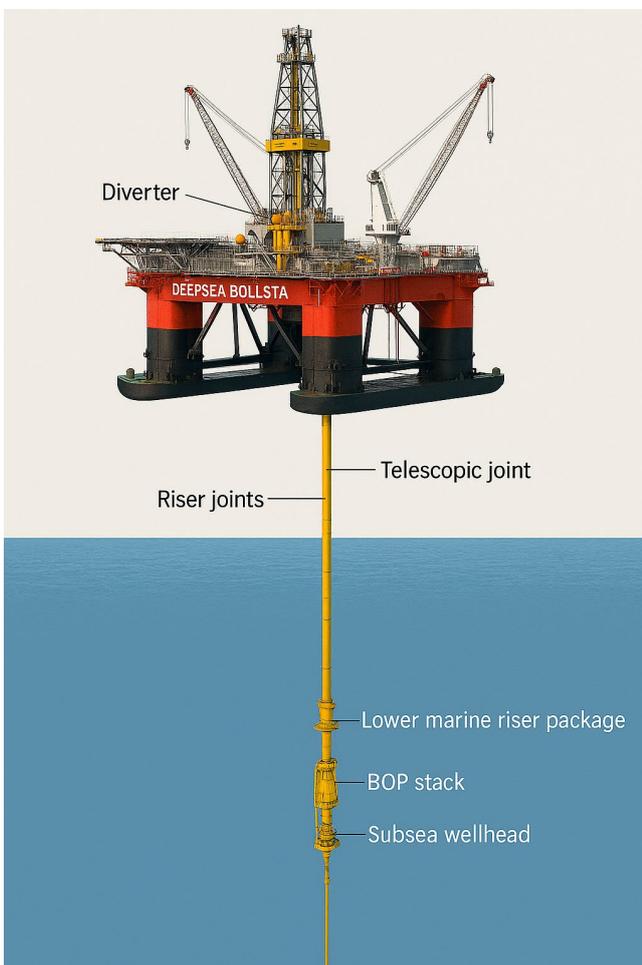


Figure 3-5: Generic overview of how a rig is connected to a well.

3.5.1 Blow out preventer (BOP)

The purpose of the Blow out Preventer (BOP) is to seal off the well in case of unexpected pressure or fluid flow from the underground. It is located on top of the wellhead and connected to the rig via a Marine Riser System. The BOP has the following functions:

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- Close off the well completely.
- Allow controlled release of pressure.
- Prevent fluids from escaping into the environment.
- Provide flexibility and redundancy in managing a well control situation.

There are two main types of BOPs.

- Annular BOP: Uses a rubber seal to close around the drill pipe or even an open hole.
 - The required response time from activation to fully closed is 60 seconds.
- Ram BOP: Uses steel blocks (rams) with rubber front seals to seal around the pipe or shear it completely in emergencies.
 - The required response time from activation to fully closed is 45 seconds.

The BOP stack on Deepsea Bollsta, as shown in Figure 3-6 and Figure 3-7, is a 15kpsi system consisting of 7 BOPs:

- 3 ea. Pipe Rams (Variable Bore Rams, VBR).
- 1 ea. Casing Shear Ram, CSR.
- 1 ea. Blind Shear Ram, BSR.
- 2 ea. Annular Preventers.

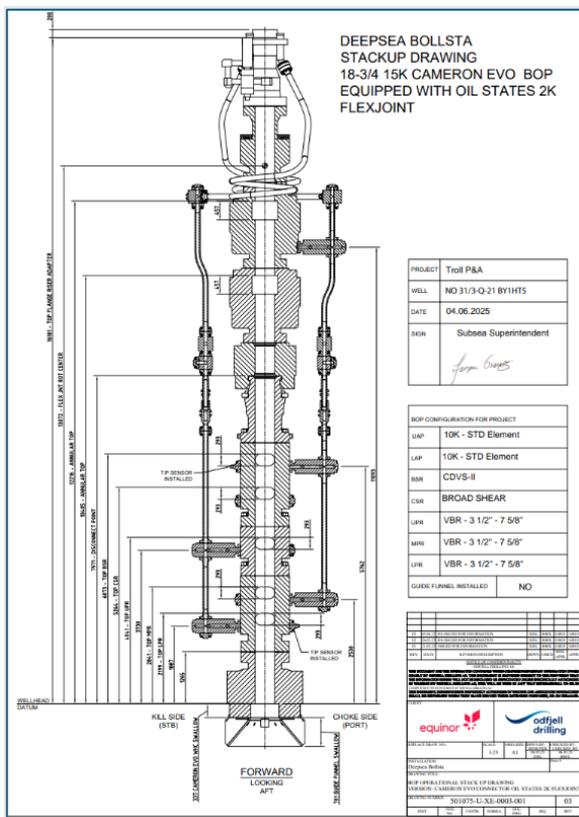


Figure 3-6: Deepsea Bollsta BOP and Lower Marine Riser Package (LMRP)

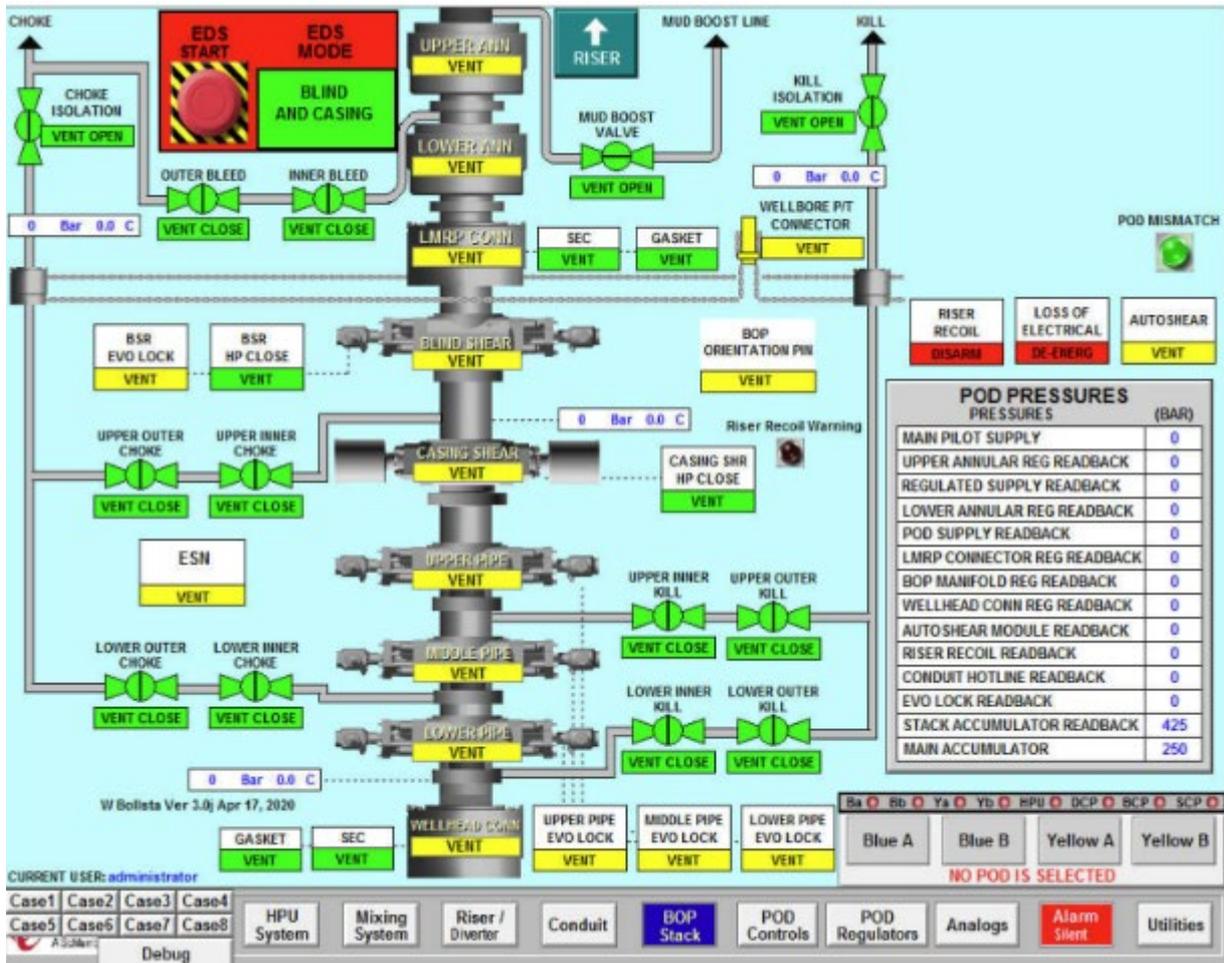


Figure 3-7: BOP and LMRP control panel

3.5.2 Diverter system

The diverter system (Figure 3-8) is designed to safely direct unexpected gas or fluid flow away from the rig, i.e. if gas has passed the BOP and entered the Marine Riser. The diverter packer is located just below the Rotary Table on drill floor. When activated in a well control situation, the expanding gas inside the riser will be diverted away from the drill floor and shaker area to an exhaust pipe downwind of the rig.

The diverter system is connected to:

- Shaker area through flow line during normal drilling operations.
- Trip tank trough, fill up valve and trip tank valve. For volume control when tripping and monitoring well.
- Overboard lines for diverting potential gas to safe areas.

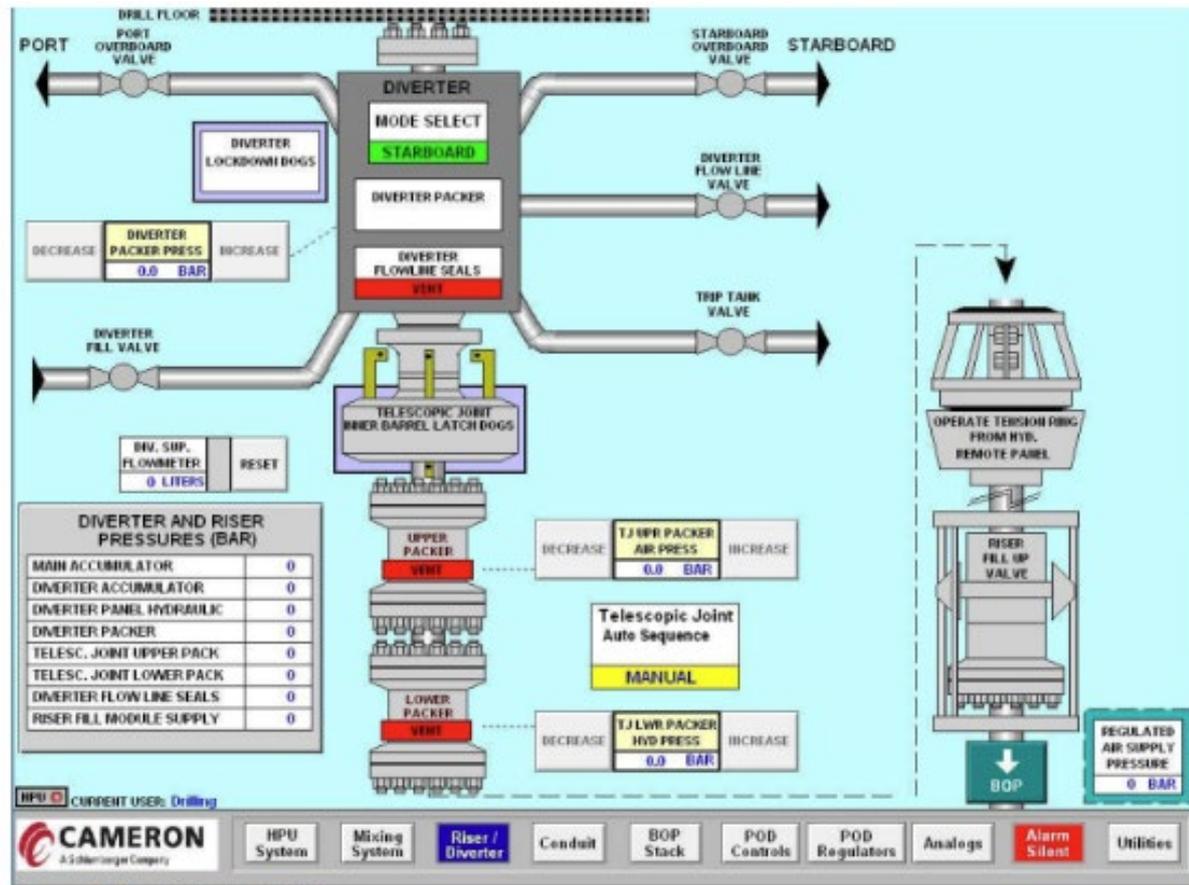


Figure 3–8: Diverter system control panel¹

3.5.3 Associated well control equipment

Surface valves, i.e. drill pipe safety valves and internal BOPs, represent associated well control equipment. In this incident an IBOP in the top drive was used to secure the string side.

3.6 Cement bond and gas evaluation

3.6.1 Cement Evaluation

The primary goal of cement placement is to provide zonal isolation while at the same time protecting the casing from corrosive fluids. However, the cement sheath can be stressed by well activity or a poor cementing job to the point where it is no longer effective. Regulatory compliance requires evaluation of the casing and cement to ensure the well integrity is maintained over the lifecycle of the well. Cement evaluation is dependent on internal access to the casing, hence logging of the 13 3/8" casing could either

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have been done after installation and before running the 10 3/4" tieback casing or during plug and abandonment where the 10 3/4" tieback casing is removed and access to the 13 3/8" casing is possible.

Cement evaluation in Equinor is based on sonic and ultrasonic measurements. These acoustic measurements are sound waves at different wavelengths sent from the logging tool and reflected at the various interfaces. Based on these reflections the product of the sound velocity and the matter density is calculated and called acoustic impedance (AI). The full waveforms are analysed and transformed to identify tubular thickness, AI of the material on the annulus and more. Based on the calculated AI the materials on the annulus are identified as gas/air/vacuum/light oil (not possible to distinguish between these materials), liquid and solids. Ultrasonic imaging is applied to present an azimuthal log that shows the impedance in 360 degrees, fully covering the entire casing annulus. Gamma Ray (GR) measurements and electromagnetic measurements (Casing Collar Locator, CCL) are used to support the depth control in the well.

The logging data is collected on the rig and communicated to a 24/7 logging duty onshore. The data is interpreted and a preliminary quality checked report is distributed with data and images that specify what is identified behind the casing in respect to interval lengths of cement and what level of potential hydraulic bonding is identified. This preliminary report is delivered to the Operation Centre, and it is essential in deciding operational steps to make well-barrier placements in compliance with regulatory requirements. A more comprehensive and final cement evaluation report is later produced and archived for historical records.

3.6.2 Gas Evaluation

Cement evaluation technology has become more advanced over time, i.e. going from single direction probing to full azimuthal coverage, and the logs have been found capable of identifying gas behind the casing. Gas evaluation has become a common secondary objective during cement bond logging, where a low value band in the impedance measurements is found to represent gas, light oil, air/vacuum. Identifying gas behind a casing before the casing is removed may be of essential value, as large amounts of gas can be difficult to handle from a safety perspective.

3.6.3 Free Pipe Correlation and Geometric correction factors

When executing the cement bond logging, the operation is separated into two main steps, a free pipe correlation log and the main logging pass. The free pipe correlation log is by best practice taken at a depth of 500–700 m Measure Depth below rotary table (MD RKB.), where the casing annulus is expected to be liquid filled. Free pipe correlation logs are used in cement bond evaluation to help distinguish between sections of the well where the casing is free to move (not cemented) and where it is bonded to the formation by cement.

How it works:

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- The cement bond log measures how well the cement has bonded the casing to the surrounding formation.
- However, to interpret the cement bond log accurately, you need to know where the casing is free (not bonded) and where it is fixed (bonded).
- The free pipe correlation log provides a reference signal from a known free section of pipe. This helps to calibrate the tool and interpret the cement bond log data accurately.

Why free pipe correlation is important:

- It ensures that poor cement bonding is not misinterpreted as good bonding.
- It helps identify channels or gaps in the cement that could allow fluid migration.

Geometric correction factors are used by the vendor in this incident to correct the log response for pipe curvature, pipe thickness, mud type etc.

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4 The incident

4.1 Course of events

4.1.1 Well history, 31/3-Q-21

Q-21 was drilled from a single slot template, located 5 km away from the nearest production template on the Troll field. The closest wellbore is 31/3-S-41, a plugged exploration/ observation well 1450 m away.

Well Q-21 was drilled in three separate phases in 2001, 2004 and 2007/2008. The initial exploration well Q-21 H was drilled in 2001 with Scarabeo 6 and the reservoir zones were permanently plugged and abandoned before the well was prepared for a future sidetrack. In 2004, West Venture re-entered the well and drilled a multi-lateral (MLT) production well, Q-21 AY1H/AY2H T2. The well produced from 2004 until 2005, when it was shut in due to low oil output. In 2007, West Venture permanently plugged and abandoned the AY1 /AY2 wellbores. As part of this operation, the 13 3/8" casing cement in the A-bore was logged on 13 June 2007, and the original well was plugged back to the 20" casing shoe. Figure 4-1 shows the Barrier Schematic from 2007.

SITUATION	DESCRIPTION OF BARRIER ELEMENTS	MONITORING OF BARRIER ELEMENTS
	B A R R I E R # 1 Formation/Cement 13 3/8" Casing Cement plug in 13 3/8" Casing	Bonding qualified through logging Pressure tested
	B A R R I E R # 2 Formation 13 3/8" Casing Cement plug in 13 3/8" Casing	Bonding qualified through logging Pressure tested
Comments: NH synergy/ 731788: Permanent deviation from APOS requirement K-16448. "Verify collapsed formation through pressure test or inflow test". The interpretation of the USI log concludes with formation bonding between 13 3/8" casing and the Green clay formation over the intervals from 988 m to 970 m, 960 m to 937 m, 860 m to 735 m MD RKB.* <small>*All depth refers to m MD RKB (RKB is 35.6 m on West Venture)</small>		
Well Control Requirements Troll Olje	Date: 14.06.07 Rev.: 0	Barrier Status 31/3-Q-21 - P&A for re-entry

Figure 4-1: Barrier status, Q-21 (2007)

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4.1.2 Barrier status, 2020

Well Q-21 was given an orange barrier status in 2020 based on: "no cement with high isolation potential in the 10 3/4" liner cement. Secondary barrier moved to 13 3/8" casing cement", as shown in Figure 4-3. The cement job on the 13 3/8" casing in the B-bore was done in 2007 but not logged. When casing cement is used as a common well barrier, i.e. representing primary and secondary barrier elements, it is required to perform a cement bond log and prove that there is a minimum of 2 x 30 m cemented interval with sufficient hydraulic bonding, where 30 m is the barrier length requirement for single well barrier element. The vertical position of the barriers shall be such that the uppermost barrier section (upper 30 m) is strong enough to sustain maximum anticipated pressure from below.

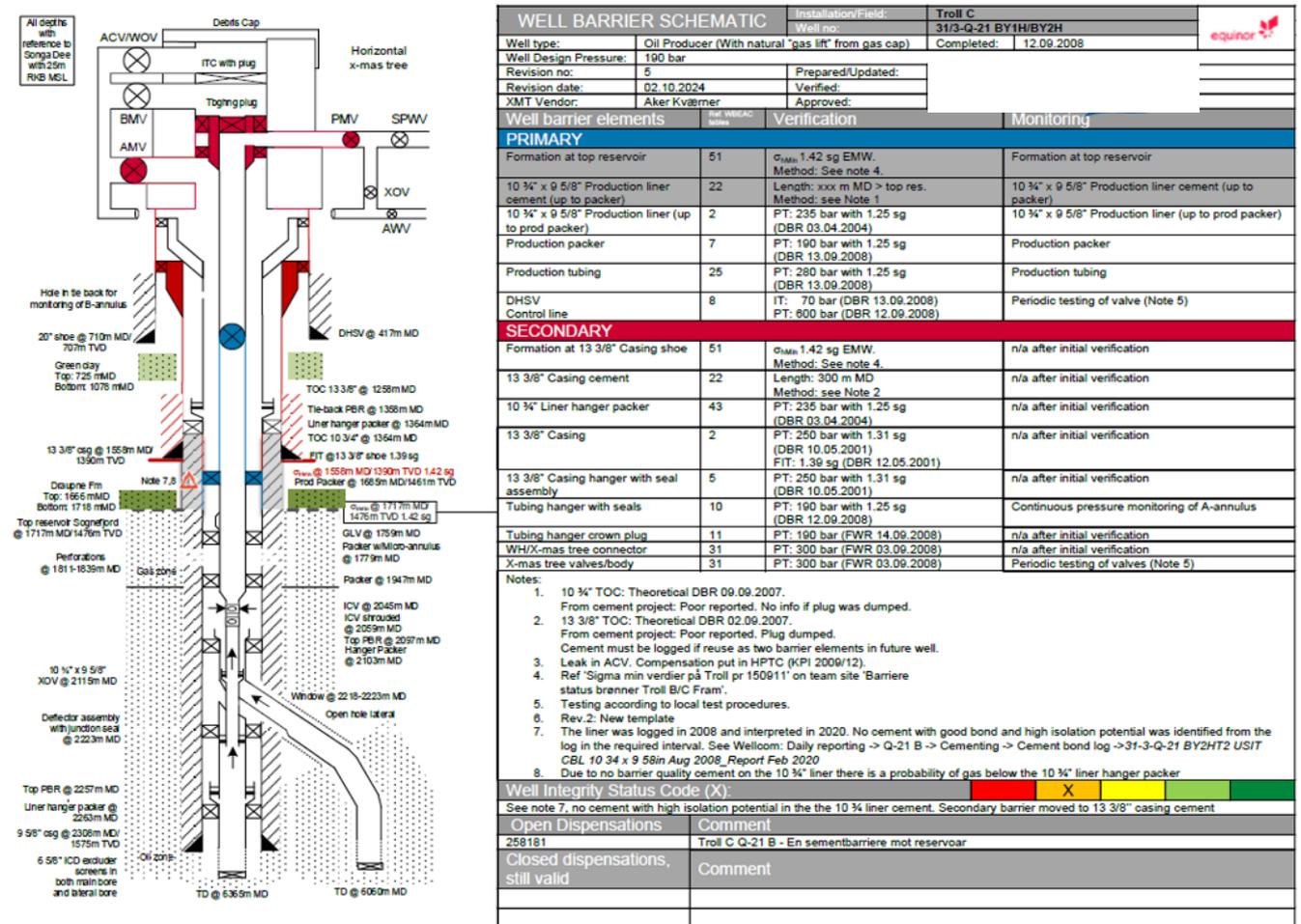


Figure 4-3: Barrier status prior to pre-P&A work in 2025 (Schematic from 2008)

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4.1.3 Planning of 31/3-Q-21 BY1H – P&A

Organization

The P&A operation was planned by PC2 PP&A sector with continuity of engineering resources from feasibility phase through to execution phase.

Planning documents

Planning work followed the Company management system well construction process for workover and PP&A offshore (DW200), where key products were:

- The feasibility report³, signed 20.03.2025.
- The concept selection report⁴, signed 01.07.2025.
- The Well Activity program for permanent P&A (rev 02)⁵, signed 26.08.2025.
- Handover from PC to OC⁶, dated 26.08.2025.
- DOP for cutting 13 3/8" casing⁷, Rev 1.0 signed 22.09.2025 19:33

4.1.4 Risk register for operation at Q-21 (2025)

The work process DW200 sets expectations for risk assessments throughout the work process:

- DW250.01 – Manage resources and establish project.
 - R-111852 Risk evaluation
 - R-37447 Risk matrix
- DW211 – Perform concept planning.
 - R-104860 Facilitator competence (facilitator for risk analysis)
 - R-114778 Feasibility risk analysis
 - R-37881 Conceptual risk analysis
- DW212 – Perform detailed planning.
 - R-11923 Operational risk analysis

Summary of the respective risk analysis belonging to each planning phase (feasibility, concept, detailed engineering) were summarized in the planning reports^{3, 4, 5}.

The risk of no/poor 13 3/8" annulus cement (bonding) was recognized in the feasibility phase of the planning process with mitigating action "Prepare contingency plan(s) to locate alternative annulus barrier intervals".

4.1.5 Dispensations

One of the valid dispensations during operation on Q-21 operation in September 2025:

- #258181: Only one cement barrier against reservoir

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- Dispensation describe that the annular cement was uncertain prior to P&A operations as the previously logged 10 3/4" cement log did not show any annular cement with sealing potential, and that the 13 3/8" cement was uncertain as it was not logged prior to operation. The 13 3/8" cement was still believed to be of good quality based on that the cement job went according to plan and well response.
- This dispensation led to an orange well integrity status for the well which triggered the P&A operations.

4.1.6 Cement bond logging

A cement bond log was performed on the 13 3/8" casing 21st of September with the following objectives as outlined in the logging request from the planning group to Cased Hole Logging Group:

- Cement bond evaluation
- Formation bond evaluation
- Casing wear evaluation
- Ovality evaluation
- Corrosion evaluation
- Gas detection behind casing

Gas evaluation was intended as a secondary objective; however, this was not adequately communicated to all relevant stakeholders, and the documents used on the rig, i.e. DOP⁷, had weak purpose description for the secondary objective to log for gas behind the 13 3/8" casing (only mentioned in the operational steps).

The logging started with a free-pipe calibration pass followed by the main log from 1348 m and up to WH to also cover fluid in the annulus above top of cement. The logging was done with normal communication procedures in place between logging engineer at the rig site and the onshore cased hole logging duty.

Free pipe calibration was performed at depth of 500–700 m according to the DOP with the assumption that annulus was liquid filled. The acoustic impedance processed from the raw data did not return expected values matching a liquid phase. Hence, in accordance with vendor procedure the geometric correction factor C0 was turned off. C0 is a constant in a polynomial used by the algorithm to adjust the measured values from the logging tool, compensating for casing curvature. When turning this constant off the algorithm, the read values shifted and resulted in the log showing the expected mud correcting factor.

Figure 4–4 shows the expected impedance values for different types of materials in the unit Mrayls, representing a product of the sound velocity and density.

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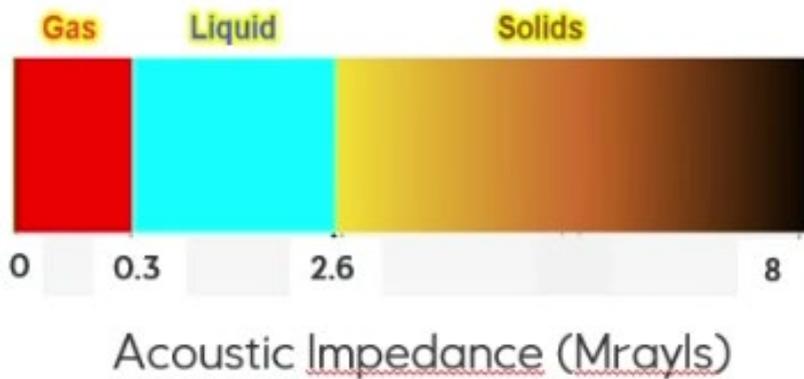


Figure 4-4: Acoustic Impedance value bands for varied materials

Turning C0 OFF caused a shift in the acoustic impedance.

The casing was logged, and the results were sent to the Cased Hole Logging group onshore. During qualification of the tool, the C0 factor was not mentioned – hence the CHLG and duty team were unaware of the possibility of disabling this factor and the consequences of doing so. The Standard Operation Procedure does not mention the C0 factor specifically – but shows it in one figure where it is shown as ON. When C0 was turned off, it caused a shift in the reported acoustic impedance values on the primary layer by approximately 1.4 MRayls, which resulted in gas appearing as liquid in the logging data provided to the Cased Hole Logging group for interpretation. This shift is not a constant value, but will depend on type and size of tubular (casing), fluid type in the well, weight of casing etc.

4.1.7 Execution of 31/3-Q-21 BY1H – P&A – Cutting of 13 3/8” casing

Before the cutting operation there was old water-based mud on the annulus side of the 13 3/8” casing and drill water inside the 13 3/8” casing and riser. U-tubing was expected and was included as a risk with regards to well control. Well Barrier Status immediately prior to the commencement of casing cutting operations is given in Figure 4-5.

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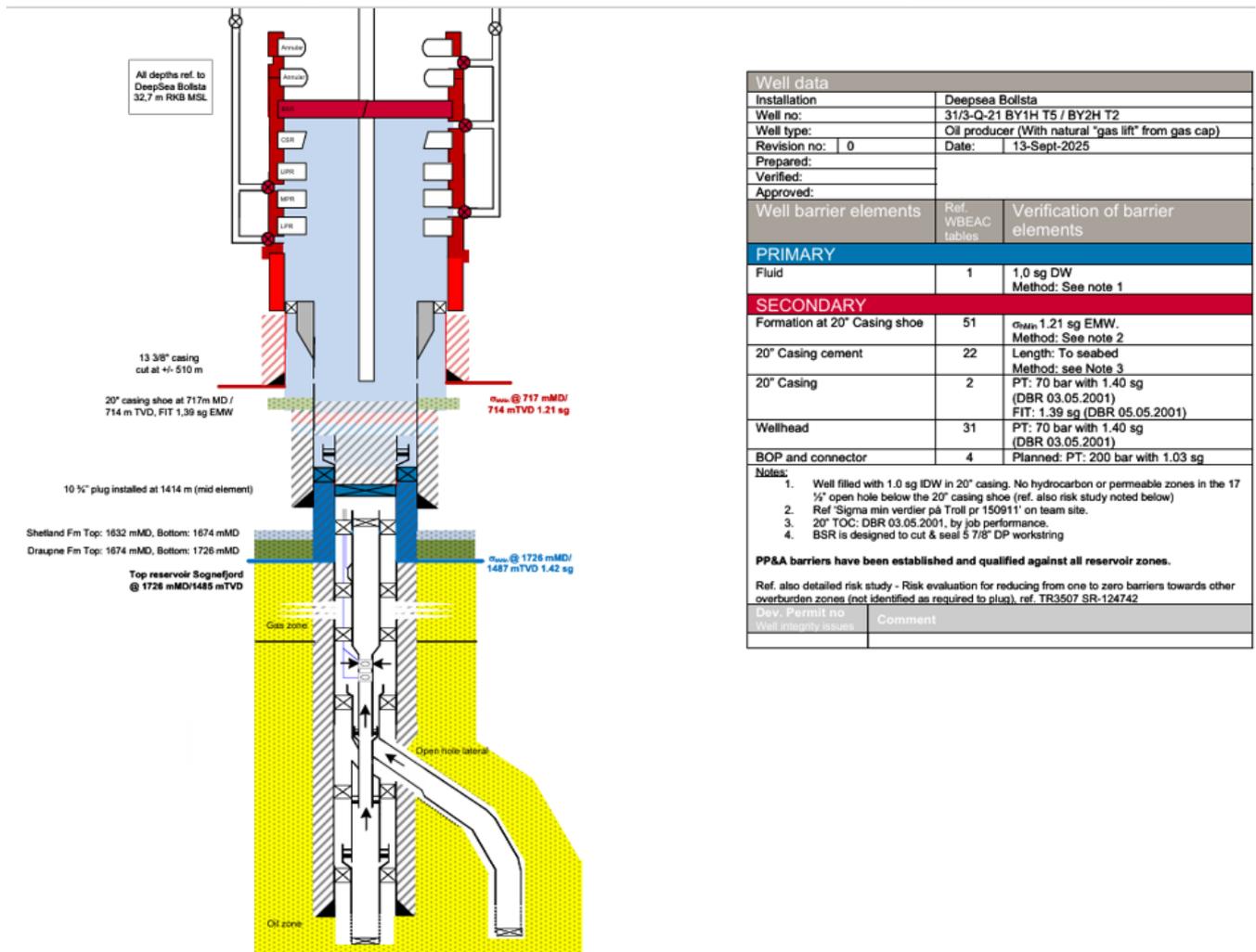


Figure 4-5: Well Barrier Status immediately prior to the commencement of casing cutting operations

At 03:57 in the morning 23rd September 2025⁸, the 13 3/8" casing was cut at 510 m and the well started to flow. Pumps were stopped, the crew on the drill floor excluded u-tubing as the cause of increased flow out and activated the BOP and diverter. Large amounts of water created overflow on the shakers, followed by mixture of water and gas. On drill floor a flow of water was observed from the rotary table followed by gas reaching above fingerboard level. HC Gas sensors activated ESD1 shutdown of all non-essential power sources according to design.

The areas with highest measurements of HC gas were detected in the timeline as presented in Figure 4-6:

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TAG	GD activation order	Activation after first GD [s]	Max [%LEL]	Location
811-F-AB-0026	1	0	99,9	HC Gas In Shale Shaker Room Stbd
811-F-AB-0113	2	0,1	20,0	HC Gas In Shale Shaker Room Exhaust Duct
811-F-AB-0114	3	2	19,9	HC Gas In Screen Cleaning Exhaust Duct
811-F-AB-0059	4	2	99,8	HC Gas In Lower Part Shale Shaker
811-F-AB-0067	5	7	100,1	HC Gas In Drill Floor Port
811-F-AB-0028	6	7	14,8	HC Gas In Drill Floor Stbd
811-F-AB-0060	7	8	71,5	HC Gas In Lower Part Shale Shaker
811-F-AB-0065	8	9	100,0	HC Gas In Shale Shaker Room
811-F-AB-0017	9	13	26,7	HC Gas In Lower Part Shale Shaker
811-F-AB-0016	10	15	25,5	HC Gas In Lower Part Shale Shaker
811-F-AB-0027	11	19	99,8	HC Gas In Shale Shaker Room Stbd
811-F-AB-0068	12	30	15,5	HC Gas In Drill Floor Aft Port

Figure 4-6: Gas sensor levels with the highest peak measurements

As gas expanded into the shale shaker room the pressure differential in the room has altered affecting the sealing elements around the doors. This pressure differential change was also experienced by the person escaping the room as making the doors more difficult to open.

Drill water was discharged from the gumbo box under pressure, resulting in damage to the ventilation ducts located under the ceiling over the gumbo box, see Figure 4-7.



Figure 4-7: Gumbo box with damage in grating on top of it, and damages to HVAC ducts in the ceiling above the gumbo box

First gas detected in shale shaker room at 03:58:20 (811-F-AB-0026 & 811-F-AB-0113). 811-F-AB-0113 reached HC gas level HH (20%LEL) at 03:58:20 in shale shaker room exhaust duct. ESD1 activated as per design and tripped essential ignition sources at 03:58:21. 811-F-AB-0059 in Lower Part of shaker reached HC gas level HH at 03:58:22 and continued to elevate ESD1 shutdown.

Due to the rapid gas filling of shaker area and surrounding areas, the ESD shutdown continued the actions with ignition sources isolation until 03:58:28.

When the diverter closed, the remaining flow was fully diverted to overboard line.

Figure 4-8 shows gas sensor event log with alarms, shaker room

Figure 4-9 and 4-10 shows the gas recordings in percentage of the LEL for the shaker room and drill floor area.

Figure 4-11 shows illustration of gas measurements on the rig in all areas with duration.

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User time: Europe/Berlin	Tag	Terminal	Description	Station	Priority	Event Text
2025-09-23 03:58:20.045	811-F-AB-0113	AlarmH	HC Gas In Shale Shaker Room Exhaust Duct	PS075	High	HC Gas Alarm High
2025-09-23 03:58:20.045	NETDO2-75-74-01		Communication from node 75	PS075	Info	A Dev trm 3.In=15 Ou
2025-09-23 03:58:20.045	811-F-AB-0113	AlarmHH	HC Gas In Shale Shaker Room Exhaust Duct	PS075	High	HC Gas Alarm HighH
2025-09-23 03:58:21.042	811IXS0156+74		Single HC Gas (MCR CAP)	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	854IXS0105+D15		Buzzer to CAP	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	811IXS0157+D15		Confirmed HC Gas Alarm to CAP	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	811IXS0257+74		Confirmed HC Gas (LCR CAP)	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	854IXS0305+74		Buzzer (DCR CAP)	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	FG-MAIN-D15		Main module for SCREEN STORE & CLEANING RM & SHALE SHAKER RI	PS074	Info	Activated
2025-09-23 03:58:21.042	811IXS0257+D15		Confirmed HC Gas Alarm to CAP	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	854IXS0105+74		Buzzer (MCR CAP)	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	811IXS0370+D15		HC(Combustible) Gas Alarm to CAP	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	854IXS0205+D15		Buzzer to CAP	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	HC1-VSA1-D15		HC Gas 8%LEL 1ooN	PS074	Info	Activated
2025-09-23 03:58:21.042	811IXS0256+D15		Single HC Gas Alarm to CAP	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	HC1-VSA2-D15		HC Gas 16%LEL 1ooN	PS074	Info	Activated
2025-09-23 03:58:21.042	811IXS0157+74		Confirmed HC Gas (MCR CAP)	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	854IXS0205+74		Buzzer (LCR CAP)	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	HC-VSA1-D15		HC Gas 20%LEL 1ooN	PS074	Info	Activated
2025-09-23 03:58:21.042	811IXS0370+74		Shale Shaker Room HC Gas (DCR CAP)	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	571-DE-111+D15		Lead/Follow Order	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	811IXS0156+D15		Single HC Gas Alarm to CAP	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	811-F-AB-0059	AlarmH	HC Gas In Lower Part Shale Shaker	PS074	High	HC Gas Alarm High
2025-09-23 03:58:21.042	811IXS0256+74		Single HC Gas (LCR CAP)	PS074	Info	Aut. activation on
2025-09-23 03:58:21.042	854IXS0305+D15		Buzzer to CAP	PS074	Info	Aut. activation on
2025-09-23 03:58:22.042	425IXA0003+D15		HC(Combustible) Gas Alarm to PAGA A	PS074	Info	Aut. activation on
2025-09-23 03:58:22.042	811-F-AB-0059	AlarmHH	HC Gas In Lower Part Shale Shaker	PS074	High	HC Gas Alarm HighH
2025-09-23 03:58:22.042	HC-VSA2-D15		HC Gas 40%LEL 1ooN	PS074	Info	Activated
2025-09-23 03:58:22.042	425IXA0003+74		HC(Combustible) Gas Alarm To PAGA A	PS074	Info	Aut. activation on
2025-09-23 03:58:22.042	425IXA0004+D15		HC(Combustible) Gas Alarm to PAGA B	PS074	Info	Aut. activation on
2025-09-23 03:58:22.042	425IXA0004+74		HC(Combustible) Gas Alarm To PAGA B	PS074	Info	Aut. activation on
2025-09-23 03:58:22.044	811-F-AB-0026	AlarmH	HC Gas In Shale Shaker Room Stbd	PS073	High	HC Gas Alarm High
2025-09-23 03:58:22.044	854-I-XS-0205		Buzzer (LCR CAP)	PS073	Info	Aut. activation on
2025-09-23 03:58:22.044	811-I-XS-0370		Shale Shaker Room HC Gas (DCR CAP)	PS072	Info	Aut. activation on
2025-09-23 03:58:22.044	811IXS0370+7472		Shale Shaker Room HC Gas (DCR CAP)	PS072	Info	Aut. activation on
2025-09-23 03:58:22.044	854IXS0205+7473		Buzzer (LCR CAP)	PS073	Info	Aut. activation on
2025-09-23 03:58:22.044	811-I-XS-0256		Single HC Gas (LCR CAP)	PS073	Info	Aut. activation on
2025-09-23 03:58:22.044	811-I-XS-0257		Confirmed HC Gas (LCR CAP)	PS073	Info	Aut. activation on
2025-09-23 03:58:22.044	NETDO2-73-74		Communication from node 73	PS073	Info	A Dev trm 3.In=7 Out
2025-09-23 03:58:22.044	811IXS0257+7473		Confirmed HC Gas (LCR CAP)	PS073	Info	Aut. activation on
2025-09-23 03:58:22.044	854IXS0305+7472		Buzzer (DCR CAP)	PS072	Info	Aut. activation on
2025-09-23 03:58:22.044	811IXS0256+7473		Single HC Gas (LCR CAP)	PS073	Info	Aut. activation on
2025-09-23 03:58:22.044	854-I-XS-0305		Buzzer (DCR CAP)	PS072	Info	Aut. activation on
2025-09-23 03:58:22.068	811IXS0157+7471		Confirmed HC Gas (MCR CAP)	PS071	Info	Aut. activation on
2025-09-23 03:58:22.068	854IXS0105+7471		Buzzer (MCR CAP)	PS071	Info	Aut. activation on
2025-09-23 03:58:22.068	811-I-XS-0156		Single HC Gas (MCR CAP)	PS071	Info	Aut. activation on
2025-09-23 03:58:22.068	854-I-XS-0105		Buzzer (MCR CAP)	PS071	Info	Aut. activation on
2025-09-23 03:58:22.068	811-I-XS-0157		Confirmed HC Gas (MCR CAP)	PS071	Info	Aut. activation on
2025-09-23 03:58:22.068	811IXS0156+7471		Single HC Gas (MCR CAP)	PS071	Info	Aut. activation on
2025-09-23 03:58:23.042	HC-VCA1-D15		HC Gas 20%LEL 2ooN	PS074	Info	Activated
2025-09-23 03:58:23.044	425IXA0004+7473		HC(Combustible) Gas Alarm To PAGA B	PS073	Info	Aut. activation on
2025-09-23 03:58:23.044	425-I-XA-0003	Conflict	HC(Combustible) Gas Alarm To PAGA A	PS073	Medium	Activation conflict
2025-09-23 03:58:23.044	425-I-XA-0003		HC(Combustible) Gas Alarm To PAGA A	PS073	Info	Activation conflict
2025-09-23 03:58:23.044	811-F-AB-0114	AlarmH	HC Gas In Screen Cleaning Room Exhaust Duct	PS075	High	HC Gas Alarm High

Figure 4-8: Gas sensor event log with alarms, shaker room

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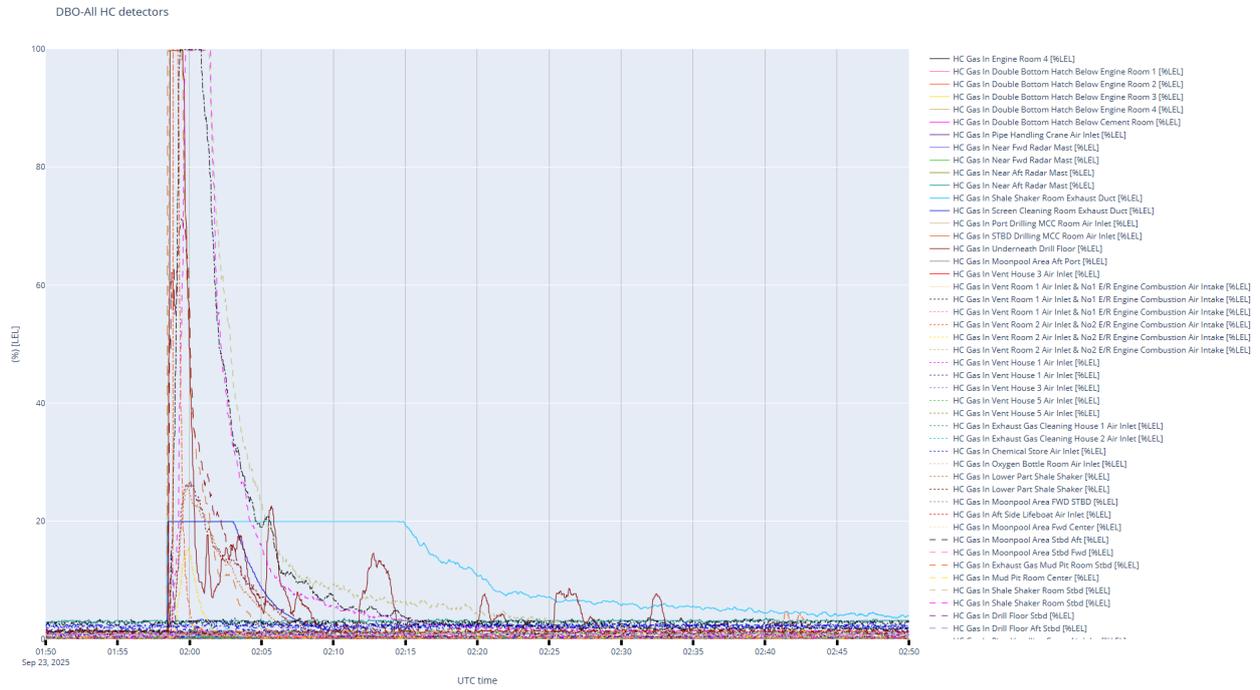


Figure 4-11: Illustration of gas measurements on the rig in all areas with duration

Figure 4-12 shows key events from K-IMS event log with timestamp of events for confirmed gas and ESD shutdown activation.

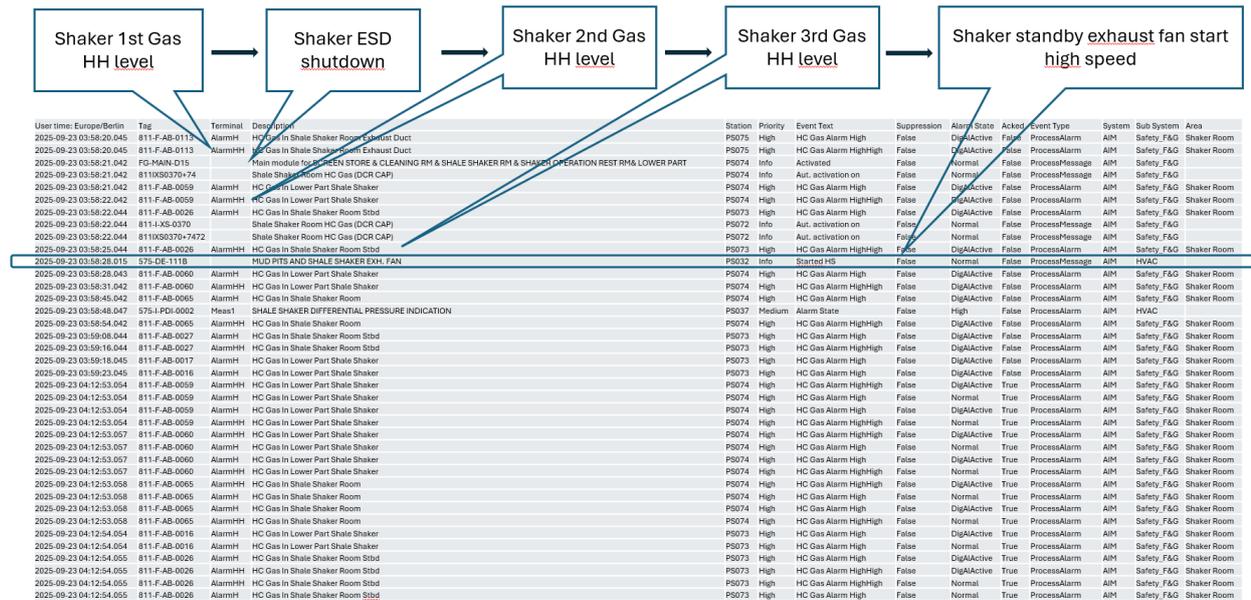


Figure 4-12: Key events from K-IMS event log with timestamp of events for confirmed gas and ESD shutdown activation.

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Following identification of gas behind the 13 3/8" casing, a reprocessing of the cement bond log data was requested and performed. The reprocessed log showed gas filled annulus from 648 m to WH.

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5 Similar incidents

The investigation team have looked through our databases of well control incidents and experience reports to identify if similar incidents have occurred. There are learnings from other incidents and experiences with underlying causes that overlap with those of this incident:

Area:

Troll has relevant experiences, such as:

Troll G-4 well with gas release during pulling of tubing hanger with open BOP. This incident was reviewed and discussed in the planning and preparation for operation.

Troll P-24 well with a significant volume of trapped gas behind the 13 3/8" casing, where sufficient annulus barriers had been verified by log results.

Well control:

The investigation team have identified that there are well control experiences during plug and abandonment operations with open BOP which triggered gas alarms.

Similar activities:

There are experiences from logging results, where log indicated one type of fluid behind casing, but it was proven false when fluid was circulated out and verified on surface.

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6 Consequences

With basis in the categorization and classification matrix, the actual and potential consequences are assessed for relevant consequence columns given in this matrix.

Category Severity level	Injury		Work-related illness (WRI)	Uncontrolled discharge/emissions		Oil/gas/flammable liquids leakages		Fire/explosion		Safety barriers Ref. section 3.3.6.	Reputation	
	Actual	Potential	Actual	Actual	Potential	Actual	Potential	Actual	Potential	Actual	Actual	Potential
1	Fatality		WRI that has led to fatalities.	Single spill with long-term effect on the environment, or discharge/emissions of component > yearly expectancies		>10 kg/sec. or brief leakages >100 kg		Whole facility/plant exposed		Critical impairment or failure in barrier	Great international negative exposure in mass media and among organisations	
2	Serious lost-time injury/serious injury		Severe WRI with probable long-term and/or significant loss of function	Single spill with medium-term effect on the environment, or discharge/emissions of component > monthly expectancies		1-10 kg/sec. or brief leakages >10 kg		Large part of facility/plant exposed		Serious impairment or failure in barrier	Medium international negative exposure in mass media and among organisations	
3	Other lost-time injury or injury involving substitute work		WRI that has led to absence or substitute work, with temporary loss of function	Single spill with short-term effect on the environment, or discharge/emissions of component > weekly expectancies		0.1-1 kg/sec. or brief leakages >1 kg		Parts of facility/plant exposed		Moderate impairment or failure in barrier	National negative exposure in mass media, from authorities on national level	
4	Medical treatment injury		WRI that has resulted in assessment and medical treatment by authorised health personnel, but has not resulted in absence or substitute work	Single spill with minor effect on the environment, or discharge/emissions of component < weekly expectancies		< 0.1 kg/s		Local area of facility/plant exposed		Minor impairment or failure in barrier	Local/regional negative exposure in mass media, from authorities and customers	
5	First aid injury		WRI that has not resulted in medical treatment, absence or substitute work	Single spill or discharge/emission with negligible effect on the environment		<<0.1 kg/sec. (significantly less than 0.1 kg/sec.)		Negligible risk for facility/plant		Negligible impairment or failure in barrier	Limited to a few persons or a single customer	

Table 6-1: Matrix for categorization and classification of severity of incidents WR9592

Severity (loss potential)	Actual consequence – Down time	Equipment/material and other non time related costs
1 (Very large cost)	More than 20 days down time	More than 50 million NOK
2 (Large cost)	10-20 days down time	More than 25 million NOK
3 (Medium cost)	5-10 days down time	More than 10 million NOK
4 (Minimum cost)	1-5 days down time	More than 500 000 NOK
5 (Negligible cost)	Less than 1 (24hrs) day down time	Less than 500 000 NOK

Table 6-2: R-105426 – Identify and register consequences/loss potential drilling and well.

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6.1 Actual consequences

6.1.1 Injury

It was difficult for IP to evacuate the shaker room, and IP had to use more force than usually, and the IP fell on the floor in the adjacent room to the shaker room and sustained an abrasion on the elbow and back pain due to falling on the floor onto the radio. The actual consequence for personal injury was therefore classified as a first-aid case.

Classification set to Green 5.

6.1.2 Uncontrolled discharge/ emissions

Discharge to open Sea

Maximum 22 cubic meters of fresh water were discharged to sea via the diverter system. The volume is based on a calculation of total volume of 75 cubic meters in the well system. 10 cubic meters were reported collected in the active pit, and 43 cubic meters were reported collected in the drain tank.

Fresh water is classified as a green chemical. According to WR9592 Table 5 Details for uncontrolled discharge/ emissions category, single spill of green chemicals below 100 m³ is classified as a single spill or discharge/emission with negligible effect on the environment.

Classification set to Green 5.

Uncontrolled discharge of gas

Calculations indicate that approximately 930 kg gas was released to the atmosphere in connection with the incident⁹. The composition of the gas is given in Memo Gas Hazard Analysis – Well control incident Deepsea Bollsta sept.25⁹ (85% CH₄, 10% C₂H₆, 5% C₃H₈)

Natural gases are classified as yellow chemicals. According to Table 5 Details for uncontrolled discharge/ emissions category, single spill of yellow chemicals below 1 tonne is classified as a single spill or discharge/emission with negligible effect on the environment.

Classification set to Green 5.

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6.1.3 Oil/gas/flammable liquids leakages

Simulations⁹ indicates a 10 kg/s gas release over 18 seconds in the shaker room. Simulations also indicate 10kg/s gas release in the drill area. The analysis indicated that it is plausible that the total mass flow during the incident exceeded 20 kg/s.

Calculations indicate that approximately 930 kg gas was released to the atmosphere in connection with the incident⁹.

Classification set to Red 1.

6.1.4 Fire/explosion

The incident did not lead to a fire or explosion.

6.1.5 Safety barriers

According to WR9592 3.3.6 the assessment of impairments or failures shall be based on relevant Performance Standards. A detailed evaluation of Performance Standards is given in Table 9-2. The safety barriers on the rig, i.e., BOP, gas detection and ESD, worked as designed and prevented escalation of the incident. The Operational Barrier Element related to activate the BOP worked as intended. Adequate well barriers against the reservoir at the time of the incident was established.

Weakness is identified within Performance Standard PS14:

PS14 Escape, Evacuation, and rescue:

- In the case of a hazardous incident, the purpose of escape route is to ensure that personnel may leave the area(s) in question by at least one safe route.
- Due to a change in the pressure differential across door into/out of the shaker room was experienced as more challenging to evacuate from the shaker room.

Based on the impairment identified in PS14, classification is set to Green 5.

6.1.6 Cost/Down time

The incident resulted in 4 days of rig down time. According to R-105426 – Identify and register consequences/loss potential for 4 days of rig down time corresponds to minimum cost.

Classification set to Green 4.

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6.2 Potential consequences

The investigation team has assessed the potential for the incident, with basis of what could have happened under slightly different circumstances. "Slightly different circumstances" means that it is only by chance that alternative outcomes of the incident did not occur, not what could have happened in worst case.

Fact box 6-1 Explanation of "slightly different circumstances"

"Slightly different circumstances" means that it was only by chance that alternative outcomes of the incident did not occur, and not what could have happened in worst case. The term is elaborated on in *GL0604 - Potential severity in safety incidents under slightly different circumstances*.

6.2.1 Injury

The investigation team has assessed that an increase in the severity level under slightly different circumstances is not likely if the gas was not ignited. Classification set to Green 5.

6.2.2 Uncontrolled discharge/ emissions

The investigation team has assessed that an increase in the severity level under slightly different circumstances is not likely.

Classification set to Green 5.

6.2.3 Oil/gas/flammable liquids leakages

The investigation team has assessed that an increase in the severity level under slightly different circumstances is not likely.

Classification set to Red 1.

6.2.4 Fire/explosion

The gas release resulted in a condition where the HC concentration reached 100% LEL in both the shaker room and on the drill floor.

According to WR9592 3.3.5 Fire/explosion "For oil/gas leakages, the potential severity for fire/explosion is normally equal to the severity of the leakage."

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Text from GL0604 *Potential severity in safety incidents under slightly different circumstances 3.5*
Flammable and toxic leaks states is given in Figure 6-1.

The potential for the leak to ignite and to develop into a fire or explosion should be assessed. Even though the probability of ignition is generally low, ignition barriers can always have integrity weaknesses, auto ignition of the leak or ignite by the failure itself. Fire and explosion must therefore be considered as a possible outcome, under slightly different circumstances, when there have been leaks of flammable fluids. The following aspects should be assessed:

- Weakening of other relevant safety barriers, e.g., gas detection, ignition source control, ventilation in the area
- Failure or delay of ESD (Emergency Shut Down) actions including disconnection of EX equipment
- Hot work planned, ongoing or recently carried out.
- Hot surfaces in the area or vicinity
- Combustion engine(s) (turbines, diesel engines, motor vehicles, etc.) in the area or vicinity
- Ignition due to personnel work/activity in the area
- Static electricity (fuelling/filling, earthing, etc.)
- Technical condition of EX equipment in the area
- Possible auto ignition i.e., hot medium contact with air
- Other possible ignition sources

Weaknesses or failures in one or more of the elements mentioned above should conclude that a leak has the potential to develop into a fire or explosion. The potential severity of a fire or explosion is normally equal to the severity of the leak. It should be documented in Synergi if it is concluded that:

- The severity of fire/explosion is lower than the severity of the leak.
- The leak could not cause a fire or explosion.

Figure 6-1: From GL0604 Potential severity in safety incidents under slightly different circumstances 3.5
Flammable and toxic leaks.

The investigation teams' assessment of these aspects:

- **Weakening of other relevant safety barriers, e.g., gas detection, ignition source control, ventilation in the area:** The gas concentration exceeded 100% LEL for three minutes in the shaker room.
- **Failure or delay of ESD (Emergency Shut Down) actions including disconnection of EX equipment:** The ESD system functioned as intended. Due to the large volume of gas entering the shaker room within a short period (1 second), there was a temporary condition where the gas concentration reached 100% LEL before the ESD fully shut down.
- **Hot work planned, ongoing or recently carried out:** The investigation team has not revealed that any hot work was planned or carried out in the area in connection with the incident.
- **Hot surfaces in the area or vicinity:** No hot surfaces in the area or in the vicinity, related to the incident has been discovered by the investigation team.
- **Combustion engine(s) (turbines, diesel engines, motor vehicles, etc.) in the area or vicinity:** There were no combustion engines in the area or vicinity of the incident.
- **Ignition due to personnel work/activity in the area:** The investigation team is not aware of any personnel work or activity in the area that could have resulted in an ignition source.
- **Static electricity (fuelling/filling, earthing, etc.):** No sources of static electricity in the area or in the vicinity, related to the incident has been discovered by the investigation team.
- **Technical condition of EX equipment in the area:** No known degradations in the condition of the EX-equipment in the affected areas are known to the investigation team. The rig had undergone a thorough review of its technical condition in connection with rig mobilization verifications shortly prior to the incident, including a 3rd party EX inspection.
- **Possible auto ignition i.e., hot medium contact with air:** There were no known sources of auto-ignition in the affected areas.
- **Other possible ignition sources:**
 - As a result of the sealing elements around the doors were altered, some of the adjacent compartments were exposed to gas. These rooms were:
 - Shaker operating rest room
 - Screen store
 - Screen cleaning room

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▪ HVAC 1

These rooms are classified as a Hazardous Area Zone 2.

The sealing elements around the door leading to HVAC 2, which is classified as a Non-Hazardous Area, were also altered. There are no gas detectors in this room. It is not known to the investigation team whether this room was exposed to gas or whether there was ignition sources present. The drawing is given in Figure 6-2.

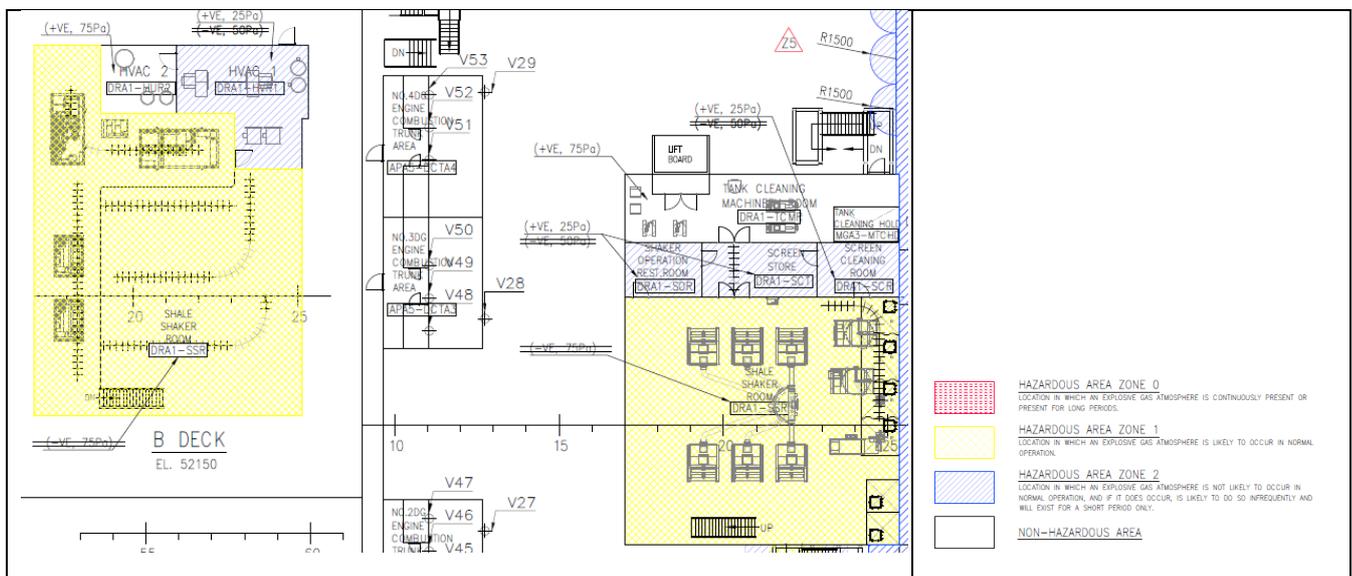


Figure 6-2: From 550-101-S-XE-001 Hazardous Area Plan A Deck Deepsea Bollsta

The Memo Gas Hazard Analysis – Well control incident Deepsea Bollsta sept.25⁹ states: «*The cumulative ignition probability is calculated, and it sums up to about 1.3% probability of ignition (in the shaker room), and it is still above 1% when the flammable cloud is at its largest (relevant for the most severe consequence).*

The same exercise for the drill floor gas dispersion results in a probability around 0.7%. Caution is advised when using modelled probabilities for evaluation of potential consequences.”

Based on an overall assessment of potential ignition sources and the rig’s overall technical condition at the time of the incident, the investigation team concluded that ignition of the gas release under slightly different circumstances was not likely at the time of the event.

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6.2.5 *Cost*

The investigation team has assessed that an increase in the severity level under slightly different circumstances is not likely.

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6.3 Classification of the incident

Category	Actual degree of seriousness	Potential degree of seriousness
Injury	5	5
Uncontrolled discharge/emissions	5	5
Oil/gas/flammable liquids leakages	1	1
Fire/ explosion	Gas not ignited	No ignition of gas
Safety barriers	5	
Costs/ losses	4	4

Table 6-3: Incident classification

6.4 Well control incident classification (GL0455)

The incident corresponds with “Level 4 –Non–Classified” according to App A (Figure 6-3) and D4.1-04 in App C in GL0455 *Guidelines for categorization and classification of well control incidents during well construction/intervention*, given in Figure 6-4.

Level 4 - Non-Classified (NC)	1. Non-continuous gas/water migration in well - with all barriers in place	1. Release of a barrier element with contained volume of gas/water trapped below or behind casing.
-------------------------------	--	--

Figure 6-3: From App A in GL0455

D4.1 - 04 Released gas after cutting or perforation of casing string - no continuous flow
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Figure 6-4: From App C in GL0455

This incident has therefore been classified as a Level 4 – non–classified (grey) well control incident, according to GL0455. GL is based on the probability for escalation of a well control incident into a full blow out. In this incident both primary and secondary barriers against all flowing units were in place, and the release was from a trapped gas volume. Equinor GL0455 is mirroring Offshore Norge GL135.

7 Causes

7.1 Well Control Incident Troll Q-21

7.1.1 Causal map Well Control Incident Troll Q-21

Fact box 7-1 Use of symbols in Figure 7-1 and 7-5

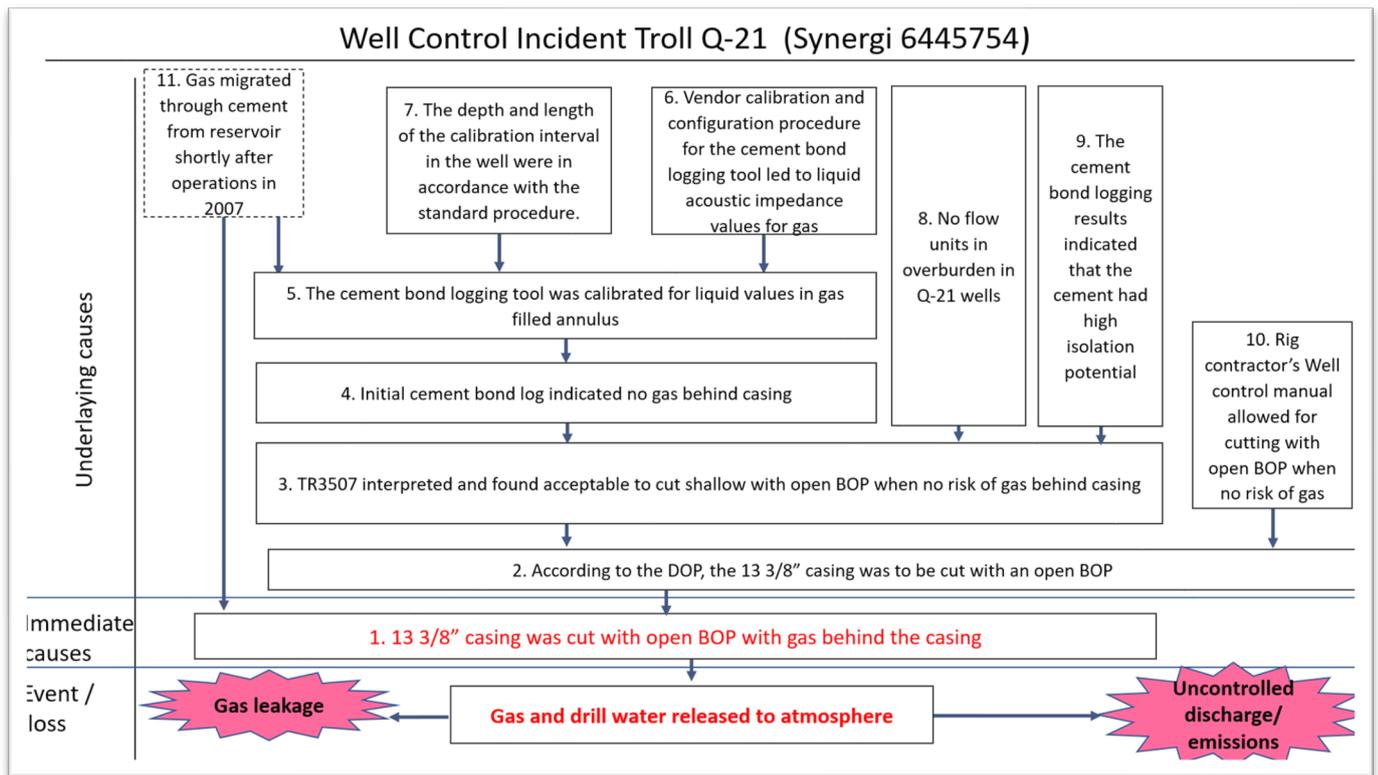
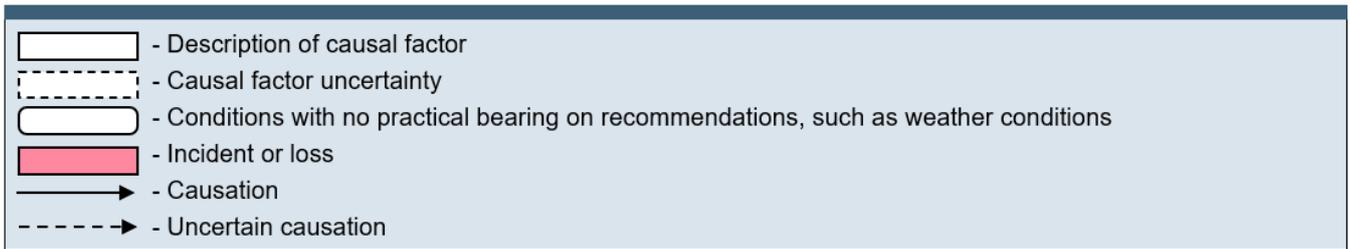


Figure 7-1: Causal map well control incident Troll Q-21

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7.1.2 Immediate causes with regards to well control incident

1. 13 3/8” casing was cut with open BOP with gas behind the casing

The immediate causes to release of gas to the atmosphere were cutting of the 13 3/8” casing with open BOP in combination with the presence of gas behind the 13 3/8” casing.

7.1.3 Underlying causes with regards to cutting of 13 3/8” casing with open BOP

2. According to the DOP, the 13 3/8” casing was to be cut with an open BOP

The rig followed the DOP¹⁴ for the operation and cut the 13 3/8” casing with an open BOP.

3. TR3507 interpreted and found acceptable to cut shallow with open BOP when there is no risk of gas behind casing

TR3507 SR-126590 is given in Figure 7-2:

SR-126590 - For operations with a risk of exposure of HC in combination with insufficient BOP activation time, the BOP shall be closed upfront the operation.

Justification	To ensure sufficient well barriers in place at all times. Ref. Norsok D-010 rev. 5 ch. 10.3.6. inclusive its intentions.
Interpretation guidance	Examples: - release and pulling of casing/tubing seal assemblies - release and pulling of shallow plugs - cutting casing shallow For deep plugs, be aware that significant volumes of HC may be present below the plug without pressure observed at surface when equalizing across the plug. For this scenario keep the annular BOP closed during circulation of bottoms up.

Figure 7-2: TR3507 SR-126590

The governing documentation in force during the planning and execution of the operation allowed for differing interpretations. The planning team interpreted SR-126590 as permitting casing cutting with an open BOP, provided there was no risk of hydrocarbon exposure. This was a common interpretation of the requirement, and the operation had been performed in a similar manner on other wells.

Several measures were implemented to verify that there was no risk of hydrocarbons. Cement logging was performed, and the logging results indicated that the cement was properly sealed and exhibited adequate zonal isolation. No flow units in overburden in Q-21 were identified during the mapping. As a final verification, a cement bond log was run to detect gas behind the casing. The results indicated that no gas was present behind the casing.

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Based on these verifications, it was assumed that there was no risk of hydrocarbon exposure and that the casing cut could be performed with the BOP in an open configuration, as the interpretation of SR126590 stated.

4. Initial cement bond log indicated no gas behind casing

The blue colour in the azimuthal impedance map in Figure 7-3 indicates liquid filled annulus.

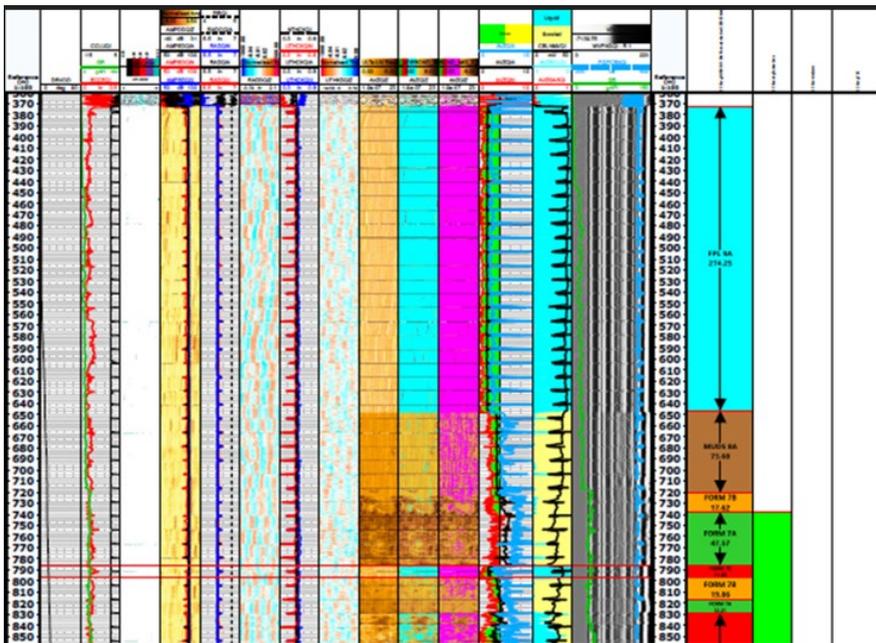


Figure 7-3: Azimuthal impedance map

Preliminary interpretation table in Figure 7-4, also stated liquid.

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Interval top (mMD)	Interval bottom (mMD)	Annular Contents	Annular Status	Annular Condition Code	Isolating potential based on cement or formation quality (annular distribution and bond quality) NB see notes: [1], [3]	Length of Interval if Isolating Potential is "High" (NB: see notes [2], [3])	Comments
13 3/8 x 20" Casing annulus below							
372	647	Free Pipe - Liquid	Liquid Filled Free Pipe	FPL 9A	Not applicable	0	
647	720	Barite	Settled mud solids - High Density / Well Bonded	MUDS 8A	Not applicable	0	
13 3/8 x 17,5" OH annulus below							
720	738	Formation	Formation Bond Medium / Not Barrier Quality	FORM 7B	Medium	0	
738	786	Formation	Formation Bond Good / Barrier Quality	FORM 7A	High	48	This formation bond is too shallow to be used for barrier purpose

Figure 7-4: Preliminary interpretation table

5. The cement bond logging tool was calibrated for liquid values in gas filled annulus

The calibration interval was done between 498 – 600 m MD RKB Deepsea Bollsta. This interval was chosen due to expectation of containing liquids, however recalculation of the logging data after the incident showed that the annulus was filled with gas. The calibration was done according to the vendors procedures for the tool.

6. Vendor calibration and configuration procedure for the cement bond logging tool led to liquid acoustic impedance values for gas

The acoustic impedance (AI) readings obtained during the correction for the Mud Correction Factor during the free pipe calibration were outside the expected range for fluids. In accordance with the vendor's procedure, the C0 constant within the algorithm was disabled, which resulted in the values falling within the expected range for fluids. However, this calibration and the deactivation of the constant caused AI values for gas to be reported as fluid values.

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7. The depth and length of the calibration interval in the well were in accordance with the standard procedure

Free pipe calibration pass was performed according to dialogue between vendor and CHLG between 498 – 600 m MD RKB Deepsea Bollsta.

8. No flow units in overburden in Q21 wells

No flow units identified when mapping overburden in Q21 wells. This strengthened the basis for the assumption that there was no gas behind the casing.

9. The cement bond logging results indicated that the cement had high isolation potential.

The cement bond logging results from the logging performed in 2025 indicated that the cement was properly sealed and exhibited sufficient barriers. This provided additional support for the decision that there was no gas behind the casing.

10. Rig contractor's Well control manual allowed cutting with open BOP when no risk of gas

Rig contractor's Well control manual was followed during the operation. The manual allowed for cutting with open BOP when there is no risk of gas.

11. Gas migrated through cement from reservoir shortly after operations in 2007

An evaluation of the source of the trapped gas volume was conducted as a part of this investigation. 4 potential leak paths were identified and investigated:

- Shallow gas
- Overburden gas
- Q-21 AYH reservoir gas, leak from old wellbore.
- Q-21 BYH reservoir gas, leak from current wellbore

The conclusion is that the gas migrated from the Troll reservoir close in time to operations in 2008 from the current wellbore B. Evident by gas cut cement behind 10 ¾" casing, and channelling tendencies in the logged 13 3/8" annulus cement.

Before this incident, early gas migration through intervals later assessed as having quality cement bonding had not been viewed as a plausible risk pathway.

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Channelling has been seen on other cement jobs from this period, e.g., 31/2-W-14 H and 31/2-W-23H. From 2011/12 there has been an increased focus for cement quality reducing this challenge.

Cement logs from 2025 show that the wellbore now has sufficient cement barriers in place to prevent further gas leaks.

For further details see Appendix B.

7.2 Damage observed in the shaker room and associated areas/ systems

7.2.1 Causal map with regards to damage observed in the shaker room and associated areas/ systems

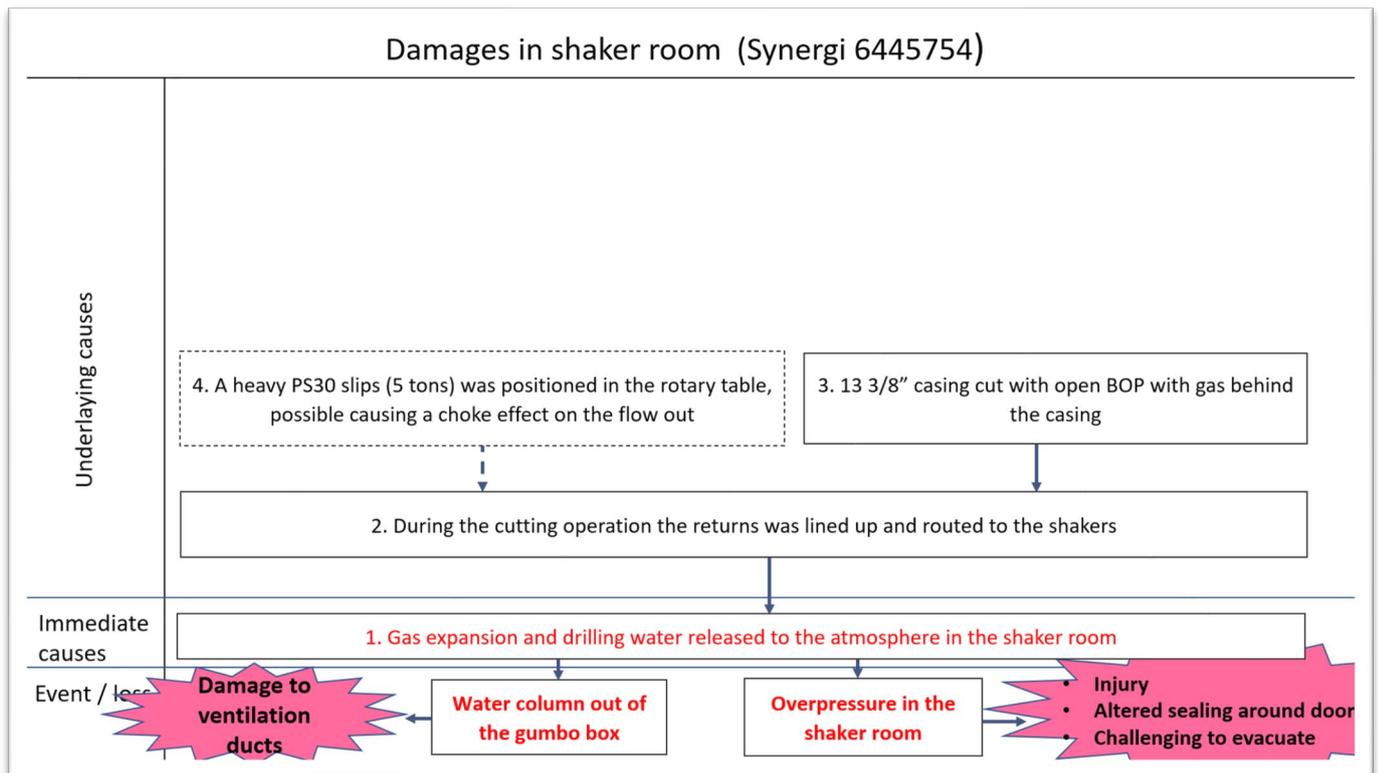


Figure 7-5: Damage observed in the shaker room and associated areas/ systems.

7.2.2 Immediate causes regarding damage in shaker room

The immediate causes of damage in the shaker room were gas expansion and drilling water released to the shaker room, a room with closed volume of 1750 m³.

Differential pressure sensors (Pascal range) between the shaker room and shaker operator cabin, screen storage, and HVAC rooms indicated a sudden change of pressure at the time of the incident. The differential pressure between the rooms was equalized when the door seals were damaged, allowing air to flow freely between the rooms.

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7.2.3 Underlying causes with regards to damage to the shaker room

2. During cutting operation, the return was lined up and routed to the shakers.

During cutting operation, the return was lined up and routed to the shakers. This is the standard flow path when the BOP is open.

3. 13 3/8" casing cut with open BOP with gas behind the casing

See causal map for Causal map Well Control Incident Troll Q-21 in Figure 7-1.

4. A PS30 slips was positioned in the rotary table, possibly causing a choke effect on the flow out.

The pressure from the gas was released upwards from the cutting depth through the BOP and marine riser to surface. A 5-ton PS30 slips was positioned in the rotary table, possibly causing a choke effect on the flow from the well. Fluid (water and gas) takes the lightest route, and shaker room was significantly exposed. This may provide an explanation for the greater extent of damage observed in the shaker room because of this incident, unlike, for example, the Well Control Incident at Troll G-4 (Songa Endurance, Synergi 1488377).

The flow to the shaker room stopped when the flow line valve was closed during the diverter sequence.

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8 Mudlogging shutdown and restart

According to design documentation "Ignition source control (ICS) philosophy" (Figure 8-1) the mudlogging unit is considered "essential equipment" and should be kept alive to maintain drilling operations.

Group 2:

Includes essential equipment that must be kept alive to maintain drilling operations and station keeping.

- Drilling equipment and electrical distribution panels, switchboards, transformers, except equipment related to group 3.
- Ex certified temporary/ 3rd party equipment (ROV, Mud Logging etc.)
- Mud system (except equipment related to group 3)
- All electrical consumers not required during ESD 1,
- Drawworks
- Diesel engines, heaters, boilers, ventilation systems unless defined as a safety critical item.

Figure 8-1: From Document 7S-7142-030 - Ignition source control (ICS) philosophy

According to design documentation "Cause and effect chart for fire and gas, emergency shutdown system" (Figure 8-2), the mud logging unit is defined as "non-essential equipment" and part of ESD1 level.

ESD CAUSE AND EFFECTS ESD1B-ESD1B			EFFECT		CAUSE	
DESCRIPTION	TAG/Title Ref	VOTING	Time Delay	ED	ESD	ESD
ESD 1 PB - CAP in LCB	84-4-338-0026	02-Voted 1ooN (HVELL/Alarm)		1	X	X
Cascade from ESD 1 A	L-ESD1A-E48	17-InterConnection		6	X	X
Confirmed One from All Fire Zone	Ref1	17-InterConnection		7	X	X
Confirmed One in Vicinity of Lattice Boom Crane	Ref2	04-Voted 2ooN (HVELL/Alarm)		8	X	X
Confirmed One in Vicinity of Lattice Boom Crane	Ref3	04-Voted 2ooN (HVELL/Alarm)		9	X	X
Pipe Handling Crane Acknowledge	Ref4	02-Voted 1ooN (HVELL/Alarm)		10	X	X
Internal Signal From D07	L-007-E44	17-InterConnection		11	X	X
ESD1 Trip Sbd Lattice Boom Crane	Ref5	04-Voted 2ooN (HVELL/Alarm)		12	X	X
ESD1 Trip Port Lattice Boom Crane	Ref6	04-Voted 2ooN (HVELL/Alarm)		13	X	X
Cascading from APS	L-APS-E34	17-InterConnection		14	X	X
Cascading from ESD 2-1	L-ESD21-E36	17-InterConnection		15	X	X
Cascading from ESD 2-2	L-ESD22-E36	17-InterConnection		16	X	X
Cascading from ESD 2-3	L-ESD23-E36	17-InterConnection		17	X	X
Cascading from ESD 2-4	L-ESD24-E36	17-InterConnection		18	X	X
Cascading from ESD DRELLING	L-ESD04-E111	17-InterConnection		19	X	X
Cascading from ESD NAV1	L-ESD04-E36	17-InterConnection		20	X	X
Cascading from ESD NAV2	L-ESD04-E37	17-InterConnection		21	X	X

Figure 8-2: From Document 3S-7812-001 - Cause and effect chart for F&G and ESD system.

The mud logging unit is located at drill floor / wheelhouse deck level on port side of derrick, in non-hazardous area.

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Unit shut down according to ESD1 and real time data streaming cut 03:58, unit restarted and real time data streaming back by 07:53. According to the K-Safe event log there was active ESD shutdown from 03:58:32 until 04:12:58.

To be able to restore power to the mud logging unit, it is necessary to achieve a normal condition on the rig. Before the control room operator can normalize the safety system status by alarm acknowledge and reset shutdowns there must be no active gas alarms.

After the normal condition of the ESD system is achieved, the mud logging unit can be powered up.

9 Barriers and nonconformity

Safety barriers typically consist of combinations of technical- and operational barrier elements. A technical barrier element is an engineered system, structure, or other design feature which is intended to prevent, detect, control, or mitigate a hazardous event. The technical safety barriers should as far as practicable be independent and resilient to failure in other systems and barriers. Operational barrier elements are safety-critical tasks performed by an operator, or team of operators. They will normally support activation of one or several technical barrier functions. Safety-critical tasks are typically related to initiation, prevention, detection, response, control, or mitigation of the development of a hazard. Operational barriers depend on and are embedded in the organizational structures.

No	Barrier element	Reference to requirement / performance standard	Barrier status	Causes
01	Well barrier schematics (WBS) missing for previously plugged Q-21 Main bore (“A-bore”) – caused that two closed deviations for old wellbore were not known during the incident.	TR3507	Weak barrier	TR3507, SR-124739, states that final WBS for the well as build including all previously plugged wellbores shall be documented in STID. This requirement did not exist when the old wellbore was plugged.
02	Technology Qualification of the logging tool.	I-103453 – Perform Failure Mode Identification and Risk Ranking	Weak barrier	Technology qualification was based on vendors qualification. Qualification focused on sensor response, and it showed correct values. The qualification process did not cover the area of use or potential for errors in the calibration process during operation.
03	The requirement in TR3507, SR-126590, was open to multiple interpretations.	TR3507 SR-126590	Weak barrier	The team applied a commonly accepted interpretation of the requirement, under which a cement log was considered

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No	Barrier element	Reference to requirement / performance standard	Barrier status	Causes
				sufficient to fully de-risk the annulus for gas and allow cutting with an open BOP.
04	The casing was cut with a lighter fluid in wellbore compared to the original fluid weight in annulus, and it was stated in the DOP that it was anticipated u-tubing.	TR3507 SR-124749	Weak barrier	Well control volume monitoring affected by U-tubing. This could affect the drill crew's ability to make rapid decisions on closing the well.
05	DOP stated the depth for free pipe calibration where it was assumed to be liquid, but it was gas		Weak barrier	The DOP indicated the depth for free pipe calibration based on the standard depth for the area where fluid was assumed to be present, determined by a separation over time. At the depth where the calibration was performed according to the procedure, it turned out to be gas. However, the tool was adjusted to display fluid values when it was gas, based on this calibration.
06	The vendors procedure for calibration of the logging tool led to incorrect data output.	Vendor's calibration procedure	Broken barrier	The vendor's calibration procedure stated if MCF was above 1.1, the C0 constant should be turned off to adjust the MCF. When the C0 calibration constant was disabled, annular gas behind the casing was misinterpreted as liquid phase in the logging data.

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No	Barrier element	Reference to requirement / performance standard	Barrier status	Causes
07	The staff in the drillers' cabin understood what was happening and acted correctly according to procedure by closing the diverter and the annular.	Odfjell Well Control Manual	Intact barrier	Operational Barrier Element

Table 9-1 Barriers

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No	Barrier element	Reference to requirement / performance standard	Barrier status	Causes
08	Natural ventilation and HVAC	PS 2	Intact barrier	Gas was ventilated out of the shaker room.
09	Leak detection	PS 3	Intact barrier	Hydrocarbon detectors worked according to philosophy and design. Some of the HVAC detectors had a max range of 20% LEL according to design.
10	Emergency shutdown (ESD)	PS 4	Intact barrier	Emergency shutdown worked according to philosophy and design.
11	Ignition source control	PS 6	Intact barrier	Ignition source control worked according to philosophy and design (Intact from a design perspective).
12	Emergency depressurization and flare/vent system	PS 8	Intact barrier	Emergency depressurization and vent system worked according to philosophy and design.
13	Emergency power and lighting	PS 11	Intact barrier	Emergency power and lighting worked according to philosophy and design.
14	Alarm and communication system for use in emergency situations	PS 13	Intact barrier	Alarm and communication systems for use in emergency situations worked according to philosophy and design, however alarms and noise in the driller cabin made it difficult to communicate.
15	Escape, evacuation and rescue (EER)	PS 14	Weak barrier	One crew member experienced temporary difficulties evacuating the shaker room due to a

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No	Barrier element	Reference to requirement / performance standard	Barrier status	Causes
				pressure differential across a door.
16	Layout design principles and explosion barriers	PS 15	Intact barrier	N/A
17	Drilling hoisting system	PS 16B	Intact barrier	N/A
18	Well Integrity for wells in operation	PS 17A	N/A	N/A
19	Well integrity for drilling, completion, and intervention	PS 17B	Intact barrier	Barriers to the reservoir were established. The BOP worked as intended when activated, and the OBE element related activating the BOP worked according to procedure.
20	Marine systems and position keeping	PS 18	Intact barrier	N/A
21	Human machine interface & alarm management	PS 22	Intact barrier	The diverter system and annular preventer were activated manually after water was detected on the rotary. The tool pusher was able to do this from a control panel in the driller's cabin.

Table 9-2: Barriers related to Performance Standards

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9.1 Nonconformity

Reference	Requirement	Status and cause
FR03 Version 3	<i>4.1 1 Well barriers and non-technical barriers related to well control and well integrity shall prevent that a single failure can escalate into an unacceptable situation</i>	Deviation: By applying the interpretation of TR3507, it was perceived that compliance with the governing documentation was achieved.

Table 9-3: Nonconformities

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10 Notification and emergency preparedness

10.1 Emergency Response organization in Equinor

The Emergency Response in Equinor is divided into three main parts with different responsibilities:

- First line (ERT) Installation Technical
- Second line (IMT) Unit serving all Equinor Tactical
- Third line (CMT) Corporate management Strategic

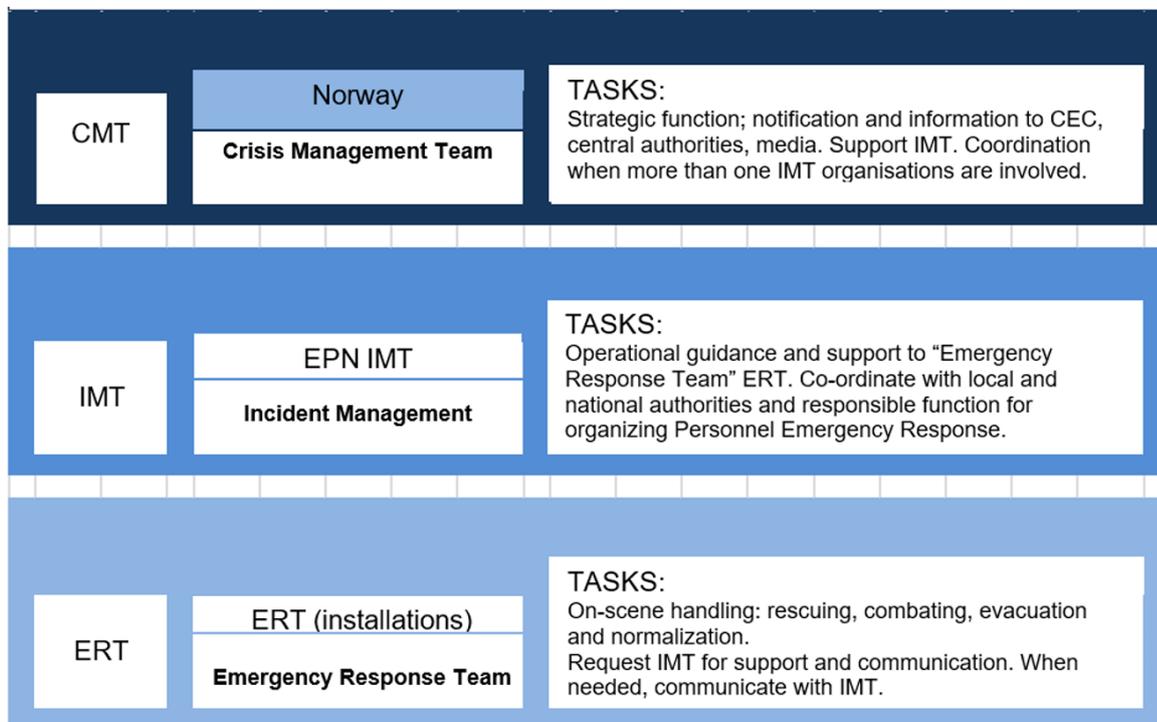


Figure 10-1: Emergency preparedness organization in Equinor ref WR1214

For mobile units Emergency Response Bridging Document and Well Control Bridging Document are issued to clarify roles and responsibilities between Equinor and rig owner (contractor) in emergency situations.

10.2 Emergency Response Notification and Follow-Up by Onshore Resources

Equinor Response and support Centre (RSC) in Stavanger was notified immediately.

The rig contact point reported to RSC that the situation was normalizing and that no support from IMT was required.

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Odfjell Drilling's 2. line emergency response duty watch was also notified immediately, and the 2. Line emergency organization was mobilized at Kokstad.

Joint Rescue Coordination Centre (JRCC) Sola was notified immediately after the incident and Havtil (Havindustritilsynet) was later notified according to requirements.

The Equinor D&W operational duty watch was notified promptly after the incident occurred and provided operational support during the initial normalization phase.

An onshore Well Control Response Team (WCRT) was subsequently established to provide operational support to the offshore team until normalization was fully established.

10.3 Emergency Response on board the rig

When the gas reached the rig topside it was detected by gas detectors, which subsequently triggered the gas alarm automatically on the rig. Emergency Shutdown 1 (ESD 1) was activated. All personnel on board mustered according to established routines, including the emergency management team in the emergency room.

Diverter was activated and diverted the gas from the riser away from the rig via the starboard side overboard line. Then the well was shut in by closing the annular preventer. It is noteworthy that high noise levels in the drilling cabin hindered effective communication inside the drillers cabin, as well as between the drillers cabin and the emergency management team. The emergency management team employed the rig's emergency response plan and initiated actions in accordance with DHS 1 (Loss of Well Control). Measures were taken to stabilize the situation, including filling the riser with water to regain contact with the fluid level in the well.

POB control was achieved within 15 minutes. The initial count indicated POB + 1, prompting a re-count, which confirmed full POB after 21 minutes.

26 minutes post-incident, the emergency management team concluded that control of the situation had been established. Thirty minutes after the incident, non-essential personnel were released, while key personnel continued to monitor the situation.

Following the incident, a thorough assessment of the damage to the rig was conducted. Damages were found on the HVAC system and doors in the shaker area.

The emergency board is found in Appendix C.

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11 Learning and improvement areas

The learning and improvement areas with connected actions described in this chapter have been prepared with the aim of preventing similar incidents occurring in the future, in addition to an increase in the general HSE level.

11.1 Implemented actions

Equinor implemented a temporary change to requirement SR-126590 in TR3507. The text at the time of incident was as follows:

- For operations with a risk of exposure of HC in combination with insufficient BOP activation time, the BOP shall be closed upfront the operation.

A temporary change, whilst the investigation is ongoing is communicated and logged with the following text:

- For operations with insufficient BOP activation time, the BOP shall be closed upfront the operation.

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11.2 Cutting Casing with Open BOP

Learning and improvement area	
<p>The 13 3/8" casing was cut at shallow depth with an open BOP. Consequently, gas was released into the shaker room and onto the drill floor.</p> <p>The planning team interpreted TR3507 to allow for cutting with open BOP was acceptable if no gas risk was verified with log. Rig contractors well control manual described logging as derisking of gas.</p> <p>Logging technology is an indirect measurement based on interpretation of measured sensor values which can give wrong conclusions.</p> <p>The DOP described risk of U-tubing, due to performing P&A in light fluid.</p> <p>The investigation team recommends clarifying requirements to ensure active barriers during casing cuts.</p>	
#	Recommended actions
1	<p>Revise TR3507 to clearly require BOP closure during shallow cuts and to ensure full alignment with requirement 4.1 in FR03, "<i>1- Well barriers and non-technical barriers related to well control and well integrity shall prevent that a single failure escalate into an unacceptable situation.</i>" As part of this revision, conduct evaluations of BOP response time and the effect of u-tubing on well control indicators. Company must also see to it that all Drilling Contractors involved in Company-operated activities review and update their Well Control Manuals based on learnings from this incident.</p>

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11.3 Cased Hole Logging

Learning and improvement area	
<p>Parameter setup (C0 coefficient) of the cement bond logging tool under the calibration led to misinterpretation of gas presence behind the casing.</p> <p>The documents the logging engineer had received did not state gas identification as an objective for the cement bond logging, nor was the purpose of the logging stated.</p> <p>The cased hole logging group does not have access to tools capable of identifying discrepancies or errors in the reported log data.</p> <p>Equinor technology qualification process focused on sensor technology and did not include manuals or data processing algorithms.</p> <p>The investigation team recommends that, for Company-operated activities, the cement bond logging tool vendor updates the cement bond logging tool manual by removing misleading instructions and identifying and eliminating error traps related to tool use and reporting.</p>	
#	Recommended actions
2	Ensure the logging tool technology used in the incident is fully qualified for risk and operational readiness, including see to it that the vendor has corrected internal procedures and instructions and removed error traps. In cooperation with vendors, eliminate error traps related to data acquisition and data interpretation, and review default free pipe calibration depths to ensure consistent and standardized depth references for both subsea and fixed installations.

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11.4 Missing Barrier Schematics

Learning and improvement area	
<p>Well barrier schematics for old wellbores were missing, reducing situational awareness. Well schematics without well barriers and without sufficient level of details were used in the planning.</p> <p>Governing documents did not enforce barrier drawings for all historical wellbores.</p> <p>The investigation team recommends improving data quality and ensuring barrier status visibility, to have control over barriers from previously plugged tracks that could affect the operations.</p>	
#	Recommended actions
3	Company must assess how to manage risk related to old well bores where barrier schematics are not available.

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11.5 DOP process P&A and Risk Register Weakness

Learning and improvement area	
<p>At the time of cutting the 13 3/8" casing, the risk of gas behind the casing was considered negligible, and the gas release risk was only described for pulling the 13 3/8" seal assembly operation and not as a specific risk in the operational risk register for cutting of the 13 3/8" casing. The following actions de-risked the likelihood of gas behind the casing when cutting:</p> <ul style="list-style-type: none"> • Verified primary and secondary barriers isolating the reservoir. • Cement bond logs confirmed no gas above the top of cement behind the casing (invalid data). <p>Preparation of good risk registers with relevant actions requires solid engagement with broad competency, experience, and imaginative capacity.</p> <p>Operational risk register and DOPs did not reflect orange barrier status or gas risk behind 13 3/8" casing.</p> <p>The investigation team has observed lack of well integrity tags in Wellcom risk registers, and insufficient linkage between Well Barrier Status, risk register, and DOPs.</p> <p>The investigation team recommend strengthening risk management to capture well integrity concerns.</p>	
#	Recommended actions
4	<p>Company should strengthen Integration of well integrity information in risk management processes:</p> <ul style="list-style-type: none"> • Clarify how well integrity tags are to be applied within the risk register in Wellcom. • Assess how to improve the linkage between the risk register, Well Barrier Status, and DOPs to ensure consistent and aligned barrier and risk management.
5	<p>Company should evaluate how to strengthen learning loop:</p> <ul style="list-style-type: none"> • Assess where to integrate lessons learned regarding the avoidance of activities such as hot work where risk of HC exists, e.g. during casing cutting or circulation in P&A operations. • Emphasis needs to gather relevant experiences from nearby area and similar activities in start of project, especially related to well control. Company must evaluate to register an IMP to change I-31811 to requirement element. Specify requirement text to include general area experiences and companywide well control and similar activity experiences. The requirement should be valid for all well planning processes

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11.6 Emergency Response Thresholds

Learning and improvement area	
<p>Equinor did not mobilize IMT while Odfjell mobilized its second line.</p> <p>Bridging documents lacked clarity on emergency notification. The RSC shall route the information to the correct receiver, in this instance, the operational section chief in the IMT. In this instance the information stopped at the RSC and did not reach the IMT. Bridging documents should clarify that the notifier establishes direct contact with the IMT to discuss the situation, in addition to notifying them via the RSC.</p> <p>The investigation team recommend updating bridging documents.</p>	
#	Recommended actions
6	<p>Company should assess to revise template on Emergency Bridging documents in D&W:</p> <ul style="list-style-type: none">• Include “<i>Notify EPN IMT 2nd line via Response and Support Centre (RSC, 51990002).</i>” This is the same wording as found in the WR1156 template.• Assess to include that a substitute for Appendix “Standard form for notifying / cooperating between Line 1 and Line 2” is to take photo of emergency board and send this to IMT.

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11.7 Shut down of mudlogging equipment

Learning and improvement area	
<p>The gas release from the well to the rig caused ESD shutdown according to design philosophy where all non-essential equipment was tripped.</p> <p>However, the third-party mud logging unit is defined as “Group-2, Essential equipment” (ref. ESD philosophy document 550-101-I-FD-003) but is also documented to be tripped at ESD level 1 in the ESD design documentation.</p> <p>The mud logging was shut down according to Cause & Effect ESD1 as per design for the mud logging unit.</p> <p>While the mudlogging unit was without electrical power, data from instruments such as the gas chromatograph was unavailable.</p>	
#	Recommended actions
7	Company should evaluate whether the Mud Logging Units should be classified as “essential” or “non-essential” equipment for operations in hazardous areas and, if appropriate, escalate classification of mud logging units to Offshore Norge to support harmonization of requirements across operators on the NCS.

11.8 Communication Barriers During Emergencies

Learning and improvement area	
<p>High alarm sound levels in driller cabin hindered communication during ESD activation.</p> <p>Alarm management and communication systems were not optimized for emergency conditions.</p> <p>Improve human-machine interface and alarm prioritization.</p>	
#	Recommended actions
8	For Company-operated operations, the Company recommends that the Rig Operator assess the alarm sound levels for the various systems in the driller’s cabin and implement noise-reduction measures where necessary.

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11.9 Evacuation from shaker room

Learning and improvement area	
<p>Pressure differential between the shaker room and the shaker operator cabin made it difficult to open the doors to evacuate from the shaker room. The door seals were damaged, so gas flowed from the shaker room to the shaker operator cabin and the screen store.</p> <p>It was difficult to evacuate from the shaker room to the shaker operator cabin, and gas filled the shaker operator cabin because of damage to the door seals.</p>	
#	Recommended actions
9	For Company-operated operations, the Company recommends that the Rig Operator assess evacuation from the shaker room and the shaker operator cabin, as well as the safety of personnel located in the shaker operator cabin during a gas leak or fire event.

11.10 Offshore Norge GL135

Learning and improvement area	
<p>This incident has demonstrated that the tables used for the classification of well control incidents in Offshore Norway GL135 may not adequately account for how serious a situation involving the release of a limited volume of gas during casing cutting can develop. The investigation team recommends that an assessment be carried out to determine whether the tables in Offshore Norway GL135 should be revised considering the experience gained from this incident.</p>	
#	Recommended actions
10	The investigation team recommends that the Company assess whether to propose a revision of the well control incident classification in GL0455 and Offshore Norge GL135, to ensure that incidents involving the release of significant volumes of trapped fluid without potential for continuous flow, are properly captured in terms of seriousness and learning potential.

12 Abbreviations and terms

ATP	Acceptance Test Program
AI	Acoustic Impedance
BOP	Blow Out Preventer
BSR	Blind Shear Ram
CBL	Cement Bond Log
CCL	Casing Collar Locator
CMT	Crisis Management Team
CO	Carbon Monoxide
CSR	Casing Shear Ram
D&W	Drilling and Well
DG	Decision Gate
DOP	Detailed Operation Procedure
EER	Escape, Evacuation and Rescue
ERT	Emergency Rescue Team
ESD	Emergency Shut Down
FR	Functional Requirement
GR	Gamma Ray
H ₂ S	Hydrogen Sulphide
Havtil	Havindustritilsynet
HC	Hydrocarbon
HSE	Health, Safety and Environment
HVAC	Heating, Ventilation and Air Conditioning
IMT	Incident Management Team
JRCC	Joint Rescue Coordination Centre
LEL	Lower Explosive Limit
LMRP	Lower Marine Riser Package
MSP	Main Service Provider
MTO	Menneske, Teknologi, Organisasjon
NCS	Norwegian Continental Shelf
P&A	Plug and Abandonment
PDP	Projects, Drilling and Procurement
POB	Persons on Board
PP&A	Permanent Plug and Abandonment
R	Requirement
SoE	Sequence of Events
TR	Technical Requirement

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VBR Variable Bore Ram

WCRT Well Control Response Team

XMT Christmas Tree

YTD Year to Date

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13 References

/1/: Courtesy of Odfjell

/2/: TR3507 Well Integrity Manual – offshore operations, rev 11.01

/3/: Troll East Q-21 – DW200 – Feasibility report Permanent Plug and Abandonment

/4/: Troll Q-21 – Concept selection report PP&A

/5/: Troll Q-21 – Activity Report PP&A

/6/: Handover from PC to OC, dated 26.08.2025

/7/: M165 – (DOP16A) – RIH 13 3/8” Dress-tag BHA w/ 13 3/8” casing cutter, rev, 1.0, 2.0, 5.0

/8/: Wellcom daily drilling report

/9/: Gas Hazard Analysis – Well control incident Deepsea Bollsta 23.09.2025 Rev: 1, 19.01.2026 Equinor
TDI OG FOS SAPT SAFETY TECH

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App A Well History – Sequence of Events (SoE)

The sequence of events is given in **Table A-1**. Focus is on events that had significance for the occurrence of the incident and consequences. Other activities are only included to the extent necessary to understand the sequence of events.

Table A-1: Sequence of events

Date	Event	Comment
25.04.2001– 24.05.2001	Drilling of the first well on slot Q-21, Well 31/3-Q-21 H (Data acquisition, coring)	First 17 ½” section on the slot drilled. This is a relevant event for tracking potential leak paths of gas from reservoir sections in wellbore A into the annulus between 13 3/8” casing and 20” casing in Wellbore B. The 12 ¼” reservoir section was plugged back.
22.03.2004– 18.04.2004	Drilling and completion of wellbores AY1H, AY2H, AY2HT2 (multilateral producer)	AY bore drilled as a 12 ¼” section out of the 13 3/8” casing in Q-21 H with two 8 ½” reservoir sections.
2005/2006	Dec.2005: Gas bubbles was observed in the wellhead area emerging between 20” casing and 30” conductor. Dec 2006 / Jan 2007: A follow-up inspection in confirmed reduced leakage.	Gas samples were taken and identified as same matched the composition found at Troll A skirt penetrations and are likely from a shallow gas zone sealed off from the wellbore behind the 20” casing.
21.05.2007– 20.06.2007	P&A of wellbore A 13.06.2007 19:00 Cement bond log of 13 3/8” casing in wellbore A 15.06.2007: Cut 13 3/8” casing, well stable. 18.06.2007 02:00 Cement bond log of the 20” casing in wellbore A	No gas reported during P&A of Wellbore A Well plugged back into the 20” casing with the cement plug inside 20” casing also representing a kickoff plug for wellbore B.

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Date	Event	Comment
	<p>Two closed dispensations related to the Q-21 A track plugged in 2007 (towards old governing documents) are registered in DISP:</p> <ul style="list-style-type: none">• #75107: 31/3-Q-21 AY1H/AY2H – Installation of two cement barriers in one barrier element<ul style="list-style-type: none">○ This dispensation describes how the cement P&A plugs set inside the 13 3/8” casing in wellbore A in 2007. Cement plugs were set “wet on wet” and not verified according to governing documentation. Instead of tagging cement plugs individually, a pressure test was conducted after the third cement plug was set. • #75967: Application for permanent deviation to requirement 'K-16448 – Verification if formation as permanent barrier element' for permanent P&A of well 31/2-Q-21 AY2H – 2nd barrier.<ul style="list-style-type: none">○ Use of Green clay collapse as part of secondary annulus barrier without verifying same through inflow or pressure test.	
19.08.2007– 18.09.2007	Drilling and completion of wellbore BY1HT5 and BY2H T2 (multilateral producer)	
24.08.2007:	Displaced the well from old 1,31 s.g. Aquadrill to 1,31 s.g. bentonite mud. Observed a maximum of 21% gas in the returns. Tagged firm cement at 672 m.	After landing the BOP the intention was to test the WH connector against the cement kick off plug in the 20” casing. This pressure test

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Date	Event	Comment
		failed. An inflatable 20" plug was run and the WH connector successfully tested. When circulating after releasing the plug a gas peak of 21% was observed.
28.08.2007	Made up the 13 3/8" shoe track and ran in the hole with 13 3/8" casing to 361 m. Shoe track with shoe joint, 2 intermediate joints and float joint, bakerlocked all connections in the shoe track. Checked float shoe and float collar on the catwalk with water prior to pick up. Circulated the riser when running casing. Observed mud losses with the casing shoe still in the riser	Losses experienced when RIH 13 3/8" casing. RIH drill string, treated with LCM and reduction in mud weight.
01.09.2007	Pumped 10 m3 of cement spacer, released the plug activation ball, and pumped 42 m3 of 1.92 sg Cement slurry. No losses when pumping cement. Released the plug dart and displaced the cement slurry with 3 m3 Drill water and 1.31 sg mud. Plugged bumped with 70 bars, after 5390 strokes, 50 strokes below the theoretical volume. 2000 lpm, 4 – 55 bar. Pumped drill water with the cement unit and mud with the rig pumps. Observed the top plug shear with 140 bar.	13 3/8" cement job. No losses reported. Plug bumped.
02.09.2007	21:00 Continued to drill out the shoe track from 1517 to 1556 m. 4000 lpm, 200 bars, 95 – 100rpm, 18 kNm. WOB 0 – 10 tons. Good cement inside the shoe track, ROP 13 m/hr.	Drilled out firm cement in 13 3/8" casing shoe track.
09.09.2007	03:00 Pumped 10 m3 of Freshwater and 10 m3 1.30 sg Spacer ahead of the Cement slurry. Mixed and pumped 38,0 m3 of 1.80 Cement slurry. Pumped 1 m3 1.7 sg cement spacer ahead of dart #2. Displaced the dart and cement slurry with 3 m3 1.7 sg Cement Spacer, 17.3 m3, 1.25 sg mud at 500 – 800 lpm. Sheared the top rupture disk with 307 bars, pumped a further 156 ltr mud to displace cement to float collar. Bled back to the cement unit, no backflow	Cemented 9 5/8"x10 3/4" liner. Note: -No rotation of liner -Low displacement flow rate
2011	Seabed gas observation	Measured C1 in gas samples, indicating shallow source.

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Date	Event	Comment
January 2025	Planning project established	Project not set up in standardized D&W Planning Centre (PC) structure.
24.02.2025	DW200 – Feasibility report – permanent P&A of Well: NO 31/3-Q-21 BY1H T5 / BY2H T2 signed	
29.04.2025	DW200 – Well concept selection report – PP&A of Well: NO 31/3-Q-21 BY1H T5 / BY2H T2 signed	
Summer 2025	IMR vessel delayed in pre-P&A scope on Q-21 well.	Contingencies were brought further into planning phases than intended.
27.06.2025	DW200 – Activity program for PP&A, Rev01, Well: NO 31/3-Q-21 BY1H T5 / BY2H T2 signed	
04.08.2025	DW200 – Activity program for PP&A, Rev02, Well: NO 31/3-Q-21 BY1H T5 / BY2H T2 signed	
29.08.2025	Handover meeting for Q-21 and X-23	From Planning to Operation Centre.

Events during plug and abandonment on Q-21

31.08	03:00	Ran BOP on Marine Riser on Q-21 well	First of P&A batch operation on wells Q-21 and X-23.
02.09	14:15	Observed 1.75° inclination on wellhead (limitation 1°inc.). Awaited further instructions while on standby for the slump test.	Management of Change (MOC#3) established for operating on a well with WH inclination >1 deg.
05.09	10:15	OOH 7" tubing on elevators. Observed backflow. Decision made to displace riser to DW.	Backflow while pulling 7" tubing out of the well.
05.09	20:00	R/U for wireline. P/U and M/U WL tools. Installed logging sub and sheaves to TDX and positioned in derrick.	Cement bond log of 10 ¾". DOP07: Objectives: -Log 10 ¾" liner for cement/formation bonding to verify if any barrier(s) are present. -Log 10 ¾" tieback for barite settling and potential gas in annulus.
06.09		Ran down to 1414 m mid. element and started setting plug according to Archer procedure. – TQ limit 12.5 kNm. Rotated with 20 RPM. Turned 10 rotations while stationary with 3-5 kNm. Lowered string at 0.5 m/s while keeping 20 RPM. Stopped rotation when hook load decreased, hook load	Installed mechanical plug inside 10 ¾" tieback casing at 1414 m. Pressure tested same to 115 bar surface pressure. Note: -Primary temporary barrier plug.

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		10 T lower than free hanging weight. Set down to 25 T lower than free hanging weight. Released torque and pulled up to 10 T above free hanging weight. – Mid element @ 1416,7m. Set down to 20 T below free hanging weight. Closed LAP and performed pressure test of annulus side to 20 / 115 bar while monitoring on DP side. Pumped 393 liters and bled back 393 liters. Bled off pressure open LAP. Closed ball valve and released RT from plug	–The plug was also later used as part of the base for the cement plug representing primary and secondary barrier elements internally in the well.
06.09	22:40	Ran down to 390 m mid. element and started setting plug	Installed mechanical plug at 390 m. Note: –Secondary temporary barrier plug.
07.09	23:30–00:00	Moved rig outside 500 m zone of Q-21.	Continued operation on X-23 well.
18.09	14:30	Deepsea Bollsta entered 500 m zone for Q-21 well for the second time.	
20.09	10:15	Cut 10 3/4" Tieback at 1553 m with 1500–2000 lpm/36–42 bar and 100 rpm/2–13 kNm. Indications of good cut after 450 strokes. Verified cut with pumps on. Displaced kill/choke lines and riser from SW to DW with 4300 lpm/55 bar. Displaced TT offline. Observed gas in return when displacing riser, max gas seen: 12 %.	12% gas (C1–C5) at this stage in the operation is an indication of potential barrier issues in the well. Note: single event.
20.09	12:15	Observed backflow with decreasing trend. TT dropped total 9 m3 before leveling out.	Backflow up the string when pulling out with the cutting assembly.
20.09	18:15	Engaged TDX and recorded up/down weights: 107 t / 105 t. Activated CMC, ventilated string, and opened kill/choke lines. RIH and landed SRT on Seal assembly at 587 m bit depth. Rotated to lock onto SA. Closed UAP with reduced pressure and pressured up between UAP and SRT to 35 bar. Verified SRT set and bled off pressure. Ventilating string and pulled SA free with 24 t overpull.	10 3/4" seal assembly pulled with closed BOP. No gas observed when pulling 10 3/4" seal assembly later in the operation.

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	23:30	Closed UAP. Lined up to pump down string and up choke line via Poorboy for displacing well. Started to displace old 1,27 sg Aquadrill WBM with 1,00 sg drill water. Established flow from 200 lpm up to 2000 lpm / 18-115 bar.	Circulated with closed BOP when displacing 10 3/4" annulus from cut to WH to drill water.
21.09	16:45	R/U WL equipment and build Ultex-CBL tool string. In well Q-21 the free pipe correlation logging was performed at a depth where the annulus was expected to be liquid filled, when it in fact was gas filled. Manual adjustments were made in the processing of raw data to give output impedance values matching liquid, specifically flipping a geometric correction factor (CO coefficient) off. The resulting consequence was that the logging interval from top of cement to wellhead showed liquid and failed to identify the presence of gas.	Cement bond log of 13 3/8" casing. DOP015: Log from 1348 m to Wellhead.
22.09	00:45	Waited for confirmation of good logging data.	1 hr waiting time.
22.09	12:15	Racked back one stand and M/U cement stand. Connected cement hose. Applied 20 bar for lineup confirmation and positioned string at 1410 m.	Set 13 3/8" common cement plug barriers (DOP016) Note: - 10 3/4" timelock plug at 1414 m installed 06.09 used as base. - Activity program 2.4. Summary of planned activities: "Set 13 3/8" primary/secondary cement barriers and cut casing at +/- 510 m (combi run) a) Use 10 3/4" plug already installed as fundament or set a new 13 3/8" plug"

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22.09	14:00	Installed 2 ea sponge balls. M/U TDX and established circulation to cut cement at 1168 m. Pumped BU with 4500 lpm/75 bar and 40 rpm/5 kNm. Reciprocating string up to 1137 m. Clear indication when cement in return. Set back one stand. Meanwhile: B/O and L/D 10 3/4" Tieback joints from setback in Aux	Cut top of cement at 1168 m, i.e., theoretical length of cement plug: 242 m.
23.09	02:15	Positioned LnL BHA above TTOC. M/U TDX and recorded up/down weights: 114 t/105 t. Free torque at 30 rpm: 110 t. Established circulation to 500 lpm/2 bar and washed down from 1168 m to WOB at 1172,4 m. Applied 60 rpm and increased to 3000 lpm/21 bar and dressed off top of cement down to 1173,8 m. Reduced flow and stopped rotation. Tagged at 1173,9 m with 10 t. Meanwhile: Changed pickup elevator in Aux.	Combined string. Verification of 13 3/8" common cement plug barriers.
	03:57:48	Cutting of casing performed	
	03:57:50	Mud return flow high (alarm)	
	03:58:16	Diverter sequence initiated	Data source: BOP control
	03:58:24	Flowline valve to shaker – signal close	Data source: BOP control
	03:58:26	STBD overboard valve – signal open	Data source: BOP control
	03:58:27	Gas above 100% LEL	Data source: K-IMS
	03:58:34	Diverter packer – signal close	Data source: BOP control
	Duration; 7 sec.	Person visible on CCTV camera from entering to leaving room	Data source: CCTV*
	Duration; 33 sec.	First flow observed until flow stopped in shaker	Data source: CCTV*

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	Duration; 52 sec.	Fluid flowing above PS 30 slips in rotary until no flow	Data source: CCTV*
	03:58:56	Diverter confirmed closed	Data source: BOP control
	03:59:01	Upper annular confirmed closed	Data source: BOP controls
	N/A	No gas out overboard line	ESD system took out CCTV system.
	04:01:27	Gas sensor below 100% LEL	Data source: K-IMS
	04:05:38	Gas sensor below 20% LEL in all areas	Data source: K-IMS
23.09.2025	11:30	DOP 16A - RIH 13 3/8" Dress-tag BHA w/ 13 3/8" casing cutter, rev 2.0 Approved	Includes procedural steps for killing of the well.
	19:30	Inspected wellhead with ROV	No findings
24.09.2025	17:00	DOP 16A - RIH 13 3/8" Dress-tag BHA w/ 13 3/8" casing cutter, rev 5.0 Approved	Includes procedural steps for killing of the well.
24.09.2025	21:33	Interpretation of reprocessed 13 3/8" log using correct setting for CO coefficient.	Re-processed log shows gas from WH down to 648 m, 24 m3 annulus volume.

- *CCTV time is incorrect compared to cameras and other timings. Only duration used for CCTV cameras.

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Investigation of:

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App B Gas source and migration into Q-21 BYH



Gas source and migration into
Q-21 BYH

Classification: Internal

Investigation of:

Status: Final

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4 potential sources identified

- Shallow gas
 - Overburden gas
 - Q-21 AYH reservoir gas
 - Q-21 BYH reservoir gas
-
- We will address these individually to show the arguments for the source and the timing of the migration into the Q-21 wellhead
-
- **Conclusion: Gas migration from the Troll reservoir occurred c.2008 during operations from the BYH reservoir. This gas was trapped until release in the 2025 incident. Cement logs from 2025 show that the wellbore is now plugged and no further gas influx can occur.**

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Shallow Gas → discounted as source

- Supporting evidence
 - Gas measured from the Q-21 BYH remedial operations whilst circulating out the influx showed a clear **thermogenic** signature
 - Shallow gas would have a biogenic, purely microbial signature

 - This fits with the Troll Oil Province understanding, where no shallow gas has been identified
 - Original site surveys for the Q-21 location had a shallow gas class level 0 – No shallow gas, however gas percolation had been noted at the seabed in 2005. Gas composition samples indicated that the samples were the same composition as on Troll A penetrating skirts. The 2003 Troll A shallow gas project concluded that this was a result of the liberation of gas from previously gas-free formations due to the heat of production.
 - On Q-21 this gas percolation zone is sealed off behind the 20" casing and could therefore not be a source for the incident. A second inspection in 2006/7 confirmed that the gas leak rate had decreased.
 - Further gas sampling in 2011 from a leak near the XT locking rod confirmed with isotopic analysis a biogenic gas source.

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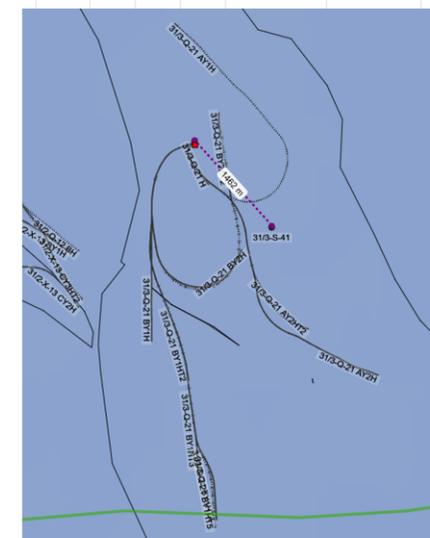


Overburden gas → discounted as source

- Prior to PP&A operations the overburden was assessed for potential flow units
- No flow units were identified above the Shetland Gp. see table.
- A re-assessment of all the Q-21 wellbores and offset well data was performed to confirm this understanding
- No exposed overburden formations in Q-21 show hydrocarbons or flow potential
- The Troll field is well known for it's wellbore density, and the question of flow from local wellbores was also considered. However, the Q-21 well is drilled from a single-slot template located on the flank of the field and there is only one well located nearby – S-41.
- No hydrocarbons are identifiable in the overburden of S-41
- This is consistent with the understanding of the overburden across the Troll field.
- No direct gas indication from seismic observed in the stratigraphic interval Top Shetland – Base Quaternary – ref https://statoilstrm.sharepoint.com/p:r/sites/PANO31_3-Q-21Y1HT5/Execution/Subsurface/Q21_seismic_indications_gas.pptx?d=w6aa1f29bbc754809ad1f5f1c182b5e4f&csf=1&web=1&e=7U8Hp9

Section	Group	Formation		Flow units / interval with flow potential (31/3-Q-21 BY1H)						Fluid phase, gradient and evaluation of number of barriers	
		[-]	[-]	Depth [mMD RKB] Top	Depth [mMD RKB] Btm	Depth [mMD]	Depth [mTVD RKB]	Permeability / Flow unit	Hydrocarbons present	Comment:	Fluid phase
17 ½	709-1558	Hordaland	Green Clay	733	1086	-	-	No	No		-
			Balder	1086	1205	-	-	No	No		-
		Rogaland	Sele	1205	1281.5	-	-	No	No		-
			Lista	1281.5	1551	-	-	No	No		-
12 ¼	1558-2308	Shetland	Våte	1551	1632	-	-	No	No		-
			Upper-Middle	1632	1668	-	-	No	No		-
			Lower	1668	1674	1668	1456	Yes one	Yes	2m HC filled sand in lowermost part	Gas or Oil
8 ½	2308-3900	Viking	Draupne	1674	1726	-	-	No	No		-
			Sognefjord / Heamer C	1726	3908	1726	1484.5	Yes	Yes	Producing reservoir	Gas / Oil

NB: Deepsea Bolstra 32.7 m RKB



Internal

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Q-21 AYH reservoir gas → discounted as source

- During P&A operations in 2007, the 13 3/8" casing of Q-21 AYH was partially logged
- A 31m high isolating potential barrier was seen in the Lista formation - 1285 - 1315 mMD RKB (31 meters)
- The casing was later cut & pulled from ca 700 meters – no indication of gas reported while pulling the casing
- All depths refer to West Venture (RKB - MSL = 35.5 m)

- Note: 21% gas seen during displacement of 1.31 sg bentonite mud prior to sidetracking to BY1H according to Wellcom
 - No further references to this gas peak are found in the vendors final well reports
 - The mud log report notes that there is missing gas and drilling data until 712m MD due to a database problem, and therefore the data is unavailable for further analysis. This peak came before drilling new formation and would not included in the logs.

- There is therefore no further data related to this. Possibilities include:
 - It is a database problem related error
 - It is a real gas source related to leakage from AYH
 - It is a real gas source related to the operations in the well – potentially from degradation of fluids in the gap in operations of two months between P&A and sidetrack, or from the fluids trapped behind the casing over time.
 - With no information about pump rates and timing it is impossible to tell how much gas was seen, but it's absence from all reports indicate it was not considered significant.

- This gas measurement does not fit with the understanding of the P&A of AYH where **no gas was seen after cutting the casing**.

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Q-21 BYH reservoir gas → migration of gas during operations in 2007

- Re-examination of the cased hole logs has been performed since the incident.
- The 10 3/4" x 9 5/8" liner was logged twice 2008 and 2025.
 - The 2025 log cannot be used for interpretation due to poor data quality.
- The 2008 log shows evidence of gas below the 10 3/4" liner hanger seal assembly. Not a gas column, but clear evidence of gas cut cement
- The 13 3/8" casing was also logged in 2025 and showed a 275m gas column.
- Channeling tendencies are observed in parts of the annulus within the logged interval where cement is present. The cement quality may have improved over time resulting in the current high quality cement which is present.
- Indication of possible gas-cut cement indicating that the gas was present during the cement placement or migrated into the cemented section post-cement displacement
- Formation creep is present in parts of the Hordaland 1 along with signs of a gas column below the creep interval
- Ref: [Troll Q-21 annular bond log evaluation](#)

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Q-21 BYH reservoir gas → migration of gas during operations in 2007

- The 10 3/4" shows signs of gas cut cement in 2008 indicating the gas was potentially able to migrate through this zone from the reservoir to shallower levels
- The 13 3/8' from 2025 shows high isolating cement in 2025, but also evidence of gas migration – gas-cut cement and gas columns below the Hordaland 1 and wellhead.
- There is also evidence of channeling in the high isolating interval

- It is believed that the reservoir gas was able to migrate past the 10 3/4" (as evidenced by gas-cut cement) and the 13 3/8" via the channeling to the wellhead during or shortly after operations in 2008.
- Over time the isolation of the cement in the 13 3/8" increased, preventing further migration as seen in 2025
- Furthermore, creep in the Hordaland 1 also occurred trapping a secondary gas column deeper behind the 13 3/8" casing
- Additionally, the annulus of 20" was not completely full of gas. These indications all support that the gas migration was limited in volume and no further leak is ongoing.

- **Conclusion: Gas migration from the Troll reservoir occurred c.2008 during operations. This gas was trapped until release in the 2025 incident. Cement logs from 2025 show that the wellbore is now plugged and no further gas influx can occur.**

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Investigation of:

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Additional info

- [#75107](#): 31/3-Q-21 AY1H/AY2H - Installation of two cement barriers in one barrier element
- [#75967](#): Application for permanent deviation to requirement 'K-16448 - Verification if formation as permanent barrier element' for permanent P&A of well 31/2-Q-21 AY2H - 2nd barrier.

- Related to the A wellbore that was plugged in 2007.

Classification: Restricted

Investigation of: Well Control

Status: Draft

Incident Troll Q-21

Date: 23.12.2025



App C Emergency board

EMERGENCY BOARD

POB	114	FOCUS	Redde personell Begrense sikre	FOCUS	Sjekk POB Begrense	FOCUS	Normalisere
COUNTED	114						
MISSING							
CASUALTY							
HOSPITAL							
POB STATUS AT:		TIME	ACTIONS / LOG	RESP.	DONE		
COUNTED		0355	General alarm / gas alarm skaker				
MISSING		0400	Closed BOP / Closed diverter		✓		
CASUALTY		0405	1. møte				
HOSPITAL		0405	ESD 1 aktivert				
POB STATUS AT:		0400	Equinor varslet				
ALERT		0405	styrbord alder skadestedsenter				
		0407	Fylle riser. åpne diverter (drillvann)				
		0410	Full POB + 1				
ODFJELL		0412	Vaktlag, Equinor informert				
OPERATOR		0412	Re count				
CHECKLIST		0413	Brannlag sikre område rundt skaker				
GPA ACTIVATED		0414	Status møte				
WELL SECURE	✓	0416	FULL POB				
ERRV INFO		0420	8% gas i etas skaker				
SUPPLY VSL INFO		0421	Vor sk. Equinor og Odjfell at kontroll på s'huset				
PTW CHECKED		0426	Status møte				
GPA SILENCED		0425	Frisjilt ikke esenstallt personell				
ESD 1	✓	0437	Riser full, Line up til triptank				
ESD 2		0440	Beredskapslag stand down, stabil triptank				
ESD 3		0447	Debrief				
		0457	Apnet choke/lne via bled -29 bar BOP Over Choke				

WIND 357 11kts
CURRENT 391
HS 1.9
VISIBILITY Good

WEATHER: Wind N, H, 107°

HELIICOPTER: [Blank]

VESSEL / OTHER: [Blank]

PLOTT: [Map of wellhead area]