LATERAL LEARNING DOCUMENT
(INVESTIGATION, EMERGENCY RESPONSE & RECOVERY)

WELL BLOW OUT EVENT

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1. Introduction
This document aims to convey the lateral learning points from the recent emergency on a well on which well control was lost, and emergency response efforts continued for a period of more than a month before well control was re-established.

In order to keep it short and crisp, findings are summarised and only major learning is listed in this document. In many instances bullet point listings are presented rather than text.

The document is split up in three parts: firstly, the Investigation Team findings of the Blow Out causes and failure mechanisms. Secondly, the surface fire fighting and capping efforts which ultimately resulted in the well being brought under control. Lastly, the efforts exerted to drill a relief well into the blow out well.

2. Blow Out Investigation
2.1. Sequence of events
A brief summary of the events which took place resulting in the blow out. For a more detailed reconstructed sequence of events see Appendix 1. Please bear in mind that the well was a near field exploration (NFE) well.

- **Rig X drilled the well.** Unable to take log pressure readings due to hole problems.
- Decision made to perform cased hole MDT (Modular Dynamics Tester).
- MDT tools not available, hence job was transferred from rig to hoist sequence.
- Rig X leaves the well with 10.1 kPa/m brine in the casing (potentially under balanced)
- **Hoist Y** moves onto location, shooting nipple incident happens (only held in Annular, nipple ejects out of the BOP while pressure testing)
- 7” rams mobilised and another shooting nipple which has 7” LTC connection on top.
- 3 wireline perforating runs without incident.
- On 4th perforating run flow and pressure are observed on surface. Well is bullheaded with 10.6 kPa/m brine but unable to bullhead entire well volume without exceeding the maximum allowable squeeze pressure to prevent impairment. Reportedly, the well is dead after a flow check.
- 5th perforating run: pressure again builds up. Stuffing box leaks and the closing pressure is increased – ok.
- Decide the POH wireline guns. At 1000 m stopped, CICHP (Closed-In Casing Head Pressure) has built up to 2700 kPa.
- Decision to bleed off the well to ‘let the gas rise to surface and bleed off’, after close in CICHP = 3,500 kPa.
- LTC (Long Thread Connection) connection jumps a thread and starts leaking. Within 3 minutes major flow to crown level.
- Attempt to shut in well on blind rams – not effective. Shut down power and evacuated hoist.
2.2. Identified Causes and Failures

The investigation team analysed the failures which contributed to the ultimate blow out. The main lateral failure categories were ‘organisation’ and ‘incompatible goals’ which covered 24 out of 33 total identified failures.

2.2.1. Direct Causes

- An inappropriate completion brine was used
- An inappropriate well control equipment system was used
- Inappropriate well control practices were used

2.2.2. Indirect and underlying failings

- This job was not recognised by anyone involved as a non-routine, potentially hazardous, well intervention caused by:
  a) the potential dangers of perforating multiple zones with significant pressure uncertainty ranges and differentials
  b) the infrequent execution of wireline perforation of new wells with no tubing in the well by hoists.
- Inadequate pre-planning of the job
  a) Poor proposal data due to insufficient input during the draft stage
  b) Inadequate program quality – no hazard identification or contingencies identified
  c) Late sequence change, non adherence to the established ‘freeze’ period.
- Established reporting lines and communications were unclear and/or breached.
- Pressure throughout the organisation and on contractors to obtain the pressure/sample data and bring the well on stream.
- High activity levels which stretched the current organisation into making decisions concerning risk and problems based on a “we have done it before basis” rather than reviewing options and making proper risk assessments.
- Insufficient empowerment of staff to STOP unsafe work.
- Supervisors not providing key checks and balances, checking whether risks have been properly evaluated.
- Inadequate well control competencies of well site staff for this type of activity from driller upwards in both hoist company and operator.
- Lack of adherence to established procedures and processes and too much reliance on custom and practise. Procedures were not “live” documents supporting efficient operations.
- Job execution is partially driven by contracted equipment rather than the equipment needed for the job.
- Hoists being used for non-routine operations without the proper processes and competencies being in place for this.
All of the above were compounded by non-involvement of key personnel who could have provided the correct checks and balances, several key staff being either new in position, operationally inexperienced or on leave, and unclear roles and responsibilities.

3. Surface firefighting and capping operations.

3.1. Outline of events

- After well control was lost the hoist was evacuated and Emergency Control procedures initiated.
- A specialist well control company Z was mobilised from Houston. Fire fighting equipment available in the country was mobilised to site.
- The first days were spent mainly on containing the spill and its effects (earthmoving) also trying to safeguard assets from the blow out location.
- After 4 days the well ignited, presumably due to metal parts in the mast causing a spark, making the removal of hoist and contractor equipment from site more difficult.
- The ignition triggered the mobilisation of major fire fighting equipment from Houston by Antonov transport plane. 3 Water supply wells were prepared.
- Preparation phase: mobilising manpower, materials and equipment; digging water pits; building monitor sheds; building heat shields for heavy earthmoving equipment; etc.
- Remove remaining equipment from location to gain access to the wellhead/BOP, commence digging around cellar.
- It was then observed that the BOP was tilted at 30 degrees, i.e. a leak path underneath the wellhead was likely, making a ‘simple’ BOP replacement impossible (well integrity was lost).
- This meant access was required at a very deep level to allow a cut underneath the wellhead. Digging/excavating continued but progress very slow due to hard rock.
- Made first successful abrasive jet cut through THS to remove BOP and shooting nipple which were dispersing the flow making work around the blow out well difficult.
- Continued digging/excavating to a level
where a second jet cut was made below the wellhead. 20" conductor was freed/removed during further excavation.

- Installed a flow tube to bring the fire ‘up high’ to allow personnel to work on wellhead.
- Cut 13 3/8” casing (cemented) with gas axe and removed same.
- Cut 9 5/8” casing with air operated ‘lathe cutter’ and removed same, exposing the 7” production casing.
- Extinguished the fire with water.
- Installed a ‘capping stack’ (Bottom to top: 7” slip rams, 7” inverted pipe rams, pump in spool, blind shear rams) with a crane. Closed slip rams and pipe rams.

- Diverted flow through side outlets by closing blind/shears.
- Closed in well on side outlet valve. Bullheaded well dead.

3.2. Emergency response learning points

- Inform authorities/share holders immediately – don’t hide anything
- Set up Internal Communication Network
- Crisis management team formation not exactly to the procedures.
- Distribution of tasks – and communicated to all.
- Deal with the media – TV & news agencies = press centre.
- HSE immediate involvement. - onsite representative 24 hours per day
- Involve Area Coordinators & major contractors/service providers.
- Document control - dedicated person at central control.
- Photography & video recording – archive
- Telecoms – International, download & surf web, multiple phone lines.
- Dedicated GSMs for the core team (field if it has coverage & office).
- Have a Public Relations Officer at location to assist in receiving visitors.
- Dedicated well control company Z electronic room (electronic document control).
- Dedicated operator company ABC website made with daily updates for all staff.
- Immediately start tracking costs for insurance purposes.
3.3. Fire fighting and well capping learning points

- Immediately determine a zoning policy – especially before ignition – dividing the entire area into “hot”, “warm” & “cold” zones – sign post it and designate which personnel are permitted in each zone.
- Secure the area as quickly as possible (preferably with local police) as the “curiosity factor” immediately kicks in and unwanted visitors begin to encroach on location.
- Ensure personnel or civilians that are down wind are evacuated if deemed necessary by HSE.
- There is a huge initial mobilization of equipment, materials and specialist personnel required to site. Have a dedicated “materials & services” co-ordinator onsite to ensure that all arriving equipment is catalogued, accounted for and signed off. This will greatly assist the Onsite Commander so that he can pay immediate attention to more pressing operational matters.
- Determine a site plan with designated storage and operational areas and communicate it to all at site.
- Organise a medivac plan and communicate it to all. Ensure those working in the “hot” zone are agreeable with the plan.

- Generate a unique cost centre/account code & communicate to all – especially logistics, supply, procurement & area co-ordinator.
- Contract call off of well control specialists. Have contracts section begin work immediately to put in place a local contract based on the framework agreement.
- Contract preparation for existing contracts in emergency situation – prepare before hand extensions to existing contracts (such as high pressure pumping equipments)
- Sufficient constant supply of drill water (not DHW) for fire monitors.
- Sufficient supply of AFFF foam agent without depleting stocks at refinery & airports
- Procurement & Logistics focal points are essential – preferably in the central control team to liaise with Area Coordinator & Onsite Commander.

- Need for a strong leader as the Onsite Commander – someone who can make decisions but work with the well capping specialists.
- A clear chain of command is established at site and adhered to – everything must go through the Onsite Commander.
- Equipment on standby – ensure that equipment that is on standby onsite, remains on site. Post guards around the clock if necessary – eg: generators at nearby water supply wells.
• Need for dedicated supervisors (day & night) to supervise the fabrication work – constant supervision (especially at night) necessary because of the non-routine nature of the work the workers/welders are performing.
• Procurement officer in the central control team must have a thorough knowledge of all local vendors and potential sources of “non routine” materials & items.
• Ensure sufficient onsite housing & catering services for the increased workforce.
• Refrain from constantly calling the site to ask individual questions or get updates. Have the site call the operator head office at designated times and let them concentrate on the operation at hand.
• Establish a clear plan of attack at the morning call depending on the weather conditions and other impacting factors on that particular day.
• Ensure the most rapid communication system is in place at site to aid the operation.
• Everyone is keen to be part of the operation & be “involved”, however those on location must be limited to essential personnel only.
• Respect the experience & knowledge of the well killing experts – however they should always work within the safety boundaries set by the operating company.
• Speed is of the essence – however not at the expense of safety. Plan very carefully every job and hold detailed tool box talks as most of the operation will be non-routine.
• Realize that there is more chance of an accident occurring in the construction & fabrication yard than there is near the well head (hot zone).
• Ensure access roads are adequately maintained.

3.4. Production Asset Team learning points

• Pressure data is presented in various formats and at various locations in well- and completion proposals, this needs to be streamlined across all Head Office Teams.
• Communication lines had over time developed between the hoist and the PE’s directly, it needs to be re-enforced that all operational matters are directed through well services operational staff.

4. Relief well planning & execution.

4.1. Outline of events
(note not all are sequential, many of these were progressed simultaneously)
• Once blow out had ignited a relief well team was assembled.
• Initiated location building immediately, 500 m laterally from blow out well. A second relief well location was picked and built as a precaution.
• Scarce directional data was available from the blow out well, hence personnel were mobilised specialised in directional uncertainty and with relief well experience.
• Mobilised homing-in tools and services. Work on contractual matters.
• Additional rig tanks for kill mud mobilised and hooked up.
• Determined the ‘most probable’ subsurface position of blow out well and the associated cone of uncertainty.
With help of well control company Z, relief well specialist wrote a drilling program taking into account the relief well specific hazards and operations (drilled pilot hole, dynamic kill simulations, extended open hole period due to homing in, etc.)

- Spudded relief well, drilled to ‘pass by’ depth.
- Performed 2 homing-in surveys with 50 meter drilled interval in between, confirming that the blow out well was located only 4 meter from its estimated ‘most probable’ location.
- Drilled ahead to required depth when surface capping operations were successful.
- Converted the relief well into producing well - this flexibility had been built into the well design from the start.

### 4.2. Relief well learning points

- Relief wells are typically started in a ‘near panic’ situation. There is a lot of pressure to get the show on the road. However, make sure that the team goes back to basics, use existing designs, materials and procedures as much as possible.
- Site staff was involved in the office in pre-planning of the well, this paid off easily when getting to the technically more complex part of the relief well.
- Set up a special cost monitoring method in the beginning. A lot of equipment will be called off ‘verbally’ in an emergency and one needs to keep in mind the fact that the insurance company will want all financial details broken out to the dollar.
- Homing-in tools have in this limestone formation excellent range. Up to 40 meters theoretically, well was detected at 26 m (+/- 10 meter).
- Consider to have a contract in place with specialist homing-in tool company, they are the sole provide for this service and it saves a lot of effort in a very busy time if the contract is in place ‘up front’.
- Relief well planning and drilling requires many different service companies to work together, and staff previously involved in this type of activity have a strong opinion. Strong yet subtle management is required to make the team work together.
- Stronger adherence to the survey policies is required. For this well the data was scarce and a lot of time and effort was spent trying to pinpoint the most probable location based on field directional trends. If such trends are not available it will be very difficult to find the well subsurface.
- A dedicated relief well folder will be established to capture learning in details (including electronic copies of programs etc) for future reference.
## 5. APPENDICES

### 5.1. Detailed sequence of events

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Facts</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rig X Drills Original Well</td>
<td>Identified as NFE well pressure range: 10-28,000 kPa, and high GOR (Gas Oil Ratio) up to 300m3/m3) UB (Underbalanced) TCP (Tubing Conveyed Perforator) job mentioned</td>
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<tr>
<td></td>
<td></td>
<td>Drilling proposal issued</td>
<td>Identified</td>
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<tr>
<td></td>
<td></td>
<td>Well spudded Rig X</td>
<td>Drilled formation ‘a’ with 12.0 kPa/m</td>
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<tr>
<td></td>
<td></td>
<td>Rig performed check trip to condition hole “Ad hoc Meeting” with asset manager</td>
<td>Decision tree made for logging/liner/pressure measurements. Good HQ Drilling Dept involvement. Identified that 600m3/d could be brought on stream</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Logged well in two runs Tried FMT/RCI (Formation Tester/Reservoir Characterization Instrument) without success</td>
<td>Logging program changed with RA (Radio Active) tools run</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rig tried RCI; unsuccessful Decision to run 7” casing Note from Team leader; run casing, likely for hoist to do MDT</td>
<td>First time that hoist is identified for doing the MDT job.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Meeting to discuss cased hole MDT</td>
<td>Job was done before; so ok. No detailed analyses. Pressure not to delay rig due to tool availability and to get well on production.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Confirmed that tools not available for this job Rig scraped well and displaced to WSW(Well Site Water)</td>
<td>Decision to mobilise alternative contractor</td>
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<tr>
<td></td>
<td></td>
<td>Rig displaced to 10.1 kPa/m filtered brine Email permission to use perforating contractor Asset Team told Res. Coord. about job; Asset team informed W/S BHJ of job</td>
<td>Discussion between Asset Team and Well Engineering Dept Audit trail for selection of contractor was good. No audit trail concerning operational decisions in asset team. Well services process is not clear to involved parties, also made more confusing by recent organisational changes in Headquarters office and field</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rig released from well and moved off Draft proposal sent to W/S, MML Res. Coord, Draft proposal from BHU to contractors</td>
<td>Still no involvement of Hoist Contractor or HQ Based Hoist Engineer V-BOP (Virtual Blowout Preventer) specified to perfo contractor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contractor received callout for perforating job to be performed by WPH by local WS</td>
<td>V-BOP specified to perfo contractor</td>
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<td></td>
<td></td>
<td>Final proposal sent from Asset Team to local base location</td>
<td>Final proposal stated V-BOP. Front sheet stated 10,000-21,500 kPa formation pressure range. Possible source of confusion.</td>
</tr>
<tr>
<td></td>
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<td>Replacement W/S field supervisor arrives at local base location</td>
<td>Proposal did not identify max expected CITHP, required for TCP circulating head equipment Team leader did not sign off as on leave, acting leader did not sign. Personel shortage and only one man available without any experience as Operator company field supervisor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outgoing and replacement Operator company W/S field supervisor do handover Hoist commences move to wellsite</td>
<td>New WS supv. consultant, unfamiliar with Operator co. procedures, unable/reluctant to challenge custom and practice.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outgoing and replacement OPCO W/S field supervisor work on Job Order (Hoist Programme)</td>
<td>Used 21,400 kPa from front sheet to calculate brine weight</td>
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<tr>
<td></td>
<td></td>
<td>Hoist Moves to well location</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Job Order faxed to Hoist Hoist rigging up on well</td>
<td>Job order was not signed by W/S Field supervisor Job Order faxed to camp Hoist supervisor did not countersign; operation already started</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shooting nipple incident, shooting nipple held in Annular Preventer, shot out of BOP while pressure testing.</td>
<td>7” rams not available</td>
</tr>
<tr>
<td>Event</td>
<td>Details</td>
<td></td>
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<td>---</td>
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<tr>
<td>Received replacement shooting nipple and 7” rams</td>
<td>Received shooting nipple with LTC thread.</td>
<td></td>
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<tr>
<td>Hoist rigged up shooting nipple and stuffing box</td>
<td>Shooting nipple not pressure tested as part of annual inspections</td>
<td></td>
<td></td>
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<tr>
<td>No night time perforating, wait on daylight</td>
<td>Rigged up but no pressure test</td>
<td></td>
<td></td>
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<tr>
<td>Ran in for first perforation run</td>
<td>Rig has no tongs to make up 7” LTC</td>
<td></td>
<td></td>
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<tr>
<td>Continued with run 2 and 3</td>
<td>Discussed with Well Eng Dept duty man (not W.E. Supervisor)</td>
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<tr>
<td>Ran no 4 perforating gun</td>
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<table>
<thead>
<tr>
<th>Start Well control situation</th>
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<tbody>
<tr>
<td>Well flowing at T piece shooting nipple (no valve) Opened rams and pulled shooting nipple and guns</td>
</tr>
<tr>
<td>Shut blind rams Observed 20 mins; final pressure: 1,800 kPa</td>
</tr>
<tr>
<td>Decision to bullhead; 12,400 kPa max, 10.1 brine Bullheaded 15 m3 10.1 kPa/m brine Could not bullhead due to 12,400 kPa limit set</td>
</tr>
<tr>
<td>Bled back 7 m3 brine</td>
</tr>
<tr>
<td>OPCO Hoist supv. spoke to Asset Team staff Discussions about MDT job and killing well</td>
</tr>
<tr>
<td>Hoist build poor-boy choke arrangement</td>
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<tr>
<td>Shut down pumps; static pressure: 5,000 kPa</td>
</tr>
<tr>
<td>Commenced bleeding off well</td>
</tr>
<tr>
<td>Well not flowing but bubbling, Misperception of downhole situation</td>
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<table>
<thead>
<tr>
<th>Well considered dead</th>
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<tbody>
<tr>
<td>Well considered dead at surface</td>
</tr>
<tr>
<td>Rigged up perfo contractor For perforating gun #5</td>
</tr>
<tr>
<td>Contractor running gun in hole</td>
</tr>
<tr>
<td>Asset Team staff phoned hoist for morning update</td>
</tr>
<tr>
<td>Perforated #5 and POH</td>
</tr>
<tr>
<td>Perforated #5 and POH</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Primary well control lost</th>
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<tbody>
<tr>
<td>Flow observed out of stuffing box at shooting nipple</td>
</tr>
<tr>
<td>When gun at 1000m, stopped POH</td>
</tr>
<tr>
<td>Hoist manager briefed 2 Hoist staff about plan ahead OPCO Hoist Supv. left location to go to base</td>
</tr>
<tr>
<td>Hoist Rig Manager starts bleeding off well</td>
</tr>
<tr>
<td>OPCO supervisor in base camp.</td>
</tr>
<tr>
<td>Various operational staff in HQ office have completed their morning operations meeting.</td>
</tr>
<tr>
<td>09:10 Hoist RM has bled off 13 m3 of fluid (water/oil/gas) and closed in well. 3,500 kPa noted.</td>
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<td>Time</td>
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<tr>
<td>09:21</td>
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<td>10:25</td>
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<td>10:55</td>
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5.2. Relief Well concept and status drawing

Relief Well - Concept

- **Relief Well Location**
- **Blow out well**
- **Distance 500 m.**
- **By Pass:** Relief well passes by the Target Well without intersecting in order to accurately determine the Target Well’s subsurface position.
- **Interception Point:** Relief Well intercepts Target Well for well kill.
- **Ranging Point:** Take homing in survey before entering cone of uncertainty.
- **Cone of Uncertainty:** Uncertainty range calculated for subsurface location of Target Well.
- **Bit depth at time of capping:** Two homing in surveys successfully located hole.