"SHARING TO BE BETTER"

"SHARING TO BE SAFER"

"Sharing to be better"

Under the direction of OLF, a joint industry task force of Operator and Drilling Contractor personnel has been formed to recommend ways to reduce the number and potential severity of well control events on the NCS.

One team recommendation was communicating actual well control incidents that have recently occurred on the NCS so lessons are shared and understood.

This is the second in a series of five case histories. This incident highlights the importance of following procedures, attention to detail and quality control of calculations performed on the rig

Please take some time at your next safety meeting to review this case history and discuss the questions raised during the presentation.
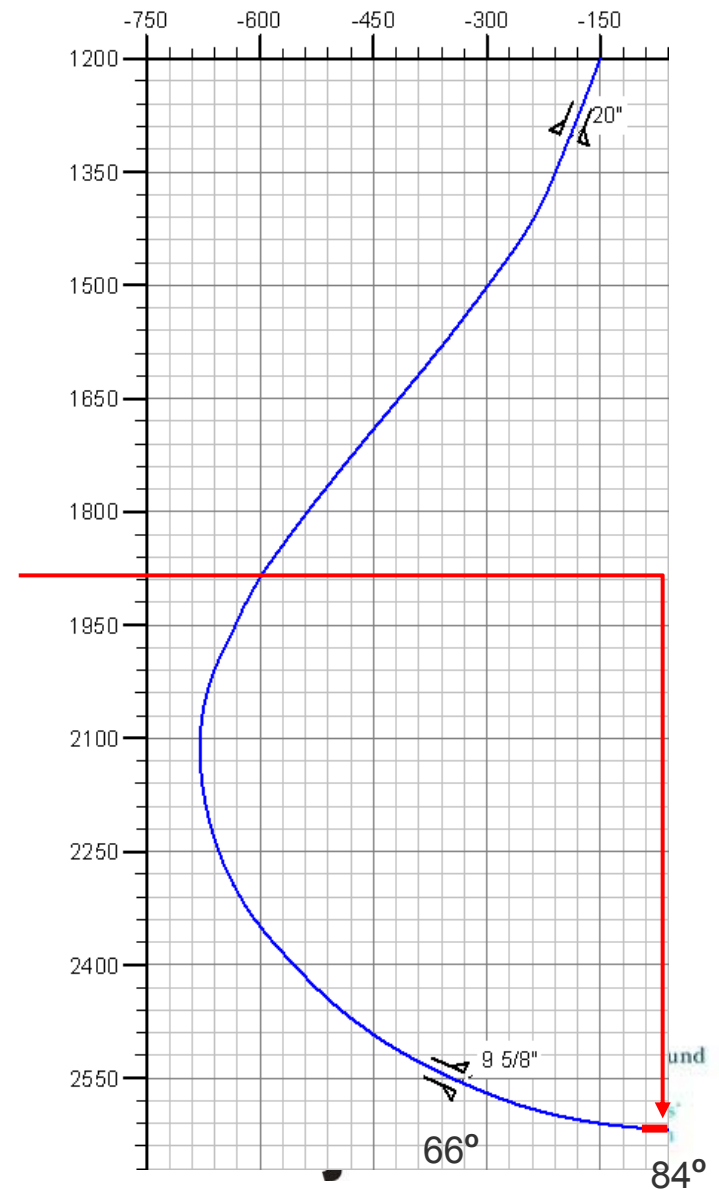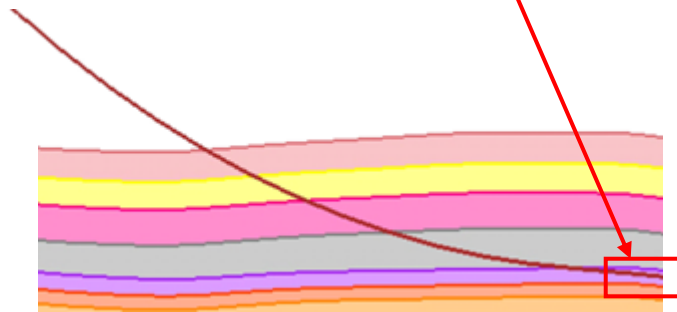
It is hoped that sharing of incidents is helpful and any feedback is welcome.

olf

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Norwegian Shipowners' Association

Offshore Semisub Rig

Well Control Incident

Drilling 8 ½" section

- Water depth: 395 m

- 9 5/8" casing shoe inclination: 66 deg

- FIT: 1.61 sg EMW

- **Mud weight: 1.30 sg OBM**

- 8 ½" open hole length: 350 m

- 8 ½" section TD inclination: 84 deg

- 8 ½" section TD: 6 mMD into permeable formation

The SWAB calculation

- During circulation at TD the Data Operator (mud logger) was preparing a swab calculation before POOH

- He contacted the Wellsite Geologist to ask which pore pressure to use in the calculation. The Wellsite Geologist was busy describing cuttings and told the Data Operator (mud logger) to look in the drilling program to find the pore pressure
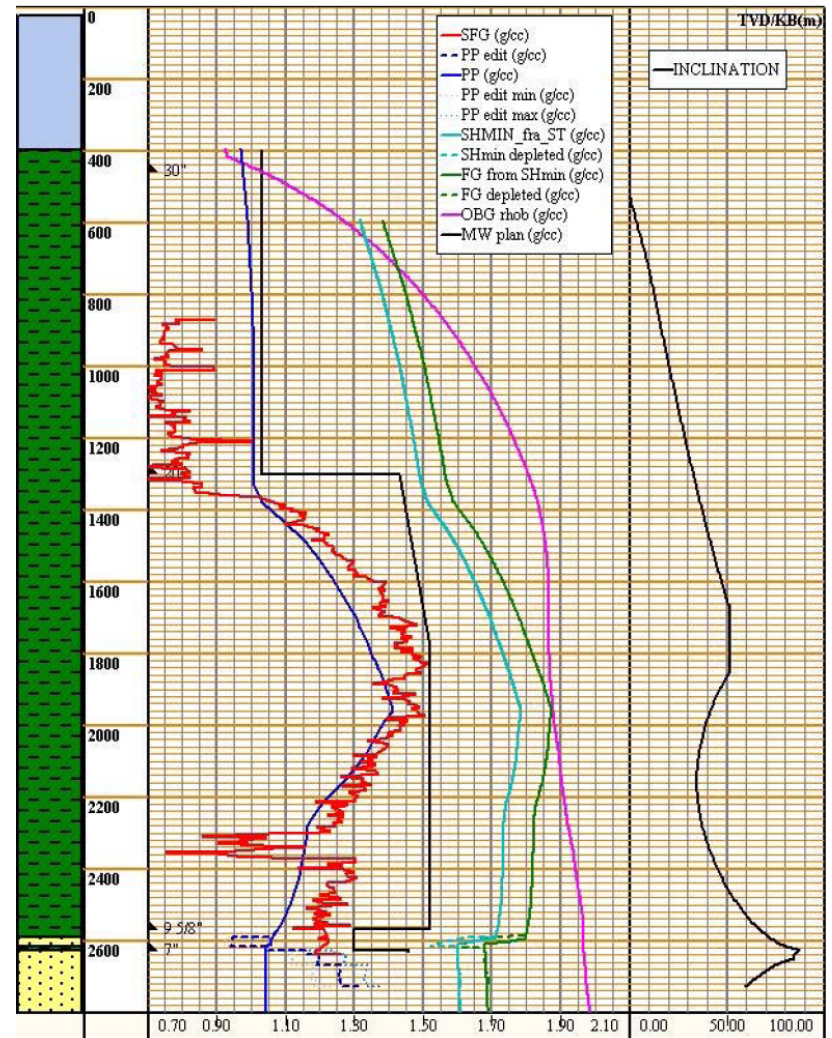
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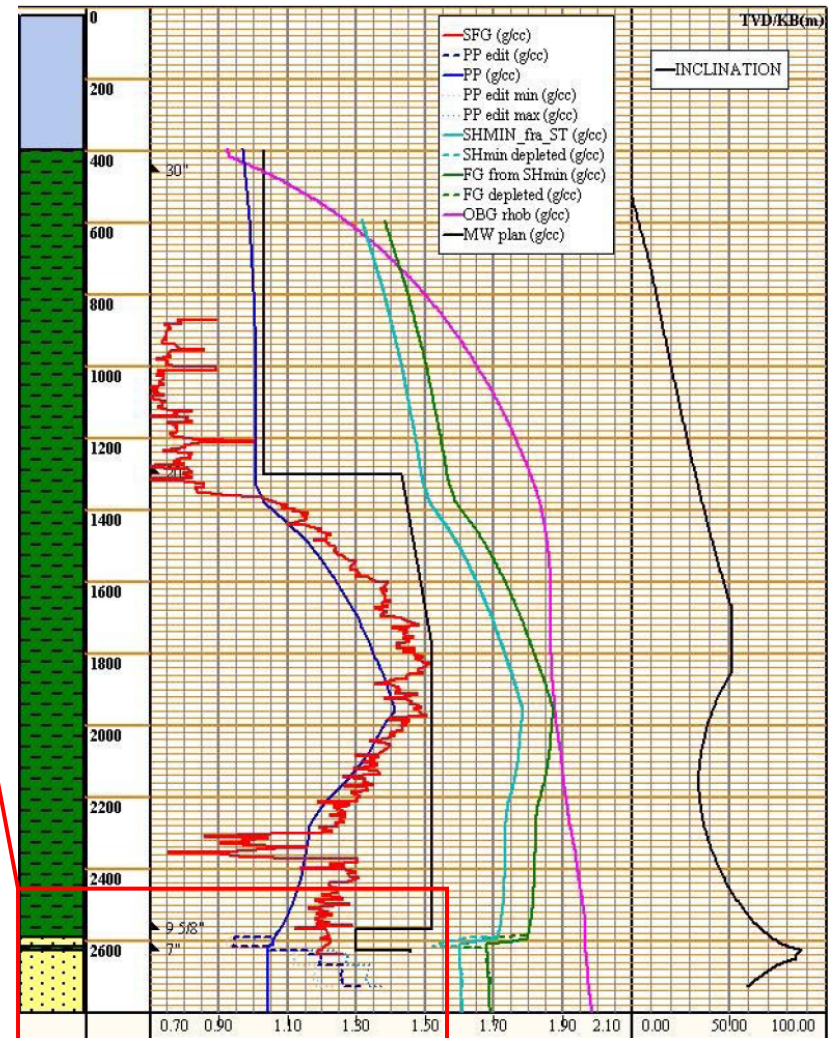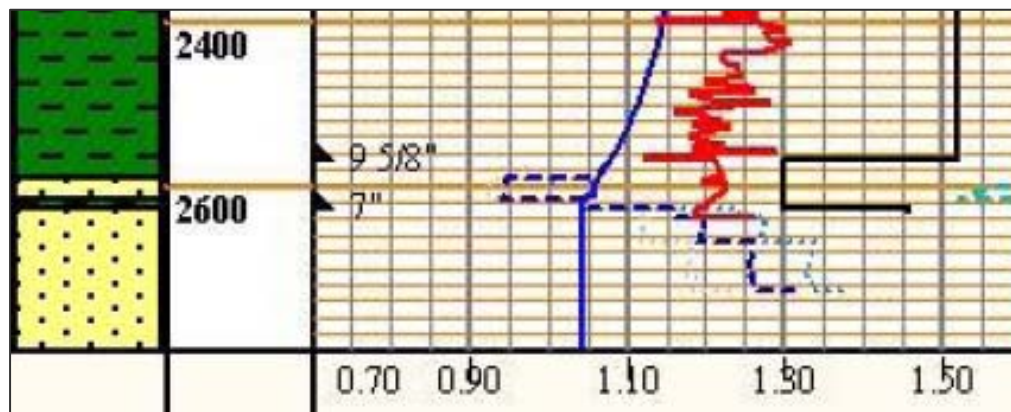
The SWAB calculation

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- He contacted the Wellsite Geologist to ask which pore pressure to use in the calculation. The Wellsite Geologist was busy describing cuttings and told the Data Operator (mud logger) to look in the drilling program to find the pore pressure

- The Data Operator read of the value 1.06 sg from the pore pressure plot. He added a safety margin of 0.02 sg and used **1.08 sg** as input to the swab calculation

The SWAB calculation

SWAB TRIPPING SPEED CALCULATIONS					
	POOH				
DATE:	28-mar-10				
STRING:	BHA #7				
TOTAL DEPTH:	3445				
MUDWEIGHT:	1.3	SG			
LAST FIT:	1.61	SG			
LAST Pore P:	1.08	SG			
Max ECD	1.41	SG			
Heave effect :	0.1	m/sec			
BIT DEPTH			Running speed w/ heave		
meters	m/sec	sec/std	m/sec	sec/std	m/hr
3500	0.78	37	0.68	43	2448
3000	0.8	36	0.70	41	2520
2500	0.85	34	0.75	39	2700
2000	0.89	33	0.79	37	2844
1500	0.91	32	0.81	36	2916
1000	0.93	31	0.83	35	2988

Would you have questioned this swab calculation?

olf

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The SWAB calculation

SWAB TRIPPING SPEED CALCULATIONS						
	POOH					
DATE:	28-mar-10					
STRING:	BHA #7					
TOTAL DEPTH:	3445					
MUDWEIGHT:	1.3	SG				
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Would you have questioned this swab calculation?

- Very high pulling speed

The SWAB calculation

SWAB TRIPPING SPEED CALCULATIONS					
	POOH				
DATE:	28-mar-10				
STRING:	BHA #7				
TOTAL DEPTH:	3445				
MUDWEIGHT:	1.3	SG			
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1000	0.93	31	0.83	35	2988

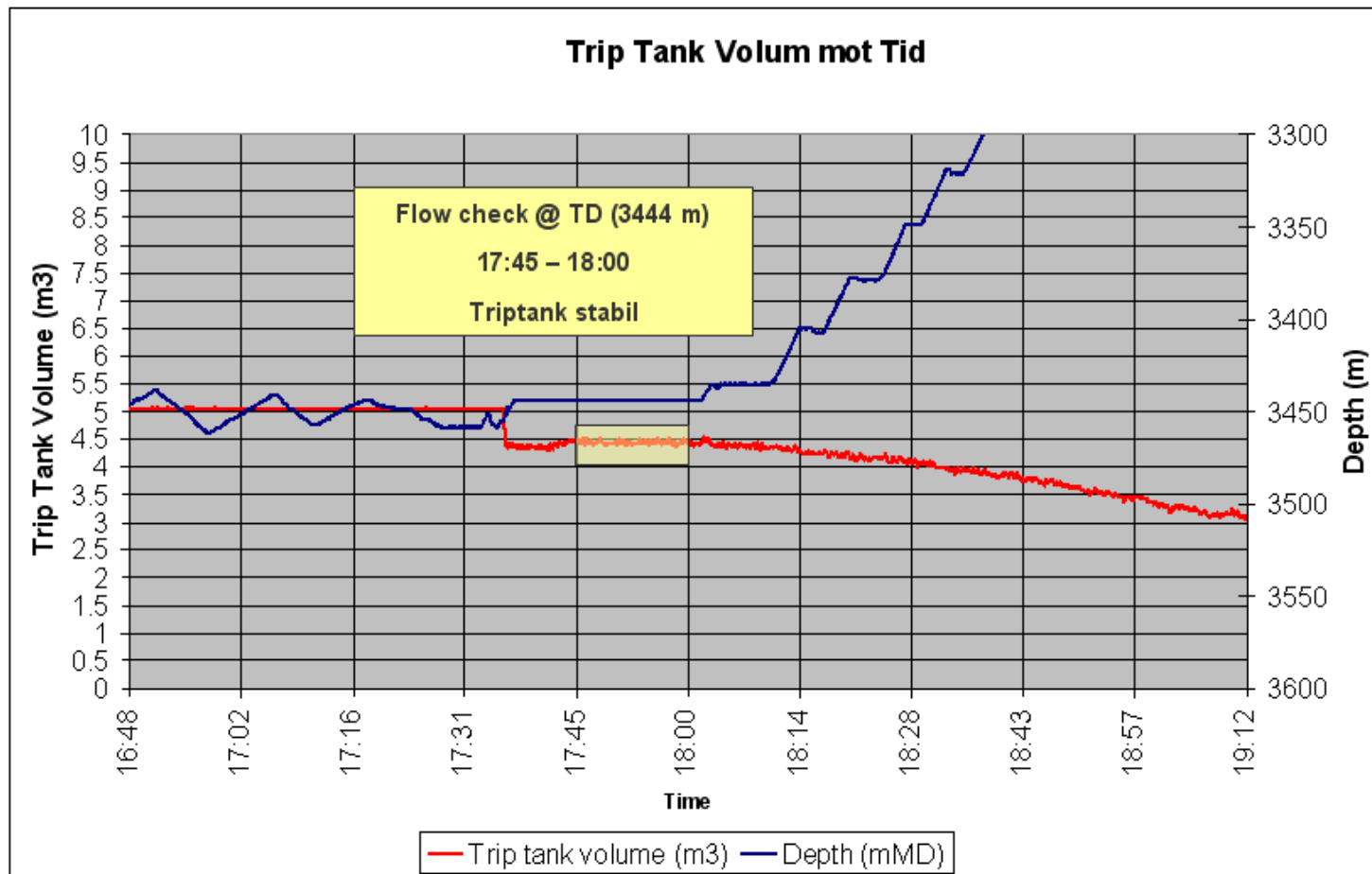**Would you have questioned this swab calculation?**

- Very high pulling speed

- The Drilling Supervisor did not quality check the input values and results of the calculation.

- Nobody (Drilling Supervisor / Toolpusher / Driller) reacted on the fast pulling speed

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Flow check at TD – well stable

This is the Data Operators (mud logger) trip sheet during the trip out of hole

TRIP TANK THOUGHTS:

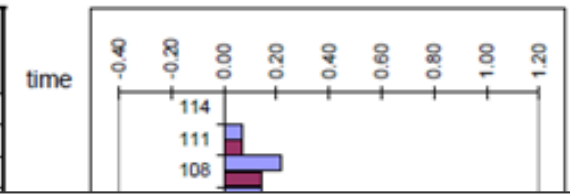**What is the accuracy of the trip tank on <u>YOUR</u> rig?**

When was the trip tank last calibrated on <u>YOUR</u> rig?

Trip sheet

Stands in hole	TT m³	Active	Transfer	Diff + / - m³	Theo. Volume m³	Gain / Loss m³	Cum. diff m³		time
114	4.44			0.00	0.000	0.00	0.00		
111	4.09			-0.35	-0.424	0.07	0.07		
108	3.81			-0.28	-0.424	0.14	0.22		

After pulling 6 stands wet in open hole

220 ltr gain (cumulative from TD)

Would you have reacted on this observation?

Trip sheet

Stands in hole	TT m³	Active	Transfer	Diff + / - m³	Theo. Volume m³	Gain / Loss m³	Cum. diff m³		time
114	4.44			0.00	0.000	0.00	0.00		
111	4.09			-0.35	-0.424	0.07	0.07		
108	3.81			-0.28	-0.424	0.14	0.22		
105	3.31			-0.50	-0.424	-0.08	0.14		
102	2.90			-0.41	-0.424	0.01	0.16		

Inside 9 5/8" casing shoe

160 ltr gain (cumulative from TD)

Would you have reacted on this observation?

Trip sheet

Stands in hole	TT m³	Active	Transfer	Diff +/- m³	Theo. Volume m³	Gain / Loss m³	Cum. diff m³		time
114	4.44			0.00	0.000	0.00	0.00		
111	4.09			-0.35	-0.424	0.07	0.07		
108	3.81			-0.28	-0.424	0.14	0.22		
105	3.31			-0.50	-0.424	-0.08	0.14		
102	2.90			-0.41	-0.424	0.01	0.16		
99	7.15		-4.49	-0.24	-0.424	0.18	0.34		
96	7.01			-0.14	-0.424	0.28	0.62		

After pulling 6 stands inside 9 5/8" casing

620 ltr gain (cumulative from TD)

**Would you have reacted on this observation?**

Trip sheet

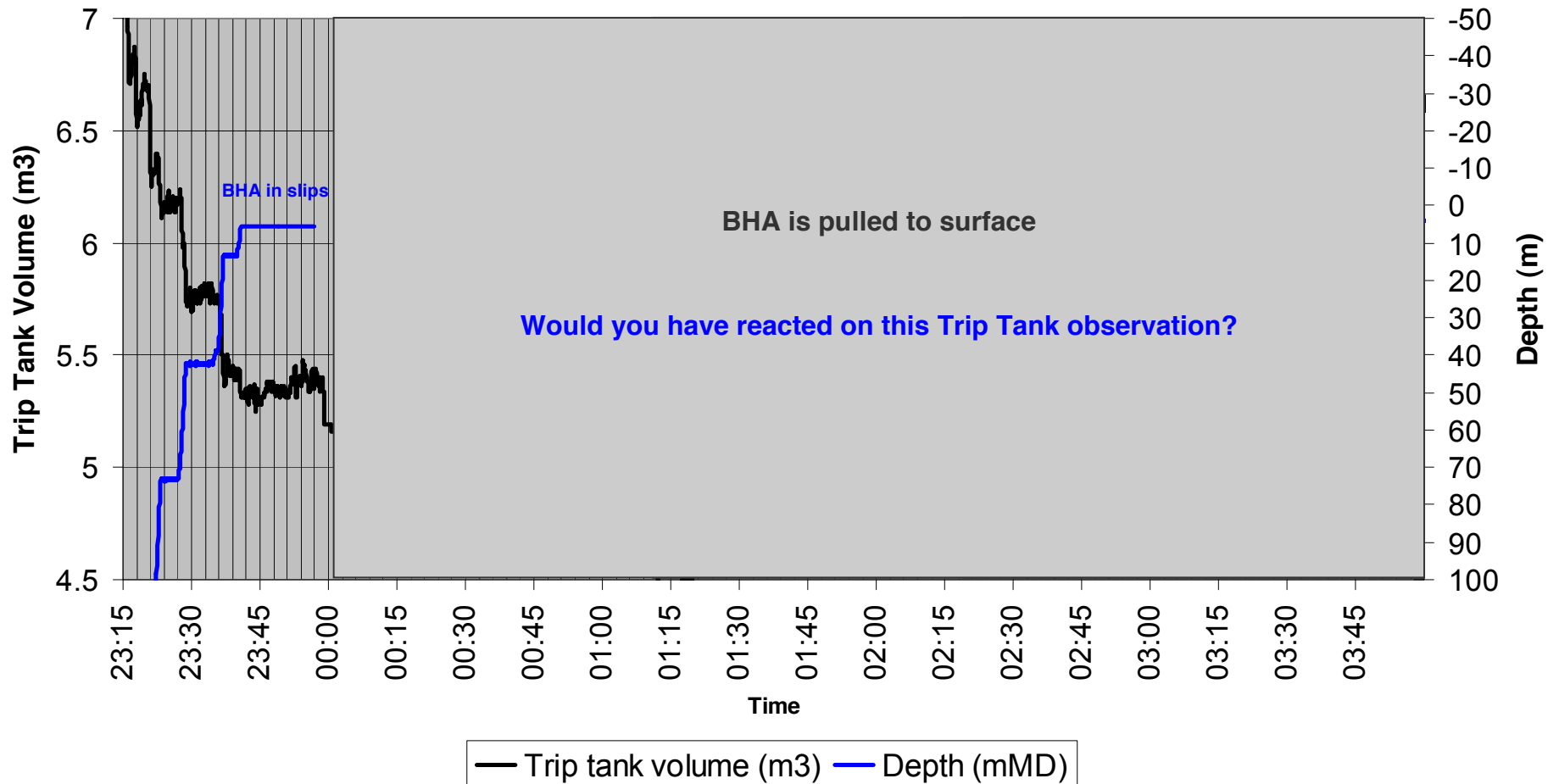| Stands in hole	TT m³	Active	Transfer	Diff + / - m³	Theo. Volume m³	Gain / Loss m³	Cum. diff m³		time
114	4.44			0.00	0.000	0.00	0.00		
111	4.09			-0.35	-0.424	0.07	0.07		
108	3.81			-0.28	-0.424	0.14	0.22		
105	3.31			-0.50	-0.424	-0.08	0.14		
102	2.90			-0.41	-0.424	0.01	0.16		
99	7.15		-4.49	-0.24	-0.424	0.18	0.34		
96	7.01			-0.14	-0.424	0.28	0.62		
93	6.58			-0.43	-0.424	-0.01	0.62		
88	5.90			-0.68	-0.706	0.03	0.64		
83	5.26			-0.64	-0.706	0.07	0.71		
78	4.74			-0.52	-0.706	0.19	0.90		
73	4.10			-0.64	-0.706	0.07	0.96		
68	3.33			-0.77	-0.706	-0.06	0.90		
63	2.62			-0.71	-0.706	0.00	0.90		
58	1.94			-0.68	-0.706	0.03	0.92		
53	1.30			-0.64	-0.706	0.07	0.99		
48	7.45		-7.00	-0.85	-0.706	-0.14	0.84		
43	6.63			-0.82	-0.706	-0.11	0.73		
38	5.79			-0.84	-0.706	-0.13	0.60		
33	5.15			-0.64	-0.706	0.07	0.66		
28	4.58			-0.57	-0.706	0.14	0.80		
23	3.83			-0.75	-0.706	-0.04	0.76		
18	3.19			-0.64	-0.706	0.07	0.82		
13	2.48			-0.71	-0.706	0.00	0.82		
8	1.63			-0.85	-0.706	-0.14	0.68		
3	0.93			-0.70	-0.706	0.01	0.68		
0	0.51			-0.42	-0.424	0.00	0.69		
-3									
-6									

No flow check before BHA pulled through BOP
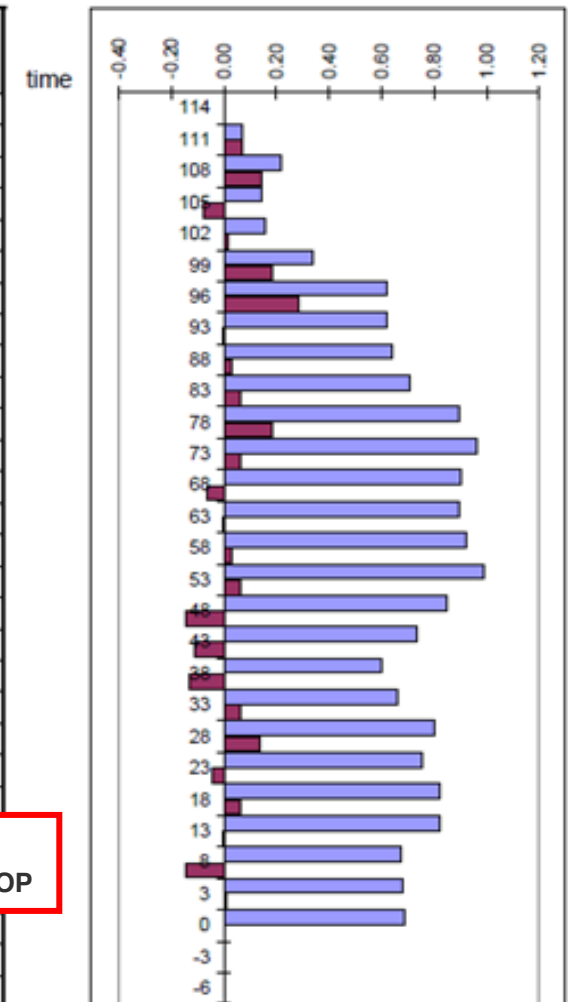
olf

Norges Rederiforbund
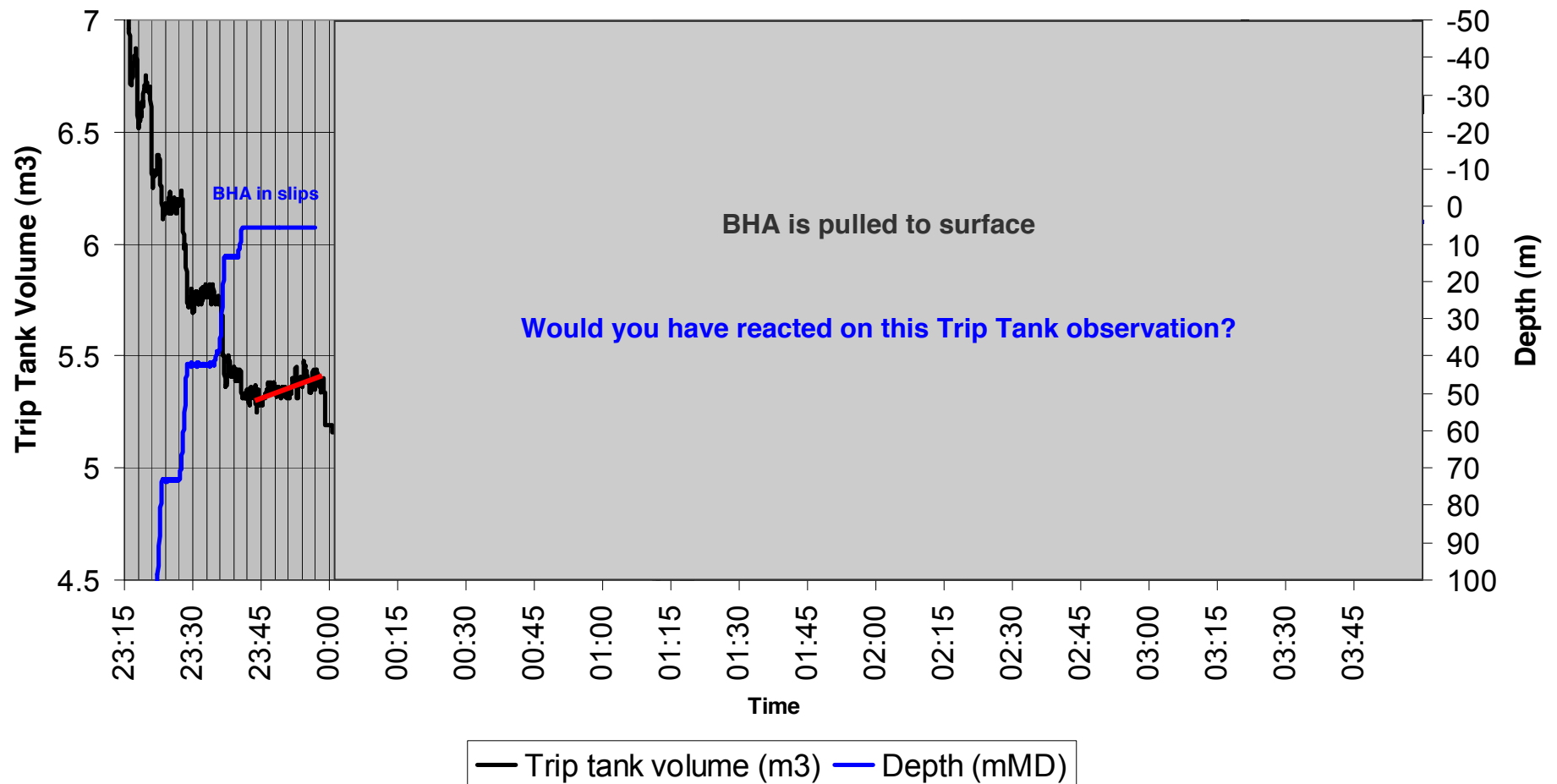Norwegian Shipowners' Association

BHA pulled to surface

Trip Tank Volum mot Tid

BHA pulled to surface

Trip Tank Volum mot Tid

Y-axis (left): Trip Tank Volume (m3): 7, 6.5, 6, 5.5, 5, 4.5

Y-axis (right): Depth (m): -50, -40, -30, -20, -10, 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

X-axis (Time): 23:15, 23:30, 23:45, 00:00, 00:15, 00:30, 00:45, 01:00, 01:15, 01:30, 01:45, 02:00, 02:15, 02:30, 02:45, 03:00, 03:15, 03:30, 03:45

BHA in slips

BHA is pulled to surface

Would you have reacted on this Trip Tank observation?

Legend: —— Trip tank volume (m3) —— Depth (mMD)

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BHA pulled to surface

Trip Tank Volum mot Tid

Lay down and rack back BHA

Would you have reacted on this

Trip Tank observation?

BHA in slips

BHA in slips

Trip Tank Volume (m3)

Depth (m)

Time

— Trip tank volume (m3) — Depth (mMD)

BHA pulled to surface

Trip Tank Volum mot Tid
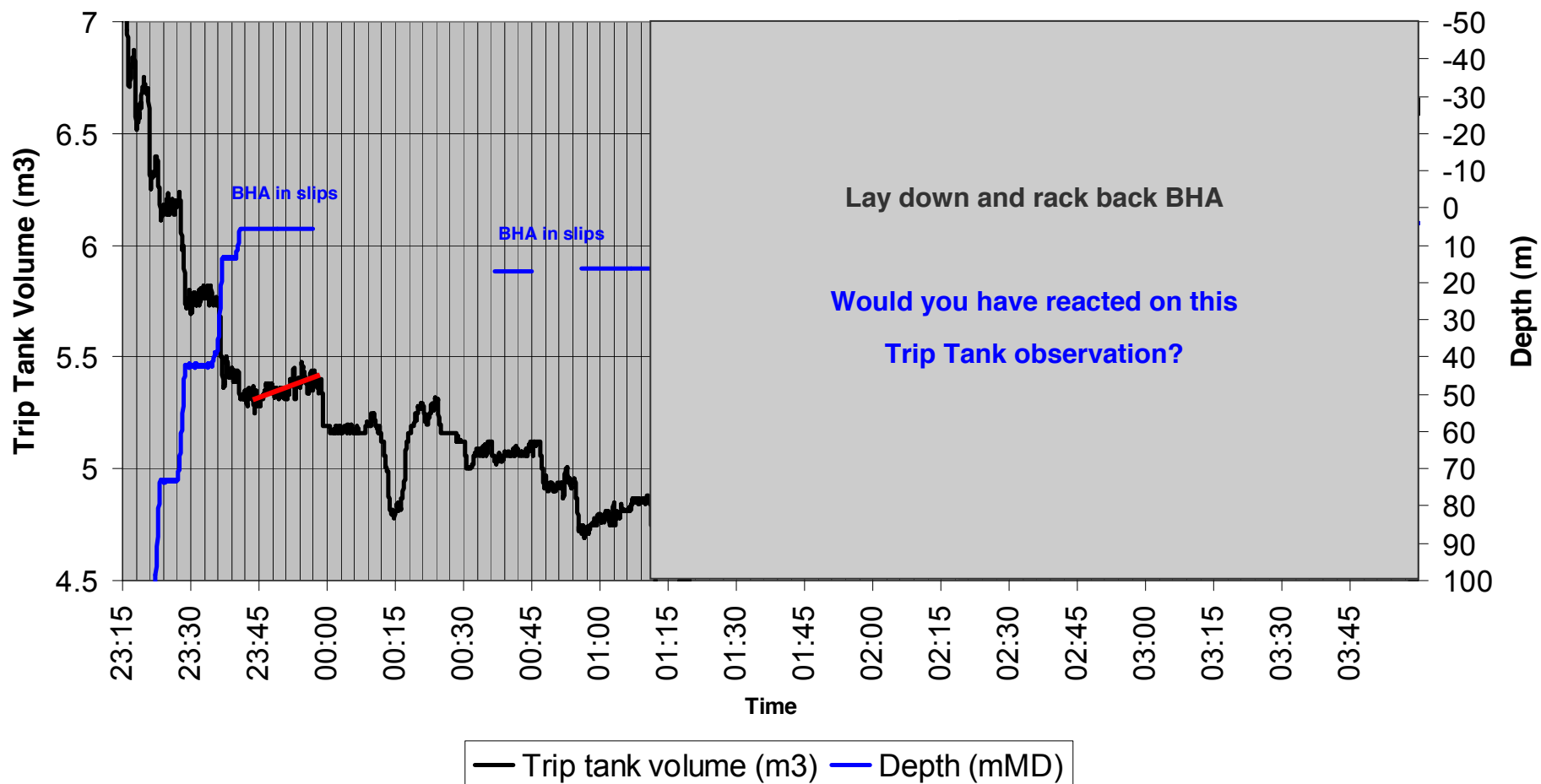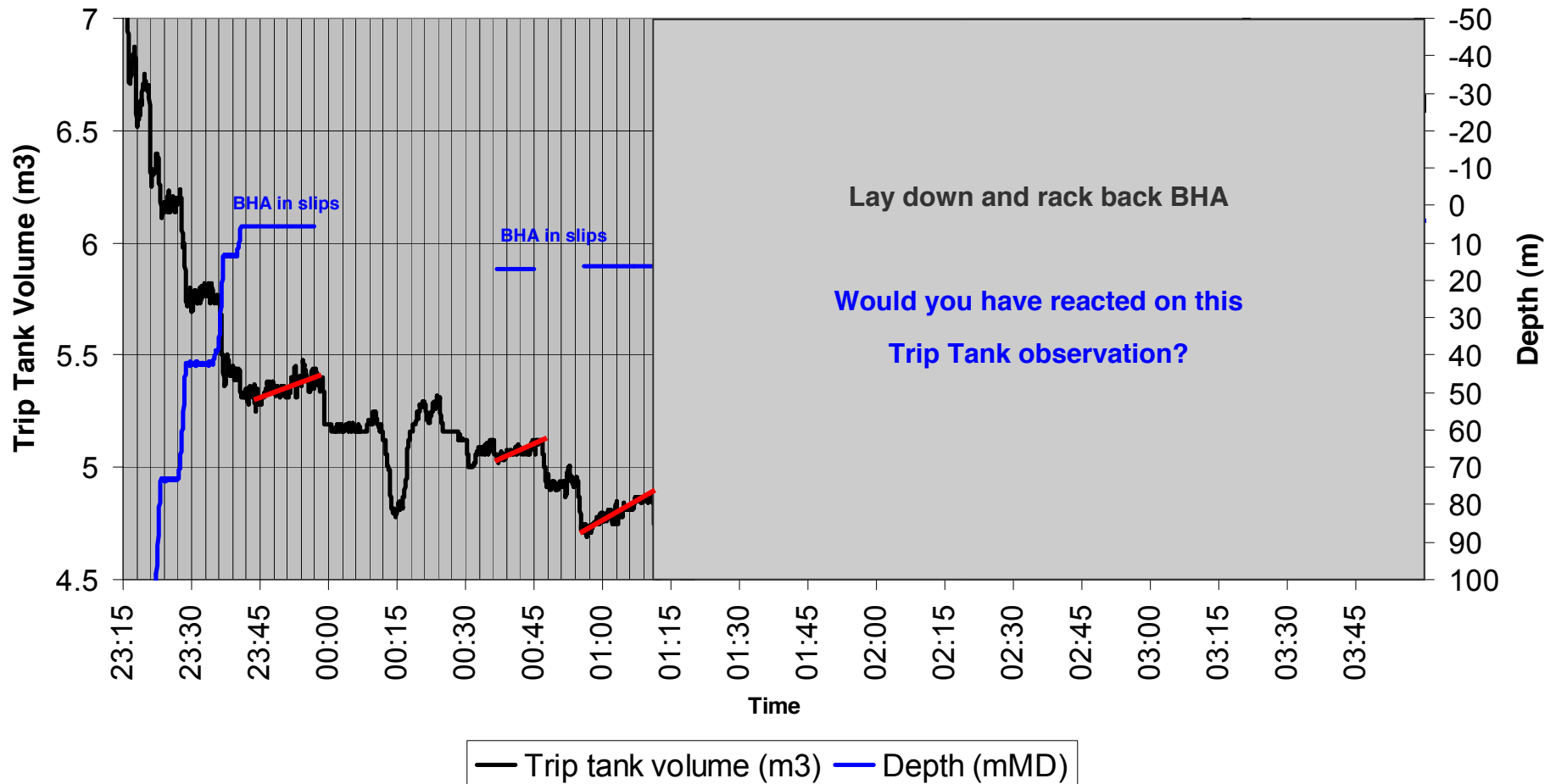
BHA pulled to surface

Trip Tank Volum mot Tid

BHA pulled to surface

Trip Tank Volum mot Tid

BHA pulled to surface

Trip Tank Volum mot Tid

Well shut in on BSR

MU cement stand

Would you have reacted on this Trip Tank observation?

1,7 m3 gain during 60 minutes

BHA in slips

BHA in slips

BHA in slips

BHA in slips

Trip Tank Volume (m3)

Time

— Trip tank volume (m3) — Depth (mMD)

olf
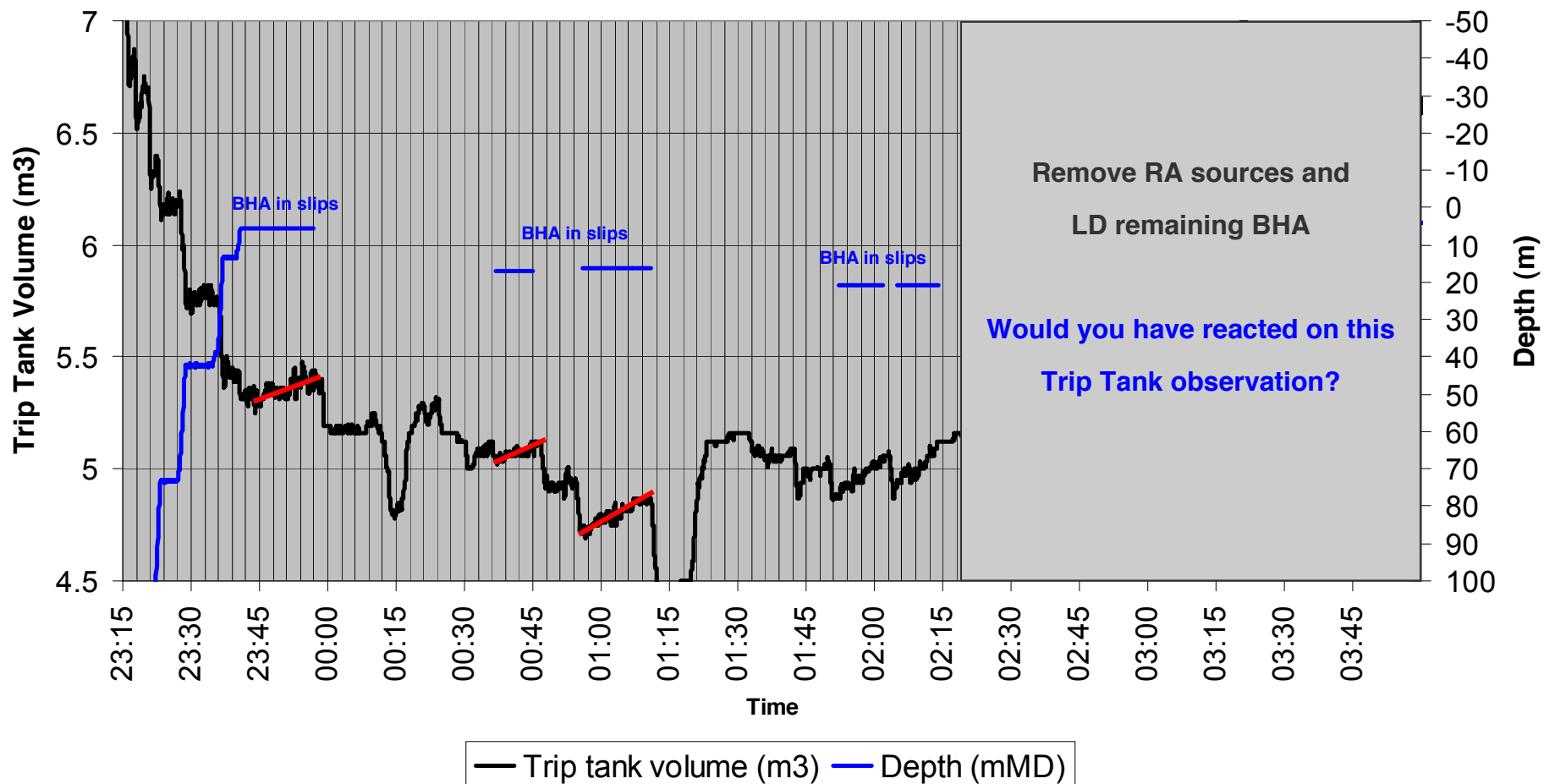
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Norwegian Shipowners' Association
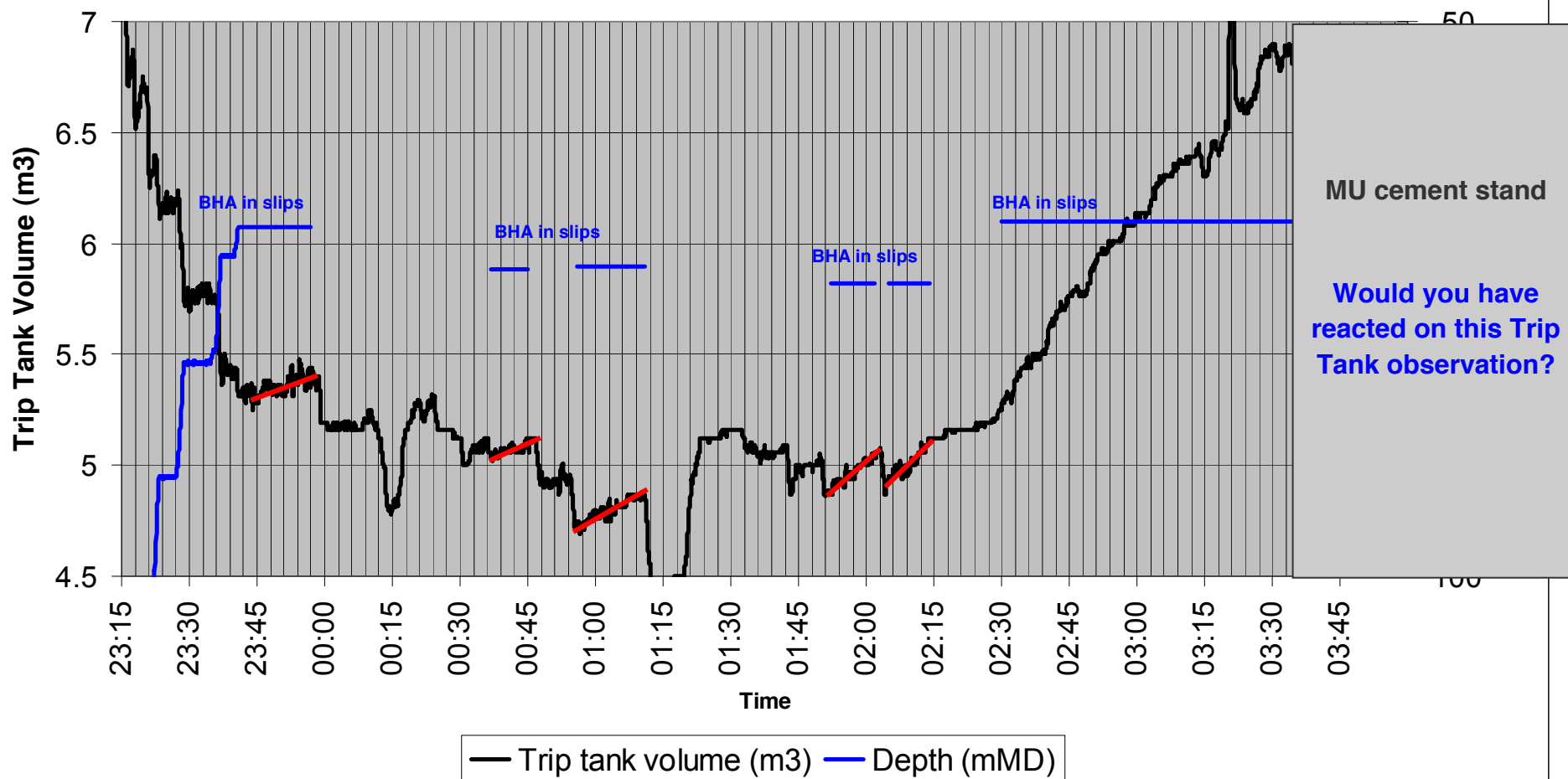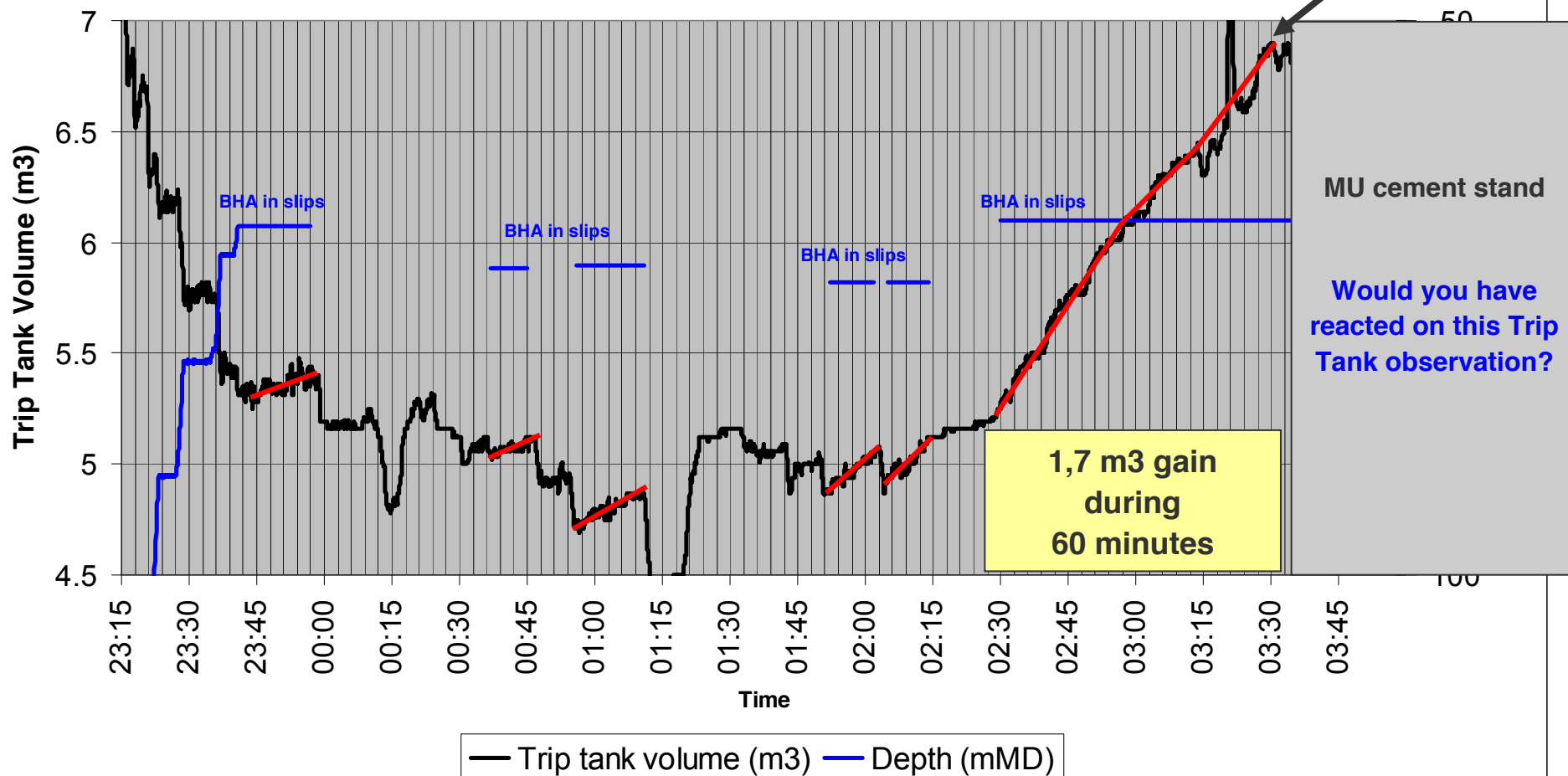
CONCLUSION

- A kick has been taken during tripping out of hole and not discovered before out of hole.

- Well shut in on Blind shear ram.

- SICP=6,6 bar

- Discuss how you would have secured well?

  - Key info:

    - Drilled 6 m permeable formation

    - 1.30 SG OBM in well

    - Influx volume approx 2 m3

    - FIT on 9 5/8" shoe 1.61 SG (2560 m TVD).

- DIRECT CAUSE: SWABBING

How primary barrier (fluid column) was regained

- RIH with bullheading assmebly to above BOP

- Drilling riser displaced to 1.54 sg OBM

- Cross circulated down kill and up choke lines with 1.54 OBM
  - ✓ Flow checked well on trip tank – well stable

- Open BSR and RIH with bullheading assembly to 700 m
  - ✓ Attempted to fracture permeable formation
    - ✓ not able to break down formation - limited by FIT at 9 5/8" casing shoe
  - ✓ Displaced well to 1.54 sg OBM – well stable

- RIH to 1000 m and displaced well to 1.52 sg OMB
  - ✓ Observed gas in return
  - ✓ Well stable

- RIH and repeated well displacement to 1.52 sg OBM at 1500, 2200, 3150 m
  - ✓ No gas observed - well stable

Root causes

- The SWAB calculation
  - The Data Operator (mud logger) was not aware that, on the next page in the drilling program, a detailed plot of the reservoir section was presented

Reservoir Section

Legend:
- PPres — PPresMin — PPresMax
- FGres — FGresMin — FGresMax
- Shres — SHresMin — ShresMax

Not Formation

Ile 2 Formation

PP Expected: 1.16 sg

PP Maximum: 1.24 sg

g/cc

The SWAB calculation

After the incident the swab calculation was performed with the maximum expected pore pressure

SWAB TRIPPING SPEED CALCULATIONS					
	POOH				
DATE:	28-mar-10				
STRING:	BHA #7				
TOTAL DEPTH:	3506mMD	2625mTVD			
MUDWEIGHT:	1.3	SG			
LAST FIT:	1.61	SG			
LAST Pore P:	1.24	SG			
Max ECD	1.41	SG			
Heave effect :	0.02	m/sec			
BIT DEPTH	EMW	1.3	**Running speed w/ heave**		
meters	m/sec	sec/std	**m/sec**	**sec/std**	**m/hr**
3500	0.1	290	0.08	363	288
3200	0.12	242	0.10	290	360
3000	0.15	193	0.13	223	468
2700	0.18	161	0.16	181	576
2000	0.21	138	0.19	153	684
1000	0.3	97	0.28	104	1008

Would you have queationed this swab calculation?

The SWAB calculation

After the incident the swab calculation was performed with the maximum expected pore pressure

SWAB TRIPPING SPEED CALCULATIONS

	POOH	
DATE:	28-mar-10	
STRING:	BHA #7	
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2000	0.21	138	0.19	153	684
1000	0.3	97	0.28	104	1008

Would you have reacted on this swab calculation?

- Consider to pump out of hole due to very low pulling speed?

The SWAB calculation

After the incident the swab calculation was performed with the maximum expected pore pressure

SWAB TRIPPING SPEED CALCULATIONS					
	POOH				
DATE:	28-mar-10				
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Would you have reacted on this swab calculation?

- Consider to pump out of hole due to very low pulling speed?

- Increase mud weight before POOH?

The SWAB calculation

After the incident the swab calculation was performed with the maximum expected pore pressure

SWAB TRIPPING SPEED CALCULATIONS

	POOH	
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STRING:	BHA #7	
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Would you have reacted on this swab calculation?

- Consider to pump out of hole due to very low pulling speed?

- Increase mud weight before POOH?

Actual PP in formation was measured in 6" hole section: **1.28 sg**

Summary

The well control incident occurred mainly due to:

- Hydrocarbons were swabbed due to high tripping speed

  ✓ The input parameters to the swab calculation were wrong

  ✓ No QC of the swab calculation was performed

- The PP was higher than the maximum estimated value

  ✓ Expected: 1.16 sg / maximum expected: 1.24 sg / measured: 1.28 sg

- No flow checks were performed inside 9 5/8" casing shoe and before the BHA was pulled through the BOP

- The trip sheet indicating gain was not reacted on

Recommendations – Planning phase onshore

- The PP estimates for the reservoir section should be presented in a table

- A comment should be entered on the PP chart stating that a detailed PP chart/table for the reservoir section is available

- The risk matrix for sections with possible permeable zones should state the risk and consequences related to surge/swab

Recommendations – Planning phase onshore/offshore

- Flow checks should be included in the detailed operating procedure (DOP):

  - At TD

  - Inside last casing shoe

  - Before BHA is pulled through BOP

  - ✓ Length of flow checks:

  - Minimum 10 minutes (HPHT: 30 minutes)

- In section- and DOP meetings, well control issues should be discussed and related risks and actions evaluated

Recommendations – Operational phase offshore

- The Wellsite Geologist should at all times know the expected and maximum expected PP in the ongoing hole section

- The Data Operator (mud logger) should verify the input parameters to the swab calculation with the Wellsite Geologist and the Drilling Supervisor

- The swab calculation should be quality controlled by the Tool pusher and Well site Geologist. The Drilling Supervisor should sign out the calculation results

- Prior to tripping, trip sheet tolerances, alarm settings, shut-in procedure and other criteria's shall be agreed between the Data Operator (mud logger), Driller, Tool pusher and Drilling Supervisor

- If the trip sheet indicate well instability, a flow check shall be performed and the Tool pusher and Drilling Supervisor notified. The driller should line up for closing the well.

- If a flow check indicate instability, the well shall be shut in as soon as possible and the Tool pusher and Drilling Supervisor notified

- Extended length of flow checks should be considered based on well geometry, drilling fluid, expected overbalance and other operational considerations

olf

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Thank you