

Enclosure 1: MIT Akzo cavern series 381, MIT setup

150216 MIT Akzo cavern series 381 rev05.xlsx



**PN 5305: Cavern neck volume list well 381**

7" LCCS at 450.6 m MD

calc. oil volume in 4 1/2" x 7" to 7" LCCS in liter:

4,595.6

calc. oil volume in neck to uppermost BCS sensor in liter:

9.8

level depth in m MD	BCS step no.	neck radius in m*	from depth in m MD	to depth in m MD	delta volume 4 1/2" x 7" in liter*	total volume 4 1/2" x 7" in liter
450.9	1	0.085	450.8	450.9	-	4,605.3
451.0	2	0.085	450.9	451.0	1.2	4,606.6
451.1	3	0.085	451.0	451.1	1.2	4,607.8
451.2	4	0.085	451.1	451.2	1.2	4,609.0
451.3	5	0.085	451.2	451.3	1.3	4,610.3
451.4	6	0.086	451.3	451.4	1.3	4,611.6
451.5	7	0.085	451.4	451.5	1.3	4,612.8
451.6	8	0.087	451.5	451.6	1.3	4,614.2
451.7	9	0.087	451.6	451.7	1.4	4,615.5
451.8	10	0.091	451.7	451.8	1.6	4,617.1
451.9	11	0.099	451.8	451.9	2.0	4,619.1
452.0	12	0.107	451.9	452.0	2.5	4,621.7
452.1	13	0.131	452.0	452.1	4.4	4,626.0
452.2	14	0.135	452.1	452.2	4.7	4,630.7
452.3	15	0.149	452.2	452.3	6.0	4,636.7
452.4	16	0.163	452.3	452.4	7.3	4,644.0
452.5	17	0.172	452.4	452.5	8.3	4,652.2
452.6	18	0.230	452.5	452.6	15.6	4,667.8
452.7	19	0.281	452.6	452.7	23.8	4,691.6
452.8	20	0.283	452.7	452.8	24.1	4,715.7

\*: based on caliper measurement on 07/11/2014

**Enclosure 2: MIT Akzo cavern well 381, Cavern neck volume list**





**PN 5305: Cavern neck volume list well 382**

7" LCCS at 452.6 m MD

calc. oil volume in 4 1/2" x 7" to 7" LCCS in liter: **4,616.0**

calc. oil volume in 4 1/2" x 7" to uppermost BCS sensor in liter: **4,607.8**

level depth in m MD	BCS step no.	neck radius in m*	from depth in m MD	to depth in m MD	delta volume 4 1/2" x 7" in liter*	total volume 4 1/2" x 7" in liter
451.8	1	0.083	451.7	451.8	-	4,607.8
451.9	2	0.083	451.8	451.9	1.2	4,609.0
452.0	3	0.083	451.9	452.0	1.2	4,610.1
452.1	4	0.083	452.0	452.1	1.1	4,611.2
452.2	5	0.083	452.1	452.2	1.2	4,612.4
452.3	6	0.083	452.2	452.3	1.2	4,613.5
452.4	7	0.083	452.3	452.4	1.1	4,614.7
452.5	8	0.082	452.4	452.5	1.1	4,615.8
452.6	9	0.082	452.5	452.6	1.1	4,616.9
452.7	10	0.109	452.6	452.7	2.7	4,619.6
452.8	11	0.082	452.7	452.8	1.1	4,620.7
452.9	12	0.082	452.8	452.9	1.1	4,621.8
453.0	13	0.082	452.9	453.0	1.1	4,622.9
453.1	14	0.082	453.0	453.1	1.1	4,624.0
453.2	15	0.082	453.1	453.2	1.1	4,625.1
453.3	16	0.082	453.2	453.3	1.1	4,626.2
453.4	17	0.082	453.3	453.4	1.1	4,627.3
453.5	18	0.082	453.4	453.5	1.1	4,628.3
453.6	19	0.366	453.5	453.6	41.1	4,669.5
453.7	20	0.368	453.6	453.7	41.5	4,711.0

\*: based on caliper measurement before cutting on 07/11/2014 under consideration of partially accomplished cut in cement from 452.6 to 452.7 m MD

**Enclosure 3: MIT Akzo cavern well 382, Cavern neck volume list**





**PN 5305: Cavern neck volume list well 383**

7" LCCS at 452.15 m MD

calc. oil volume in 4 1/2" x 7" to 7" LCCS in liter: 4,611.4

calc. oil volume in 4 1/2" x 7" to uppermost BCS sensor in liter: 4,596.1

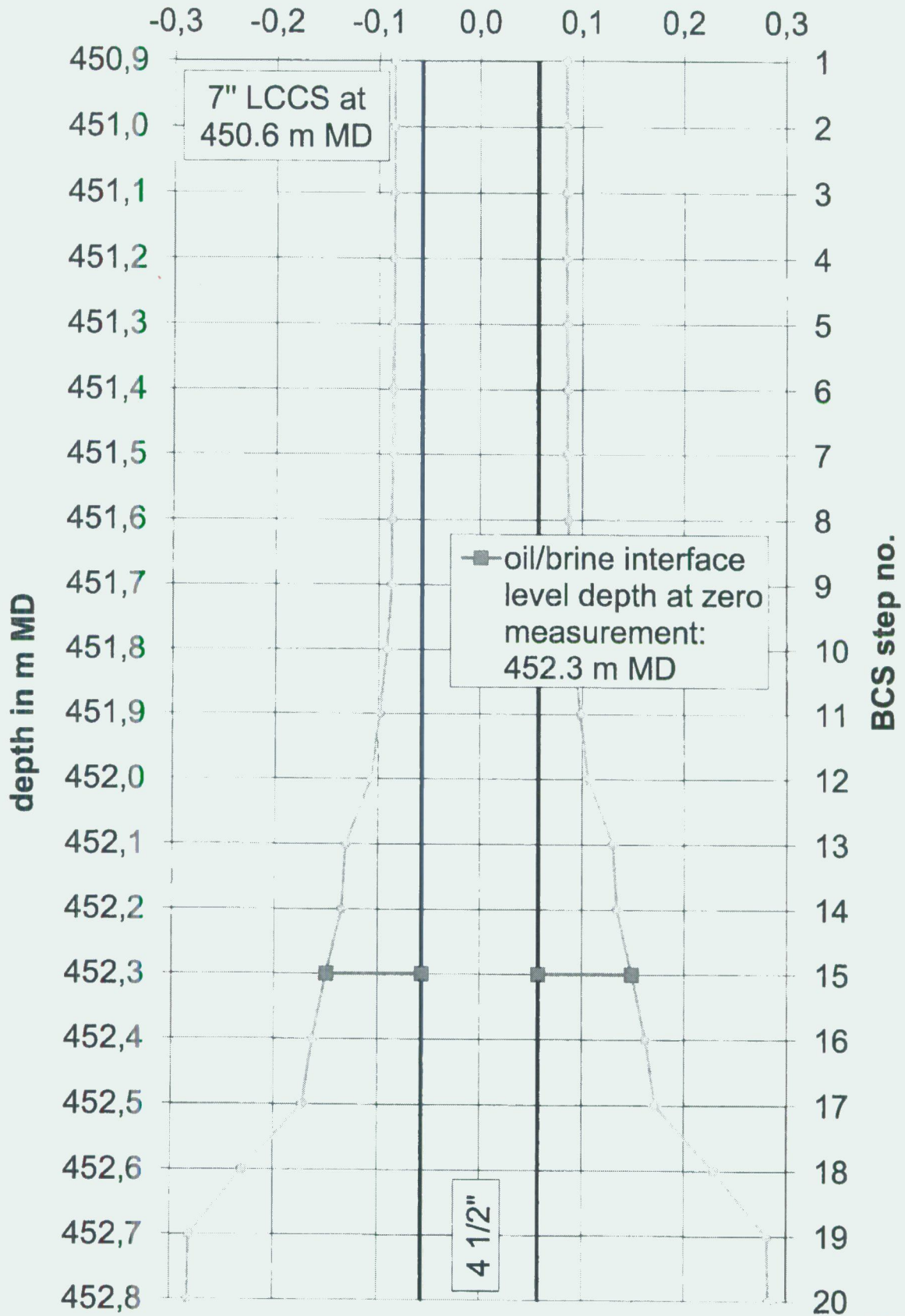
level depth in m MD	BCS step no.	neck radius in m*	from depth in m MD	to depth in m MD	delta volume 4 1/2" x 7" in liter*	total volume 4 1/2" x 7" in liter
450.65	1	0.086	450.55	450.65	-	4,596.1
450.75	2	0.086	450.65	450.75	1.3	4,597.4
450.85	3	0.086	450.75	450.85	1.3	4,598.7
450.95	4	0.086	450.85	450.95	1.3	4,600.0
451.05	5	0.086	450.95	451.05	1.3	4,601.3
451.15	6	0.086	451.05	451.15	1.3	4,602.6
451.25	7	0.086	451.15	451.25	1.3	4,603.9
451.35	8	0.086	451.25	451.35	1.3	4,605.2
451.45	9	0.086	451.35	451.45	1.3	4,606.5
451.55	10	0.086	451.45	451.55	1.3	4,607.8
451.65	11	0.086	451.55	451.65	1.3	4,609.1
451.75	12	0.086	451.65	451.75	1.3	4,610.4
451.85	13	0.086	451.75	451.85	1.3	4,611.7
451.95	14	0.087	451.85	451.95	1.3	4,613.1
452.05	15	0.090	451.95	452.05	1.5	4,614.6
452.15	16	0.099	452.05	452.15	2.0	4,616.6
452.25	17	0.155	452.15	452.25	6.5	4,623.1
452.35	18	0.126	452.25	452.35	4.0	4,627.1
452.45	19	0.133	452.35	452.45	4.5	4,631.6
452.55	20	0.140	452.45	452.55	5.1	4,636.7

\*: based on caliper measurement after cutting on 10/11/2014 under consideration of cut in cement from 452.15 to 452.25 m MD

**Enclosure 4: MIT Akzo cavern well 383, Cavern neck volume list**

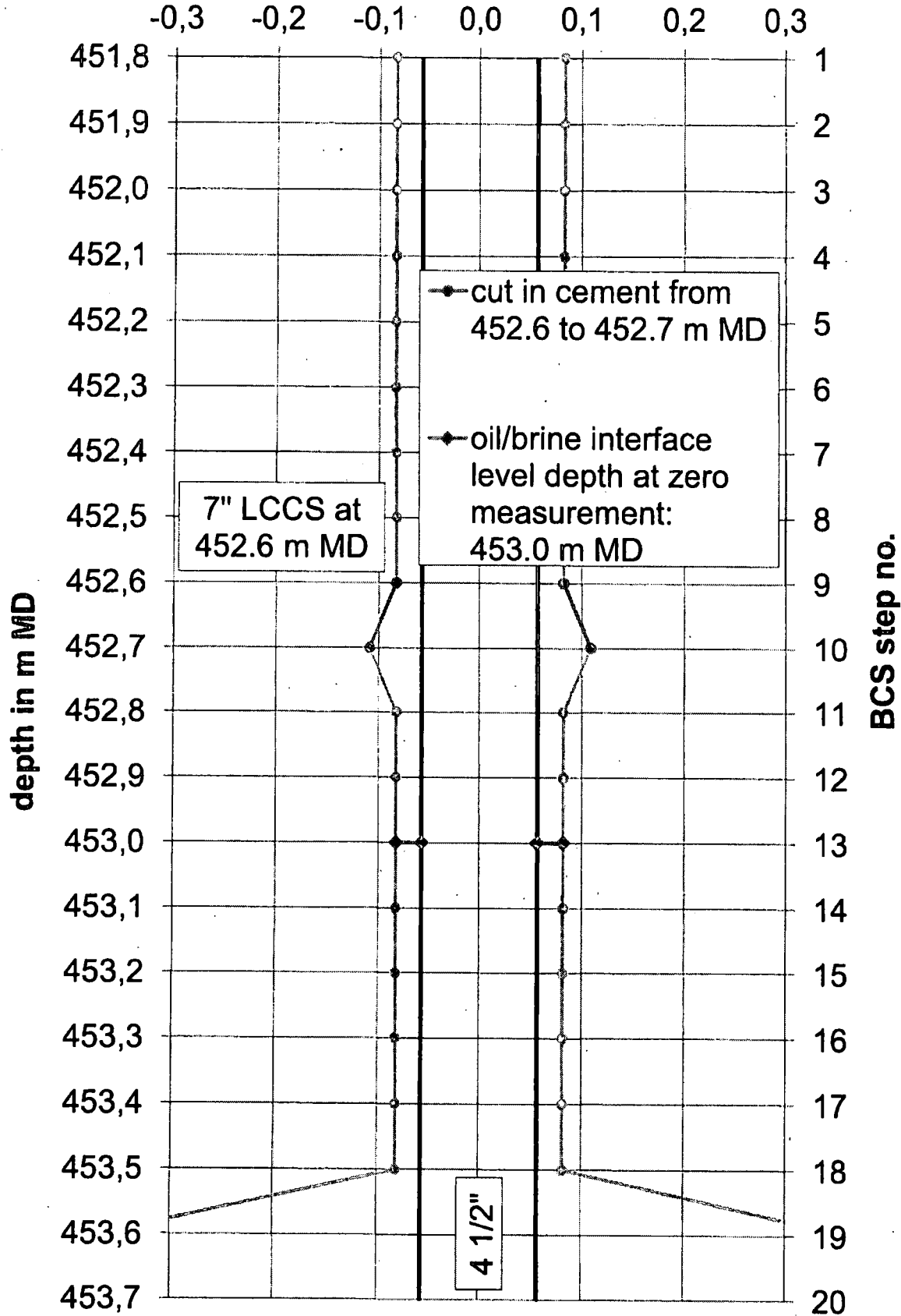


neck radius based on caliper measurement in m



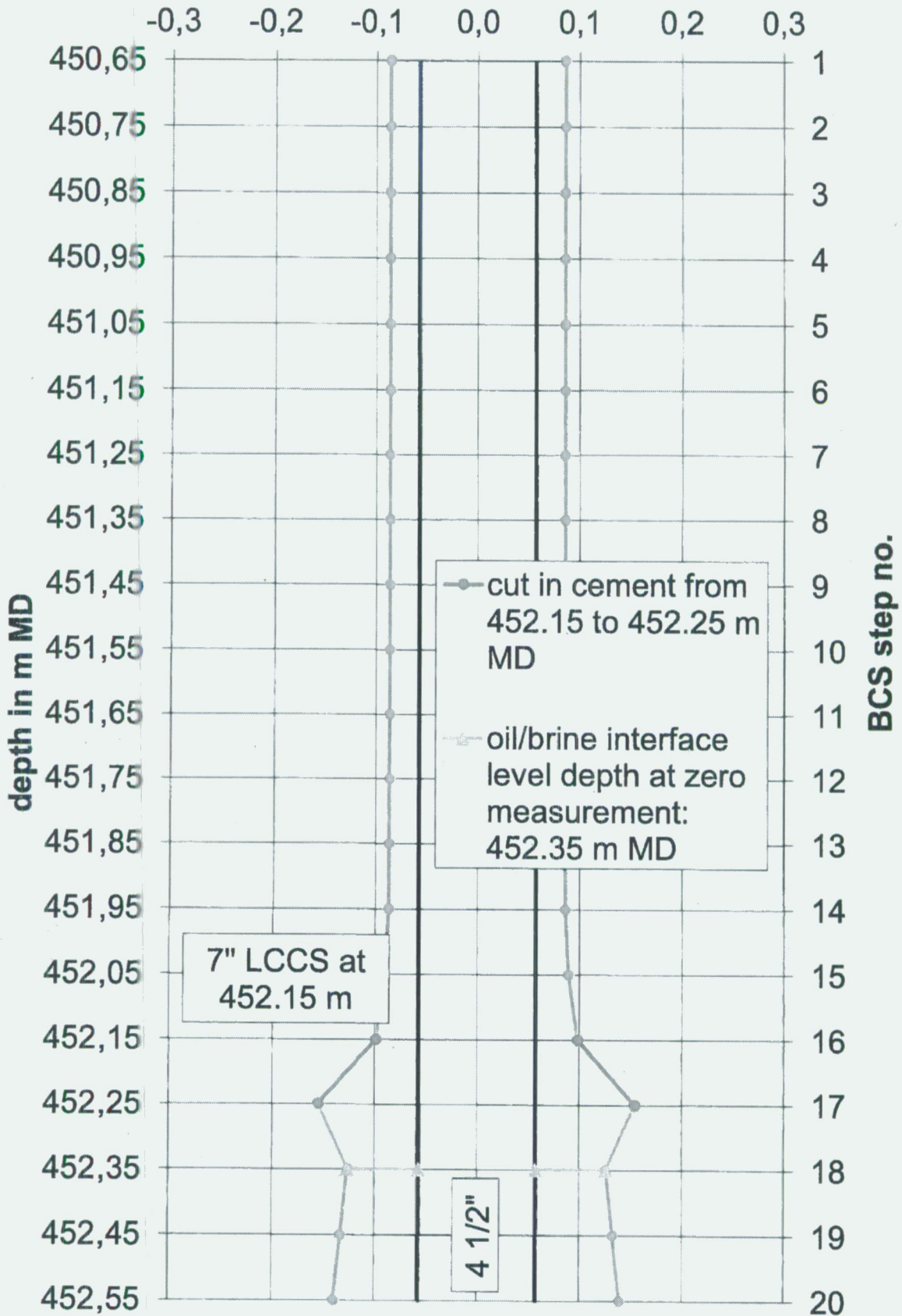
Enclosure 5: MIT Akzo cavern well 381, Cavern neck

neck radius based on caliper measurement incl. cut in m



Enclosure 6: MIT Akzo cavern well 382, Cavern neck

neck radius based on caliper measurement incl. cut in m

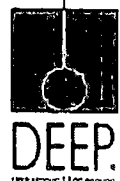


Enclosure 7: MIT Akzo cavern well 383, Cavern neck



Enclosure 8: MIT Akzo cavern series 381,  
Oil pump and release records

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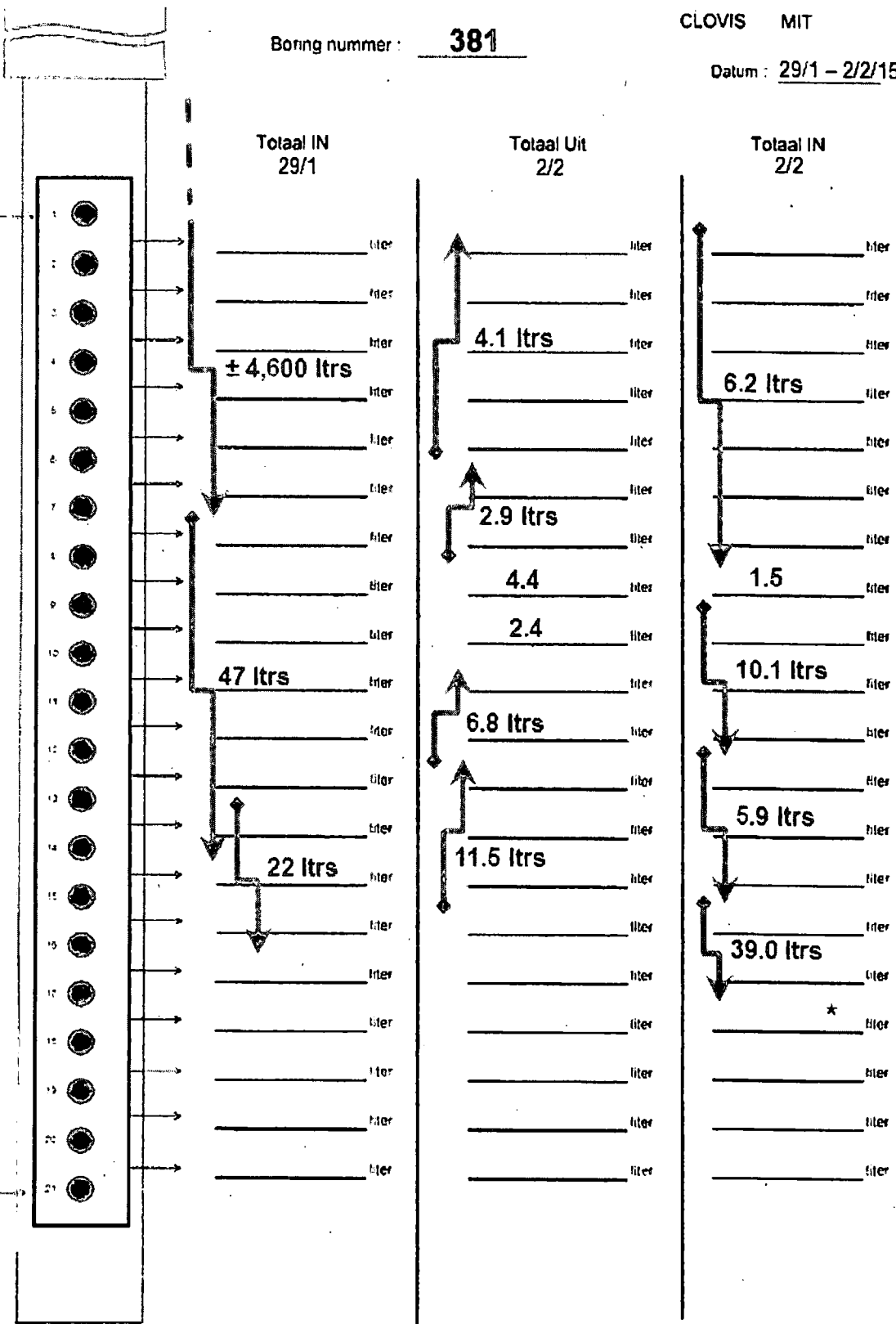
Boring nummer : 381

CLOVIS MIT

Datum : 29/1 - 2/2/15

Downhole BCS trap on  
451.0 m.MV

Downhole BCS trap on  
453.0 m.MV



\* BCS-level at 2/2/15 - 15.30: 452.6

Boring number : 382(1)

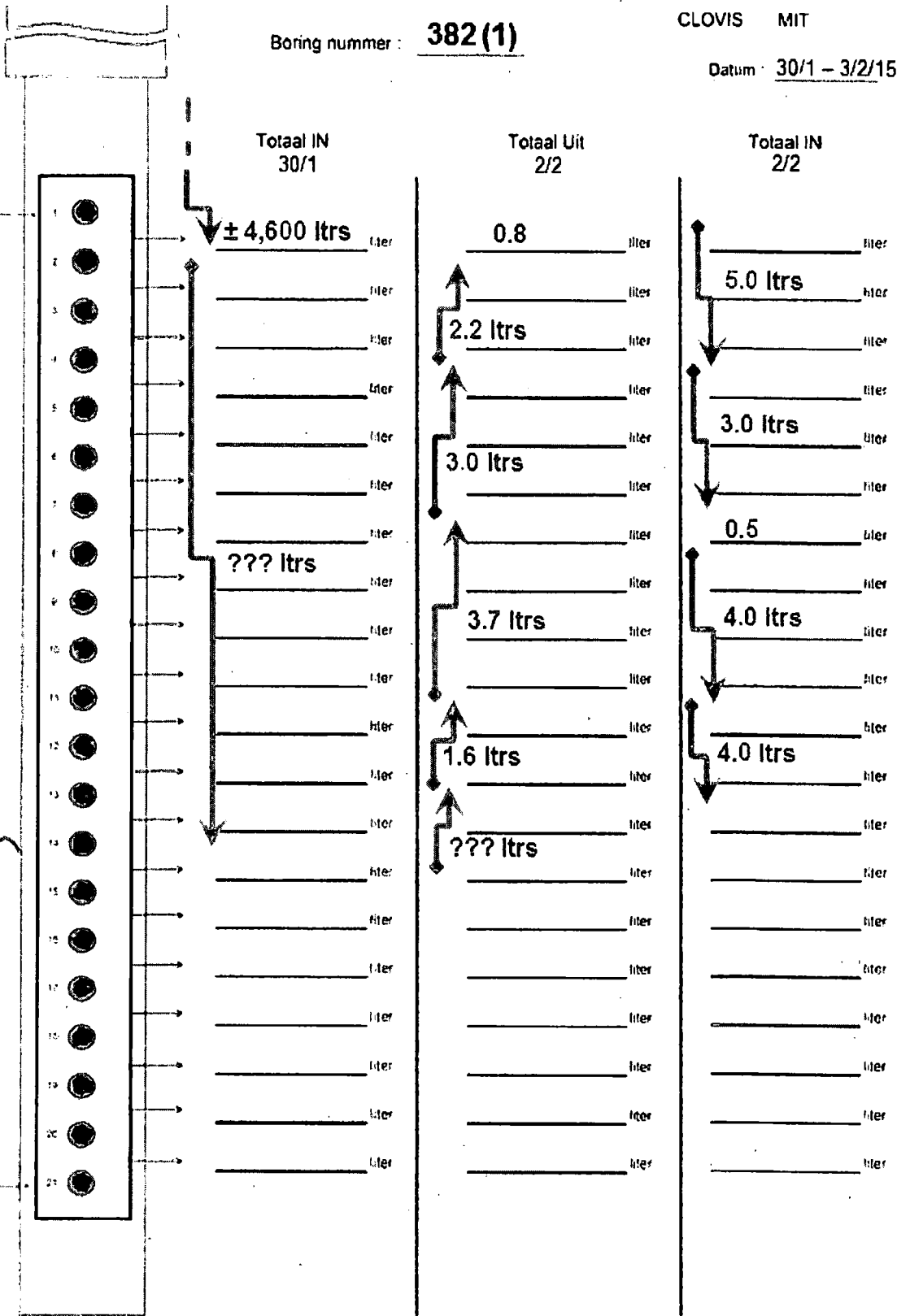
CLOVIS MIT

Datum : 30/1 - 3/2/15

Bovenste BCS stand op  
451,7 m

Cavern roof

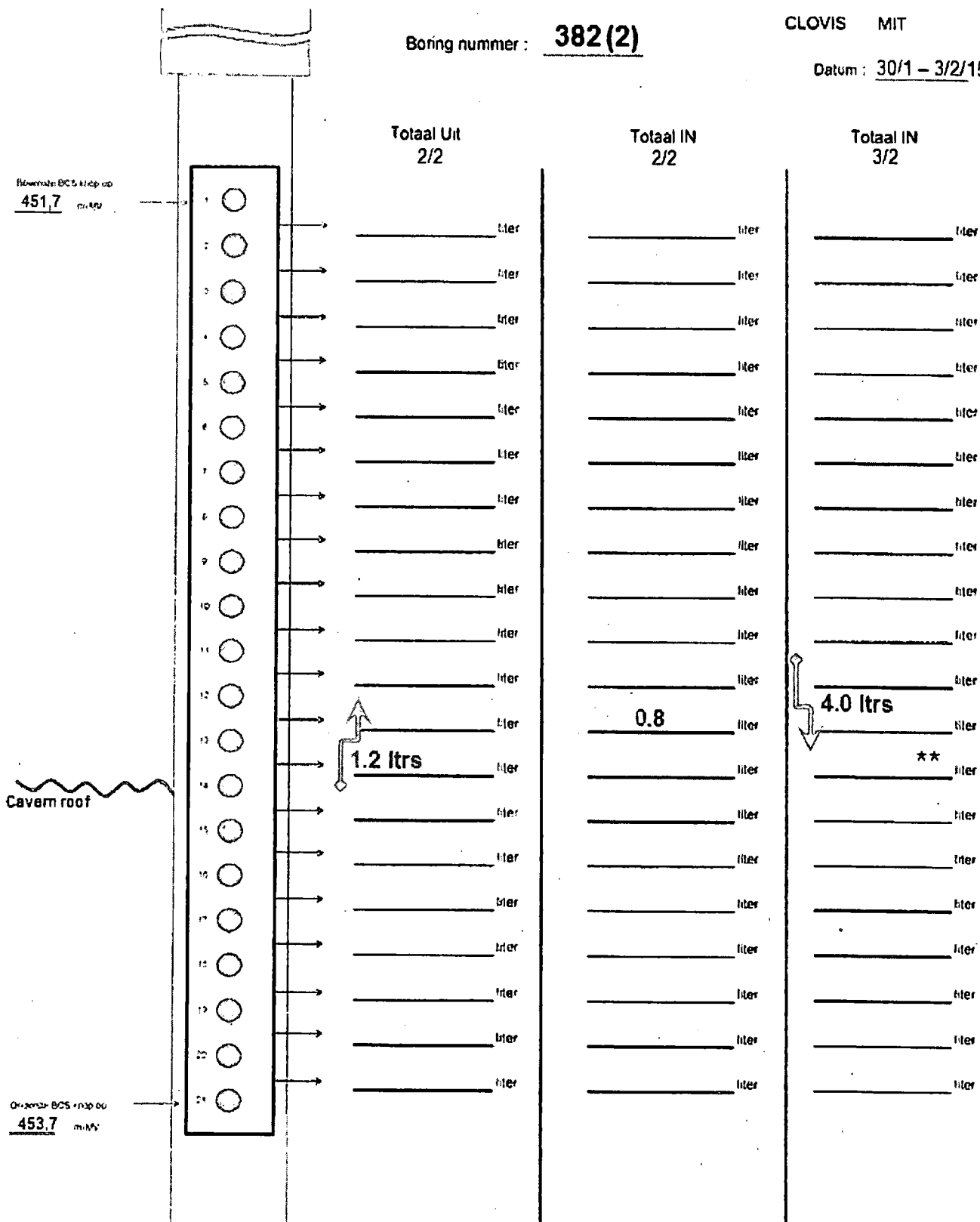
Onderste BCS stand op  
453,7 m



Boring nummer : **382 (2)**

CLOVIS MIT

Datum : 30/1 - 3/2/15



\*\* After pressurization extra amounts of oil have been added at:

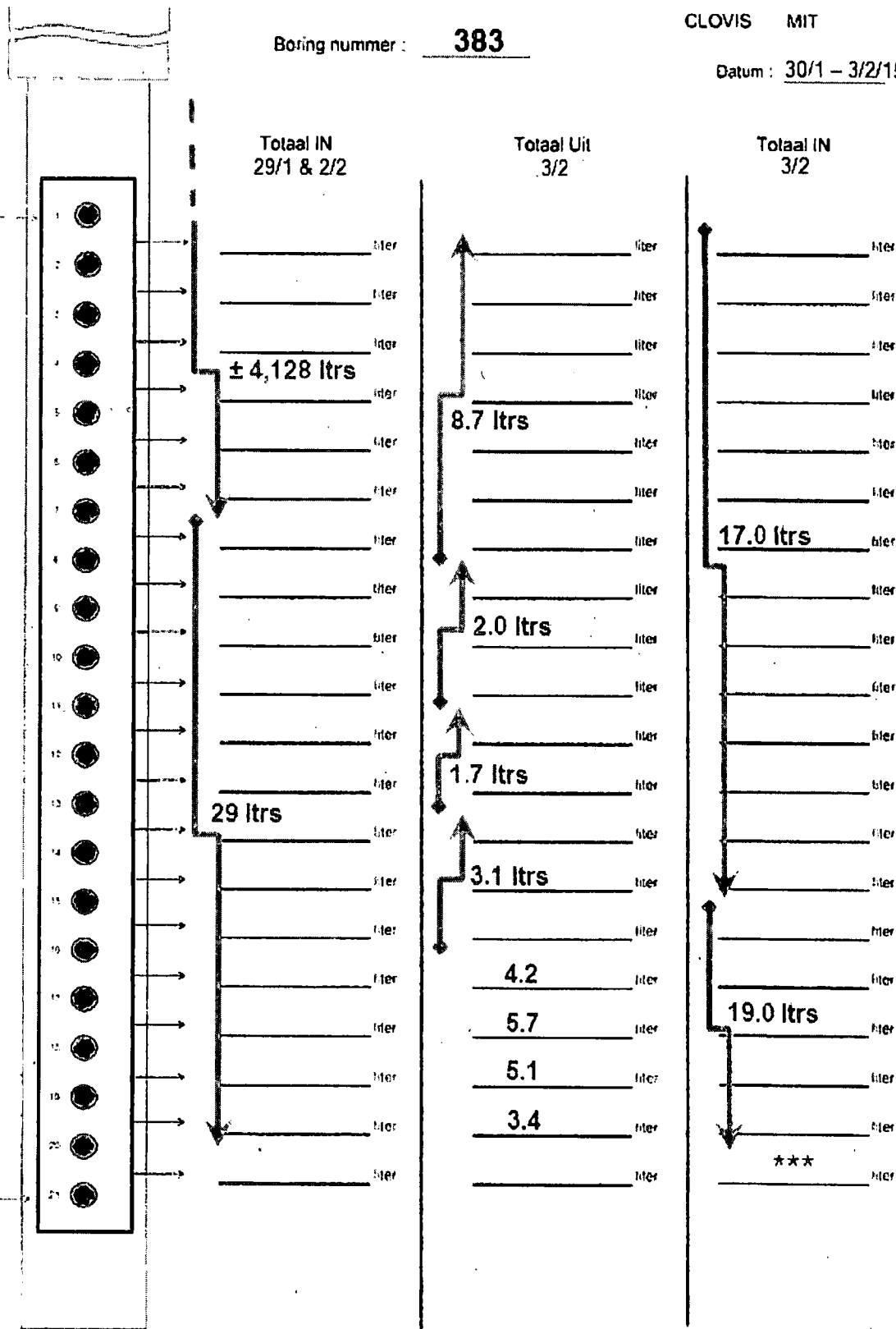
- 5/2: 0.4 liter (raising the BCS from 452.0 to 452.9)
- 6/2: 1.4 liter (raising the BCS from 452.8 to 452.9)
- 8/2: 1.4 liter (raising the BCS from 452.8 to 452.9)

Boring nummer : 383

CLOVIS MIT

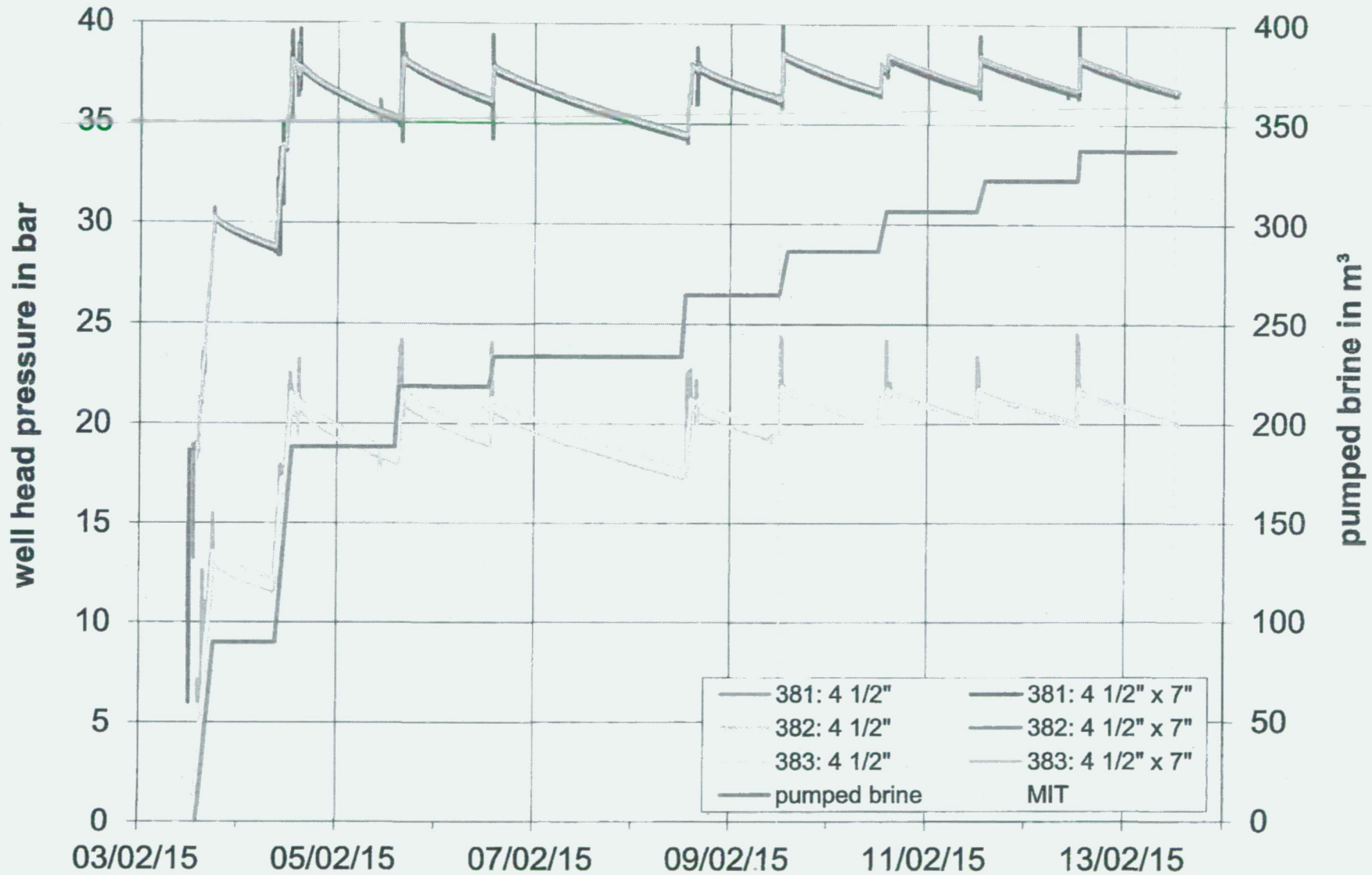
Datum : 30/1 - 3/2/15

Downside BCS level on  
450,7 m MV



Downside BCS level on  
452,7 m MV

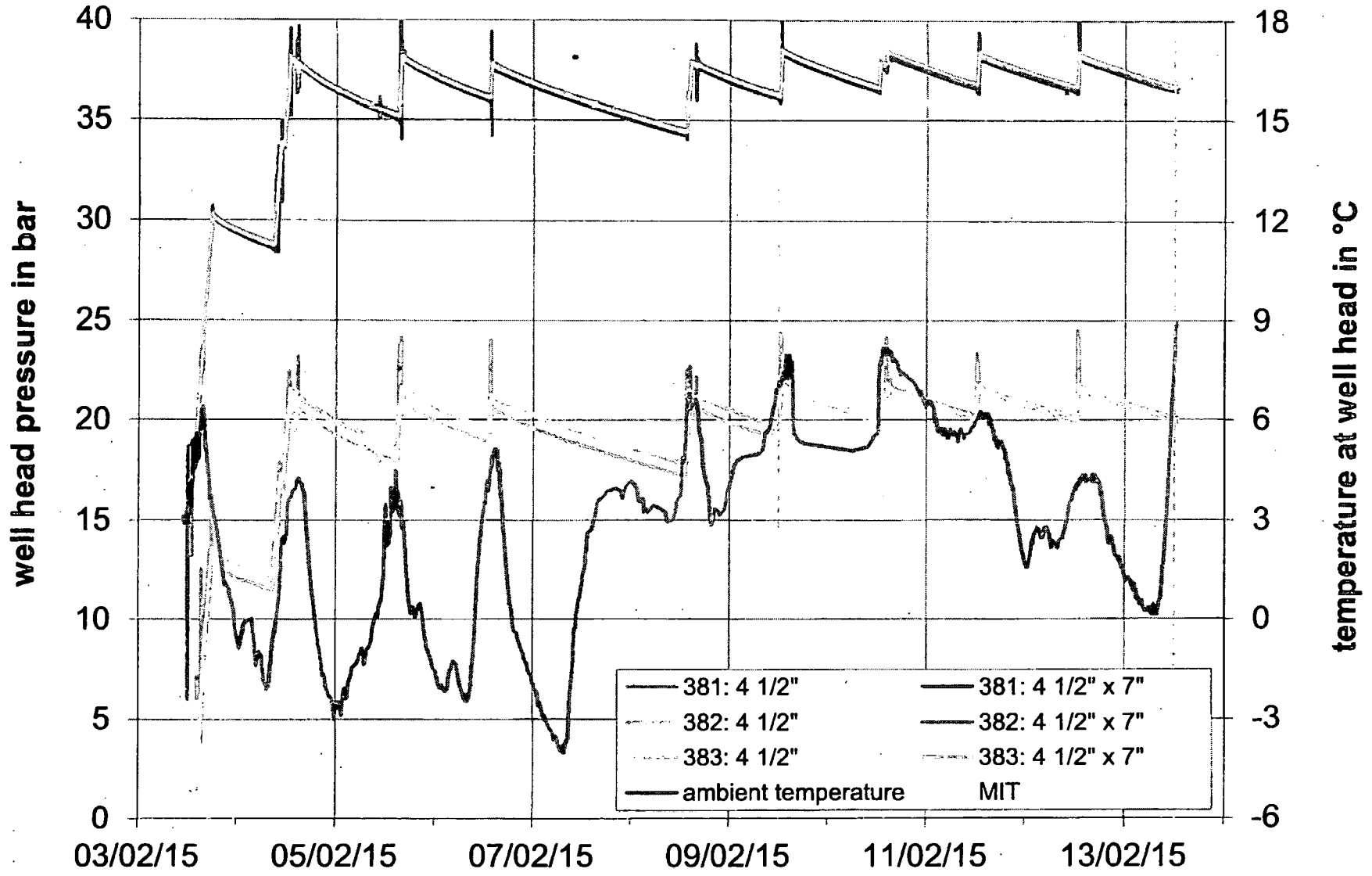
\*\*\* BCS-level at 3/2/15 - 10.00 452.6



Enclosure 9: MIT Akzo cavern series 381, Well head data 1

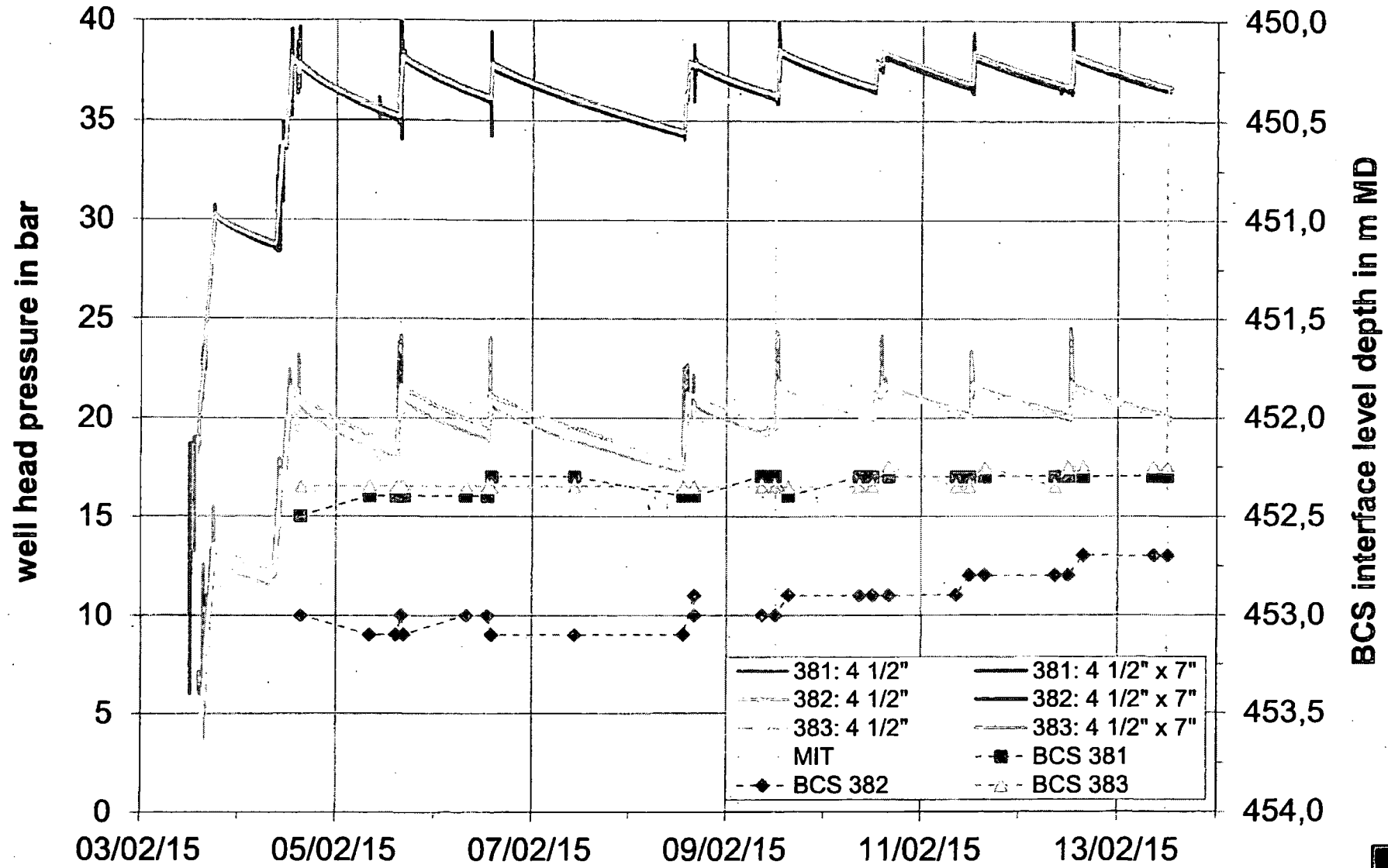
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Enclosure 10: MIT Akzo cavern series 381, Well head data 2





Enclosure 11: MIT Akzo cavern series 381, Well head pressure and interface depth data





Enclosure 12: MIT Akzo cavern series 381, Daily reports

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## Daily Report No. 1

### AkzoNobel Cavern Series 381 – MIT

**Project-No.:** 5305

**Date:** 03/02/2015

**Editor:**

**Distribution List:** (AkzoNobel),

#### Supervisor:

<b>Working time from:</b>	08:00	<b>Daily report no.:</b>	1
<b>Working time to:</b>	18:30	<b>Date:</b>	03/02/2015

from	to	Working operations
08:00	08:30	KBB arrival and registration at AkzoNobel Gate 1, sign work permit.
08:30	14:00	Operations meeting on site, install KBB pressure and temperature sensors at 4 ½" and 4 ½" x 7" of wells 381, 382 and 383, install ICM flow meter at 4 ½" of 381, check and start recording KBB pressure and temperature sensors:ok, oil injection for oil/brine interface adjustment at wells 382 and 383.
14:00	18:00	Start brine pumping at 4 ½" of 381, check ICM flow meter: not ok, remove rust on outside of inflow pipe and reset flow meter, check ICM flow meter: ok. Brine injection at 4 ½" of 381 to approx. 30 bar at 4 ½" x 7" of 381. Total brine injection approx. 90 m <sup>3</sup> (70m <sup>3</sup> recorded by flow meter and approx. 20 m <sup>3</sup> during 1 h failure of flow meter).
18:00	18:30	Change ½" NPT connector at well 383 due to minor leak at brine site, secure and leave cavern site.

#### Well data on 03/02/2015, 18:00:

<b>Well 381:</b>	pressure 4 ½": 13.6 bar pressure 4 ½" x 7": 30.1 bar interface level: 452.7 m MD (BCS no. 18: 5,505) temperature at interface: 22.7 °C
<b>Well 382:</b>	pressure 4 ½": 12.8 bar pressure 4 ½" x 7": 30.3 bar interface level: 452.4 m MD (BCS no. 8: 1,590) temperature at interface: 23.4 °C
<b>Well 383:</b>	pressure 4 ½": 13.5 bar pressure 4 ½" x 7": 30.23 bar interface level: 452.5 m MD (BCS no. 19: 3,349) temperature at interface: 24.1 °C

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**Further programme:**

04/02/2015 - 08/02/2015: Brine injection to test pressure, damping period.  
09/02/2015: Start MIT at cavern series 381.

Sgd.



## Daily Report No. 2

### AkzoNobel Cavern Series 381 – MIT

**Project-No.:** 5305  
**Date:** 04/02/2015  
**Editor:**  
**Distribution List:** (AkzoNobel),

#### Supervisor:

<b>Working time from:</b>	08:00	<b>Daily report no.:</b>	2
<b>Working time to:</b>	16:00	<b>Date:</b>	04/02/2015

from	to	Working operations
08:00	08:45	Sign work permit, operations meeting, check BCS System and KBB pressure / temperature sensors and record data.
08:45	13:00	Check flow meter: ok, start pumping brine at 4 ½" of 381 for approx. 1 h, stop pumping brine due to repair work at HP-Pump (approx. 1.5 h), parallel replace batteries at BCS of well 382. Stop pumping brine at 12:45.  Amount of brine pumped: 98.5 m <sup>3</sup> ,  Total amount pumped: 98.5 m <sup>3</sup> + 90 m <sup>3</sup> (03/02/15) → 188.5 m <sup>3</sup>
13:00	14:30	Bleed off brine pressure at pressure recording sensor/tube of well 382 and displace tubing brine content (approx. 4.5 m <sup>3</sup> ) to evaluate and check for Δ p of 0.75 bar between well 381 and 382 brine site.
14:30	16:00	Start pumping brine (4.5 m <sup>3</sup> ) to pressurize cavern up to MIT test pressure >21 bar. Record all well data, secure and leave cavern site.

#### Well data on 04/02/2015, 08:30:

Well 381:	pressure 4 ½": 12.1 bar pressure 4 ½" x 7": 28.6 bar interface level: 452.5 m MD (BCS no. 15: 1,000) temperature at interface: 24.3 °C
Well 382:	pressure 4 ½": 11.5 bar pressure 4 ½" x 7": 28.9 bar interface level: 452.3 m MD (BCS no. 7: 1,030) temperature at interface: 23.4 °C
Well 383:	pressure 4 ½": 12.1 bar pressure 4 ½" x 7": 28.8 bar interface level: 452.5 m MD (BCS no. 13: 3,215) temperature at interface: 24.1 °C

Well data on 04/02/2015, 13:00:

Well 381:                      pressure 4 ½": 21.55 bar  
                                    pressure 4 ½" x 7": 37.98 bar  
                                    interface level: 452.6 m MD (BCS no. 17: 2,801)  
                                    temperature at interface: 23.0 °C

Well 382:                      pressure 4 ½": 20.80 bar  
                                    pressure 4 ½" x 7": 38.10 bar  
                                    interface level: 452.3 m MD (BCS no. 4: 776)  
                                    temperature at interface: 23.4 °C

Well 383:                      pressure 4 ½": 21.40 bar  
                                    pressure 4 ½" x 7": 38.03 bar  
                                    interface level: 452.4 m MD (BCS no. 18: 2,647)  
                                    temperature at interface: 24.1 °C

Well data on 04/02/2015, 15:15:

Well 381:                      pressure 4 ½": 21.12 bar  
                                    pressure 4 ½" x 7": 37.55 bar  
                                    interface level: 452.6 m MD (BCS no. 17: 3,432)  
                                    temperature at interface: 21.4 °C

Well 382:                      pressure 4 ½": 20.50 bar  
                                    pressure 4 ½" x 7": 37.80 bar  
                                    interface level: 452.7 m MD (BCS no. 11: 1,516)  
                                    temperature at interface: 23.4 °C

Well 383:                      pressure 4 ½": 21.00 bar  
                                    pressure 4 ½" x 7": 37.66 bar  
                                    interface level: 452.4 m MD (BCS no. 18: 2,884)  
                                    temperature at interface: 24.1 °C

Further programme:

05/02/2015 - 09/02/2015:      Damping period at cavern series 381,  
09/02/2015:                      Start MIT at cavern series 381.

Sgd.



**Daily Report No. 3 Rev.01**  
**AkzoNobel Cavern Series 381 – MIT**

**Project-No.:** 5305  
**Date:** 09/02/2015  
**Editor:**  
**Distribution List:** (AkzoNobel),

**Supervisor:**

<b>Working time from:</b>	08:00	<b>Daily report no.:</b>	3
<b>Working time to:</b>	16:30	<b>Date:</b>	09/02/2015

from	to	Working operations
08:00	12:00	Sign work permit, operations meeting, check BCS System and KBB pressure / temperature sensors and record data, parallel repair work at HP-pump unit. Change of 4 ½" brine pressure recording sensor 1 to sensor 3 at well 382.
12:00	12:15	MIT zero (reference) measurement at all wells.
12:15	13:00	Check flow meter: ok, start pumping brine at 4 ½" of 381 for approx. 0.5 h until WH pressure at 4 ½" of 383 at 21.7 bar Amount of brine pumped: 22.0 m <sup>3</sup> , Total amount pumped: 188.5 m <sup>3</sup> + 76 m <sup>3</sup> (05/02/-08/02/15) + 22 m <sup>3</sup> → 286.5 m <sup>3</sup>
13:00	16:30	Observe and record WH pressure at all wells, secure and leave well site cavern series 381.

Well data on 09/02/2015, 08:45:

**Well 381:** pressure 4 ½": 19.83 bar  
pressure 4 ½" x 7": 36.25 bar  
interface level: 452.4 m MD (BCS no. 15: 2,668)  
temperature at interface: 23.7 °C

**Well 382:** pressure 4 ½": 19.23 bar  
pressure 4 ½" x 7": 36.54 bar  
interface level: 452.9 m MD (BCS no. 13: 2,026)  
temperature at interface: 23.4 °C

**Well 383:** pressure 4 ½": 19.82 bar  
pressure 4 ½" x 7": 36.46 bar  
interface level: 452.4 m MD (BCS no. 18: 2,920)  
temperature at interface: 24.1 °C



**Well data on 09/02/2015, 12:00 (reference measurement):**

Well 381:	pressure 4 ½": 19.59 bar pressure 4 ½" x 7": 36.03 bar interface level: 452.4 m MD (BCS no. 15: 2,661) temperature at interface: 23.7 °C
Well 382:	pressure 4 ½": 19.45 bar pressure 4 ½" x 7": 36.32 bar interface level: 452.9 m MD (BCS no. 13: 2,088) temperature at interface: 23.7 °C
Well 383:	pressure 4 ½": 19.56 bar pressure 4 ½" x 7": 36.24 bar interface level: 452.4 m MD (BCS no. 18: 2,940) temperature at interface: 24.7 °C

**Well data on 09/02/2015, 15:15:**

Well 381:	pressure 4 ½": 21.60 bar pressure 4 ½" x 7": 38.04 bar interface level: 452.5 m MD (BCS no. 15: 683) temperature at interface: 22.0 °C
Well 382:	pressure 4 ½": 21.44 bar pressure 4 ½" x 7": 38.30 bar interface level: 452.8 m MD (BCS no. 12: 1,359) temperature at interface: 23.4 °C
Well 383:	pressure 4 ½": 21.53 bar pressure 4 ½" x 7": 38.22 bar interface level: 452.4 m MD (BCS no. 18: 2,915) temperature at interface: 24.1 °C

**Further programme:**

10/02/2015 - 13/02/2015:	Daily MIT measurements, if pressure decreases then pump brine in 4 ½" of 381 until WH pressure at 4 ½" of 383 at 21.7 bar.
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Sgd.



## Daily Report No. 4

### AkzoNobel Cavern Series 381 – MIT

**Project-No.:** 5305  
**Date:** 10/02/2015  
**Editor:**  
**Distribution List:** (AkzoNobel).

#### Supervisor:

<b>Working time from:</b>	08:00	<b>Daily report no.:</b>	4
<b>Working time to:</b>	17:30	<b>Date:</b>	10/02/2015

from	to	Working operations
08:00	12:00	Sign work permit, operations meeting, check BCS System and KBB pressure / temperature sensors and record data.
12:00	12:15	MIT first measurement at all wells.
12:15	13:00	Check flow meter: ok, start pumping brine at 4 ½" of 381 for approx. 0.5 h (12.5 m <sup>3</sup> ) until WH pressure at 4 ½" of 383 at 21.25 bar, stop pumping due to brine shortage.
13:00	14:15	Wait on brine, start pumping brine for approx. 0.5 h (7.5 m <sup>3</sup> ) until WH pressure at 4 ½" of 383 at 21.70 bar Amount of brine pumped: 20 m <sup>3</sup> , Total amount pumped: 286.5 m <sup>3</sup> + 20 m <sup>3</sup> → 306.5 m <sup>3</sup>
13:00	17:30	Uninstall GEOSTOCK pressure sensors at 4 ½" and 4 ½" x 7" of 382 and install at 381, observe and record WH pressure at all wells, secure and leave well site cavern series 381.

#### Well data on 10/02/2015, 08:45:

Well 381:	pressure 4 ½": 20.22 bar pressure 4 ½" x 7": 36.67 bar interface level: 452.4 m MD (BCS no. 15: 2,842) temperature at interface: 23.7 °C
Well 382:	pressure 4 ½": 20.10 bar pressure 4 ½" x 7": 36.96 bar interface level: 452.8 m MD (BCS no. 12: 1,289) temperature at interface: 23.4 °C
Well 383:	pressure 4 ½": 20.24 bar pressure 4 ½" x 7": 36.88 bar interface level: 452.4 m MD (BCS no. 18: 2,960) temperature at interface: 24.1 °C



**Well data on 10/02/2015, 12:00 (first measurement):**

Well 381:                      pressure 4 ½": 20.01 bar  
                                    pressure 4 ½" x 7": 36.46 bar  
                                    interface level: 452.4 m MD (BCS no. 15: 2,878)  
                                    temperature at interface: 23.7 °C

Well 382:                      pressure 4 ½": 19.88 bar  
                                    pressure 4 ½" x 7": 36.75 bar  
                                    interface level: 452.8 m MD (BCS no. 12: 1,403)  
                                    temperature at interface: 23.7 °C

Well 383:                      pressure 4 ½": 20.00 bar  
                                    pressure 4 ½" x 7": 36.67 bar  
                                    interface level: 452.4 m MD (BCS no. 18: 2,944)  
                                    temperature at interface: 24.1 °C

**Well data on 10/02/2015, 16:00:**

Well 381:                      pressure 4 ½": 21.56 bar  
                                    pressure 4 ½" x 7": 38.05 bar  
                                    interface level: 452.4 m MD (BCS no. 15: 1,835)  
                                    temperature at interface: 21.1 °C

Well 382:                      pressure 4 ½": 21.48 bar  
                                    pressure 4 ½" x 7": 38.34 bar  
                                    interface level: 452.8 m MD (BCS no. 11: 362)  
                                    temperature at interface: 23.4 °C

Well 383:                      pressure 4 ½": 21.58 bar  
                                    pressure 4 ½" x 7": 38.26 bar  
                                    interface level: 452.3 m MD (BCS no. 16: 225)  
                                    temperature at interface: 24.4 °C

**Further programme:**

11/02/2015 - 13/02/2015:      Daily MIT measurements, if pressure decreases then pump brine in 4 ½" of 381 until WH pressure at 4 ½" of 383 at 21.7 bar.

Sgd.



**Daily Report No. 5**  
**AkzoNobel Cavern Series 381 – MIT**

**Project-No.:** 5305  
**Date:** 11/02/2015  
**Editor:**  
**Distribution List:** (AkzoNobel),

**Supervisor:**

<b>Working time from:</b>	08:00	<b>Daily report no.:</b>	5
<b>Working time to:</b>	17:00	<b>Date:</b>	11/02/2015

from	to	Working operations
08:00	12:00	Sign work permit, operations meeting, check BCS System and KBB pressure / temperature sensors and record data.
12:00	12:15	MIT second measurement at all wells.
12:15	13:45	Check flow meter: ok, start pumping brine at 4 1/2" of 381 for approx. 0.5 h (15.5 m <sup>3</sup> ) until WH pressure at 4 1/2" of 383 at 21.7 bar.  Total amount pumped: 306.5 m <sup>3</sup> + 15.5 m <sup>3</sup> → 322 m <sup>3</sup>
13:45	17:00	Observe and record WH pressure at all wells, secure and leave well site cavern series 381.

Well data on 11/02/2015, 08:45:

Well 381: pressure 4 1/2": 20.37 bar  
pressure 4 1/2" x 7": 36.82 bar  
interface level: 452.4 m MD (BCS no. 15: 1,766)  
temperature at interface: 23.7 °C

Well 382: pressure 4 1/2": 20.25 bar  
pressure 4 1/2" x 7": 37.11 bar  
interface level: 452.8 m MD (BCS no. 11: 649)  
temperature at interface: 23.4 °C

Well 383: pressure 4 1/2": 20.41 bar  
pressure 4 1/2" x 7": 37.04 bar  
interface level: 452.4 m MD (BCS no. 18: 2,971)  
temperature at interface: 24.1 °C



**Well data on 11/02/2015, 12:00 (second measurement):**

Well 381: pressure 4 ½": 20.17 bar  
 pressure 4 ½" x 7": 36.61 bar  
 interface level: 452.4 m MD (BCS no. 15: 1,746)  
 temperature at interface: 23.7 °C

Well 382: pressure 4 ½": 20.04 bar  
 pressure 4 ½" x 7": 36.91 bar  
 interface level: 452.7 m MD (BCS no. 11: 736)  
 temperature at interface: 23.4 °C

Well 383: pressure 4 ½": 20.19 bar  
 pressure 4 ½" x 7": 36.83 bar  
 interface level: 452.4 m MD (BCS no. 18: 3,000)  
 temperature at interface: 24.1 °C

**Well data on 11/02/2015, 15:45:**

Well 381: pressure 4 ½": 21.37 bar  
 pressure 4 ½" x 7": 37.83 bar  
 interface level: 452.4 m MD (BCS no. 15: 1,788)  
 temperature at interface: 21.4 °C

Well 382: pressure 4 ½": 21.28 bar  
 pressure 4 ½" x 7": 38.14 bar  
 interface level: 452.7 m MD (BCS no. 11: 1,641)  
 temperature at interface: 23.4 °C

Well 383: pressure 4 ½": 21.43 bar  
 pressure 4 ½" x 7": 38.07 bar  
 interface level: 452.3 m MD (BCS no. 16: 352)  
 temperature at interface: 24.4 °C

**Further programme:**

12/02/2015 - 13/02/2015: Daily MIT measurements, if pressure decreases then pump brine in 4 ½" of 381 until WH pressure at 4 ½" of 383 at 21.7 bar.

13/02/2015: Uninstall KBB pressure sensors and ICM flow meter.

Sgd.

**Daily Report No. 6**  
**AkzoNobel Cavern Series 381 – MIT**

**Project-No.:** 5305  
**Date:** 12/02/2015  
**Editor:**  
**Distribution List:**

**Supervisor:**

<b>Working time from:</b>	08:00	<b>Daily report no.:</b>	6
<b>Working time to:</b>	16:30	<b>Date:</b>	12/02/2015

from	to	Working operations
08:00	12:00	Sign work permit, operations meeting, check BCS System and KBB pressure / temperature sensors and record data. Uninstall GEOSTOCK pressure sensors at 4 ½" and 4 ½" x 7" of 381 and install at 383 (0.2 l oil release during dismantling at well 383).
12:00	12:15	MIT third measurement at all wells.
12:15	12:45	Check flow meter: ok, start pumping brine at 4 ½" of 381 for approx. 0.5 h (15 m <sup>3</sup> ) until WH pressure at 4 ½" of 383 at 21.7 bar.  Total amount pumped: 322 m <sup>3</sup> + 15 m <sup>3</sup> → 321,5 m <sup>3</sup>
12:45	16:30	Observe and record WH pressure at all wells, secure and leave well site cavern series 381.

Well data on 12/02/2015, 08:45:

**Well 381:** pressure 4 ½": 20.25 bar  
pressure 4 ½" x 7": 36.67 bar  
interface level: 452.4 m MD (BCS no. 15: 1,791)  
temperature at interface: 23.7 °C

**Well 382:** pressure 4 ½": 20.10 bar  
pressure 4 ½" x 7": 36.96 bar  
interface level: 452.7 m MD (BCS no. 11: 1,687)  
temperature at interface: 23.4 °C

**Well 383:** pressure 4 ½": 20.35 bar  
pressure 4 ½" x 7": 36.88 bar  
interface level: 452.4 m MD (BCS no. 17: 320)  
temperature at interface: 24.1 °C

**Well data on 12/02/2015, 12:00 (third measurement):**

Well 381:                    pressure 4 ½": 20.03 bar  
                                  pressure 4 ½" x 7": 36.47 bar  
                                  interface level: 452.4 m MD (BCS no. 15: 1,784)  
                                  temperature at interface: 23.7 °C

Well 382:                    pressure 4 ½": 19.91 bar  
                                  pressure 4 ½" x 7": 36.77 bar  
                                  interface level: 452.7 m MD (BCS no. 11: 1,688)  
                                  temperature at interface: 23.7 °C

Well 383:                    pressure 4 ½": 20.11 bar  
                                  pressure 4 ½" x 7": 36.96 bar  
                                  interface level: 452.3 m MD (BCS no. 16: 708)  
                                  temperature at interface: 24.4 °C

**Well data on 12/02/2015, 15:45:**

Well 381:                    pressure 4 ½": 21.39 bar  
                                  pressure 4 ½" x 7": 37.81 bar  
                                  interface level: 452.4 m MD (BCS no. 15: 1,759)  
                                  temperature at interface: 21.4 °C

Well 382:                    pressure 4 ½": 21.26 bar  
                                  pressure 4 ½" x 7": 38.12 bar  
                                  interface level: 452.6 m MD (BCS no. 10: 2,330)  
                                  temperature at interface: 23.4 °C

Well 383:                    pressure 4 ½": 21.47 bar  
                                  pressure 4 ½" x 7": 38.05 bar  
                                  interface level: 452.3 m MD (BCS no. 16: 466)  
                                  temperature at interface: 24.1 °C

**Further programme:**

13/02/2015:                    Fourth MIT measurement,  
    Uninstall KBB pressure sensors and ICM flow meter.

Sgd.



## Daily Report No. 7

### AkzoNobel Cavern Series 381 – MIT

Project-No.: 5305  
 Date: 13/02/2015  
 Editor:  
 Distribution List:

#### Supervisor:

Working time from:	08:00	Daily report no.:	7
Working time to:	15:30	Date:	13/02/2015

from	to	Working operations
08:00	12:00	Sign work permit, operations meeting, check BCS System and KBB pressure / temperature sensors and record data.
12:00	12:15	MIT fourth measurement at all wells.
12:15	12:45	Relieve 8 litre of oil at well 383 to increase interface for Geo-stock-calibration, measurement at all wells.
12:45	15:30	Dismount KBB equipment, secure and leave well site cavern series 381.

#### Well data on 13/02/2015, 08:45:

Well 381: pressure 4 ½": 20.28 bar  
 pressure 4 ½" x 7": 36.67 bar  
 interface level: 452.4 m MD (BCS no. 15: 1,812)  
 temperature at interface: 23.7 °C

Well 382: pressure 4 ½": 20.09 bar  
 pressure 4 ½" x 7": 36.95 bar  
 interface level: 452.6 m MD (BCS no. 10: 1,429)  
 temperature at interface: 23.4 °C

Well 383: pressure 4 ½": 20.31 bar  
 pressure 4 ½" x 7": 36.88 bar  
 interface level: 452.3 m MD (BCS no. 16: 312)  
 temperature at interface: 24.1 °C





<b>Well data on 13/02/2015, 12:00 (fourth measurement):</b>	
Well 381:	pressure 4 ½": 20.05 bar pressure 4 ½" x 7": 36.47 bar interface level: 452.4 m MD (BCS no. 15: 1,803) temperature at interface: 23.7 °C
Well 382:	pressure 4 ½": 19.91 bar pressure 4 ½" x 7": 36.77 bar interface level: 452.6 m MD (BCS no. 10: 1,763) temperature at interface: 23.7 °C
Well 383:	pressure 4 ½": 20.07 bar pressure 4 ½" x 7": 36.70 bar interface level: 452.3 m MD (BCS no. 16: 342) temperature at interface: 24.4 °C
<b>Further programme:</b>	MIT Measurement at Cavern Series 381 completed.

Sgd.



PN 5305: Evaluation MIT Akzo cavern well 381

Well 381: 7" LCCS at 450.6 m MD					
Measurement no.	reference	first	second	third	fourth
Time [dd/mm/yy hh:mm]	09/02/15 12:00	10/02/15 12:00	11/02/15 12:00	12/02/15 12:00	13/02/15 12:00
Initial BCS interface level depth [m MD]*	452.4	452.4	452.4	452.4	452.4
Corrected BCS interface level depth [m MD]**	452.3	452.3	452.3	452.3	452.3
Ambient temperature at well head [°C]	7.0	5.5	5.9	3.9	7.8
Oil temperature at interface [°C]	23.7	23.7	23.7	23.7	23.7
Brine well head pressure at 4 1/2" [bar]	19.6	20.0	20.2	20.0	20.0
Oil well head pressure at 4 1/2" x 7" [bar]	36.0	36.5	36.6	36.5	36.5
Calculated test pressure at 7" LCCS [bar]***	72.9	73.3	73.5	73.3	73.3
Calculated oil volume of interval [l]****	4,636.7	4,636.7	4,636.7	4,636.7	4,636.7
Apparent leak rate of interval [l/d in-situ]*****	-	0.0	0.0	0.0	0.0
<b>Overall accuracy [l/d in-situ]</b>	<b>+/- 3.5</b>				
<b>Average apparent leak rate [l/d in-situ]*****</b>	<b>0.0</b>				

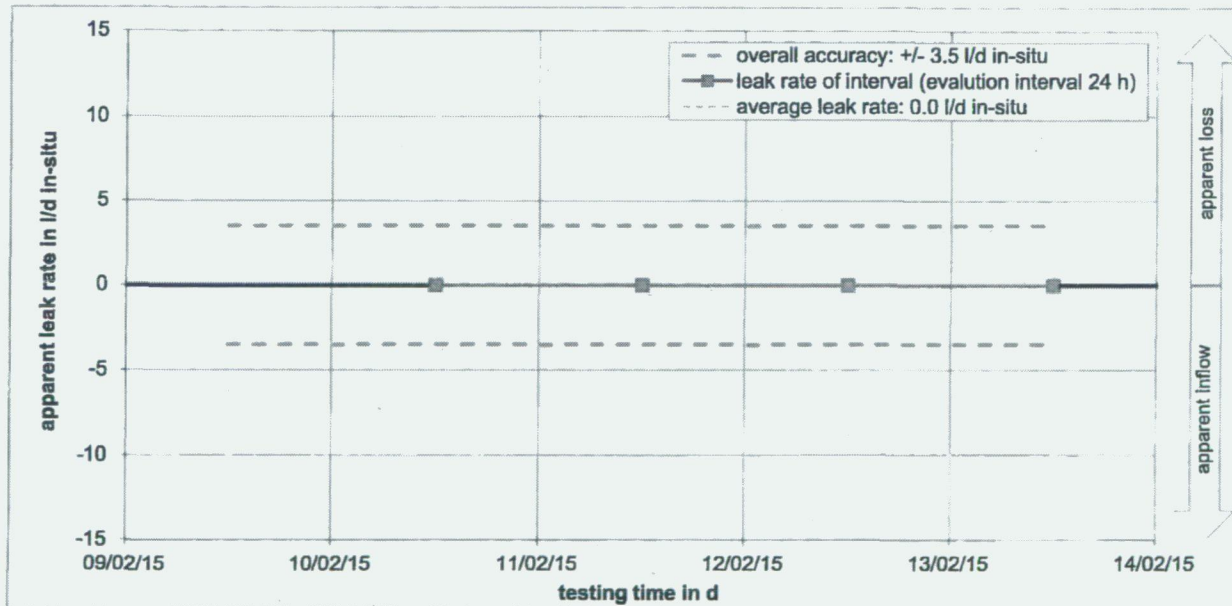
\* See Daily Reports in Enclosure 12

\*\* See Chapter 4.1.2

\*\*\* Calculated specific weight of oil: 834 kg/m<sup>3</sup>

\*\*\*\* According to cas./tub. dimensions and caliper run

\*\*\*\*\* Negative leak rates signify an inflow of oil, whereas positive leak rates indicate a loss of oil.



Enclosure 13: MIT Akzo cavern well 381, Evaluation and apparent leak rates

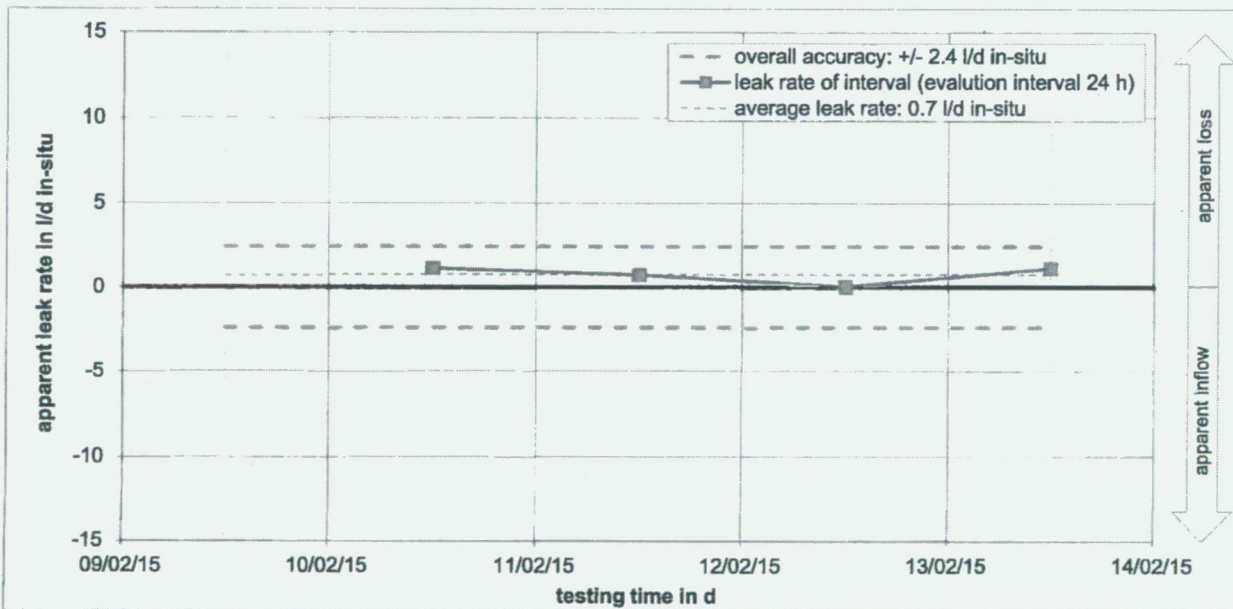


PN 5305: Evaluation MIT Akzo cavern well 382

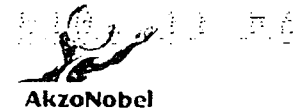
Well 382: 7" LCCS at 452.6 m MD					
Measurement no.	reference	first	second	third	fourth
Time [dd/mm/yy hh:mm]	09/02/15 12:00	10/02/15 12:00	11/02/15 12:00	12/02/15 12:00	13/02/15 12:00
Initial BCS interface level depth [m MD]*	452.9	452.8	452.7	452.7	452.6
Corrected BCS interface level depth [m MD]**	453.0	452.9	452.8	452.8	452.7
Ambient temperature at well head [°C]	7.0	5.5	5.9	3.9	7.8
Oil temperature at interface [°C]	23.7	23.7	23.4	23.7	23.7
Brine well head pressure at 4 1/2" [bar]	19.5	19.9	20.2	20.1	20.1
Oil well head pressure at 4 1/2" x 7" [bar]	36.3	36.8	36.8	36.7	36.7
Calculated test pressure at 7" LCCS [bar]***	72.9	73.3	73.4	73.3	73.3
Calculated oil volume of interval [l]****	4,622.9	4,621.8	4,620.7	4,620.7	4,619.6
Released oil volume of interval [l]	0.0	0.0	0.4	0.0	0.0
Resulting oil volume of interval [l]	4,622.9	4,621.8	4,621.1	4,621.1	4,620.0
Apparent leak rate of interval [l/d in-situ]*****	-	1.1	0.7	0.0	1.1
<b>Overall accuracy [l/d in-situ]</b>	<b>+/- 2.4</b>				
<b>Average apparent leak rate [l/d in-situ]*****</b>	<b>0.7</b>				

\* See Daily Reports in Enclosure 12  
 \*\* See Chapter 4.1.2

\*\*\* Calculated specific weight of oil: 824 kg/m<sup>3</sup>  
 \*\*\*\* According to cas./tub. dimensions, caliper run and cut  
 \*\*\*\*\* Negative leak rates signify an inflow of oil, whereas positive leak rates indicate a loss of oil.



Enclosure 14: MIT Akzo cavern well 382, Evaluation and apparent leak rates



PN 5305: Evaluation MIT Akzo cavern well 383

Well 383: 7" LCCS at 452.15 m MD					
Measurement no.	reference	first	second	third	fourth
Time [dd/mm/yy hh:mm]	09/02/15 12:00	10/02/15 12:00	11/02/15 12:00	12/02/15 12:00	13/02/15 12:00
Initial BCS interface level depth [m MD]*	452.40	452.40	452.40	452.30	452.30
Corrected BCS interface level depth [m MD]**	452.35	452.35	452.35	452.25	452.25
Ambient temperature at well head [°C]	7.0	5.5	5.9	3.9	7.8
Oil temperature at interface [°C]	24.7	24.1	24.1	24.4	24.4
Brine well head pressure at 4 1/2" [bar]	19.6	20.0	20.0	19.9	19.9
Oil well head pressure at 4 1/2" x 7" [bar]	36.3	36.7	36.9	36.8	36.8
Calculated test pressure at 7" LCCS [bar]***	73.0	73.4	73.6	73.5	73.5
Calculated oil volume of interval [l]****	4,627.1	4,627.1	4,627.1	4,623.1	4,623.1
Released oil volume of interval [l]	0.0	0.0	0.0	0.2	0.0
Resulting oil volume of interval [l]	4,627.1	4,627.1	4,627.1	4,623.3	4,623.3
Apparent leak rate of interval [l/d in-situ]*****	-	0.0	0.0	3.8	0.0
<b>Overall accuracy [l/d in-situ]</b>	<b>+/- 3.3</b>				
<b>Average apparent leak rate [l/d in-situ]*****</b>	<b>0.9</b>				

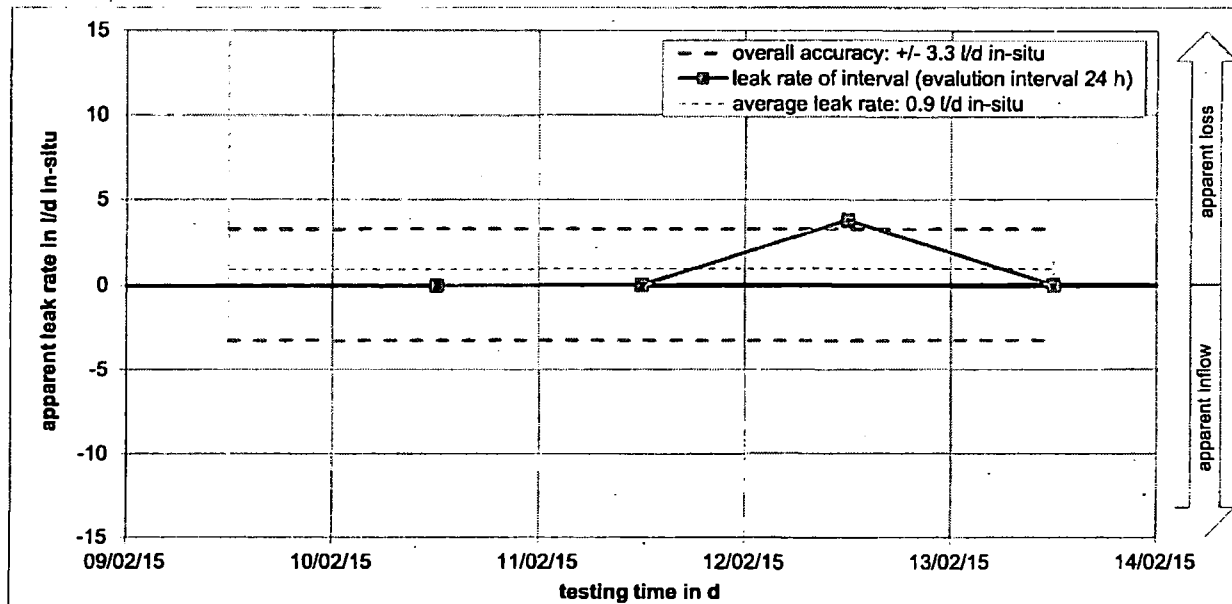
\* See Daily Reports in Enclosure 12

\*\* See Chapter 4.1.2

\*\*\* Calculated specific weight of oil: 828 kg/m<sup>3</sup>

\*\*\*\* According to cas./tub. dimensions, caliper run and cut

\*\*\*\*\* Negative leak rates signify an inflow of oil, whereas positive leak rates indicate a loss of oil.



Enclosure 15: MIT Akzo cavern well 383, Evaluation and apparent leak rates



**Van:**  
**Verzonden:** maandag 23 maart 2015 11:08  
**Aan:** SodM algemeen  
**Onderwerp:**

Ter registratie (afdoening nr. 15041100)

**Van**  
**Verzonden:** maandag 23 maart 2015 10:09  
**Aan:**  
**CC:**  
**Onderwerp:** Re: pilot stabilisatie cavernes Twente

Geachte

Binnenkort spreken wij met Akzo over de status van het project. Daarna zullen wij contact met u opnemen over een mogelijke afspraak.

Met vriendelijke groet,

Verstuurd vanaf mijn iPad

Op 20 mrt. 2015 om 14:58 heeft stichting Huize Aarde

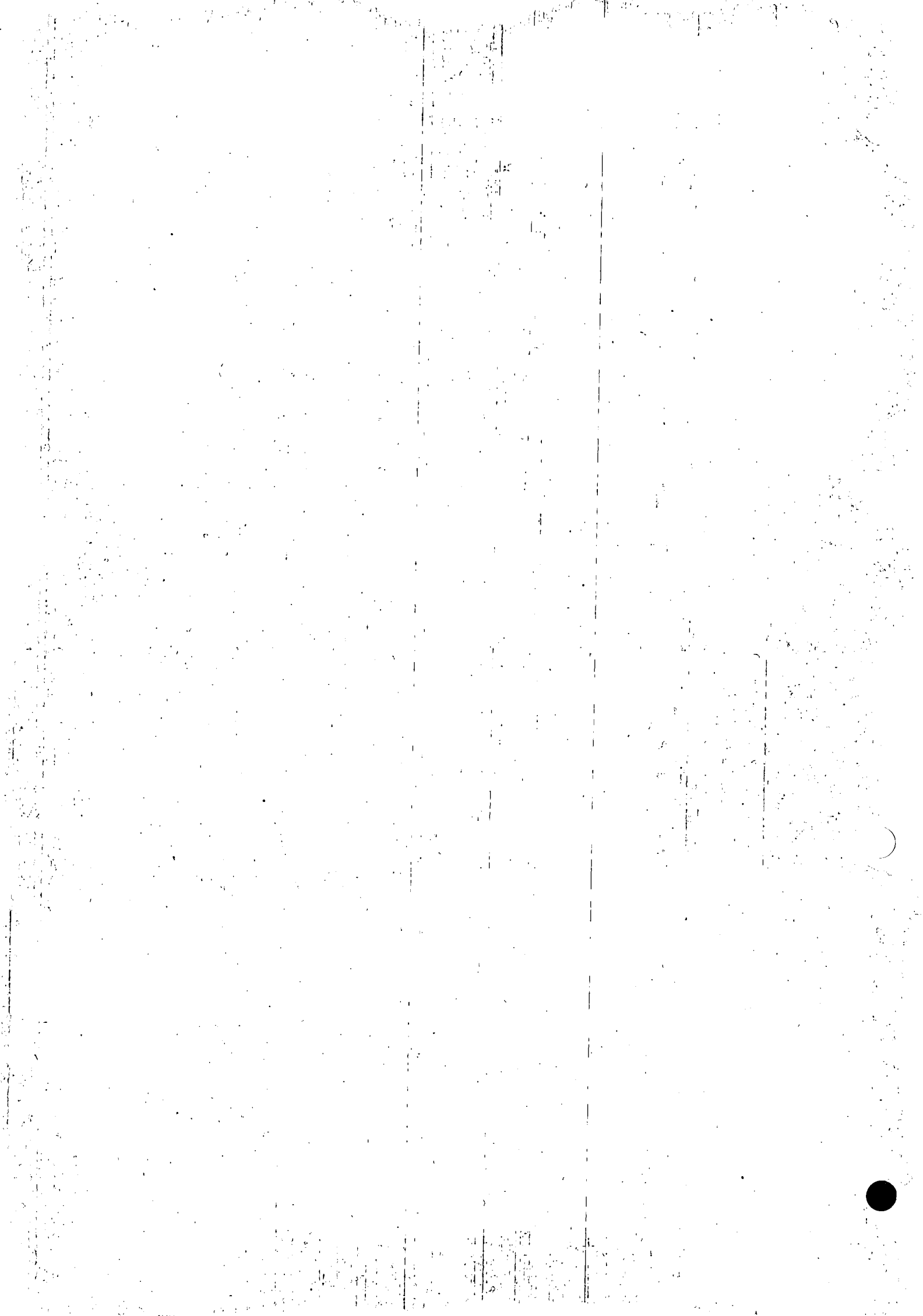
het volgende geschreven:

Geachte

Met hartelijke groet,

conceptontwikkelaar  
Stichting Huize Aarde - re-creatie voor duurzame ontwikkeling

<logoHAtekstkl2.gif>



De transitie naar een duurzame samenleving staat of valt bij integratie van en afstemming tussen verschillende beleidsrichtingen en bij goede samenwerking en communicatie tussen sectoren. Hiertoe werkt SHA samen met instellingen en bedrijven aan de introductie van sectoroverstijgende concepten als groene chemie en groene farmacie. Om nieuwe generaties discipline- en sectoroverstijgend denken en handelen in de praktijk te laten ervaren, betreft SHA studenten en docenten van hogescholen en universiteiten bij haar werkzaamheden.

Begin doorgestuurd bericht:

**Van:** stichting Huize Aarde <

**Onderwerp:** pilot stabilisatie cavernes Twente

**Datum:** 27 februari 2015 11:27:11 CET

**Aan:** [@mineleni.nl](mailto:@mineleni.nl)

Beste

Hopelijk tot spoedig,

Met hartelijke groot,

conceptontwikkelaar

<logoHAtekstk2.gif>

De transitie naar een duurzame samenleving staat of valt bij integratie van en afstemming tussen verschillende beleidsrichtingen en bij goede samenwerking en communicatie tussen sectoren. Hiertoe werkt SHA samen met instellingen en bedrijven aan de introductie van sectoroverstijgende concepten als groene chemie en groene farmacie. Om nieuwe generaties discipline- en sectoroverstijgend denken en handelen in de praktijk te laten ervaren, betreft SHA studenten en docenten van hogescholen en universiteiten bij haar werkzaamheden.

**Van:** @akzonobel.com>  
**Verzonden:** maandag 30 maart 2015 15:15  
**Aan:**  
**CC:**  
**Onderwerp:** RE: MIT's gasolieopslag putten  
**Bijlagen:** 150116 MIT at AkzoNobel Cavern Series 472 rev01.pdf; AKZ-F-J-0001-B - Peer review of the Hengelo 472 MIT.pdf  
**Opvolgingsmarkering:** Flag for follow up  
**Markeringsstatus:** Voltooid

Beste

Bijgevoegd ontvangen jullie de definitieve rapporten over de MIT van caverne 472, uitgevoerd in november/december 2014, bestaande uit:

- de rapportage van KBB (documentnaam: 150116 MIT at AkzoNobel Cavern Series 472 rev01.pdf)
- de Peer review door Geostock (documentnaam: AKZ-F-J-0001-B - Peer review of the Hengelo 472 MIT.pdf)

Ik hoop jullie hiermee voldoende geïnformeerd te hebben.

Met vriendelijke groet,

-----Original Appointment-----

**From:**

**Sent:** maandag 16 maart 2015 11:59

**To:**

**Subject:** MIT's gasolieopslag putten

**When:** maandag 13 april 2015 13:00-15:00 (UTC+01:00) Amsterdam, Berlin, Bern, Rome, Stockholm, Vienna.

**Where:** MT zaal (SODM)

Dit bericht kan informatie bevatten die niet voor u is bestemd. Indien u niet de geadresseerde bent of dit bericht abusievelijk aan u is gezonden, wordt u verzocht dat aan de afzender te melden en het bericht te verwijderen.

De Staat aanvaardt geen aansprakelijkheid voor schade, van welke aard



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# MIT cavernes 472 en 381 t.b.v. gasolieopslag

Werkwijze, resultaten en conclusies

**AkzoNobel**

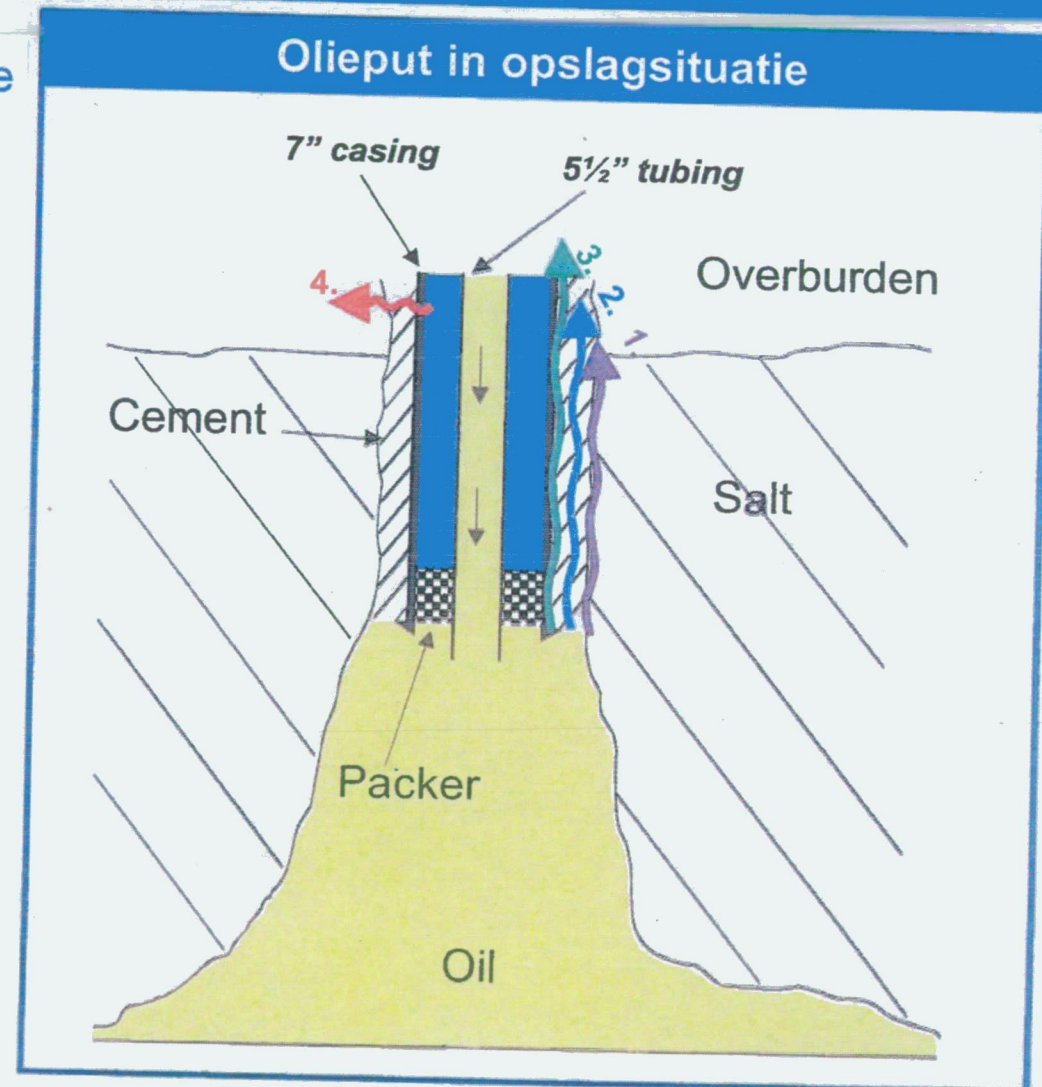


# Inhoud presentatie

1. Doel van de MIT
2. Bepaling testdruk
3. Werkwijze MIT Twente
4. Leak criteria
5. Korte recap van de resultaten en conclusies van de tweede MIT caverne 472
6. Resultaten millen/cutten & en resultaten en conclusies MIT caverne 381
7. Resultaten 381 & 472 in internationaal perspectief
8. Hoe nu verder? (oordeel & communicatie)

# 1. Doel MIT: uitsluiten van lekpaden

- Hoofddoel: uitsluiten van lekkage langs de overgang caverne-cement-7"-casing. Dit is de enige plek waar géén sprake is van zout of van een dubbele barrière tussen de olie en het omliggende gesteente
- Met voeistof-MIT (Liquid-leak-test (LLT); hydraulic MIT) worden vier lekpaden getest:
  1. Lekpad tussen zout en cement
  2. Lekpad door het cement
  3. Lekpad tussen cement en de 7" casing
  4. Lekpad door de 7" casing



## 2. Bepaling testdruk

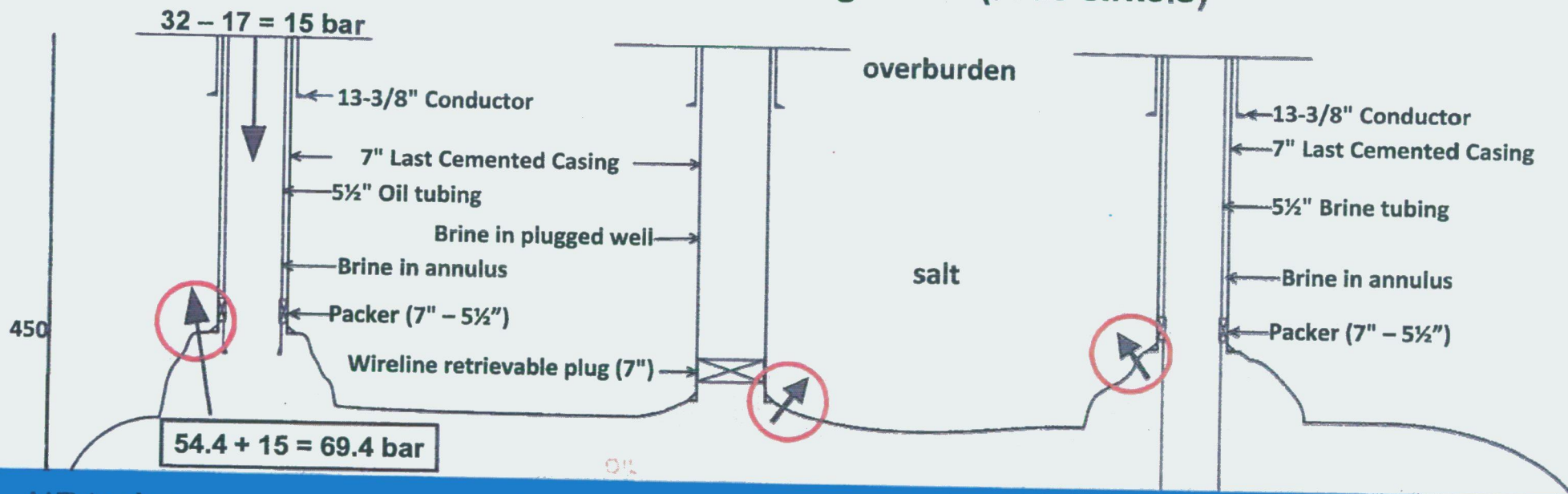
# Bepaling maximale werkdruk @ LCCS

Maximale werkdruk @LCCS treedt op tijdens oliepompen:

$$P_{\text{pump\_eff}} = P_{\text{pump}} - (h_{\text{oil-brine contact}} * (0,12 - 0,083)) = 32 - 17 = 15 \text{ bar}$$

$$P_{\text{max\_LCCS}} = P_{\text{pump\_eff}} + P_{\text{halmo}} = 15 + 54.4 = 69.4 \text{ bar } (\approx \text{IfG pressure gradient of } 0.15 \text{ bar/m})$$

→ Olie wordt dan met 69,4 bar het cement ingedrukt (rode cirkels)



NB1: de pomp gaat waarschijnlijk werken met max. 26 bar i.p.v. 32 bar

NB2: hoogste druk op schoen treedt alleen op pekelafoer plots dicht gaat

NB3: tijdens vullen met 26 bar is, door de dynamische drukval, de druk nog ca. 3 bar lager

NB4: tijdens opslagfase is de druk op de schoen 54 bar (dus gelijk aan  $P_{\text{halmo}}$ )

# MIT testdruk

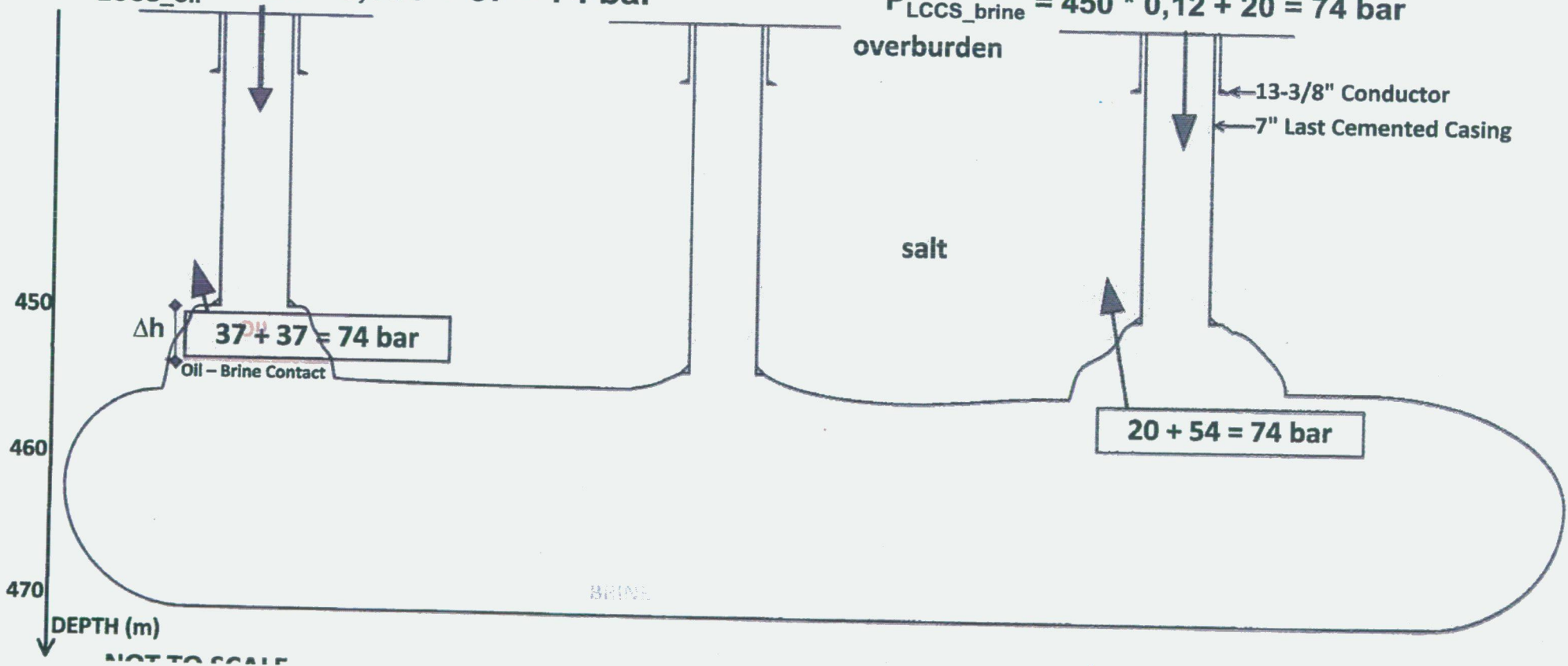
MIT-testdruk @LCCS = max. werkdruk + 5 bar = 69,4 bar + 5 bar = 74,4 bar  
 (of volgens IfG: MIT-testgradient = 0,161 bar/m)

Hoe bereiken we dat tijdens de MIT?

$$P_{LCCS\_oil} = 450 * 0,083 + 37 = 74 \text{ bar}$$

$$P_{LCCS\_brine} = 450 * 0,12 + 20 = 74 \text{ bar}$$

overburden

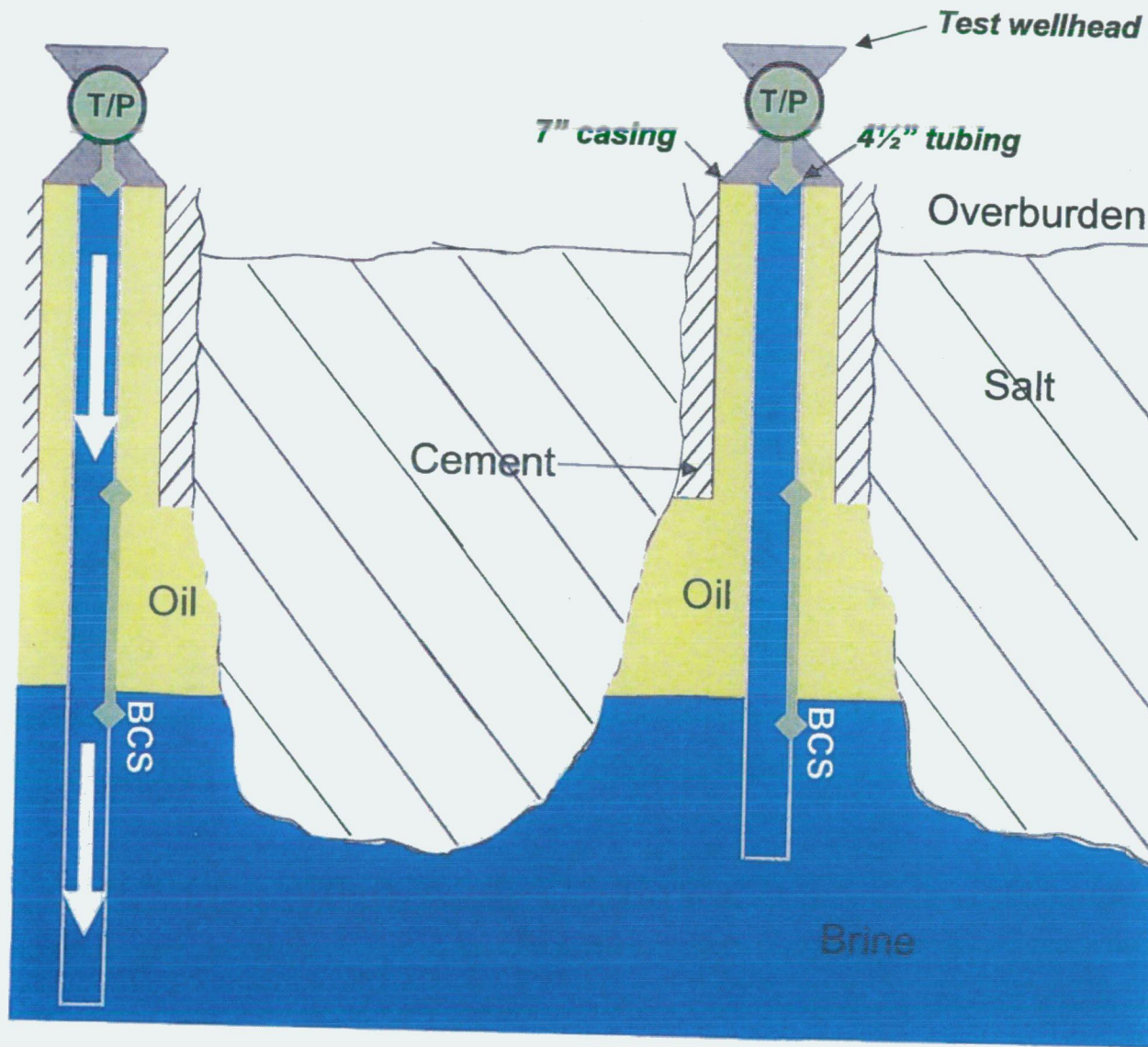


### **3. Werkwijze MIT Twente**



# MIT procedure @ Twente cavernes

AkzoNobel



1. Toevoer exact volume olie (ca. 4 m<sup>3</sup> per put)
2. Olie rustig aflaten → check nekvolume per 10 cm
3. Toevoer exacte hoeveelheid olie
4. Opdrukken caverne met pekels tot >21 bar
5. 'Damping period' van ca. 5-7 dagen (caverne op ca. 20 bar; indien nodig pekels toevoeren)
6. 0-meting (T, P, BCS; referentiemeting)
7. 24 uur wachten (voer pekels toe als druk nabij 20 bar komt; op vast moment op de dag)
8. 1<sup>e</sup> meting
9. 24 uur wachten (voer pekels toe als druk nabij 20 bar komt; op vast moment op de dag)
10. 2<sup>e</sup> meting
11. 24 uur wachten (voer pekels toe als druk nabij 20 bar komt; op vast moment op de dag)
12. 3<sup>e</sup> meting
13. 24 uur wachten (voer pekels toe als druk nabij 20 bar komt; op vast moment op de dag)
14. 4<sup>e</sup> meting
15. Laat olie af tot bovenzijde BCS en checkvolume

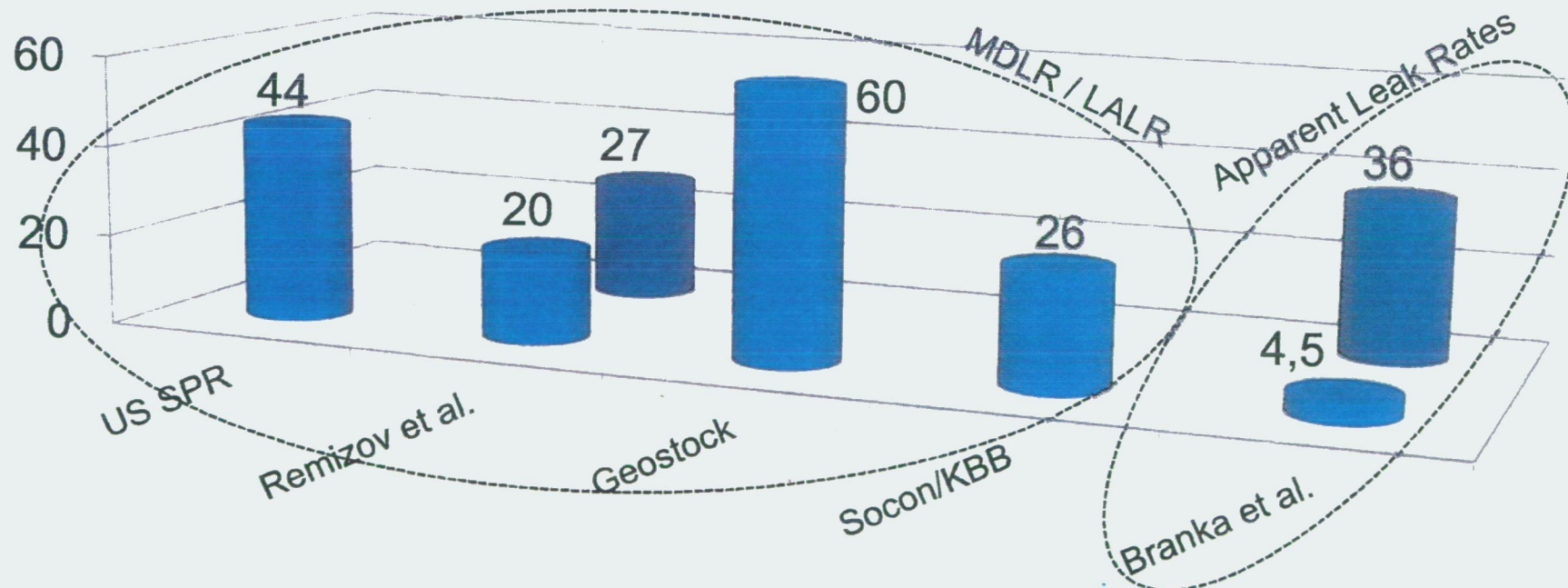
## 4. Leak criteria

## Leak criteria

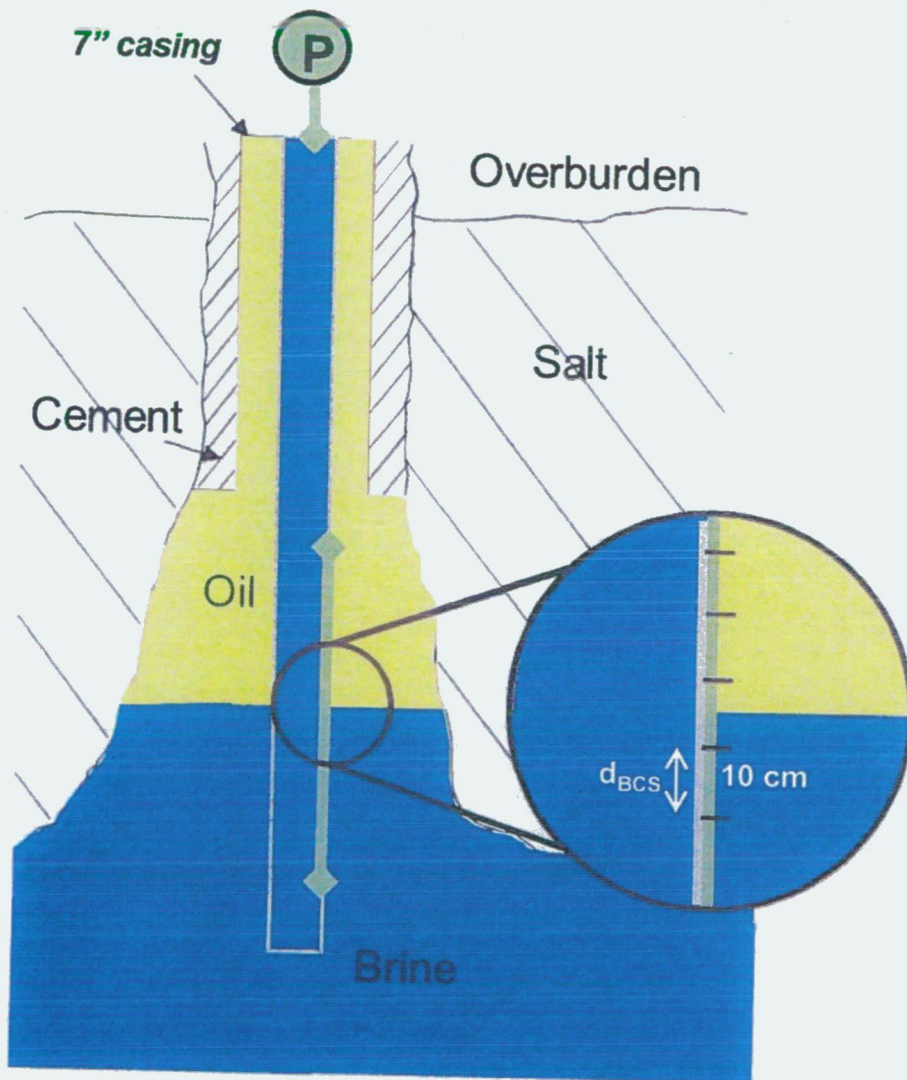
- **Definities:**
  - apparent leak (AL) & apparent leak rate (ALR)
  - minimum detectable leak rate (MDLR)
  - lowest admissible leak rate (LALR)
- **MDLR rate wordt bepaald door:**
  - de nauwkeurigheid van de niveaumeting
    - afhankelijk van de afstand tussen de meetpunten op de BCS
    - de diameter van de cavernenek
  - verstorende factoren, zoals temperatuur, druk, pekeltoevoer, etc.
- **De caverne nek is technically tight als de apparent leak rate kleiner is dan de minimum detectable leak rate én de apparent leak rate kleiner is dan de lowest admissible leak rate**
  - $[ALR] < [MDLR] < [LALR]$

# Internationaal gehanteerde criteria

Wie	Wat	Criterium
U.S. Strategic Petroleum Reserve	LALR	44 ltrs/day
Remizov et al. [2000]	LALR	20 – 27 ltrs/day
Socon / KBB (SMRI, 2013)	MDLR / LALR	26 ltrs/day
Geostock @ Géosel France (2013)	MDLR / LALR	60 ltrs/day
Branka et al. [2002]	Apparent leak rates	4.5 – 36 ltrs/day



# MDLR wordt o.a. bepaald door de nauwkeurigheid van de niveaumeting



## BCS-nauwkeurigheid:

- $d_{BCS} = 10 \text{ cm}$
- startpunt tussen 2 BCS-knoppen is niet bekend
- BCS-nauwkeurigheid =  $1,5 * d_{BCS} = 15 \text{ cm}$

## Nekvolume per BCS-stap:

- nauwkeurigheid hangt af van de nek diameter
- nek diameter bepaald middels caliper log of neksonar → onnauwkeurigheid  $\pm 10\%$  /  $\pm 25\%$
- $V_{10\text{cm}}$  wordt gecheckt vóór start MIT door olie toevoer en aflaten → onnauwkeurigheid  $\pm 25\%$

## Conclusie m.b.t. nauwkeurigheid niveaumeting:

$$\approx 1,9 * V_{10\text{cm}}$$

NB1: versturende factoren (zie volgende slide)

NB2: door langere MIT-periode is nauwkeurigheid te verbeteren

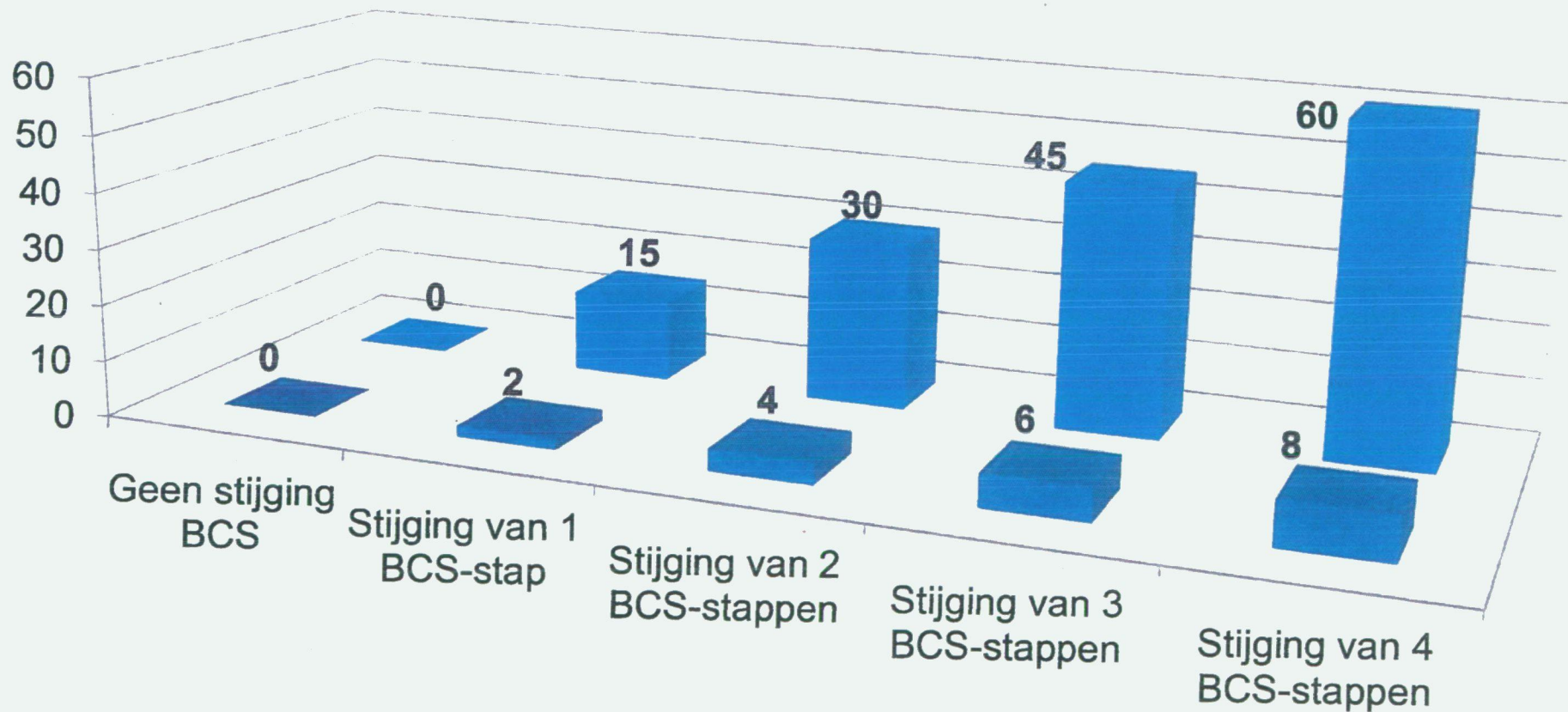
## Belangrijkste versturende factoren

- **temperatuur**
  - beïnvloedt het olievolume in de buis (4 m<sup>3</sup> olie krimpt ruim 3 liter bij 1°C temperatuurdaling)
  - beperkt vanwege relatief gering verschil tussen  $T_{\text{maaiveld}}$  (0°C) en  $T_{\text{caverne}}$  ( $\approx 21^\circ\text{C}$ )
  - m.n. van belang als nekvolume klein is (382)
  - geminimaliseerd door 5 dagen damping period
  
- **compressibiliteit van de olie**
  - beïnvloedt het olievolume in de buis (4 m<sup>3</sup> olie krimpt 0,3 liter bij 1 bar drukstijging)
  - beperkt door drukschommelingen te minimaliseren ( $P_{\text{olie}} \approx 37$  bar)
  - m.n. van belang als nekvolume klein is (382)
  
- **compressibiliteit van caverne en pek**
  - beperkt door drukschommelingen te minimaliseren ( $P_{\text{olie}} \approx 37$  bar)
  
- **overige factoren (gering effect): getijden, pekelpermeatie bij druktoename, ...**

# Volumeverandering (apparent leak; liter) t.o.v. niveauverandering op BCS voor 2 nekdiameters (2 en 15 liter)

AkzoNobel

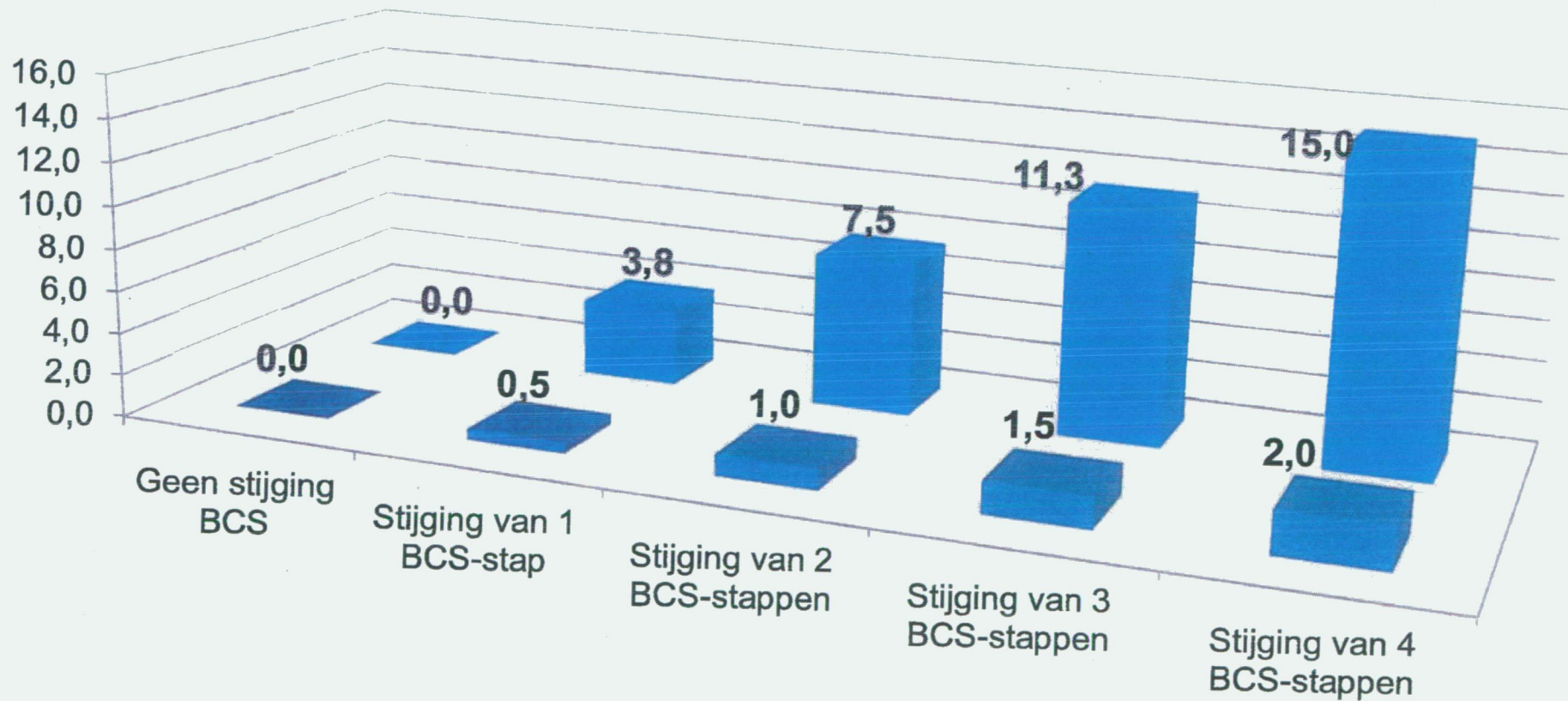
- Apparent leak (Vneck = 2 liter)
- Apparent leak (Vneck = 15 liter)



# Apparent leak rate (liter/dag) t.o.v. waargenomen niveauverandering op BCS voor nekdiameters 2 en 15 liter

AkzoNobel

- Apparent leak rate ( $V_{\text{neck}} = 2$  liter)
- Apparent leak rate ( $V_{\text{neck}} = 15$  liter)



Minimum Detectable Leak Rate ( $V_{\text{neck}} = 2$  L) = 1 l/d (excl. verstorende factoren)

Minimum Detectable Leak Rate ( $V_{\text{neck}} = 15$  L) = 7 l/d (excl. verstorende factoren)



## Conclusies m.b.t. nauwkeurigheid

- **Nauwkeurigheid van olieniveaumeting hangt grotendeels af van nekdiаметer/-volume**
- **Nekvolume per 10 cm ligt tussen de 1 en 17 liter**
- **Temperatuur, druk, compressibiliteit en andere factoren verminderen de nauwkeurigheid → mogelijk met één tot enkele liters/dag**
- **Meetperiode = 4 dagen → voldoende lang t.b.v. hoge nauwkeurigheid (lage MDLR)**
- **Minimum Detactable Leak Rate ligt, afhankelijk van de nekdiаметer, tussen de 2 en 5,1 liter per dag (zie verderop)**
- **Conclusie: Minimum Detactable Leak Rate is voldoende laag voor een betrouwbare uitspraak over de technische dichtheid van de boorgaten**

## 5. Korte recap van de resultaten en conclusies van de tweede MIT in caverne 472

AkzoNobel

- Resultaten nekvolumebepaling
  - m.b.v. caliper (472/474) en neksonar (473)
  - controle tijdens olie vullen
- Resultaten MIT: drukverloop i.r.t. ingepompt pekelvolume
- Resultaten MIT: drukverloop i.r.t. BCS-standen
- Resultaten en conclusies testomstandigheden
- Conclusies KBB en Geostock (Peer Review)

# Resultaten nekvolumebepaling (caliper/sonar) en check daarvan (olie)

- **Boorgat 472:**

- verwacht o.b.v. caliper-meting:  $V_{dm} = 6,3 \pm 0,4$  liter
  - controle tijdens vullen BCS-traject:  $V_{dm} = \text{ca. } 6,3$  liter
- Nek is recht en volume is zoals verwacht

- **Boorgat 473:**

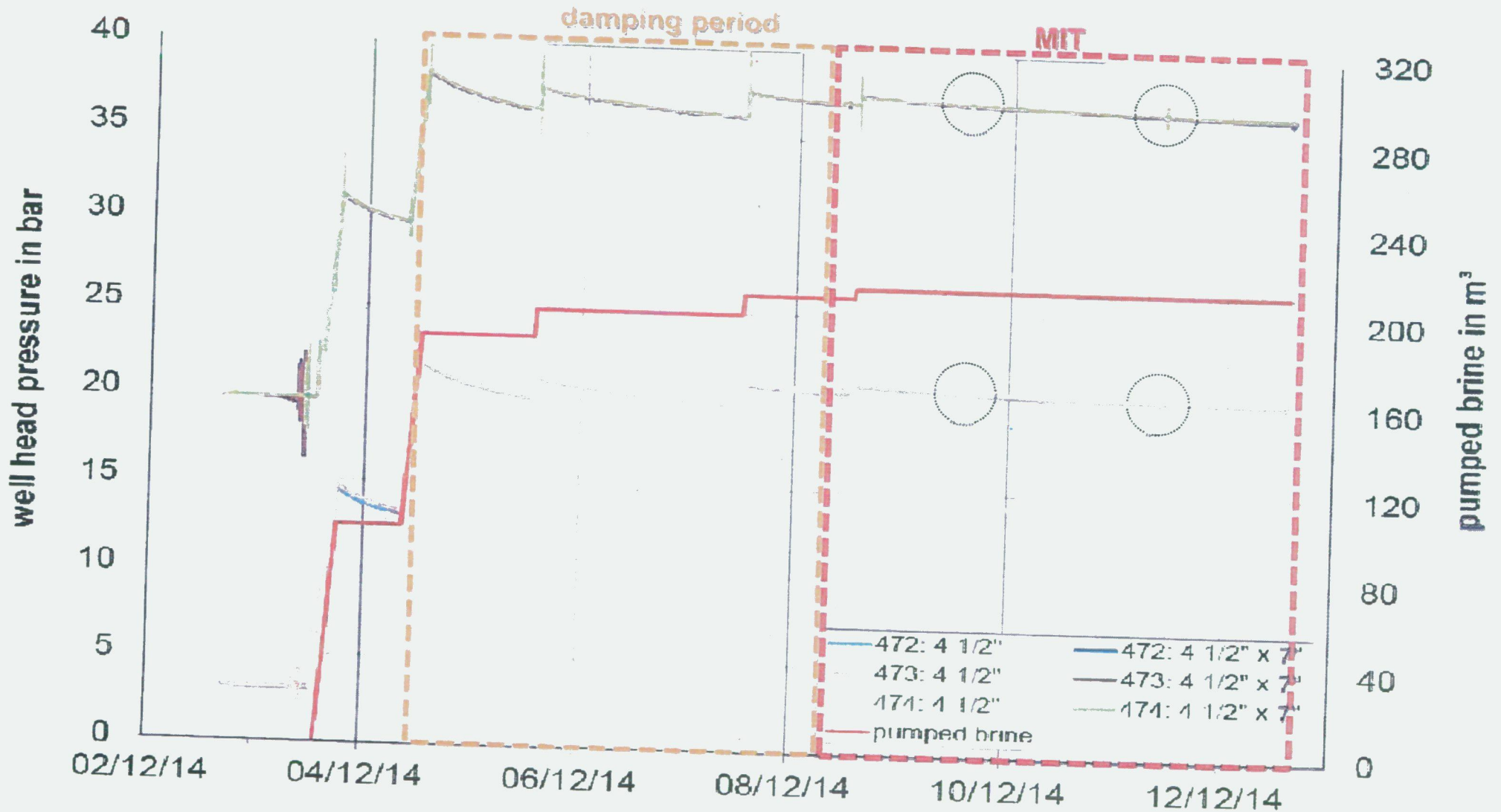
- verwacht o.b.v. neksonar-meting:  $V_{dm} = 12 \pm 3$  liter
  - controle tijdens vullen BCS-traject:  $V_{dm} = 14 \pm 4$  liter
- Nekdiameter varieert wat en lijkt ruimer dan verwacht

- **Boorgat 474:**

- verwacht o.b.v. caliper-meting:  $V_{dm} = V_{dm} = 14 \pm 3$  liter
  - controle tijdens vullen BCS-traject :  $V_{dm} = 15 \pm 4$  liter
- Nekdiameter varieert wat en lijkt klein beetje ruimer dan verwacht

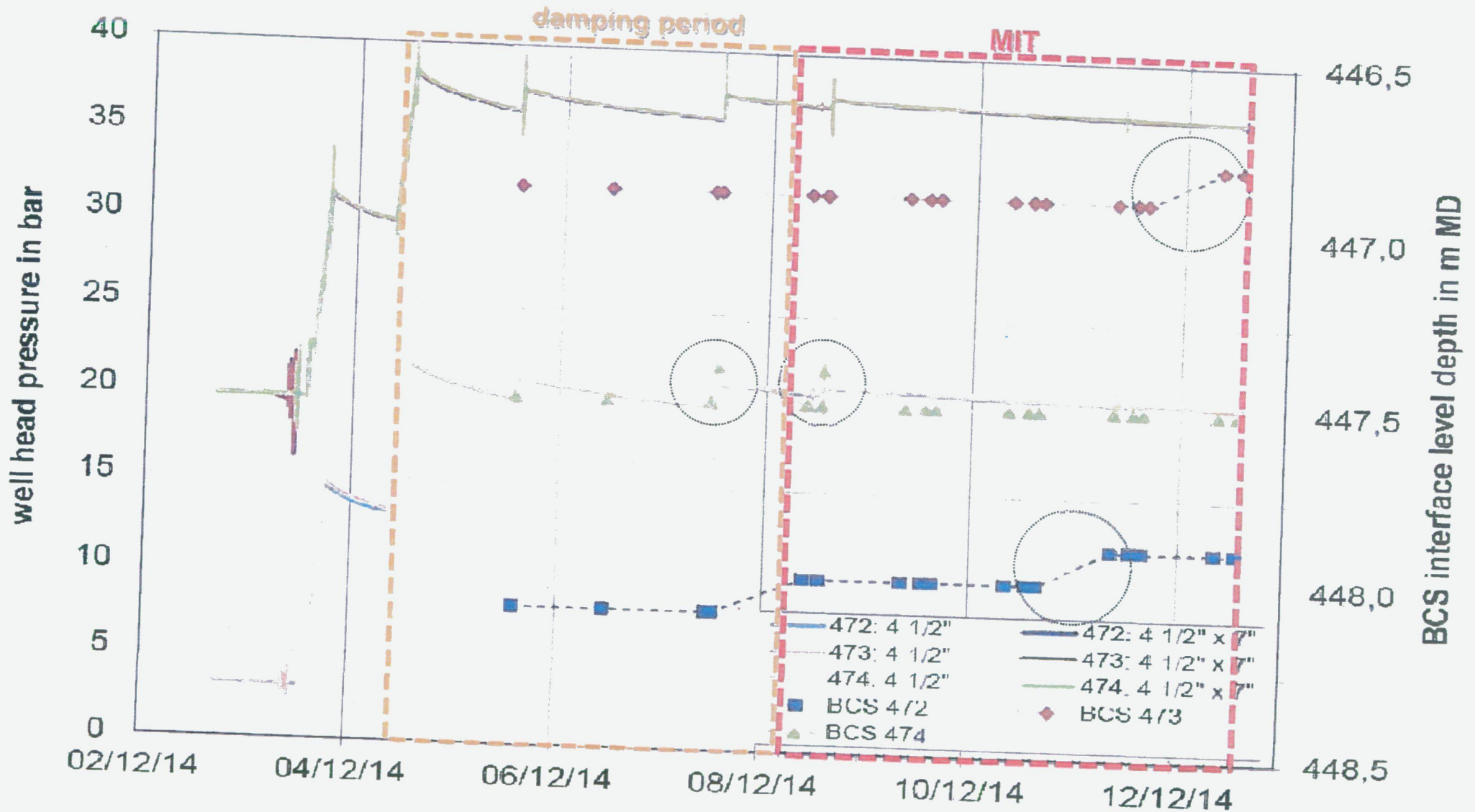
# Resultaten MIT: drukverloop i.r.t. ingepompt pekervolume

AkzoNobel



# Resultaten MIT: drukverloop i.r.t. BCS-standen

AkzoNobel



## Conclusies testomstandigheden

### Testdruk

- Tijdens MIT is de druk permanent (ruim) boven de minimale testdruk geweest
- Minimale testdruk is 5 bar boven maximale werkdruk
- Tijdens MIT is slechts één keer de druk verhoogd middels pekeltoevoer

### Testduur

- MIT-test heeft 4 dagen geduurd

### Testnauwkeurigheid

- Het BCS-systeem heeft tijdens hele test goed gefunctioneerd en is vijfvoudig gecheckt op de werking ervan (o.a. met diff. drukmeting Geostock)
- De nauwkeurigheid van het BCS-systeem is ruim voldoende:
  - Minimum Detectable Leak Rate (MDLR) = 2 – 5,1 liter/dag
  - 3,2 – 4,7 liter/dag



## Conclusies MIT boorgat 472

### Apparent leak

- In 472 is een verandering van één BCS-stap waargenomen
- $V_{dm\_472} = 6,4$  liter



### Apparent leak rate (l/d) volgens Geometrical Volume Balancing methode

- ALR = 1,6 l/d
  - Accuracy (MDLR) = 2,0 l/d
- ALR < MDLR → boorgat 472 is *technically hydraulic tight*



### Apparent leak rate (l/d) volgens Mass Balancing methode

- ALR = 1,53 l/d
  - MDLR = 3,2 l/d
- ALR < MDLR → boorgat 472 is *technically tight*



### Check BCS met Liquid-Liquid Interface methode (differentiële druk)

- $\Delta t = 24$  uur →  $dP = 16.573 \pm 1$  mbar → olieniveau =  $447,92 \pm 0,02$  m



## Conclusies MIT boorgat 473

### Apparent leak

- In 473 is een verandering van één BCS-stap waargenomen
- $V_{dm\_473} = 9,9$  liter



### Apparent leak rate (l/d) volgens Geometrical Volume Balancing methode

- ALR = 2,5 l/d
- Accuracy (MDLR) = 3,0 l/d
- ALR < MDLR → boorgat 473 is *technically hydraulic tight*



### Apparent leak rate (l/d) volgens Mass Balancing methode

- ALR = 2,27 l/d
- MDLR = 4,7 l/d
- ALR < MDLR → boorgat 473 is *technically tight*



### Check BCS met Liquid-Liquid Interface methode (differentiële druk)

- $\Delta t = 21$  uur →  $dP = 16.597 \pm 1$  mbar → olieniveau =  $446,92 \pm 0,02$  m





## Conclusies MIT boorgat 474

### Apparent leak

- In 474 is géén verandering van de BCS waargenomen
- $V_{dm\_474} = 16,6$  liter



### Apparent leak rate (l/d) volgens Geometrical Volume Balancing methode

- ALR = 0 l/d
- Accuracy (MDLR) = 5,1 l/d
- ALR < MDLR → boorgat 474 is *technically hydraulic tight*



### Apparent leak rate (l/d) volgens Mass Balancing methode

- ALR = - 0,05 l/d
- MDLR = 4,6 l/d
- ALR < MDLR → boorgat 474 is *technically tight*



### Check BCS met Liquid-Liquid Interface methode (differentiële druk)

- $\Delta t = 40$  uur →  $dP = 16.518 \pm 1$  mbar → olieniveau =  $447,50 + 0,03$  m



## 6. Resultaten en conclusies van de MIT in caverne 381

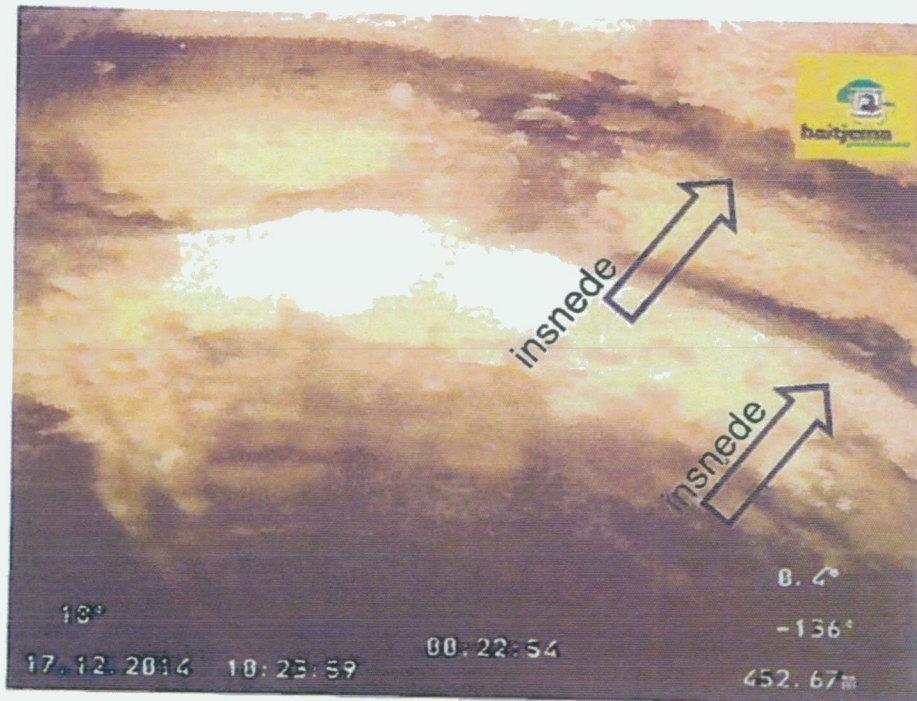
AkzoNobel

- Resultaten van het millen / cutten
- Resultaten nekvolumebepaling
  - m.b.v. caliper en neksonar
  - controle tijdens olie vullen
- Resultaten MIT: drukverloop i.r.t. ingepompt pekervolume
- Resultaten MIT: drukverloop i.r.t. BCS-standen
- Resultaten en conclusies testomstandigheden
- Conclusies KBB en Geostock (Peer Review)

# Resultaten millen/cutten 382 & 383

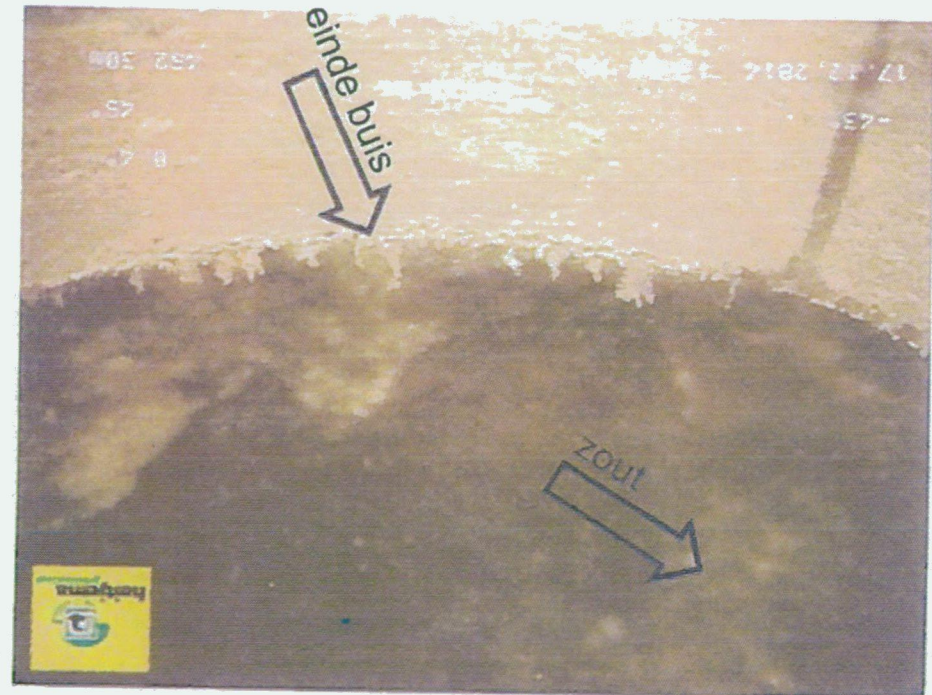
## 382

- caliper: gecementeerde nek tot aan dak
- nek ingesneden: 452.6 – 452.7 m-mv
- resultaat: 2 cuts van <2 cm breed
- bevestigd met video run



## 383

- caliper: gecementeerde nek tot aan dak
- buis ingesneden: 452.15 – 452.25 m-mv
- buis + deel cement weggevallen
- bevestigd met video run



# Resultaten nekvolumebepaling (caliper/sonar) en check daarvan (olie)

- **Boorgat 381:**

- verwacht o.b.v. caliper-meting:  $V_{dm} = 2 \rightarrow 24$  liter
- controle tijdens vullen BCS-traject:  $V_{dm} = \text{ca. } 2 \rightarrow \text{ca. } 20$  liter
- Nek verwijdt en volume is zoals verwacht → olieniveau kiezen waar  $V_{dm} = 4 - 8$  liter

- **Boorgat 382:**

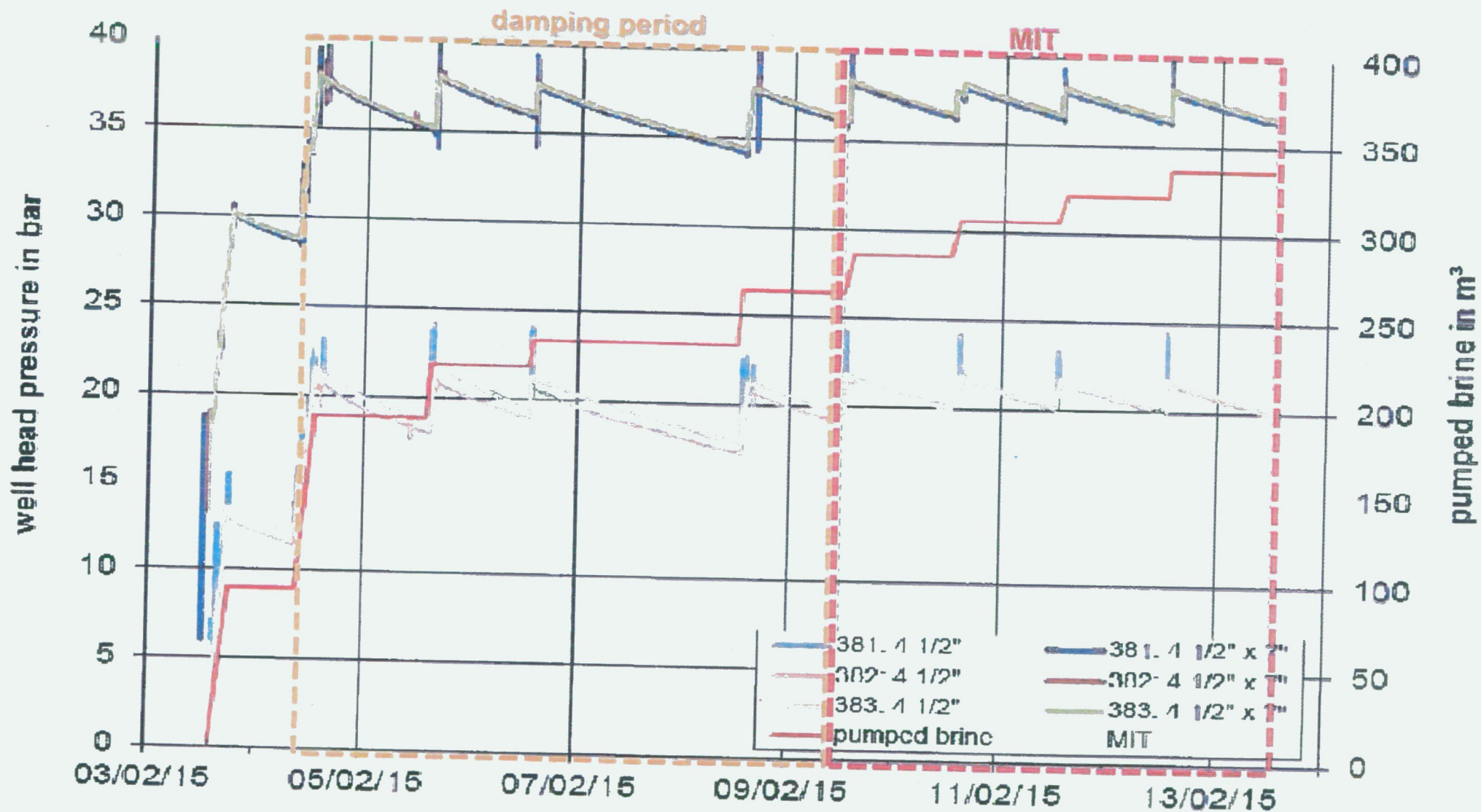
- verwacht o.b.v. neksonar-meting + insnijding:  $V_{dm} = \text{ca. } 1,1$  liter (+ 1,5 liter in insnede)
- controle tijdens vullen BCS-traject:  $V_{dm} = \text{ca. } 1 - 1,5$  liter
- → Nekdiameter zoals verwacht → kies olieniveau tussen dak en insnede

- **Boorgat 383:**

- verwacht o.b.v. caliper-meting + insnijding:  $V_{dm} = \text{ca. } 2 - 6,5$  liter (hoogste in insnede)
- controle tijdens vullen BCS-traject:  $V_{dm} = \text{ca. } 3 - 6$  liter
- → Nekdiameter zoals verwacht → kies olieniveau  $\pm 0,1 - 0,3$  m onder einde 7"-buis

# Resultaten MIT: drukverloop i.r.t. ingepompt pekervolume

AkzoNobel



# Resultaten MIT: drukverloop i.r.t. BCS-standen

AkzoNobel

