Engineering/Technical Investigation Report

Loss of Well Control at Suncor Altares

Table of Contents

About the

BC Oil and Gas Commission

The BC Oil and Gas Commission is the single-window regulatory agency with responsibilities for regulating oil and gas activities in British Columbia, including exploration, development, pipeline transportation and reclamation.

The Commission's core roles include reviewing and assessing applications for industry activities, consulting with First Nations, ensuring industry complies with provincial legislation and cooperating with partner agencies. The public interest is protected by ensuring public safety, protecting the environment, conserving petroleum resources and ensuring equitable participation in production.

For general information about the Commission, please visit www.bcogc.ca or phone 250-794-5200.

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1 Incident Summary

On Feb. 4, 2012 Suncor Energy Inc. (Suncor) commenced drilling a Montney gas well at 16-12-84-26 in the Altares field, approximately 30 kilometres (km) north of Hudson's Hope, B.C. The drilling contractor was Nabors Drilling Canada (Nabors).

On March 9, 2012 at approximately 10:05 p.m., a pit gain alarm occurred, alerting the drilling rig crew of a 0.5 cubic metre (m^3) increase in drilling fluid volume. At the time of the alarm, drilling was occurring in the Doig formation at a depth of 2,124 metres (m). The crew immediately called a general alarm and proceeded to shut the well in by closing the blowout preventers (upper pipe rams). By the time the well was shut in, the drilling fluid volume gain was seven m^3 and the casing pressure was 14,174 kilopascals (kPa).

As the casing pressure continued to climb and exceed the posted maximum allowable casing pressure (MACP) of 14,400 kPa, the crew opened the well to flow in an attempt to reduce the casing pressure. As the crew continued its attempts to reduce casing pressure, the well continued to flow and casing pressure continued to rise as drilling fluid was evacuated from the well.

A rig crew member was in the choke manifold shack attempting to make valving changes and a second crew member was en route to provide assistance when a loud bang was heard and a fluid release occurred near the main door of the manifold shack. The force of the fluid release was sufficient to knock the second crew member into the manifold shack. The two crew members were able to escape from the manifold through a different door.

The failure occurred at approximately 10:45 p.m. At that time, the casing pressure exceeded 27,000 kPa. Immediately following the failure, all personnel evacuated the site. The drilling rig caught fire at approximately 11:12 p.m. and was subsequently destroyed.

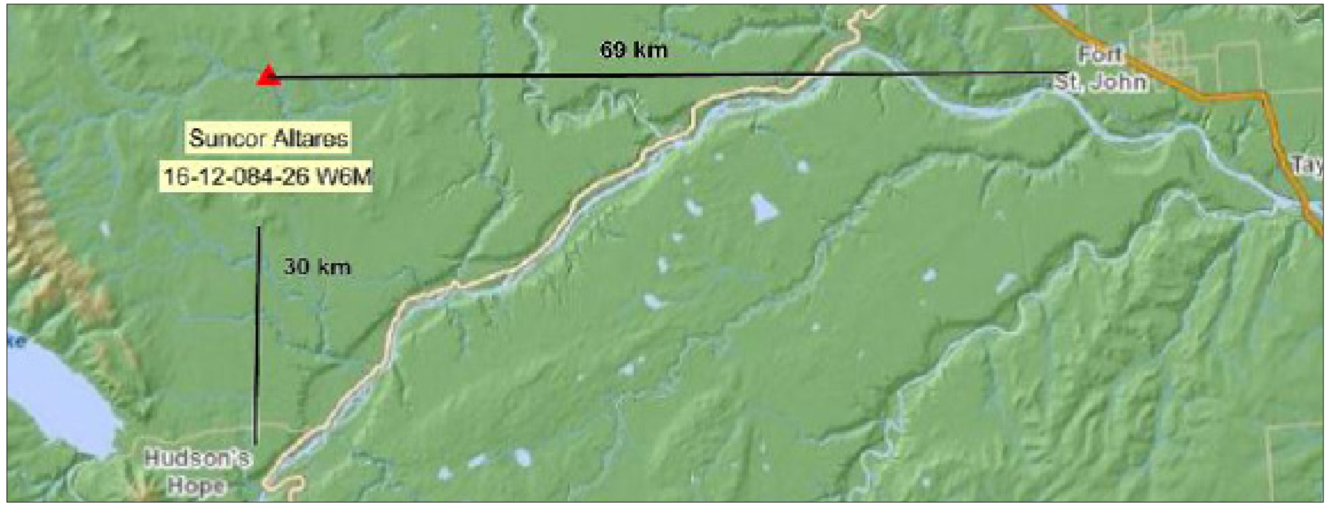

Figure 1: Location of the Suncor Altares 16-12-84-26 well.

Suncor activated its emergency response plan and dispatched safety and well control experts to the site. The BC Oil and Gas Commission (Commission) was notified of the incident at 11:33 p.m.

Due to the potential for hydrogen sulphide (H_2S) in the gas release, both Suncor and the Commission dispatched air monitoring units to the site. Air monitoring units were on site from March 10 to April 24. The monitors did not detect any offsite exceedences of air quality objectives for H_2S or sulphur dioxide (SO_2). The nearest resident was located 7.5 km to the west of the well.

By March 23, the well flow had reduced substantially. The high initial flowrate, followed by rapid depletion, is indicative of gas flow from natural fractures contained within a low permeability formation.

During the blowout, the upper portion of the well was damaged. The collapse of the derrick bent the upper portion of the casing so the blowout preventers were at a 45-degree angle. High velocity flow eroded a hole in the casing at a depth of approximately five m below ground level. Due to damage to the upper portion of the well, the area around the wellbore was excavated to a depth of 11.3 m, the casings were cut and a spool assembly was installed in order to extend the well back up to original ground level.

Unstable soil conditions resulting from spring breakup combined with the need to excavate and backfill caused delays in operations to abandon the well. On May 16, plugging operations were completed and Suncor began to demobilize from the site.

2. Investigation Procedures

All companies engaged in oil and gas activities in British Columbia are required to report incidents wherein the safety of persons or quality of the environment has been placed at risk. The Commission receives and reviews these reports and provides regulatory oversight of the follow-up responses and mitigation by the company.

Certain incidents may prompt a more detailed investigation by the Commission. As a general rule, the Commission may launch an Engineering/Technical Investigation into an incident when the incident:

- Results in significant impacts to the public or other stakeholders.
- May stem from a systemic issue within the company's management systems.
- May identify deficiencies in current practices and procedures within industry.
- May identify opportunities for improvement of processes and procedures within the Commission or industry.
- Results or may have resulted in serious injury or death.
- Attracts significant public attention.

The goals in conducting Engineering/Technical Investigations are to identify cause and contributing factors. The results are summarized in a publicly accessible report posted on the Commission website. By sharing the results of these investigations, the Commission aims to reduce the likelihood of similar events. Enforcement actions may arise during an investigation but are not the primary purpose.

3. Relevant Information

3.1 Incident Chronology

The following observations and statements have been compiled following a review of incident logs and responses to information requests made by the Commission. The events took place between Nov. 18, 2011 and May 21, 2012. The timing of events and emergency response to the incident are provided in Table 1.

Table 1: Incident Time Log (in Mountain Standard Time)

Time	Detail
Nov. 18	Commission issues well permit.
Feb. 4	Well is spud (drilling commences).
Feb. 6	Emergency Response Plan meeting completed prior to entering any potential sour gas zones.
Feb. 7	Surface casing set at 451 m.
Feb. 8	34.5 megapascal (MPa) blowout preventer (BOP) stack is installed.
Feb. 12-17	On-site well control training provided by Global Technologies.
Feb. 20	Intermediate casing set at 1,512 m.

Feb 21	Installed managed pressure drilling equipment.
Mar 9	
9:30 p.m.	Rig crew attempts to pattern diamond impregnated drill bit.
9:49 to 9:57 p.m.	Pump pressure increases from 18 MPa to 20.6 MPa. Increase is not noticed by rig crew.
10:04 p.m.	Kick detected. Alarm triggered due to 0.5 m^3 increase in drilling fluid volume.
10:06 p.m.	Blowout preventers closed. Well is successfully shut in.
10:35 p.m.	As casing pressure approaches maximum allowable casing pressure, the well is opened to flow in an attempt to reduce pressure.
10:46 p.m.	Well control is lost.
11:25 p.m.	Incident reported to PEP.
11:30 p.m.	Suncor reports incident to Northern Health, Peace River Regional District and RCMP.
11:33 p.m.	PEP reports incident to the Commission.
Mar 10	
1:00 a.m.	Roadblocks put in place.
1:45 a.m.	Well control and air monitoring equipment mobilized.
2:00 a.m.	Suncor's Calgary emergency response management team is operational.
3:00 a.m.	Commission personnel arrive on site.
4:00 a.m.	HSE firefighters arrive on site from Grande Prairie.
4:30-6:30 a.m.	Suncor notifies Halfway River First Nation, West Moberly First Nation, Saulteau First Nation, District of Hudson's Hope, Ministry of Environment and local Crown land tenure holders.
5:12 p.m.	Mobile air monitoring unit EMU1 deployed on site.
10:00 p.m.	Suncor completes notification of area residents.
Mar 11	Debris clearing and staging area prepared. Mobile air monitoring unit EMU2 deployed as a roving monitor.
Mar 13	Mobile air monitoring unit EMU3 deployed at the Talisman camp, 8.6 km northeast of the incident location.
Mar 13	Commission deploys independent mobile air monitoring unit as a roving monitor.
Mar 16	Drilling rig moved away from wellhead.
Mar 17	Excavation begins around wellhead.
Mar 18	Chimney flare stack installed on well.
Mar 20	Conductor casing removal. Gas flow discovered between surface casing and conductor casing.
Mar 23	Insufficient gas flow to maintain flame on flare stack.

Mar 27	Casing bowl (casing flange) welded onto cut casing, approximately 12 m below ground level.
Mar 31	Commission demobilizes roving air monitoring unit.
April 3	Casing extended back to ground level. Backfilling of excavation complete.
April 5	Installed capping BOP stack.
April 13	Suncor demobilizes offsite air monitoring units EMU2 and EMU3.
April 24	Suncor demobilizes onsite air monitoring unit EMU1.
May 10	Complete removal of drill pipe from well.
May 11	Condition wellbore and plugging operations begin.
May 16	Complete plugging operations.
May 17-21	Rig out equipment from site.

3.2 Information Requests

On April 20, 2012 a formal request for information was issued to Suncor to obtain evidence required to determine the incident cause and contributing factors. The request was separated into two areas:

- Technical information in order to determine the root cause of the incident and contributing factors.
- Emergency management information in order to assess the adequacy and effectiveness of Suncor's emergency preparedness and response.

3.3 Failure Analysis

The Commission visited the site immediately following the blowout in order to assist with the incident response and to gather evidence. The blowout prevention equipment and associated piping was transported to a secure facility in Nisku, Alta. where it was examined by Commission, Suncor, Nabors and Weatherford Canada Partnership investigators.

Due to the intense fire following the incident, many of the piping components exhibited some form of failure. The Acuren Group Inc. (Acuren) completed analysis of the piping components in order to determine if an initial failure point could be identified and the cause of the initial failure. The examination included visual examination, diameter measurements (to determine if piping had expanded due to excessive pressure) and metallographic examination. Radiography of the flow control valves was conducted in order to determine valve positions (direction of flow) at the time of the failure.

Acuren was able to identify one failure that occurred on the drilling fluid (mud) return line between the managed pressure drilling separator and the shale shaker that did not occur as a result of damage caused by the fire. A metallographic section of the components and observation of the failure indicated that a pre-existing fatigue crack was present. The presence of such a pre-existing crack would render the joint susceptible to failure with the application of a relatively small bending load. Acuren did not find any evidence that any of the piping components were damaged as a result of overpressuring.

Figure 2: Photograph showing the drilling fluid return line failure location.

Figure 3: Photograph showing the fracture on the drilling fluid return line.

Considering the piping configuration, witness statements and analysis of materials, it appears the failure of the drilling fluid return line was a contributing factor to the loss of well control. While the failure of the drilling fluid return line is believed to be a significant event that contributed to the blowout, there are a number of other factors that must be considered in order to understand the cause of the blowout.

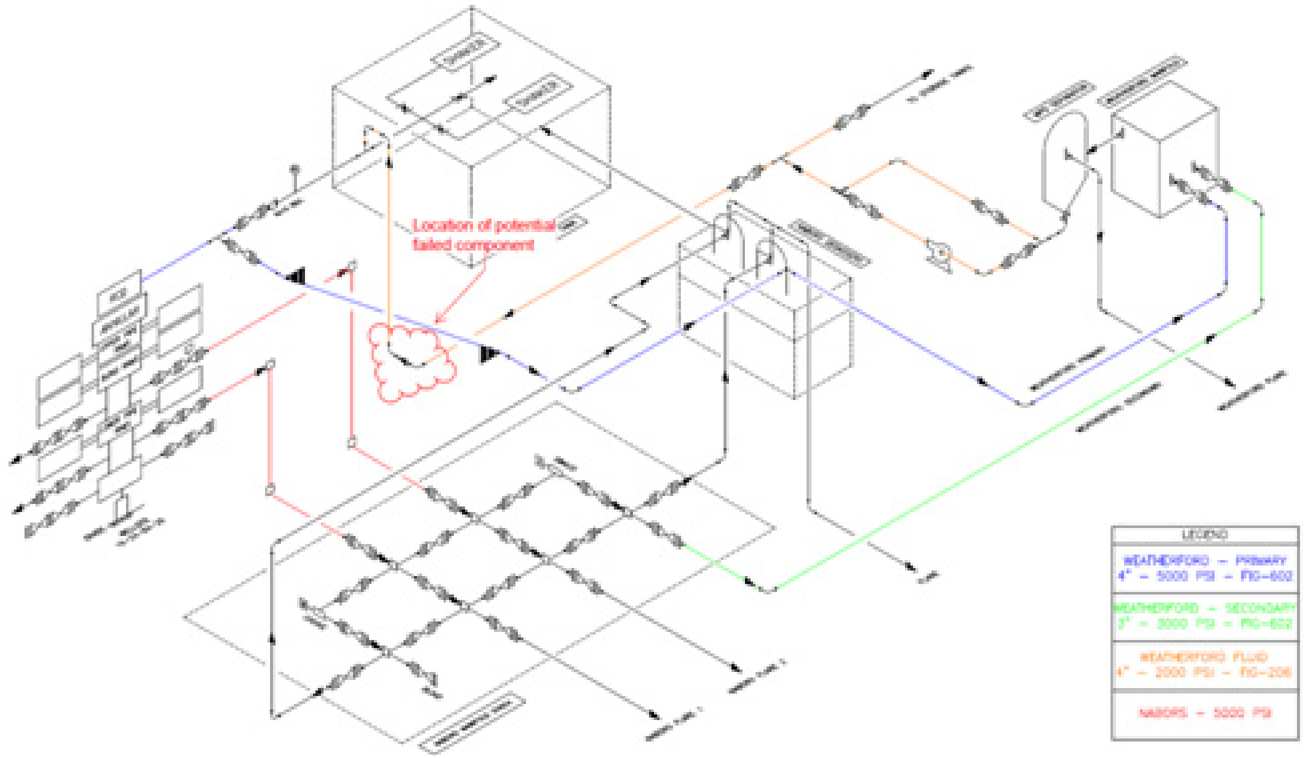

Figure 4: Isometric drawing of the Nabors 9 piping configuration showing the mud return line failure location (not to scale).

4. Analysis

4.1 Failure Cause and Contributing Factors

The following observations and statements are based on a review of the evidence:

- The well was licensed as a Montney gas well. This vertical well was being drilled to confirm stratigraphy and depths prior to drilling a horizontal well from the location.
- The well was being drilled by Nabors 9. The rig had been relocated from Suncor's Firebag heavy oil project in eastern Alberta and, since moving to B.C., had drilled two wells in the Kobes field prior to the incident.
- Nabors 9 was equipped with a Class C BOP system rated for a maximum pressure of 34,000 kPa and a managed pressure drilling (MPD) system rated for a maximum pressure of 21,000 kPa.
- The MPD drilling program stated the MPD equipment should not be used if the casing pressure exceeded 12,960 kPa (>90 per cent of posted MACP) and that well control operations should be carried out using the drilling rig's BOP system.
- The driller on duty at the time of the incident had a valid Enform 1st Line Supervisor's Blowout Prevention certificate.
- The night shift rig manager on duty at the time of the incident had a valid 2nd Line Supervisor's Blowout Prevention certificate.
- The Suncor site representative that was on duty at the time of the incident had a valid Enform 2nd Line Supervisor's Blowout Prevention certificate.
- From February 12-17, Global Technologies Transfer and Training Inc. conducted on-site well control training for Suncor and Nabors personnel.
- When drilling with an invert drilling fluid, kick detection is more difficult due to the ability of gas to dissolve in the drilling fluid.
- The drilling program did not make reference to MACP, or define the procedures to follow, should the casing pressure approach or exceed MACP.
- The Suncor Well Control Guideline outlined MACP in general terms, but lacked specific direction and appeared to pertain more to shallow well drilling programs.
- At the time of the initial kick, the rig was drilling at a depth of 2,124 m in the Doig formation, intermediate casing was set to a depth of 1,512 m and the well was being drilled with an oil-based (invert) drilling fluid with a density of 1,585 kg/m^3.
- At the time of the kick, the MPD system was in use and was holding 1,000 kPA of back pressure on the casing.
- At the time of the kick, the posted MACP was 14,400 kPa.
- The initial kick was detected and the well was successfully shut-in within two minutes of detection.
- Shut-in casing pressure was 14,024 kPa and the total drilling fluid volume gain was seven m^3.
- Casing pressure increased above the MACP of 14,400 kPa. The well was opened to flow in an attempt to reduce the casing pressure.
- As the well flowed, casing pressure continued to increase and drilling fluid was removed from the well.
- Due to problems keeping the Nabors flare stack pilot lit, flow was diverted to the Weatherford MPD system. The flow diversion did not comply with the Weatherford MPD program.
- A fluid release occurred, resulting in a complete loss of well control. It is believed the fluid release resulted from a failure in the drilling fluid return line.

Based on the preceding observations and statements, the Commission has determined the root cause of the Suncor Altares 16-12-84-26 blowout was the lack of adequate well control procedures. Had a clear procedure been in place to respond to well control events where the casing pressure approached or exceeded MACP, it is unlikely well control would have been lost.

Factors that contributed to the loss of well control include:

1. Training – Blowout prevention training is provided by Enform, an organization that provides training to the oil and gas industry. Training emphasizes MACP should not be exceeded during well control operations. This emphasis is appropriate for wells with shallow surface casing setting depths due to the potential consequences of a shallow underground blowout.
2. Experience – The drilling rig crew's experience was primarily with heavy oil wells in eastern Alberta. While the crew had received specialized well control training on site, they did not have any significant experience drilling deep, high-pressure gas wells. As the incident progressed, the rig crew's actions defaulted to their previous training and experience.

3. The MPD program stated the MPD equipment should not be used if the casing pressure exceeded (>90 per cent of posted MACP) 12,960 kPa. Casing pressure exceeded this threshold and the rig crew should not have been attempting to conduct well control operations through the MPD equipment.
4. The drilling fluid return line on the MPD system failed. It is believed this failure resulted in the loss of well control.

4.2 Emergency Management

The following observations and statements are based on a review of incident logs and responses to the information request:

- The emergency response zone for the well during drilling operations was 533 m.
- The nearest residents were located 7.4 km to the west and 7.9 km to the southeast of the location.
- The loss of well control occurred at 10:45 p.m. on March 9.
- The incident was reported to PEP at 11:25 p.m. The incident was classified as a Level 3 emergency.
- By 1 a.m. on March 10 roadblocks were in place.
- By 1:45 a.m. air monitoring crews and well control specialists had been dispatched and the Suncor response management team in Calgary was operational.
- By 3 a.m., Commission personnel were on site.
- By 4 a.m., HSE firefighters were on site and the Suncor response management team in Calgary was fully functional.
- By 5:12 p.m., a mobile air monitoring unit was on site and began monitoring for H_2S and SO_2.

The Commission is satisfied that Suncor's response to the incident was timely and appropriate.

4.3 Air Quality Monitoring

Throughout the incident response, air was monitored on site through the use of personal gas monitors. Additionally, Suncor and the Commission deployed mobile air monitoring units to monitor air quality in the vicinity of the site.

Suncor EMU1 was located at the 16-12 wellsite from March 10 to April 24. Suncor EMU2 was a roving monitor that collected readings at 10 locations in the vicinity of the site from March 11 to April 13. Suncor EMU3 was located at the Talisman 112 camp from March 13 to April 13.

The Suncor air monitors did not detect any offsite exceedence of air quality guidelines for H_2S or SO_2. The offsite air quality guideline is 10 parts per billion (ppb) for H_2S and 172 ppb for SO_2.

The Commission deployed a mobile air monitoring unit from March 13-31 in order to provide independent air quality data. The Commission air monitor did not detect any offsite exceedence of air quality guidelines for H_2S or SO_2.

The maximum recorded H_2S concentration at the wellsite was 34.7 ppb at 11 a.m. on March 27. The WorkSafeBC short-term exposure limit for H_2S is 10 parts per million (10,000 ppb).

The maximum recorded SO_2 concentration at the wellsite was 15.3 ppb at 6 p.m. on April 11. The WorkSafeBC short-term exposure limit for SO_2 is five ppm (5,000 ppb).

4.4 Soil and Water

During the incident, an unknown quantity of invert drilling fluid was spilled on the lease. The invert ignited during the fire, leaving a solid residue on the soil. Approximately 375 tonnes of soil and invert residue was stockpiled and later trucked to the Tervita Silverberry landfill.

On March 16, 2012 a 1.5 m^3 spill occurred while transferring drilling fluid from a storage tank located at the wellsite. Approximately one m^3 was recovered as a liquid and the remaining 0.5 m^3 was absorbed using sawdust.

Beginning on March 22, 2012 the fire was extinguished and small quantities of produced liquids were intermittently released from the wellbore. Due to excavation in the vicinity of the well, it was not possible to contain the produced liquids. Any impacted soils were removed immediately and added to the soil stockpile for disposal.

The nearest stream is Farrell Creek, located approximately 150 m to the northwest of the wellsite boundary. The entire wellsite was bermed prior to the start of drilling and all spilled material was contained on site.

According to the BC Water Wells Database, the nearest water well is located approximately 8.2 km to the west of the site.

5. Directions

The following are directions that were provided to Suncor, as well as the responses as of January 2013.

1. Suncor shall ensure all wellsite personnel are adequately trained and competent.
   - Suncor is developing a well complexity matrix to support the determination of what skills are required for a given well program.
   - Suncor has adopted an enhanced competency assessment model for wellsite supervisors which align with the Canadian Association of Petroleum Producers' current competency assessment model.
   - Specific to the Kobes/Altares area Suncor has worked with a third party provider to develop a five-day well control training course. The course is designed specific to the area risks and characteristics. Participants are graded to determine their level of retention of the program. The program is attended by the well engineering team as well as the onsite personnel in charge of drilling operations.

2. Suncor shall ensure well control procedures are clear, unambiguous and appropriate.
   - Suncor has reviewed evaluated and revised relevant internal procedures, re-designed its drilling program by adding clear guidance and instruction regarding MACP, details respecting tolerances, and referencing all 3rd party programs to ensure that wellsite personnel have a detailed and aligned program.

3. Suncor shall ensure site-specific risks are identified and the risks and mitigation strategies are clearly communicated to wellsite personnel.
   - Suncor has designed a Well Delivery Model (WDM) applicable to all areas of Suncor's drilling operations (North American Onshore Gas, East Coast, and International). Embedded in the model is a detailed consolidated risk assessment that requires the identification of risk mitigation processes. An Operations Readiness Review (ORR) process will be undertaken to ensure that the project team is ready to proceed. Depending on the risks associated with the well, the process may also require a Drill Well on Paper (DWOP) exercise to be attended by all personnel executing the drill operation on site. Prior to drilling activities, risk assessment and mitigations will be reviewed by all personnel. Once drilling has commenced, risk assessment and mitigations will be reviewed on a continual basis at shift and safety meetings.

6. Recommendations

The following recommendation is being pursued by the Commission.

1. The Commission intends to approach industry bodies including Enform and the Drilling and Completions Committee in order to address the identified gaps in well control training courses.

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