PETROLEUMSTILSYNET

Investigation report

Report	
Report title Report of the investigation into the fire in the mud laboratory on *West Phoenix* on 5 November 2018.	Activity number 404004006

Security grading		
☑ Public	☐ Restricted	☐ Strictly confidential
☐ Not publicly available	☐ Confidential	

Involved	
Team T-Mobile	Approved by/date Irja Viste-Ollestad/25 February 2019
Members of the investigation team Eivind Sande, Anita Oplenskedal, Svein Harald Glette	Investigation leader Svein Harald Glette

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1 Summary

A fire broke out on 5 November 2018 in the mud laboratory on Seadrill's *West Phoenix* facility. The rig was then drilling exploration well 6406/2-9 S Ragnfrid North in production licence 199 for Equinor. This is an HPHT well.

The Petroleum Safety Authority Norway (PSA) decided on 7 November 2018 to investigate the incident. In addition, the PSA supported the police inquiry into the fire.

At 14.48 on 5 November 2018, the smoke alarm in the mud lab was activated. The derrickman and motor man were contacted to check whether a fire had broken out in the room. The derrickman was the first to open the door into the lab. Having observed flames, he closed the door and confirmed the fire to the CCR. A general alarm was activated at 14.52 and all personnel mustered. The POB check was confirmed at 14.59.

The fire team was mobilised to the lab at 14.59. Powder was first deployed, followed by water. The heat was too great for the room to be entered, and the fire was therefore fought through the doorway. It was confirmed to be extinguished at 15.10.

At the time the fire began, drilling mud was being tested in the lab's retort. The mud engineer was not present when the fire started. The lab was partly destroyed by the fire. This was not regarded as an area with a high probability for a fire, and the walls met fire class A0.

The site showed that the fire began in the fume cabinet where the retort was placed. The retort and the extension power cord used in the cabinet were taken ashore by the police for more detailed forensic examination.

Investigations by the National Criminal Investigation Service concluded that the fire was probably caused by serial arcing in the extension cord used. This arcing developed a high temperature and thereby ignited flammable material in the vicinity. The arcing has occurred in all likelihood as a result of insulation failure following mechanical damage. The cord used was taken new from the stockroom on 7 October 2018.

Chemicals used for mud testing were stored in the fume cabinet. Design drawings indicate that this cabinet should be made of stainless steel, but the fire damage shows that it was clad internally with flammable sheets. The chemicals and the flammable sheets inside the cabinet contributed to the rapid escalation of the fire.

Three nonconformities have been registered, related to the following conditions.

- Use of extension cords with a 16A overcurrent protected device
- Retort
- Fume cabinet design

Four improvement points have been registered, related to the following conditions.

- Portable third-party equipment taken on board
- Checking of extension cords
- Storage of flammable materials in the mud laboratory
- Maintenance of retorts

See chapter 9 below for further details of these conditions.

2 Background information

2.1 Description of the facility and the organisation

West Phoenix is a sixth-generation semi-submersible drilling rig built to the Moss CS50 MkII-DP design at Samsung Heavy Industries (SHI) in South Korea. It was delivered by SHI in 2008, and an acknowledgement of compliance (AoC) was issued to Seadrill for *West Phoenix* in June 2008.

The facility is registered in Panama and has class certificates from DNV GL. It has been active over the past year off both Norway and the UK. At the time of the incident, it was engaged in drilling an exploration well for Equinor on Ragnfrid North in the Norwegian Sea.

2.2 Position before the incident

When the incident occurred, the facility was drilling a 12 ¼-inch hole at a measured depth of 4 155 metres, with 14-inch conductors set from 3 418 metres. There were 117 people aboard.

A retort (figure 1) was used several times a day in the facility's mud lab during drilling in order to monitor the quantities of water, oil and solids in the drilling fluid. This is normal practice during such operations, and is done to check the density and content of solids and water in the fluid. Equinor had a contract with Halliburton to provide this drilling fluid service on the facility.

The retort was in use when the incident occurred.

2.3 Abbreviations

AoC	Acknowledgement of compliance
CCR	Central control room
ECR	Emergency control room
HPHT	High pressure, high temperature
JRCC	Joint rescue coordination centre
POB	Personnel on board

2.4 Definitions and terms

Retort
An apparatus which separates water and oil from drilling fluid. In the retort, 50ml of fluid is heated to about 500°C until the liquid vaporises. The vapour passes through a condenser and is collected in a cylinder where oil and water quantities can be read off. Solids are determined by subtracting the oil and water volumes from the total sample volume.

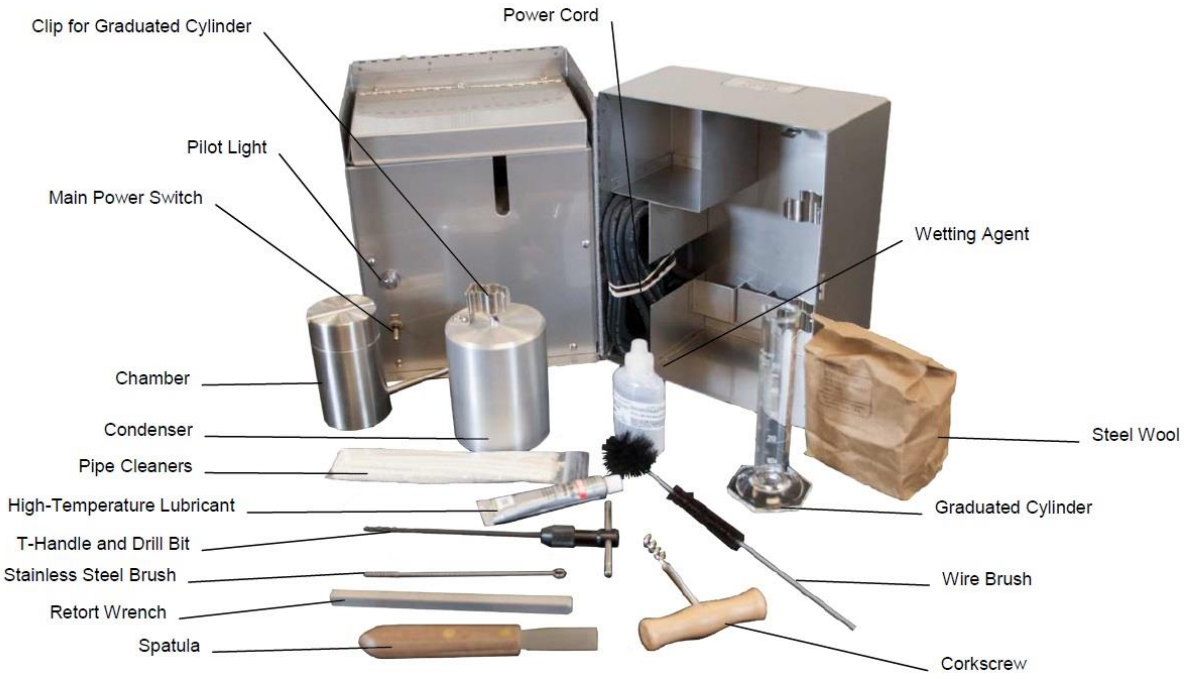

Figure 1 Retort with parts (from the Fann user guide).

3 The PSA's investigation

Composition of the investigation team:
Svein Harald Glette, F-process integrity (investigation leader)
Eivind Sande, F-process integrity
Anita Oplenskedal, F-logistics and emergency preparedness

Procedure
The PSA investigation team flew out to *West Phoenix* together with the police on 8 November 2018 and returned on 9 November 2018. After a safety briefing and kick-off meeting, the police and the team inspected the fire site before conducting their interviews.

The PSA supported the police in two interviews and during the site inspection. It also conducted interviews where Seadrill had an observer present.

A document package was ready on arrival and reviewed on the facility. Additional documentation was also acquired.

The police technician took the extension cord and retort ashore for further investigation.

On 16 November 2018, a meeting was held with Halliburton in Tananger in the presence of observers from Equinor and Seadrill. The retort's mode of operation, calibration and maintenance were described at this meeting. Risks associated with using the retort, previous incidents and training systems for using the equipment were also presented.

The cladding used in the fume cabinet was analysed as an ordinary asbestos sample, and also by looking directly at the material. No asbestos was found. A direct investigation of the cut face reveals a fibrous structure.

4 Course of events

A brand new extension cord was taken from the stockroom on board on 7 October 2018 for use in the mud lab. This was laid behind the retort and the magnetic stirrer in the lab's fume cabinet, and both these devices were connected to it. The socket outlet was located outside the cabinet. The hatch on the cabinet has an opening at the bottom to draw in fresh air, and the cord had clearance through this.

At 13.30 on Monday 5 November 2018, the mud engineer tested drilling fluid in the lab's retort. This test lasts about two hours, and the engineer left the room to do other things. The test is performed about twice a day in a retort placed in a fume cabinet. At that point, only the retort was in use in the cabinet.

Containers of chemicals used for testing drilling fluid were also stored in the cabinet. One of these, Dowanol (about 300ml), is flammable.

At 14.48, the smoke alarm in the mud lab was activated. This was registered in the CCR. The derrickman and the motor man were contacted by the CCR operator to verify a possible fire in the room. The derrickman was the first to open the door to the lab, observed flames, closed the door and confirmed the fire to the CCR.

At 14.52, a general alarm was activated and all personnel mustered. Fans and fire dampers were shut off. The *Siddis Mariner* standby ship was contacted at 14.52 to move closer. The JRCC, Seadrill second line and Equinor second line were notified. Yellow status was activated on the facility at 14.53. The POB check was completed at 14.59.

The fire team was in place at 14.59 with smoke-diving and portable extinguishing equipment. Fire team 1 entered at 15.02 while team 2 prepared the water hose. An initial 50kg of powder was followed by water. Electrical equipment was isolated before using water. The high temperature in the room meant that powder and water were deployed through a small opening in the door. When the fire was extinguished, the fire team entered the room for further cooling with water. The fire was confirmed as extinguished at 15.10.

The well was secured and personnel mustered when the incident occurred.

Figure 2 shows the placement and arrangement of equipment in the mud lab. It is located on the tween deck near the pump room and operator stations for mud and cement.

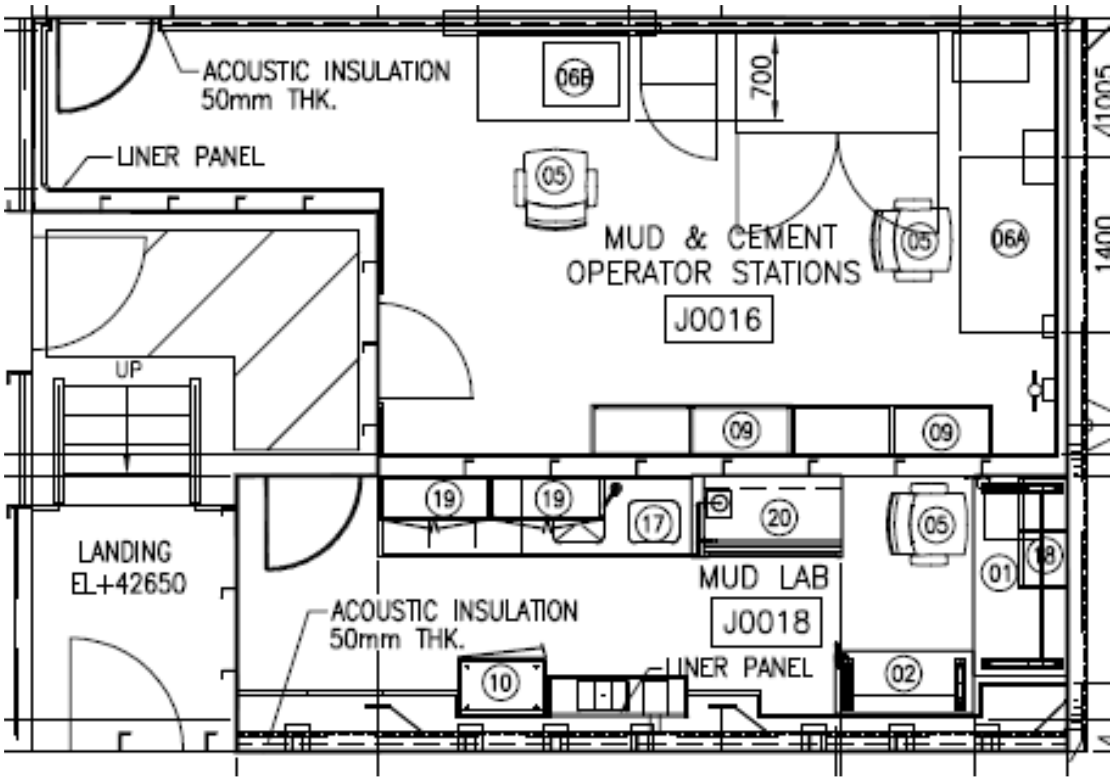

Figure 2 Positioning of the mud lab and the room layout.

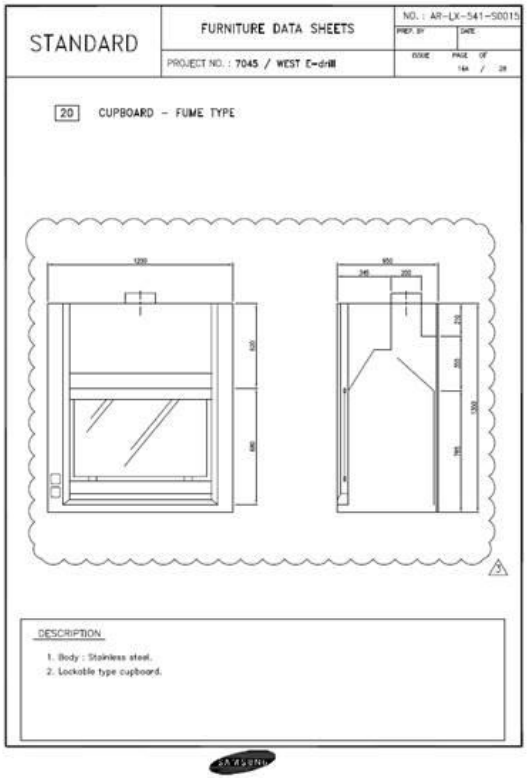

Figure 3 The fume cabinet in the mud lab (see figure 2, unit 20).

5 Potential of the incident

Actual consequence
The consequence of the incident was material damage and a five-day halt to drilling. Seadrill has specified 75.25 hours of downtime as a result. Material damage was confined to the mud lab. See figures 4 and 5. Checks of bulkheads, cable conduits and equipment in adjacent rooms after the fire registered no visible damage. Before drilling could resume, a new mud lab had to be requisitioned from land, sent to the facility and made ready.

No people were injured during the incident.

Potential consequences
The mud lab had A0 firewalls with adjacent rooms. Had the fire not been quickly extinguished, it would probably have spread because flammable materials were stored and used in the room. Fire damage to cables passing through the mud lab and/or the fire spreading to the cement operator station would have meant a longer halt to drilling and substantially greater material damage. Spreading of the fire could also have distributed smoke to large areas of the facility.

Chemicals were stored in the fume cabinet. In their relevant dilution and quantities, these have only had an insignificant effect in making the smoke a greater health hazard than it already was. Smoke from fires is hazardous to health, and will normally contain a selection of carcinogens and other substances which pose a health hazard. Only response personnel with smoke diving equipment were exposed to the smoke, and the investigation team therefore does not consider the smoke to have had any consequence in this case.

Figure 4 Overview of the mud lab after the fire (from Seadrill).

Figure 5 The fume cabinet in the mud lab (from the police).

6 Direct and underlying causes

The extension cord with power strip was used for a retort inside a fume cabinet in the mud lab.

Investigations by the criminal investigation service found traces of serial arcing in the cord, which was very probably the cause of the fire. The arcing has almost certainly occurred as the result of insulation failure owing to mechanical damage.

An underlying cause is the inadequate design of the cabinet. It did not have its own internal power point, which necessitated the use of the extension cord. Flammable cladding was also used on its internal walls. Drawings for the cabinet showed that stainless steel should have been used for such cladding. Storing flammable chemicals in the cabinet and flammable materials in the lab could have contributed to the scale of the fire.

Figure 6 Extension cord corresponding to the one used in the mud laboratory.

7 Emergency response

The emergency response organisation during the *West Phoenix* activity on the Ragnfrid North field is specified in a bridge document, which forms an agreement between the operator and drilling contractor for this operation.

An immediate announcement was made over the public address system and a general alarm sounded following confirmation of the fire. The first line response mobilised immediately to the emergency control room (ECR). Crew mustered in accordance with the alarm instructions and POB were checked within seven minutes. Notification was given to the JRCC as well as the Seadrill and Equinor second lines in accordance with the applicable emergency response plans. Fire team 1 and 2 mobilised in accordance with the plans and prepared to respond in the fire area.

The well was secured when the incident occurred.

In the investigation team’s view, the emergency response functioned well.

8 Regulations

Seadrill has opted to apply section 3 of the framework regulations with the specifications and limitations which follow from section 1 of the facilities regulations. Section 3 of the framework regulations states that, with mobile facilities registered in a national ships' register, and which follow a maritime operational concept, relevant technical requirements in the regulations from the Norwegian Maritime Authority (NMA) for mobile facilities with supplementary classification rules provided by a classification society, or international flag state rules with supplementary classification rules providing the same level of safety, can be used.

Where technical conditions on the facility for handling this type of incident are concerned, the relevant legal authority is the NMA's regulations No 227 of 31 January 1984 concerning precautionary measures against fire and explosions on mobile offshore units (the fire regulations).

Where technical conditions on the facility related to electrical installations and equipment are concerned, the relevant legal authority is section 6a on electrical installations and equipment in the NMA's regulations No 856 of 4 September 1987 concerning construction of mobile offshore units (the construction regulations).

9 Observations

The PSA's observations fall generally into two categories.

- Nonconformities: this category embraces observations where the PSA has identified a breach of the regulations.
- Improvement points: these relate to observations where deficiencies are seen, but insufficient information is available to establish a breach of the regulations.

9.1 Nonconformities

9.1.1 Use of extensions cords with a 16A overcurrent-protected device

Nonconformity
The extension cord used in the mud lab was not dimensioned and sufficiently robust to avoid a high temperature or arcing.

Grounds
The cord used was three metres long and had a cross-section area of one square millimetre. The standard requires at least 1.5 square millimetres Cu (copper) for such cords.

Section 524.1 in the NEK 400:2018 standard from the Norwegian Electrotechnical Committee (NEK) states: "Based on NEK EN 60799, the minimum cross-section area for extension cords intended to be connected to socket outlets with a nominal current of maximum 16A should be 1.5 square millimetres Cu. For extension cords with a length of less than two metres, the minimum cross-section area may be one square millimetre Cu."

Requirement
Section 3 of the framework regulations on the application of maritime regulations in the offshore petroleum activities, see section 6a on electrical installations and equipment in the

NMA regulations No 856 of 4 September 1987 concerning construction of mobile offshore units (the construction regulations), see section 16, paragraph 1 of the regulations on maritime electrical installations (FME), see section 524.1 of NEK 400:2018.

9.1.2 Retort

Nonconformity
Lack of disconnection device to prevent overheating of the retort.

Grounds
The heating element in the retort has a capacity of 700W and is controlled by a thermostat. No thermal fuse or other disconnection device was installed in the retort to prevent overheating if the thermostat failed.

Requirement
Section 3 of the framework regulations on the application of maritime regulations in the offshore petroleum activities, see section 6a on electrical installations and equipment in the NMA regulations No 856 of 4 September 1987 concerning construction of mobile offshore units (the construction regulations), see section 16, paragraph 2 of the regulations on maritime electrical installations (FME).

9.1.3 Fume cabinet design

Nonconformity
Cladding material used in the fume cabinet was flammable, and no power socket was installed inside it.

Grounds
The fume cabinet drawings showed that it should be made from stainless steel sheets. These were not used in its construction. The cabinet was clad internally with flammable fibre sheets.

No separate power socket was installed in the cabinet to avoid having to run an extension cord through the opening under the hatch.

Requirements
Section 3 of the framework regulations on the application of maritime regulations in the offshore petroleum activities, see section 19, items 6 and 9 on protection of living quarters, workrooms, engine rooms and control stations in the NMA's regulations No 227 of 31 January 1984 concerning precautionary measures against fire and explosions on mobile offshore units (the fire regulations).
Section 4 of the management regulations on risk reduction.

9.2 Improvement points

9.2.1 Portable third-party equipment taken on board

Improvement point
Portable third-party equipment taken on board the facility was not checked for damage before being put into use.

Grounds
All third-party containers and larger equipment items were subject to reception checks on the facility before being connected to the facility's permanent systems. This was documented using dedicated check lists. Portable third-party equipment taken on board was not subject to corresponding checks. That related, for instance, to retorts and other portable equipment used in the mud lab.

Requirement
Section 21 of the management regulations on maintenance.

9.2.2 Checking of extension cords

Improvement point
No routines were established for checking the type of extension cord used.

Grounds
Routines had not been established, either when issued or during use, for following up whether extension cords of the type used in the mud lab were damaged or correctly utilised.

Requirement
Section 45 of the activities regulations on maintenance.

9.2.3 Storage of flammable materials in the mud lab

Improvement point
Incautious storage of flammable equipment and materials.

Grounds
The PSA team was told that chemicals and flammable liquids were stored in the fume cabinet. Dowanol (300ml) was present in the cabinet during the fire, for example.

No separate cabinet for storing chemicals and flammable substances was installed in the mud lab. Packaging and other flammable materials were also kept in the room.

Requirements
Section 3 of the framework regulations on the application of maritime regulations in the offshore petroleum activities, see section 5, sub-section 2 on general provisions in the NMA's regulations No 227 of 31 January 1984 concerning precautionary measures against fire and explosions on mobile offshore units (the fire regulations).
Section 4 of the management regulations on risk reduction.

9.2.4 Maintenance of retorts

Improvement point
Faults where not registered when calibrating and maintaining equipment.

Grounds
The retort used on *West Phoenix* was calibrated on land in August 2018. The team was told that this type of equipment required no adjustment, testing or maintenance during offshore

use. In the event of a failure, it was replaced and sent ashore for maintenance and repair. During maintenance on land, no records were kept of possible faults. Failure rates and the history of heating elements, for example, were therefore not traceable.

Requirements
Sections 47 and 49 of the activities regulations on maintenance programme and on maintenance effectiveness respectively.

10 Barriers which have functioned

The fire in the lab was discovered because a smoke detector in the room alerted the CCR. It was confirmed when the derrickman checked the room and reported smoke and fire to the CCR.

At an early stage in the course of events, the CCR initiated measures for manual closure of the ventilation system. Verification after the incident showed that the damper was shut and the fuse for closing the damper on the extractor from the room was activated

The emergency response functioned as planned. Confirmation that the fire had been extinguished came 18 minutes after the report of a confirmed fire was received. Electrical isolation was implemented before fire water was used in the room

11 Discussion of uncertainties

It is uncertain how the damage to the extension cord has occurred. It could be a manufacturing fault, the cord could have lain crushed or it could have been damaged in another way. The cord used did not accord with the specified standard in terms of length and cross-section. A larger cross-section would have made it more resistant to damage, but it is uncertain whether that had any significance for the incident.

Although the likeliest explanation is that the cord caused the fire, some uncertainty related to the escalation exists. A chemical in the fume cabinet was flammable, which could have contributed to escalating the fire. So could the internal cladding in the cabinet, as well as flammable material in the room in general.

12 Assessment of the player’s investigation report

Seadrill established an investigation team with participation from Equinor and Halliburton. Its report was received on 12 December 2018. The description of the course of events and the probable direct causes coincides with the PSA team’s observations and assessments. Seadrill had identified the extension cord or the retort as the direct cause of the incident.

Seadrill has divided recommended measures by their outcome for the direct cause, whether that is the cord or the retort. The report gives three underlying causes for the fire, and specifies many good measures, both short- and long-term, which could help to avoid similar incidents. The PSA believes all the measures are relevant, regardless of the direct cause of the fire.

13 Appendices

A. The investigation has drawn on the following documents.

Report on the forensic investigation by the National Criminal Investigation Service, document no 84291866
Equinor Synergi reports for retort and mud lab
Seadrill investigation report: *West Phoenix fire in mud lab Incident November 05, 2018*
Analysis of cladding from fume cabinet, Sintef Molab report dated 29 January 2019
Bridging document for emergency response between Seadrill and Equinor
Weather report from StormGeo
Schematic fire area
Schematic muster area
Fire and gas alarm – print-out
West Phoenix personnel list
Halliburton presentation
Baroid Core Outline 2017_Innhold Boreslam School Halliburton
CL-SCA-HAL-BAR-DF-401_HSE inspection checklist – offshore boreslam test laboratory
JSA-GL-HAL-BAR-LAB-RD-010_Risk analyse retort
Dowanol PNP safety data sheet
FO-GL-HAL-BAR-LAB-CAL-015_Global calibration form retort
FO-NO-HAL-BAR-LAB-818_Norwegian calibration form retort
SQ Alert - Dangers of Analyzing Formate Fluids using a Retort
GD-GL-HAL-BAR-AG-4379 testing & treatment_assessment guideline_competence
GD-GL-HAL-BAR-OJD-4379 testing & treatment_on the job delevopment_competence
JSA-NO-HAL-BAR-LAB-201_safe job analysis retort
MAN-GL-HAL-BAR-005_Baroid fluids handbook
Phenolphthalein indicator 0.9% in ethanol_safety data sheet
Retort_Apparatus_Safety_Poster Retort
Safety Alert Retort_Melted heater block
WM-GL-HAL-BAR-LAB-CAL-000 Baroid lab equipment calibration
WM-GL-HAL-BAR-LAB-CAL-011_Work method calibration of retort
Data sheets for chemicals stored in the fume cabinet
Furniture data sheet
Instruction manual – 50ml oil and water retort
Photographs – Fire dampers
Photographs – switchboard in ECR
Photographs – mud laboratory
Investigation mandate Seadrill
Notification of undesirable incident
Safety alert Halliburton 2015 - fire mud laboratory - melted heater block in retort

B. Overview of participants