LATERAL LEARNING DOCUMENT
(INVESTIGATION, EMERGENCY RESPONSE & RECOVERY)

WELL BLOW OUT EVENT

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

Picture 1: close up of shooting nipple

- 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
- 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.

Picture 2: BOP at 30 degrees

- 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.

Picture3: capping stack in place

Picture 4: well closed in.

- 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 contol **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 liase 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

Date	Time	Facts	Remarks
		Rig X Drills Original Well	
		Drilling proposal issued	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
		Drilling program issued	Designed on P50 case
		Well spudded Rig X	Drilled formation 'a' with 12.0 kPa/m
		Could not log open hole due to hole problems.	Wash-out in lower formation 'b'
		Rig performed check trip to condition hole "Ad hoc Meeting" with asset manager	Decision tree made for logging/liner/pressure measurements. Good HQ Drilling Dept involvement. Identified that 600m3/d could be brought on stream
		Logged well in two runs Tried FMT/RCI (Formation Tester/Reservoir Characterization Instrument) without success	Logging program changed with RA (Radio Active) tools run
		Rig tried RCI; unsuccessful Decision to run 7" casing Note from Team leader; run casing, likely for hoist to do MDT	First time that hoist is identified for doing the MDT job.
		Meeting to discuss cased hole MDT	Job was done before; so ok. No detailed analyses. Pressure not to delay rig due to tool availability and to get well on production.
		Confirmed that tools not available for this job Rig scraped well and displaced to WSW(Well Site Water)	Decision to mobilise alternative contractor Final Decision made to use hoist and MDT because logging tools not fully available to prevent waiting time on rig
		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	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
		Rig released from well and moved off Draft proposal sent to W/S, MML Res. Coord, Draft proposal from BHJ to contractors	 Still no involvement of Hoist Contractor or HQ Based Hoist Engineer V-BOP (Virtual Blowout Preventer) specified to perfo contractor
		Contractor received callout for perforating job to be performed by WPH by local WS	V-BOP specified to perfo contractor
		Final proposal sent from Asset Team to local base location	Final proposal stated V-BOP. Front sheet stated 10,000-21,500 kPa formation pressure range. Possible source of confusion.
		Replacement W/S field supervisor arrives at local base location	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. Personnel shortage and only one man available without any experience as Operator company field supervisor
		Outgoing and replacement Operator company W/S field supervisor do handover Hoist commences move to wellsite	New WS supv, consultant, unfamilair with Operator co. procedures, unable/reluctant to challenge custom and practice.
		Outgoing and replacement OPCO W/S field supervisor work on Job Order (Hoist Programme)	Used 21,400 kPa from front sheet to calculate brine weight
		Hoist Moves to well location	
		Job Order faxed to Hoist Hoist rigging up on well	Job order was not signed by W/S Field supervisor Job Order faxed to camp Hoist supervisor did not countersign; operation already started
		Shooting nipple incident, shooting nipple held in Annular Preventer, shot out of BOP while pressure testing.	7" rams not available

		Received replacement shooting nipple and 7" rams	Received shooting nipple with LTC thread. Shooting nipple not pressure tested as part of annual inspections
		Hoist rigged up shooting nipple and stuffing box	Rigged up but no pressure test Rig has no tongs to make up 7" LTC
		No night time perforating, wait on daylight	Discussed with Well Eng Dept duty man (not W.E. Supervisor)
		Ran in for first perforation run Continued with run 2 and 3 Continued with run 2 and 3 Ran no 4 perforating gun	Used V-BOP system Left shooting nipple T and spool side-outlet open Left shooting nipple T and spool side-outlet open
Start Well control situation			
		Well flowing at T piece shooting nipple (no valve) Opened rams and pulled shooting nipple and guns	Crew installed valve at T piece and closed in well Customary practice
		Shut blind rams Observed 20 mins ; final pressure : 1,800 kPa	Well closed in and under control
		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	Various decisions between hoist and Asset Team and field sup. Bullheaded with under balanced brine Unclear why limit was set Hoist staff worked without understanding of plan
		Bled back 7 m3 brine	Invited well to flow
		OPCO Hoist supv. spoke to Asset Team staff Discussions about MDT job and killing well	Decision to go to 10.6 kPa/m kill brine
		Hoist Manager called back to rig with books	Calculations wrt brine gradients Company man not happy with decision but went ahead
		Hoist build poor-boy choke arrangement	WS procedures state that choke shall be available
		Hoist bullheaded with 10.6 kPa/m brine	Agreed that 10.8 kPa/m was kill weight
		After 5 m3 pressure at 11,000 kPa, low injectivity Shut down pumps; static pressure : 5,000 kPa	Stopped as to not exceed 12,400 kPa Well control problem persisting
		Commenced bleeding off well Bled off 20 m3 minimal ; 80% gas; 20% oil Flowing oily/gassy water to surface Company Man on the choke	Allowed well to flow Flowed back all kill brine and invited well to flow Preconceived idea about flowing gas bubble to surface
		Continued bleeding down Flow check Well considered dead at surface	Well not flowing but bubbling, Misperception of downhole situation No big concern from supervisory staff
Well considered dead			
		Well considered dead at surface	No big concern from supervisory staff
		Rigged up perfo contractor For perforating gun #5	PTW raised without special considerations, schl signed
		Contractor running gun in hole	Stuffing box open: no flow. Driller checking bleed-off line; no flow
		Asset Team staff phoned hoist for morning update	Well Control situation not recognised
		Perforated #5 and POH	
		Perforated #5 and POH	
Primary well control lost			
		Flow observed out of stuffing box at shooting nipple	Perfo. contractor pressured up shooting nipple ; no more flow
		When gun at 1000m, stopped POH	
		Hoist manager briefed 2 Hoist staff about plan ahead OPCO Hoist Supv. left location to go to base Hoist Rig Manager starts bleeding off well	Plan: let kick come to surface and bleed off gas; well dead Wanted to drop off logs and pick up PT Invited well to flow
		OPCO supervisor in base camp.	
		Various operational staff in HQ office have completed their morning operations meeting.	No-one at the morning meeting, base camp or Hoist contractor picks up the seriousness of the problem yesterday or potential problem prior to 5th perf run
	09:10	Hoist RM has bled off 13 m3 of fluid (water/oil/gas) and closed in well. 3,500 kPa noted.	

	09:21	RM calls WS supv at base and informed them pressure was increasing, was told to bullhead the well but not exceed 12,400 kPa.	OPCO Hoist supv in base camp and involved in call
	09:40	Leak starts at stuffing box to shooting nipple 7" LTC connection. Shortly after Hoist RM attempts unsuccessfully to tighten with rig wrench. Asks for perfo. contractor to be called	
	10:06	Perfo. contractor team back on site. Hoist RM asks them to tighten connection to their BOP-V. Perfo. contractor crew refuse to tighten or go to rigfloor – Hoist Rig manager attempts to lower CHP to enable tightening	
	10:07	RM phones WS supv base to say he has a leak from the stuffing box. Was told to close shear rams. Actually only had blinds.	Why did the rig manager not close the blind rams here?
	10:15-10:30	WS field supervisor calls base Res Coord.l to tell him he has ordered Hoist to close the Blind rams on perfo contractor cable. Resource coordinator informed HQ engineer and told him of well control problem.	
	10:15	Stuffing box and shooting nipple thread connection jumps threads. Uncontrolled flow from resulting opening. All site personnel evacuate location and gather at muster point. Major flow 3-4 minutes later as gas broke through, geyser above crown block.	Situation out of control, require wild well fighters but severity not appreciated by staff on site as total loss. Staff thought there was a chance of closing blind rams. Position of shooting nipple and cable not known but tension still on cable.
Secondary well control lost			
	10:15	Stuffing box and shooting nipple thread connection jumps threads. Uncontrolled flow from resulting opening. All site personnel evacuate location and gather at muster point. Major flow 3-4 minutes later as gas broke through, geyser above crown block.	Situation out of control, require wild well fighters but severity not appreciated by staff on site as total loss. Staff thought there was a chance of closing blind rams. Position of shooting nipple and cable not known but tension still on cable.
	10:17	RM attempts to close Blind rams did not work. Shutdown power	No phones on site available due to power shut down. Position of shooting nipple and cable not known but tension still on cable.
	10:25	Hoist rig manager attempts re-entry with crew masked up unable to reach BOP trailer.	Oil spray blinds BA masks
	10:55	OPCO at HQ informed of situation. (details not specified or investigated)	Why was it not apparent to HQ staff at this point that secondary control had been lost and that the situation was too dangerous to allow further personal access to the site- e.g. final attempt at entering blowing area

5.2. Relief Well concept and status drawing