LucoeX WP4, Multi Purpose Test Project Progress Meeting 05, May 13th , 2014

Magnus Kronberg

Contents

- Recap of test MPT/WP4 setup and objectives
- Component assembly
- Final drift preparations
- MPT installation
- Initial test data
  - Buffer block manufacturing
  - Test data
- WP4 plans
  - Deliverables and schedule

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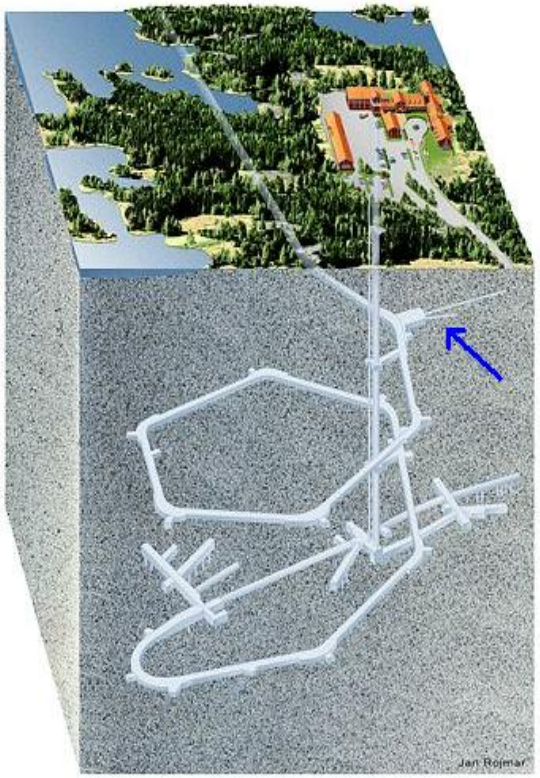
LucoeX WP 4, Multi Purpose Test (MPT)

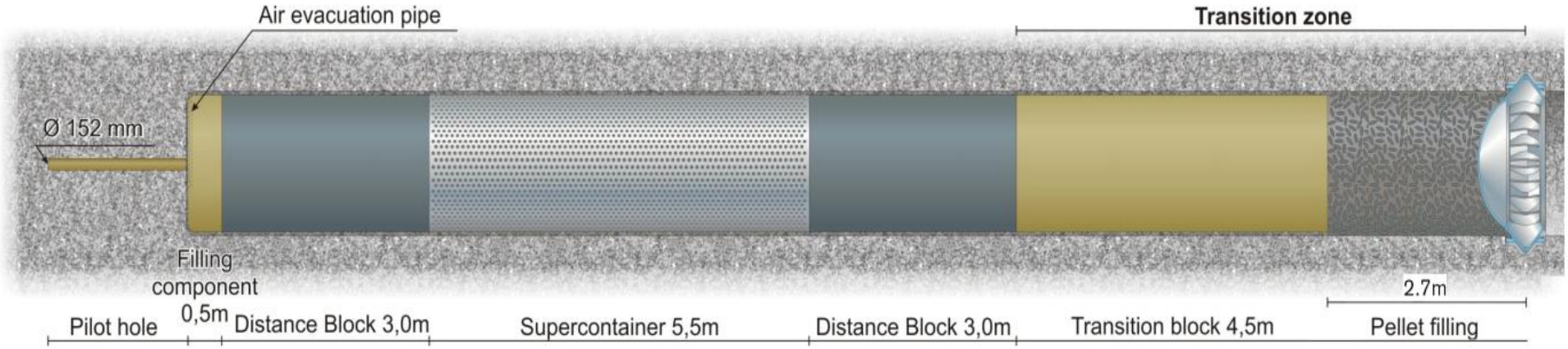
- Äspö HRL, KBS-3H test site at the -220 m level
  - Deposition drift DA1619A02, 95 m long
  - Deposition equipment is located at the site



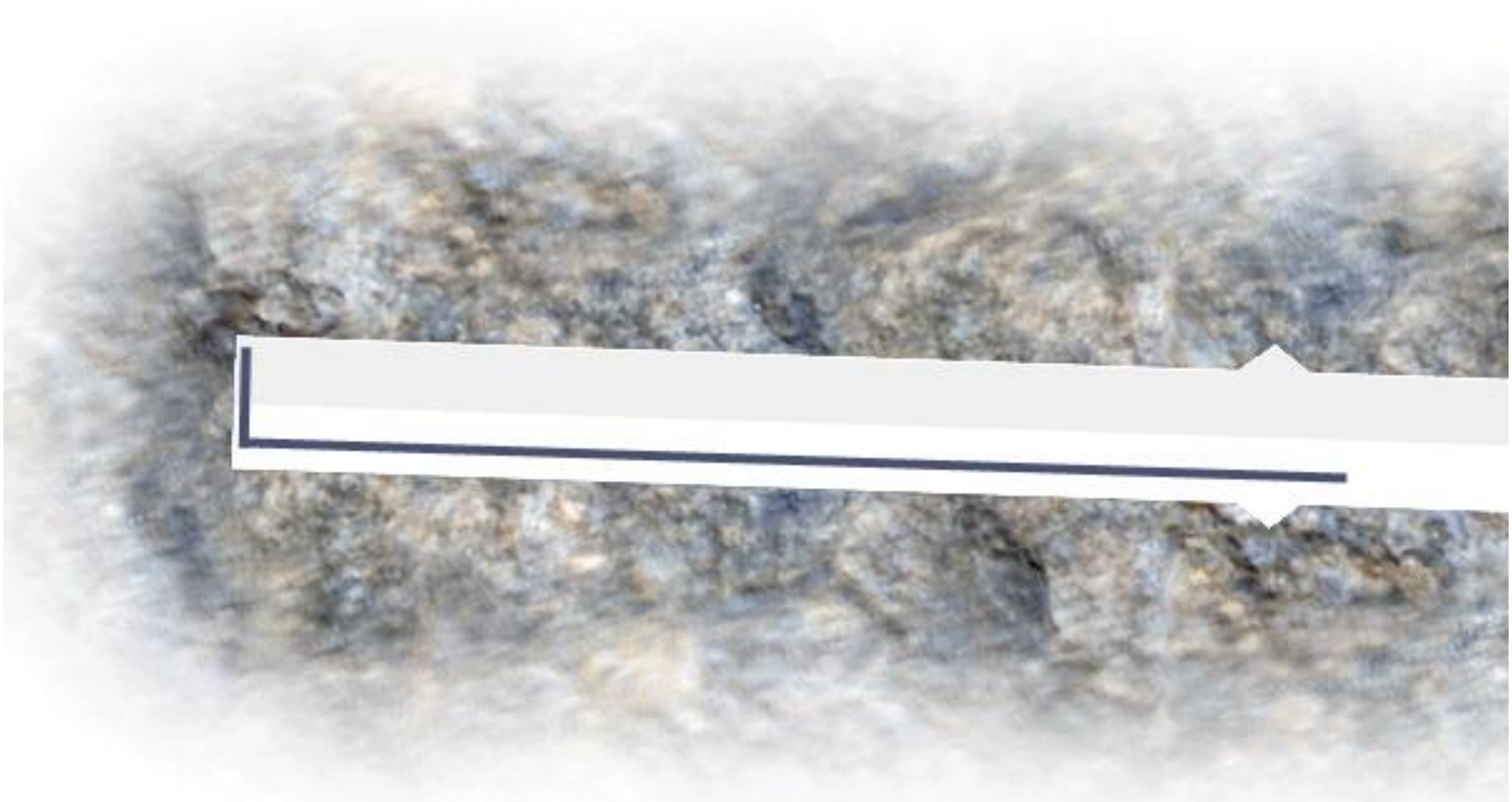
LucoeX WP 4, MPT

Objectives:

- Test the system components in full scale and in combination with each other to obtain an initial verification of design implementation and component function
- This includes the ability to manufacture full scale components, carry out installation (according to DAWE) and monitor the initial system state of the MPT and its subsequent evolution



LucoeX WP 4, MPT Installation and water filling



Schematic illustration of the MPT (only the main components included, animation is not made to scale)

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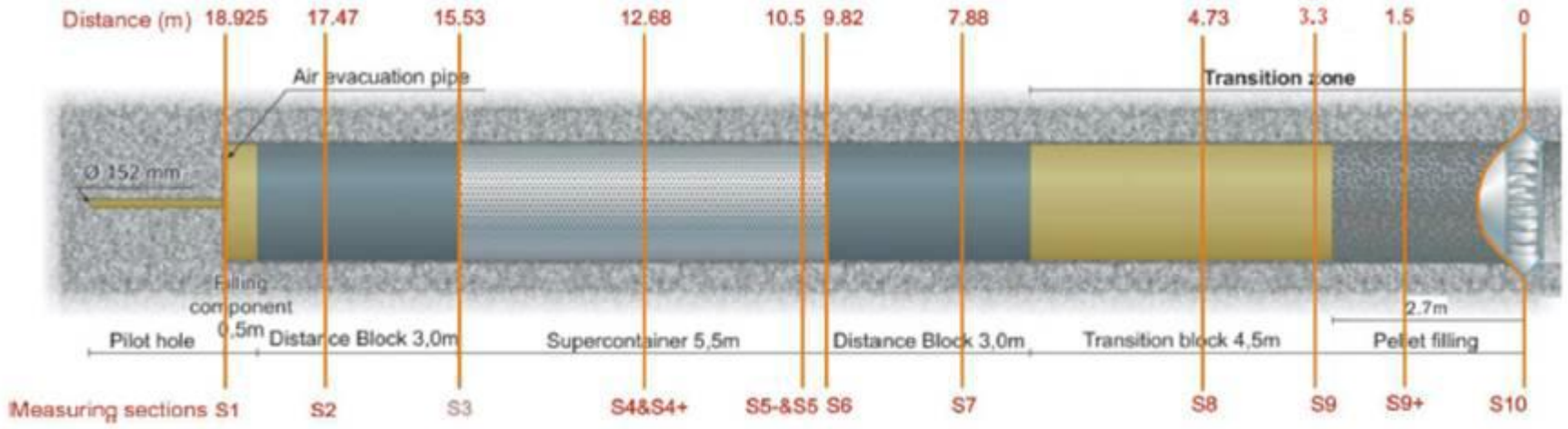
Component assembly, sensor setup



	SECTIONS												
Sensors	S1	S2	S3	S4	S5	S6	S7	S8	S9	S9+	S10	OUT	TOT
TP rock/plug	5	4		2			4	4	2	6			27
TP plug											1		1
TP buffer				4	4	4			1		2		15
PP rock short	1	4					4						9
PP rock borehole									18				18
PP buffer		1+3		4	2+3		1+3				4+3		24
WC		3+3		4	2+3		3+3	4+3	3+3				34
WP		6		4	4		6	6	6				32
WF	1	2		2	2		2	2	2				13
DS				4	4								8
DB									2				2
DC												3	3
IS				2									2
IB		1					1		2				4
GP	1					1					1		3
SG			8									16	24
FM												1	1
Total	8	27	8	26	24	5	27	19	39	6	11	20	220
Tubings	2	4	0	0	0	1	4	0	0	0	1	0	12
Wireless	0	6	0	0	6	0	6	5	7	0	4	0	34
Wired	6	17	8	26	18	4	17	14	32	6	6	20	174

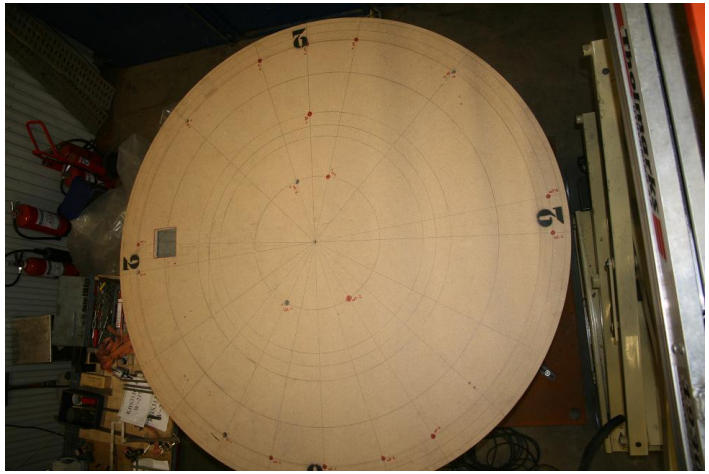
Code	Sensor
TP	Total pressure
PP	Pore pressure
WC	Water content capacitive
WP	Water content psychometric
WF	Water content FDR
DS	Displacement Supercontainer
DB	Displacement bentonite
DC	Displacement collar
IS	Inclination Supercontainer
IB	Inclination bentonite
SG	Strain Gage
GP	Gas Pressure
FM	Flow Meter

Wireless are marked with red nummers

Distance block assembly, preparations

- The RH inside the assembly building was optimized for the blocks being assembled, ~86 % for distance blocks.
- Wooden templates were used for all sensor sections
- Lifts were done using a vacuum tool and in some instances a mechanical tool.

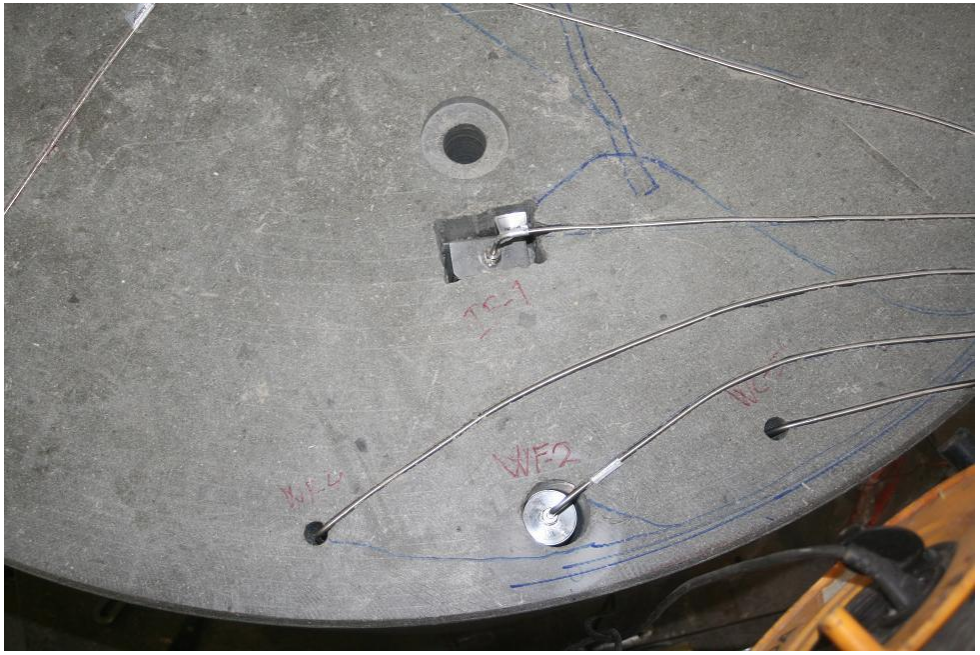
Humidifier



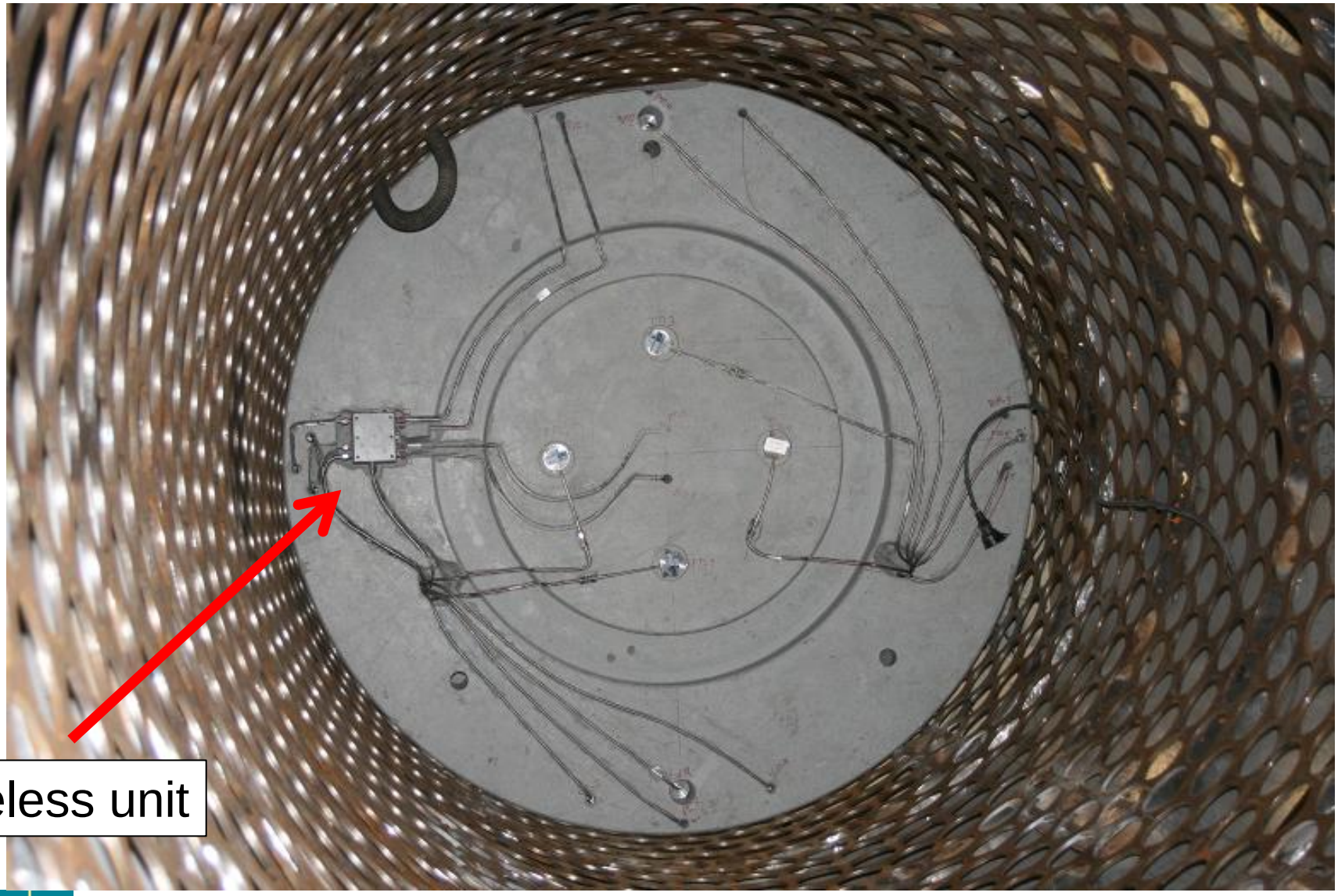
Template

Vacuum tool and mechanical tool

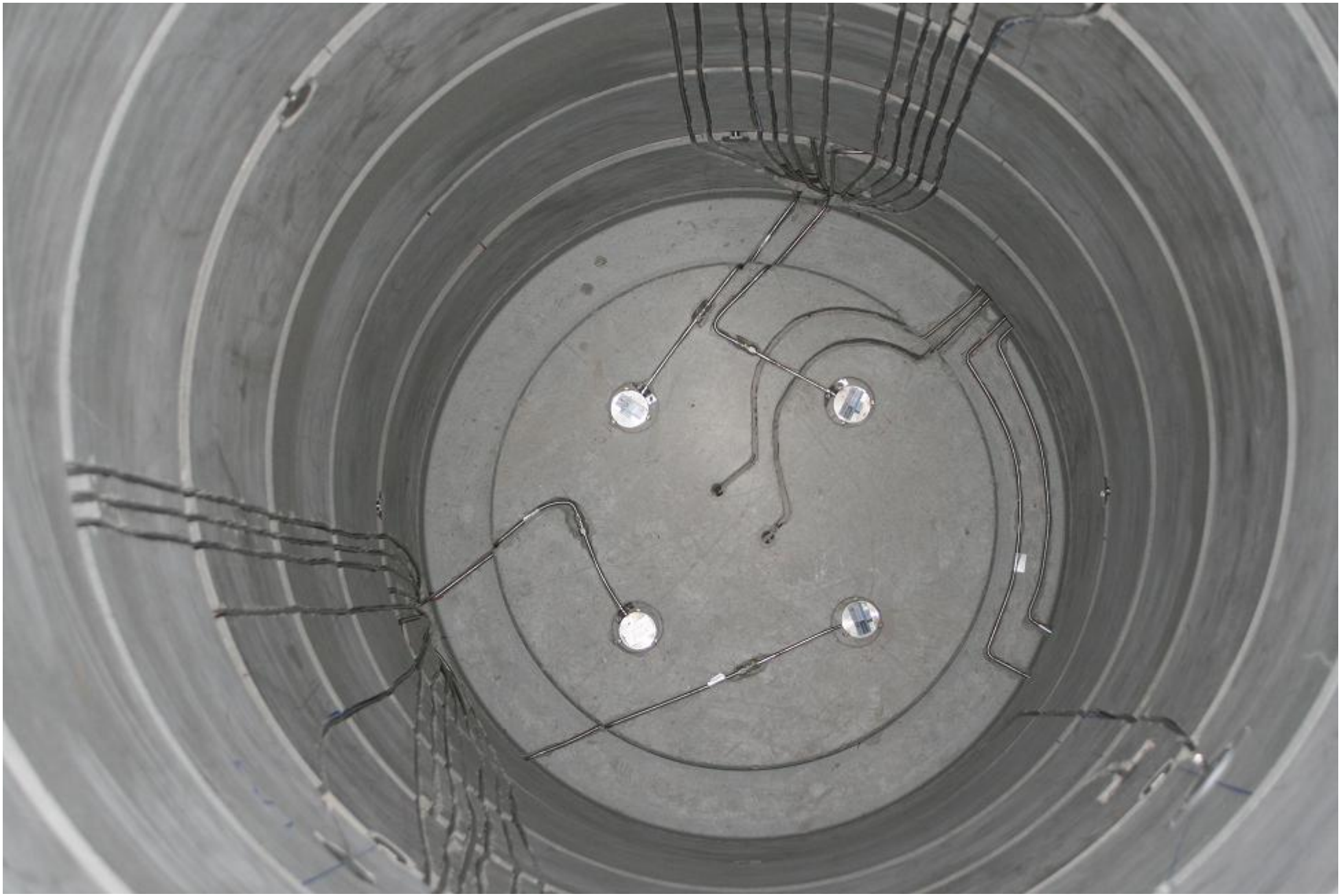
Distance block assembly



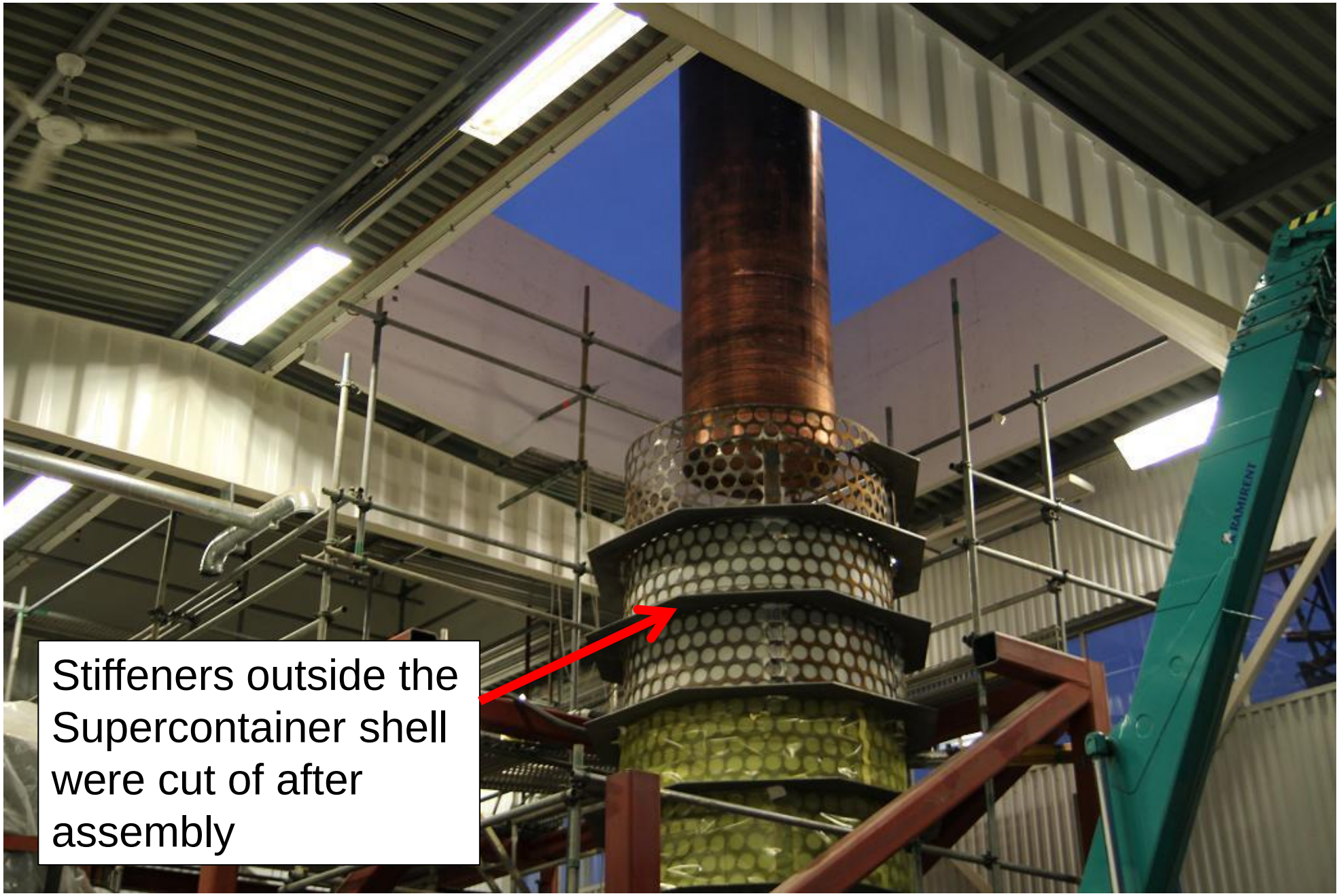
Supercontiner assembly, bottom block



Supercontiner assembly, rings added



Supercontiner assembly, canister installation



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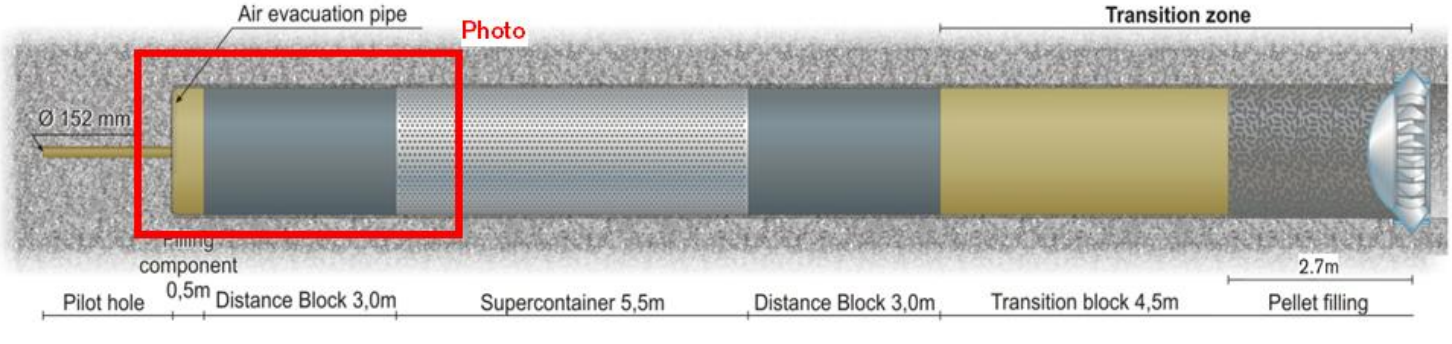
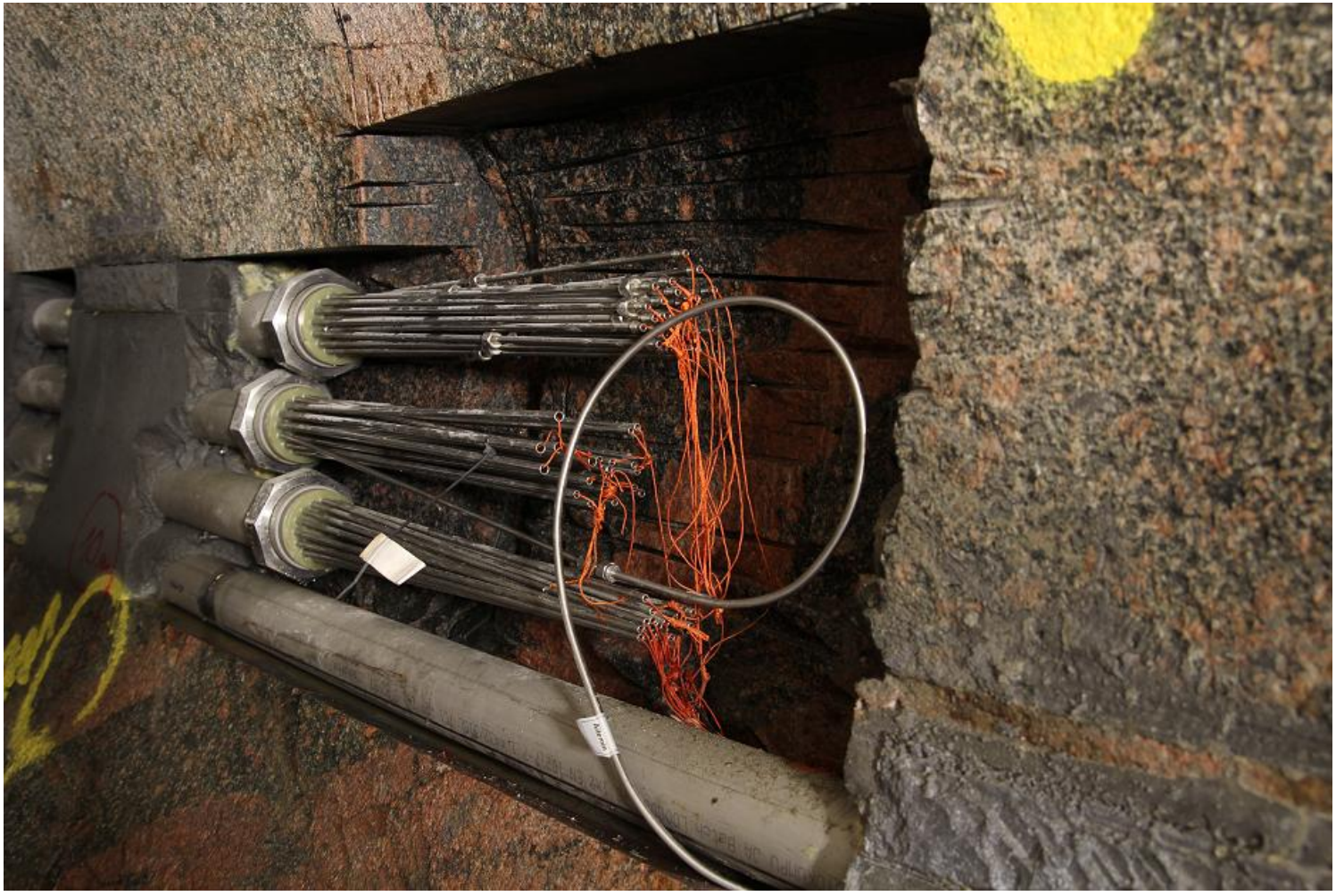
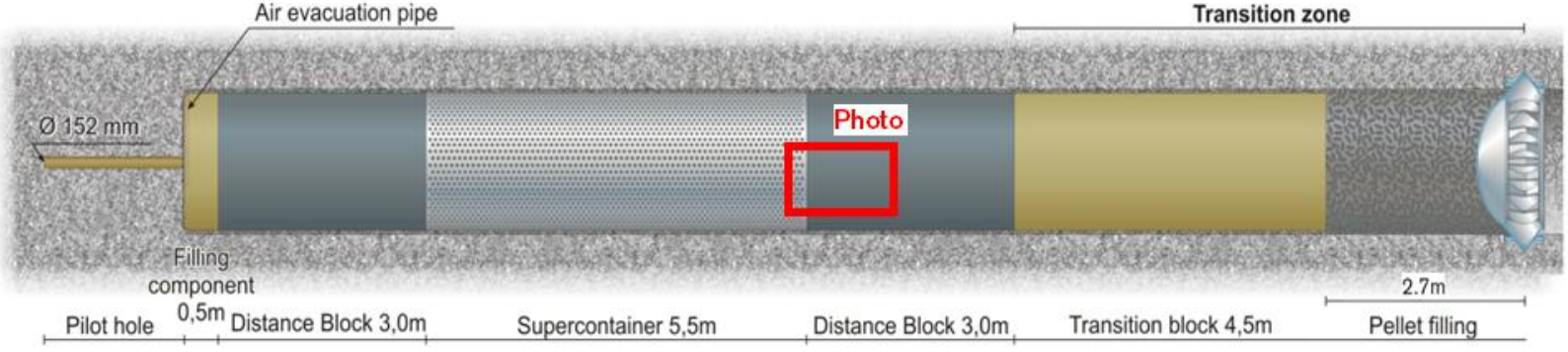
Final drift preparations, connecting the rock sensors

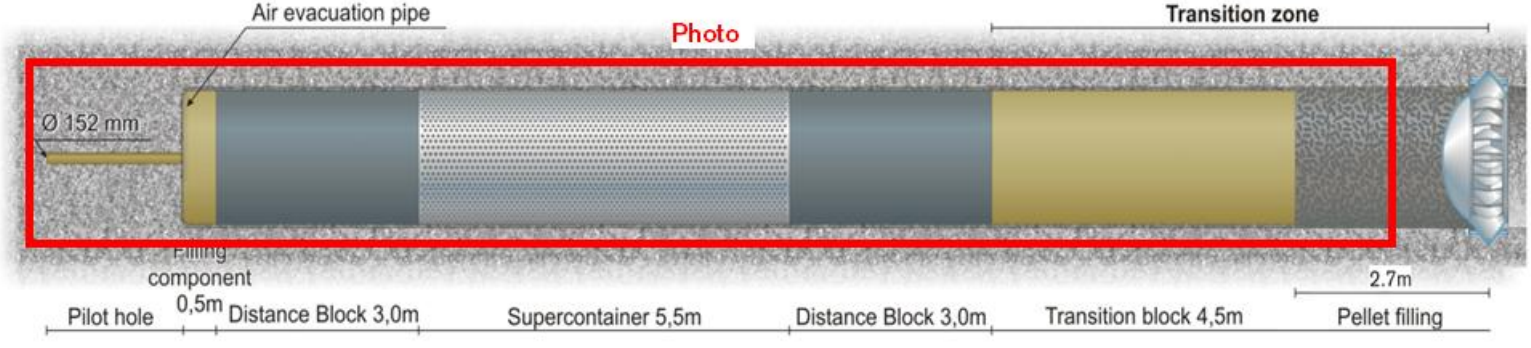


Supercontiner position prepared for installation





Tubing positioned in cable cutouts, ready for installation



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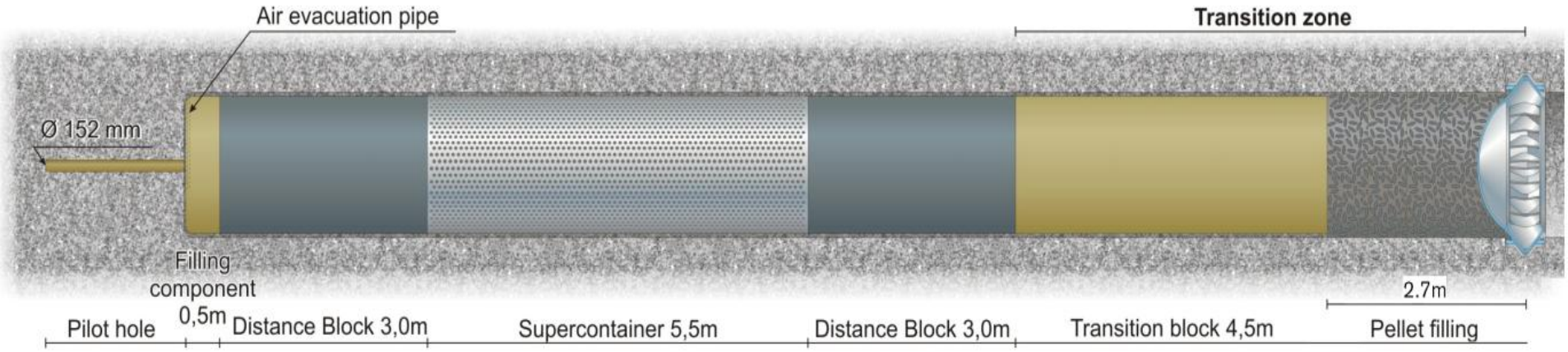
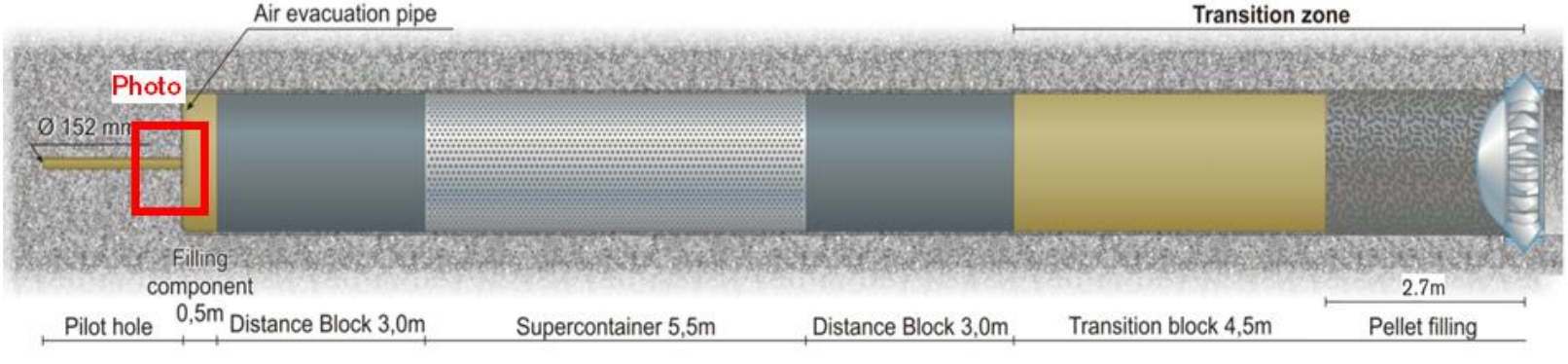
Components prepared for installation at Högdelen

Installation schedule, 14th Nov - 7th Dec 2013

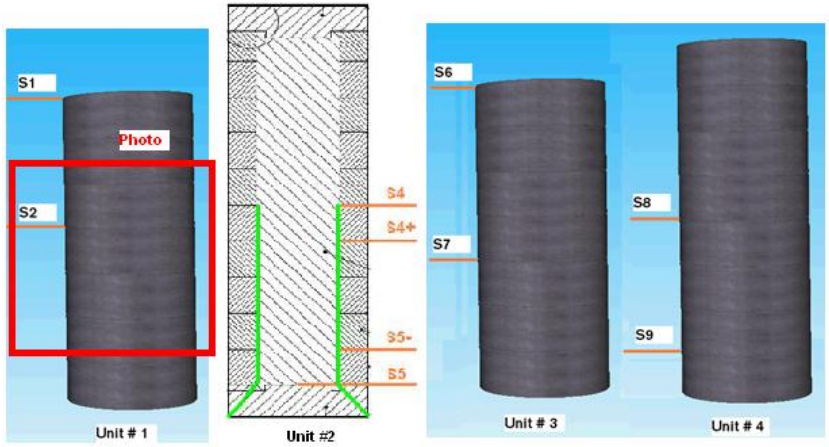
Activity	November																	December						
	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7
Filling components pilot holes																								
Inner distance block and cables																								
Supercontiner and cables																								
Outer distance block and cables																								
Transition block																								
Cables and sensors on last block																								
Plug and cables																								
Pellets filling																								
Connecting the DAS																								
Contact grouting plug																								
DAWE																								



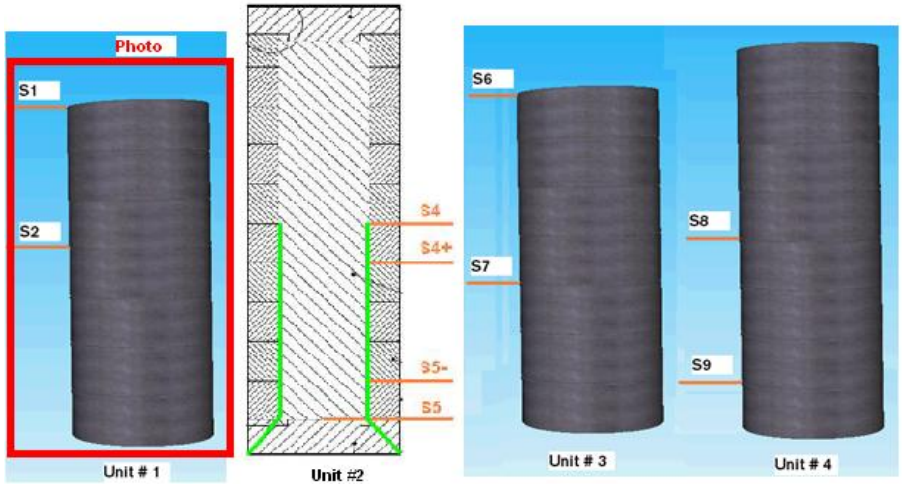
Filling components, pilot holes, 14th Nov 2013



Final preparation of the inner distance block, 14th Nov

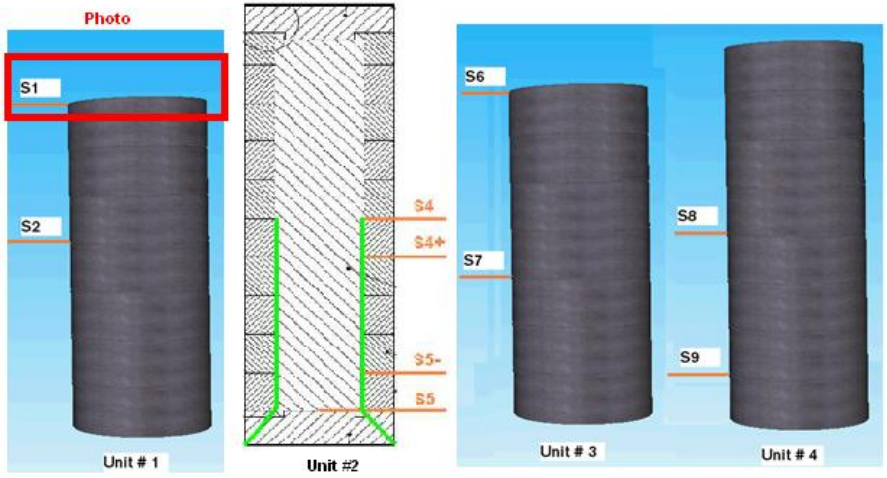


Moving the inner distance block out



Placing the transport tube

Block positioned in the transport tube

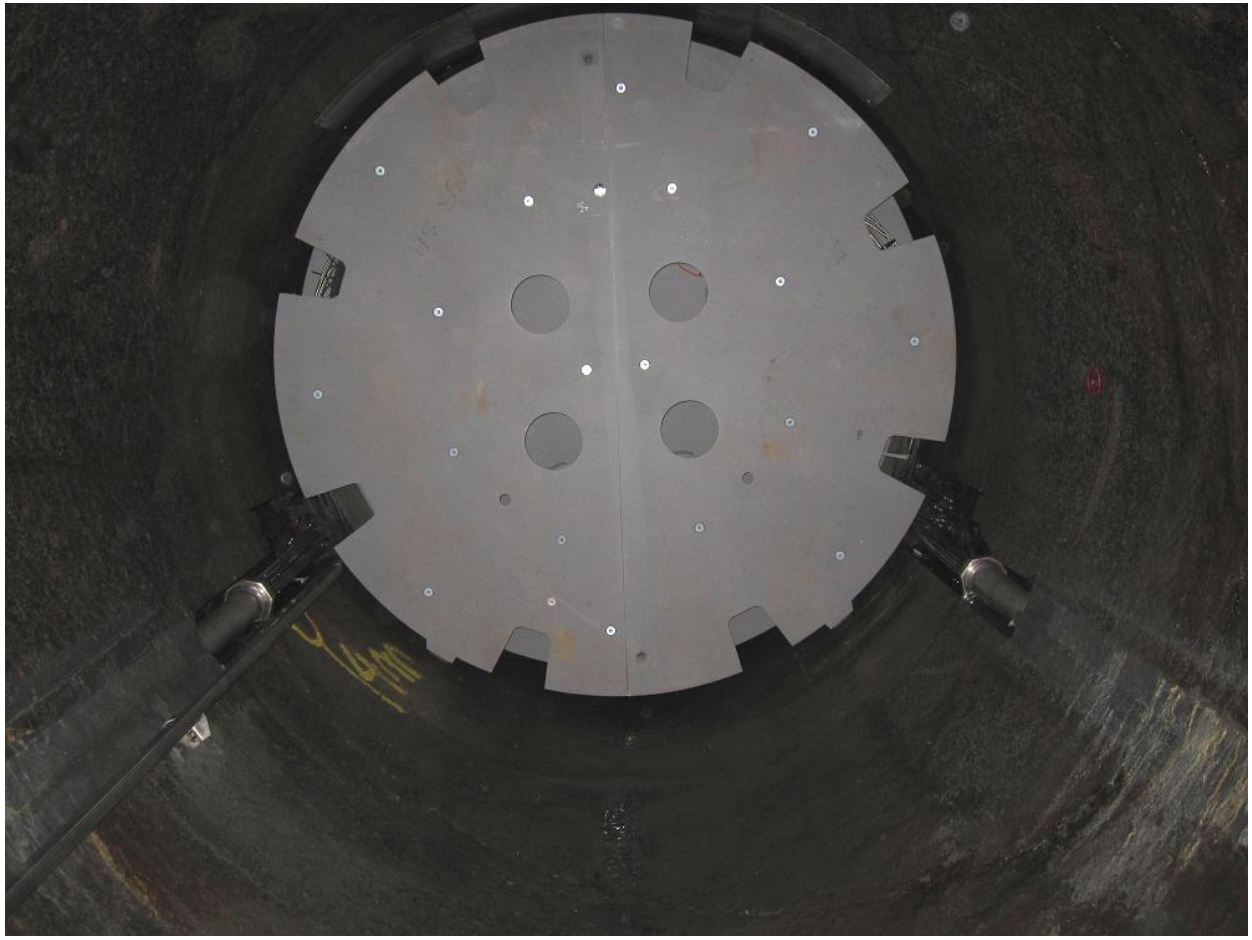


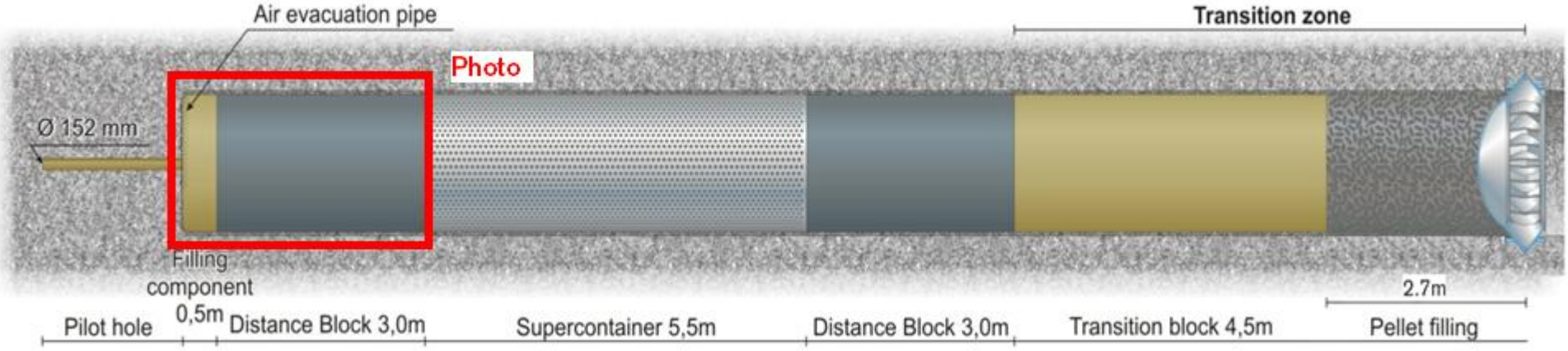
Transportation

Beginning to position the equipment at -220 m

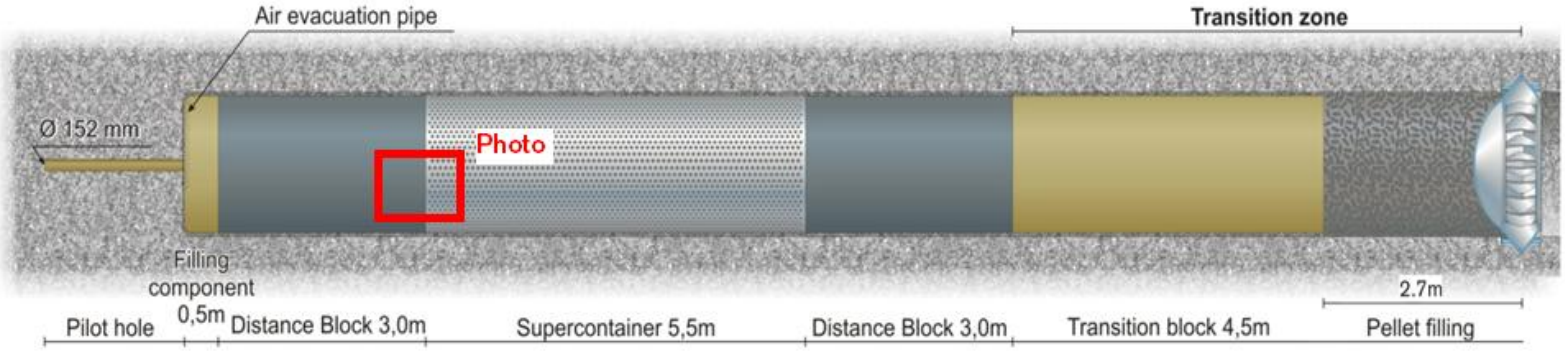
Deposition work

Inner Distance block just positioned, 14th Nov, 2013



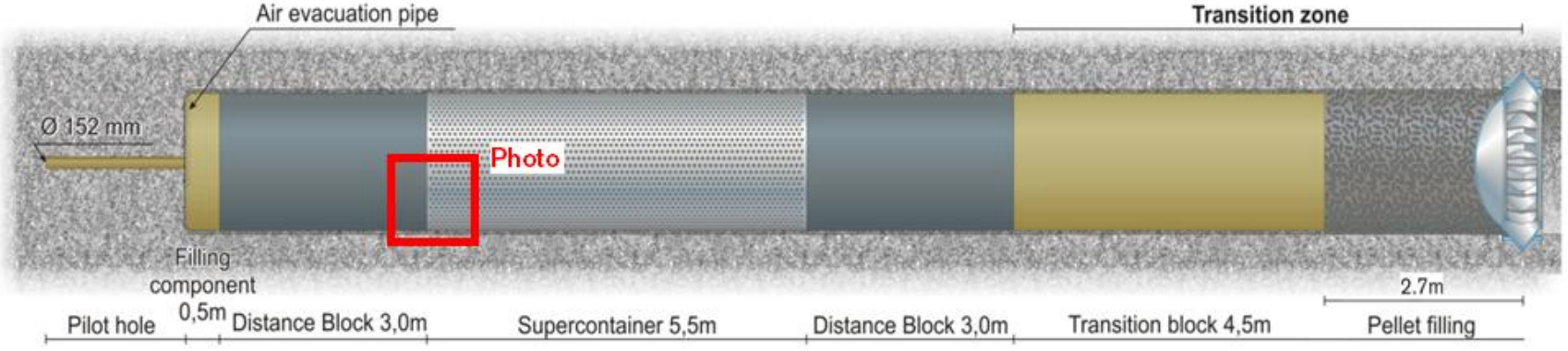


Inner distance block in place and connected, 14th Nov, 2013

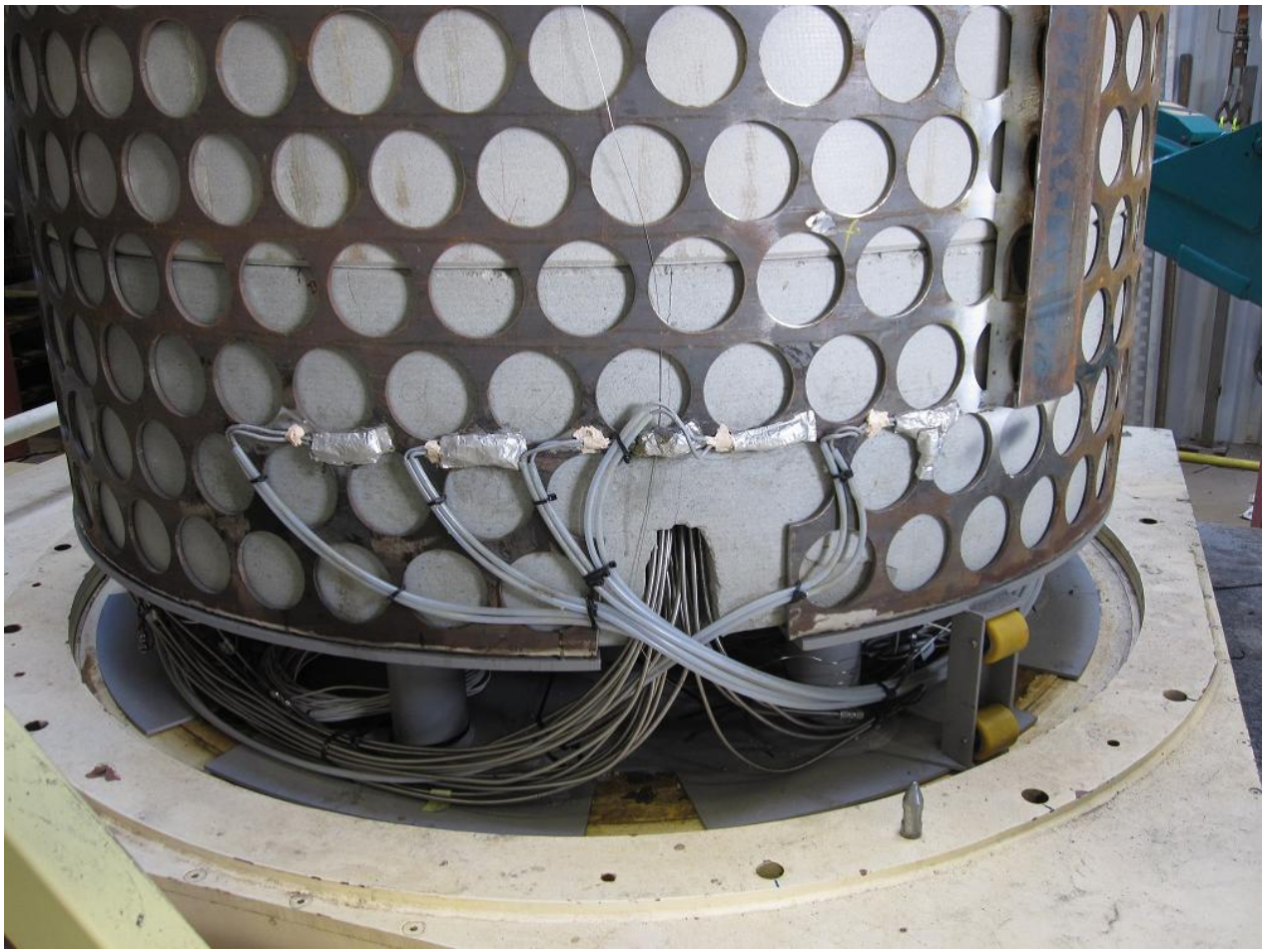


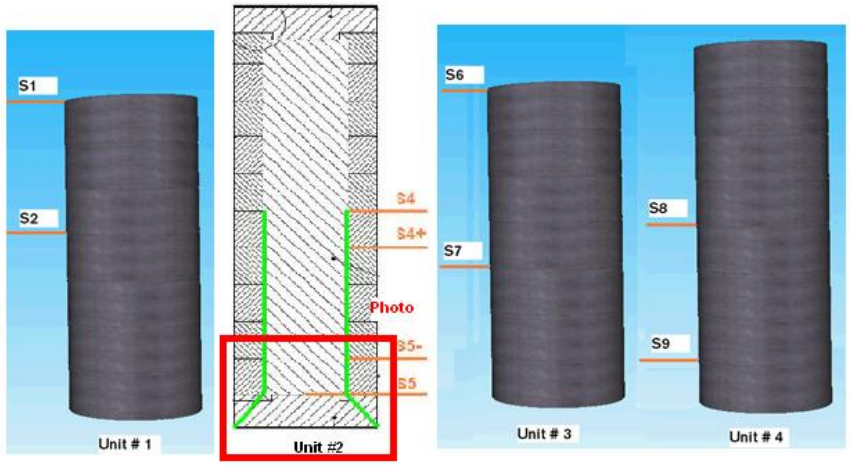
Inner distance block, cracking

Cracking visible when the cable block was removed



Instrumented Supercontiner on cable block

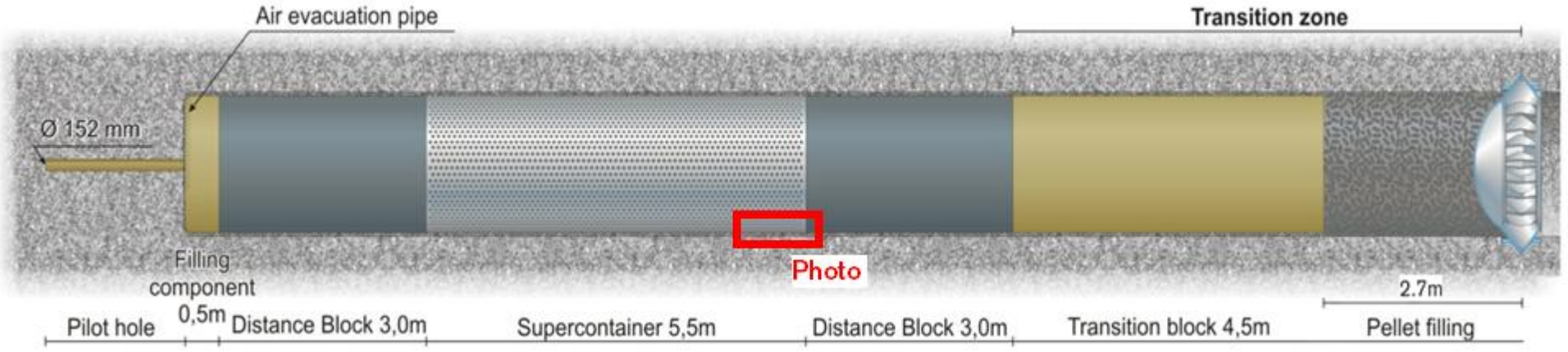




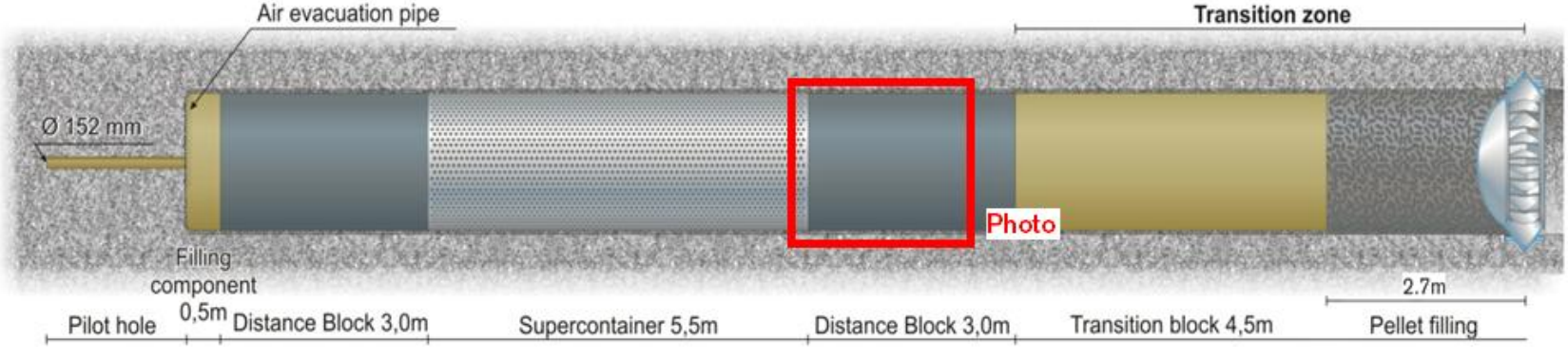
Loading the Supercontiner, 15th Nov

Under the Supercontainer after deposition

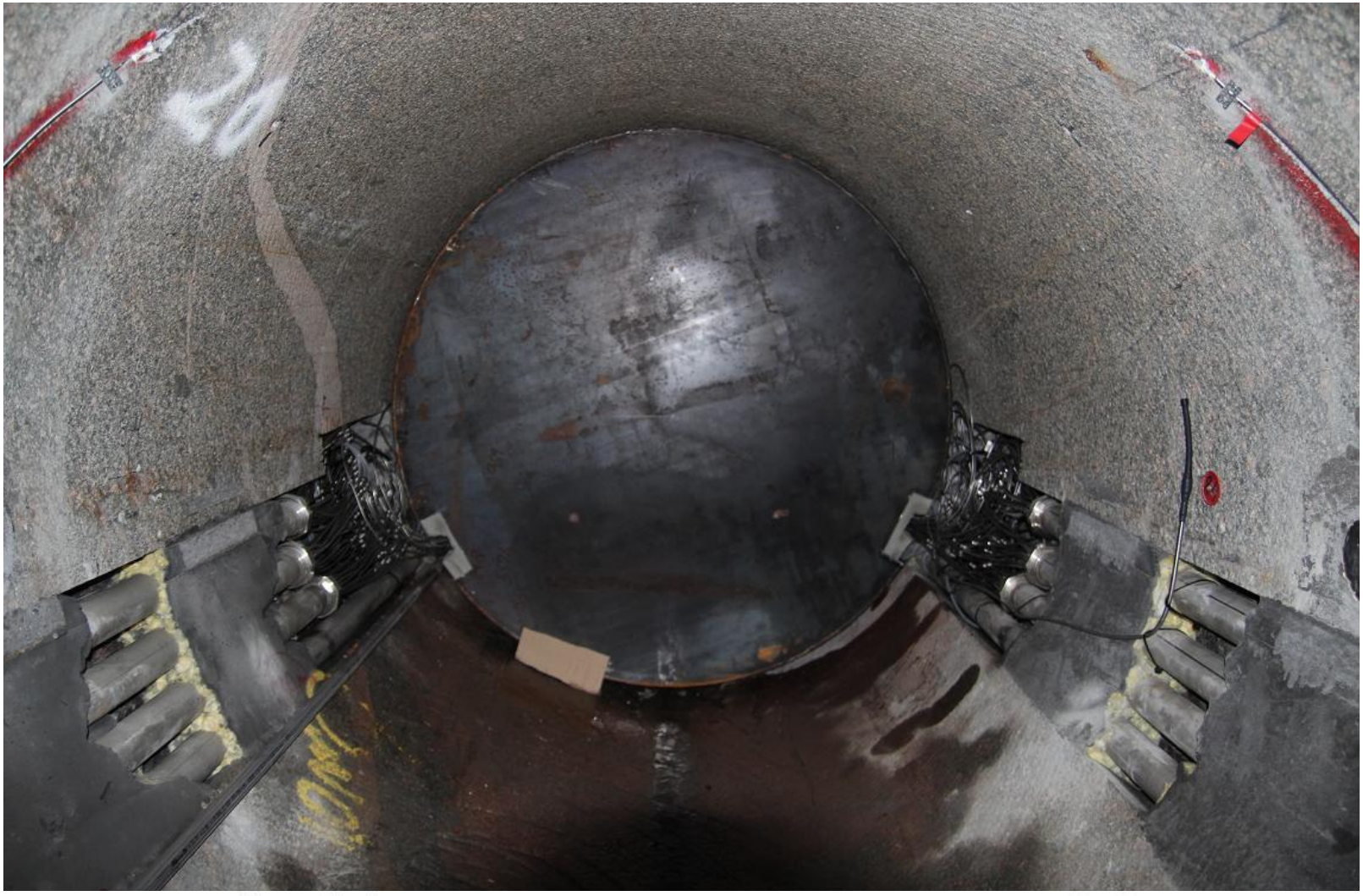
Bentonite, due to splashing, small amounts

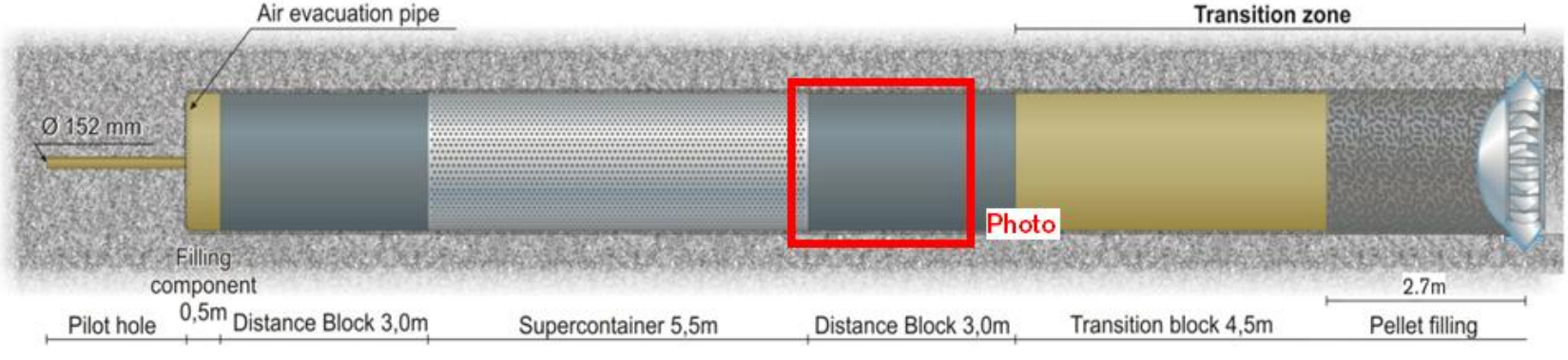


Cable work, Supercontainer, 15 – 17th Nov 2013

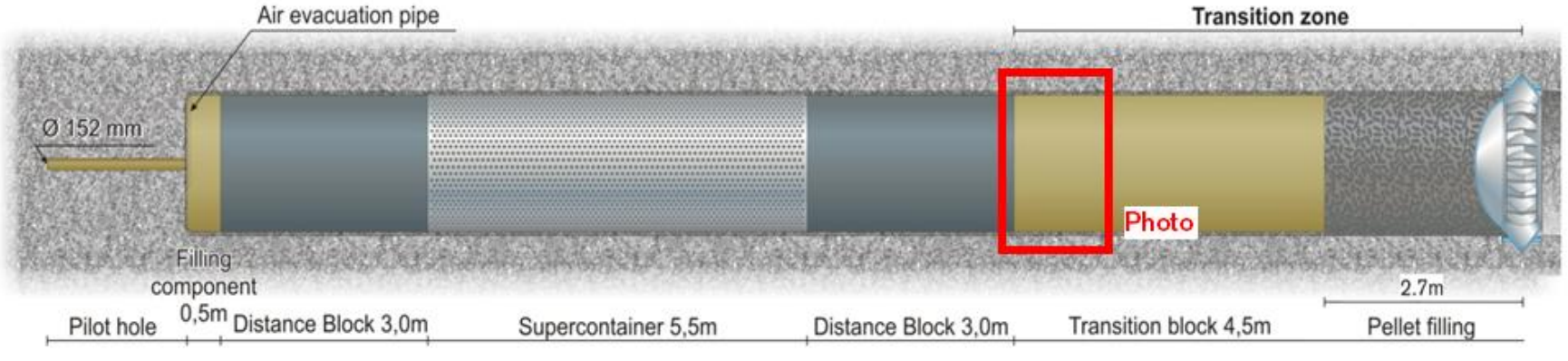


Supercontainer, all cables pulled, 17th Nov

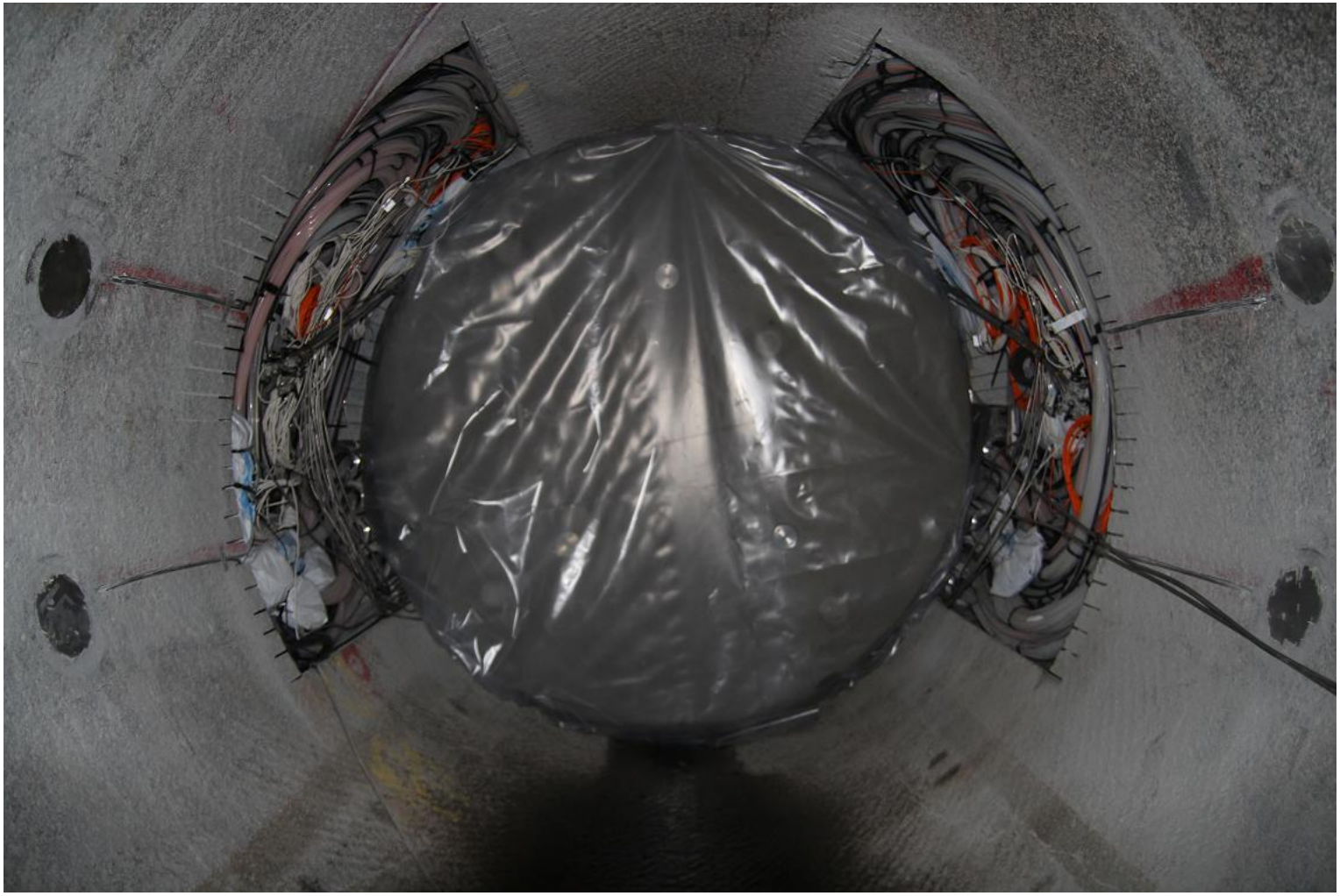


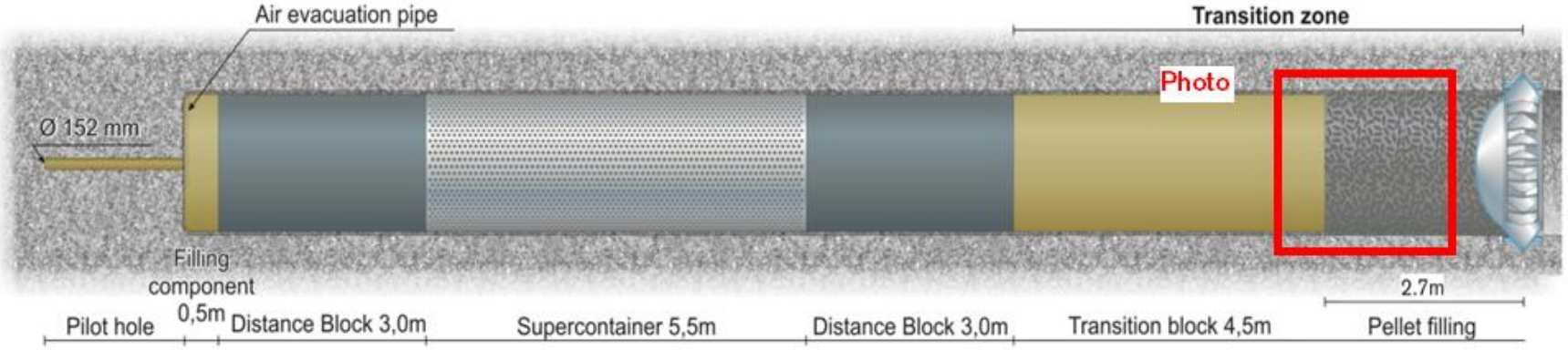


Outer distance block installed and cables pulled, 18th Nov

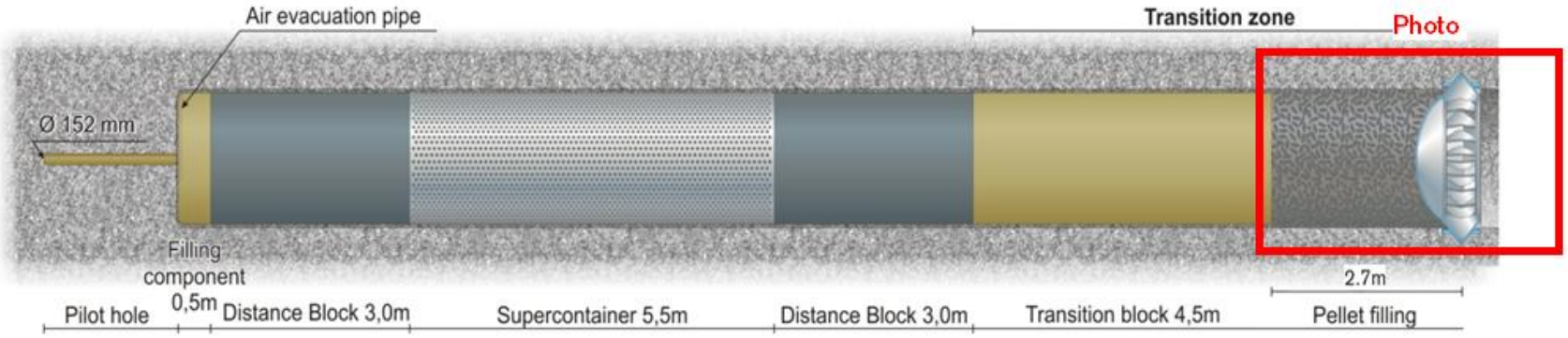


Transition block installed, 19th Nov 2013

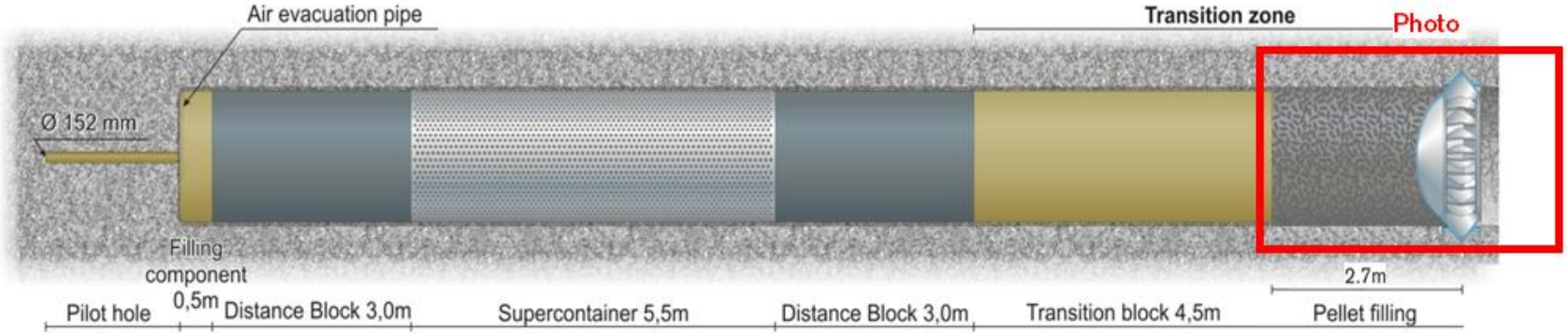




Plug installation, collar, 21st Nov 2013

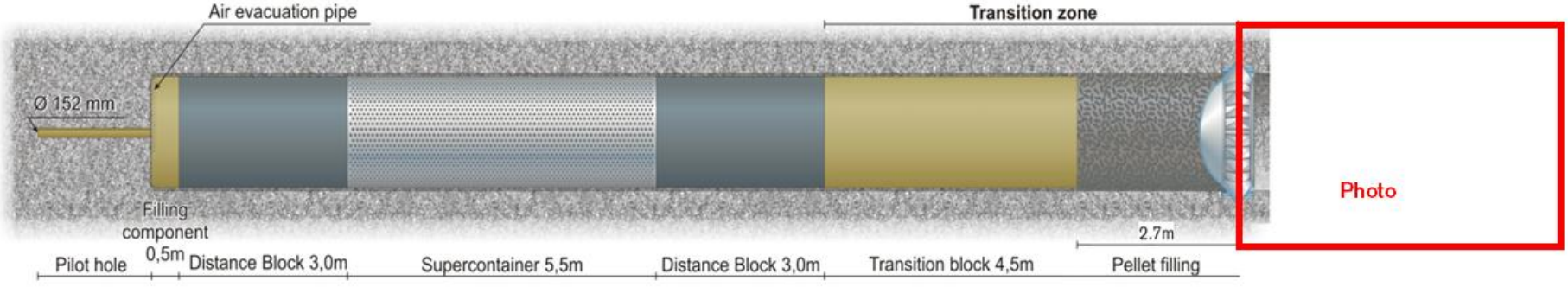


Lead- throughs taken through the collar, cap raised and welded, 27th Nov 2013



Pellets filling, 28th Nov 2013

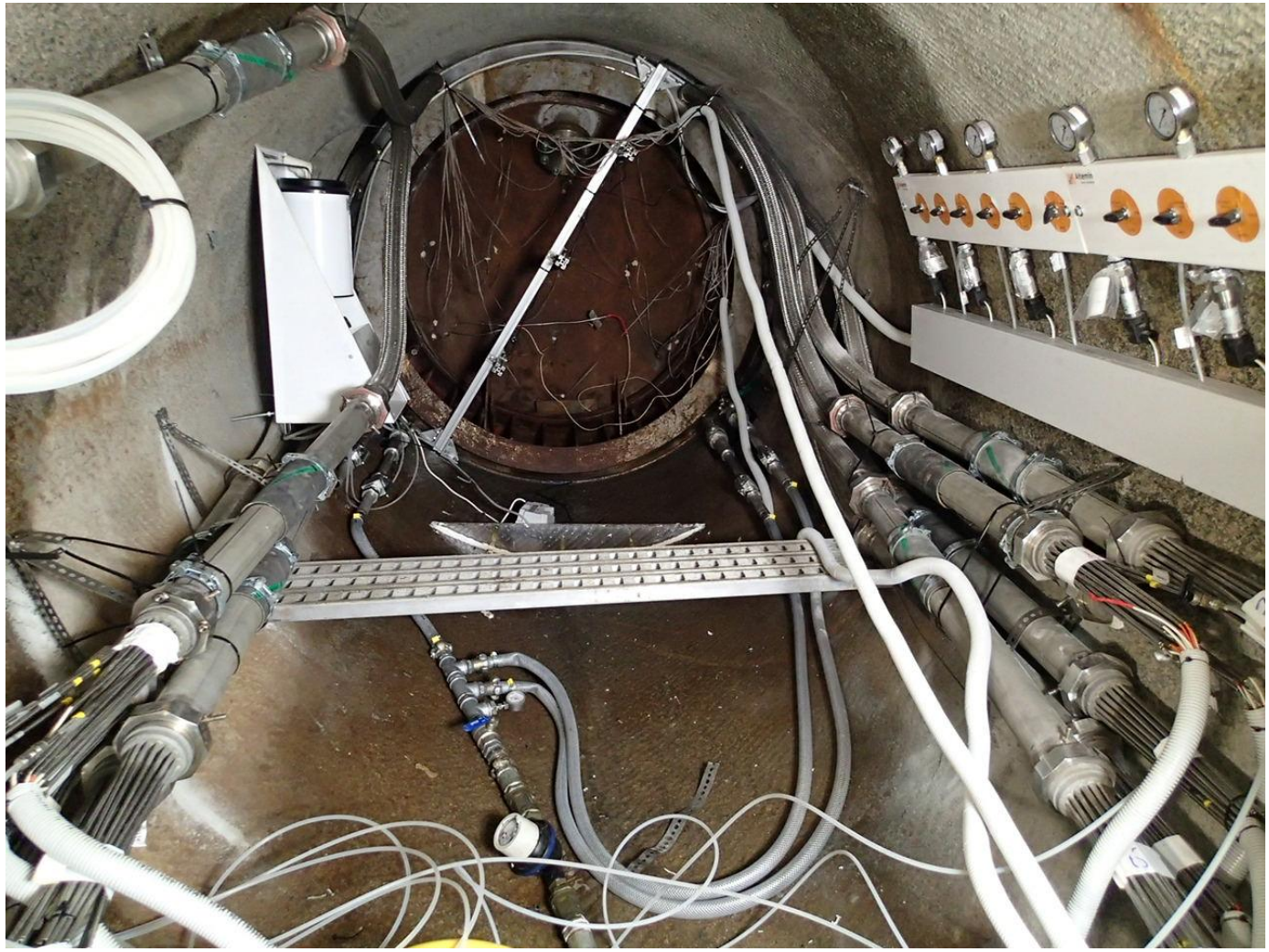
Sensor system installation 29th Nov - 5th Dec 2013

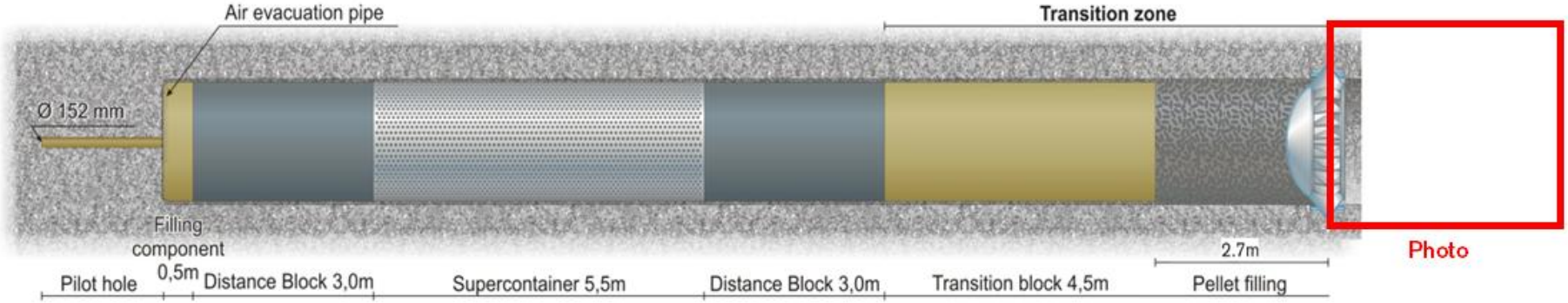


Silica-sol contact grouting, 6th Dec 2013

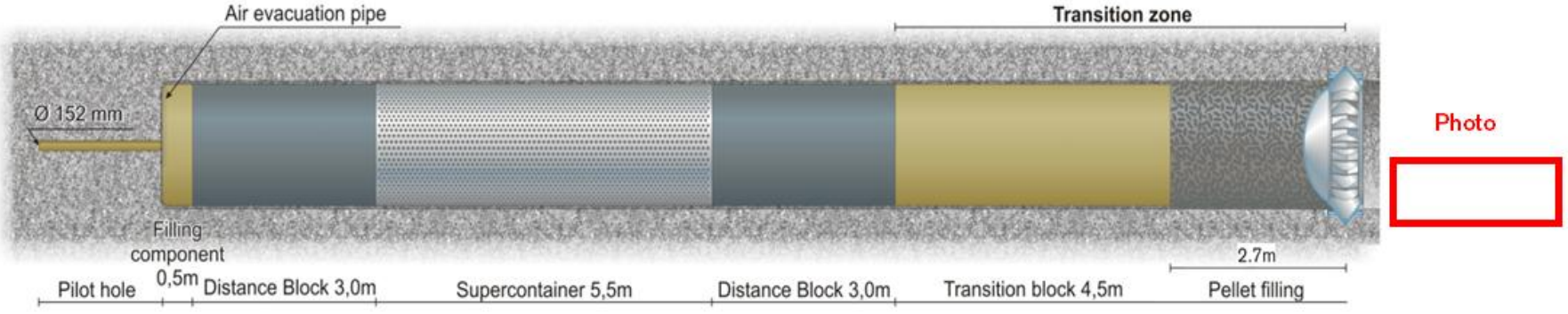
Rock-casting and casting-steel was grouted simultaneously using Silica-sol

DAWE, 7th Dec 2013



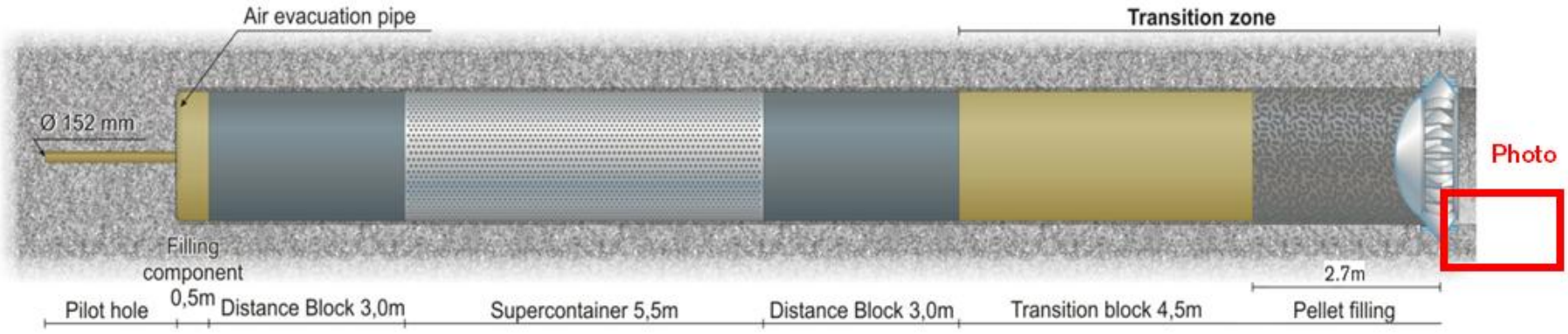


Pipe removal, 7th Dec 2013

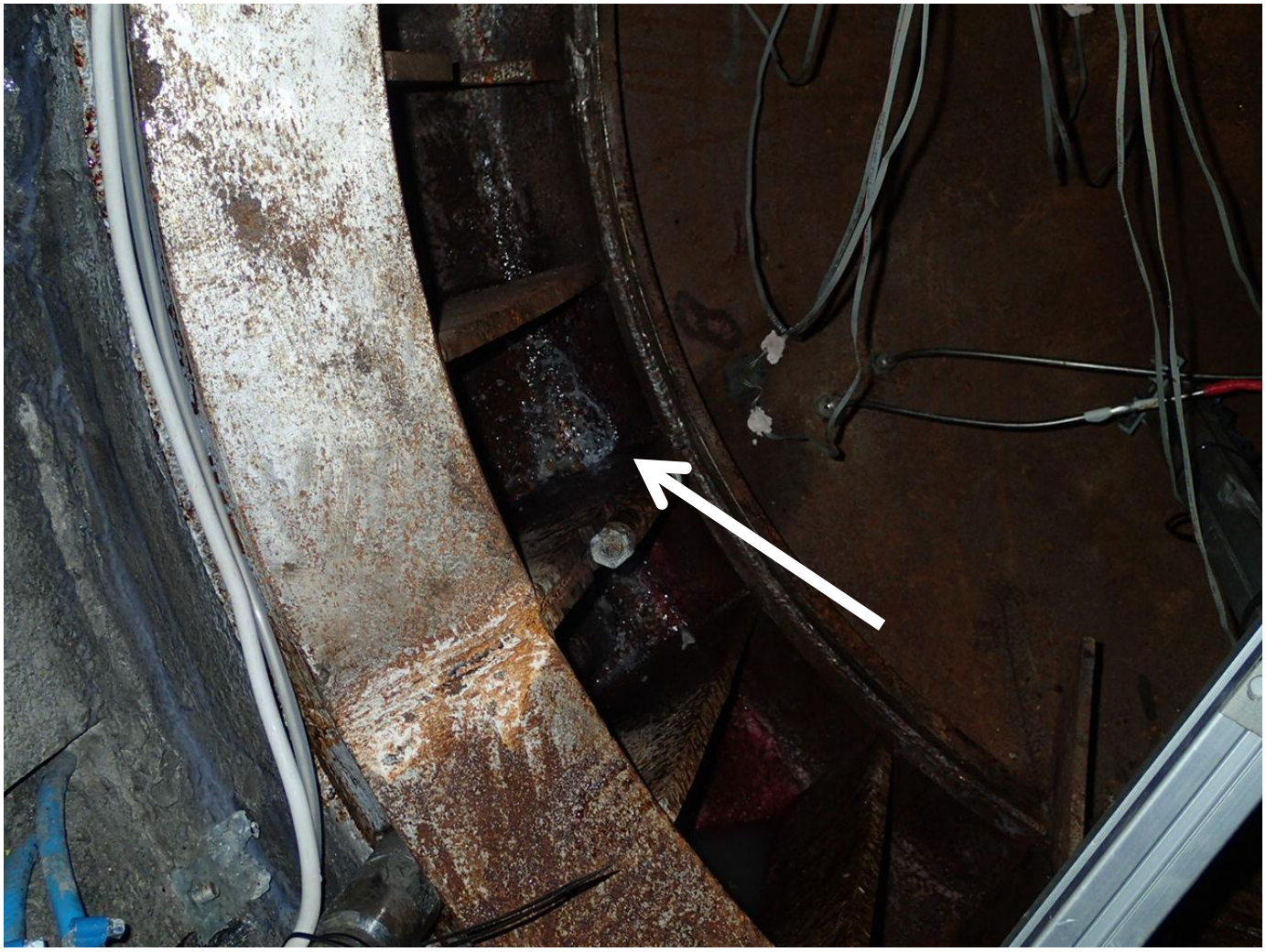


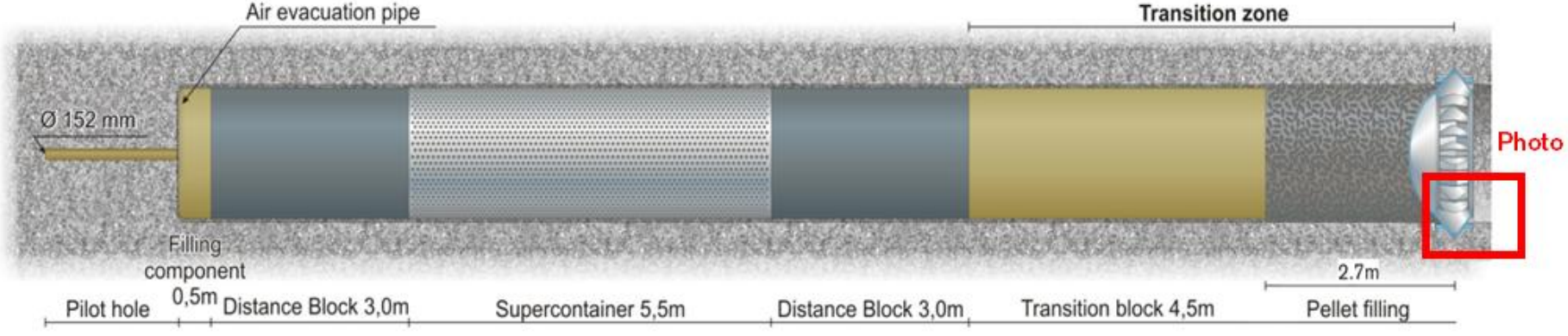
Photo

Air evacuation pipe just out, 7th Dec 2013



Weld leaking, leakage was sealed (welded) in Jan 2014





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Block data

Component	Block No	Date of comp,	water content (%)	wc requirement (%)	Bulk density (kg/m3)	Degree of sat,	Void ratio	Dry density (kg/m3)	Dry density requirement (kg/m3)	weight (kg)	Height (mm)	Weight machined (kg)
Distance block (inner)	KBS313C11	2013-07-29	20,6	21±1	2075	0,929	0,615	1721	1712±20	2610	503,5	
	KBS313C10	2013-02-19	20,7	21±1	2078	0,935	0,615	1721	1712±20	2602	501,8	2476
	KBS313C28	2013-07-31	19,9	21±1	2064	0,899	0,615	1721	1712±20	2610	506,4	2471
	KBS313C20	2013-07-30	20,9	21±1	2074	0,936	0,621	1715	1712±20	2648	511,9	2472
	KBS313C21	2013-07-30	20,4	21±1	2065	0,914	0,621	1715	1712±20	2612	506,6	2450
	KBS313C8	2013-02-19	21,1	21±1	2059	0,925	0,636	1700	1712±20	2592	504	2472
	KBS313C25	2013-07-31	19,8	21±1	2064	0,896	0,613	1723	1712±20	2606	506	2462
Supercontiner	KBS313C1	2013-02-19	17,8	17±1	2068	0,846	0,583	1756	1753±20	2570	496,9	1722
	KBS313R12	2013-02-22	11,0	11±1	2111	0,663	0,462	1902	1885±20	1752	507,6	1217
	KBS313R6	2013-02-21	11,2	11±1	2118	0,677	0,46	1904	1885±20	1758	508,7	1533
	KBS313R7	2013-02-21	11,1	11±1	2104	0,658	0,468	1894	1885±20	1750	508,2	1528
	KBS313R2	2013-02-20	10,9	11±1	2110	0,657	0,461	1903	1885±20	1732	502,6	1542
	KBS313R11	2013-02-22	11,0	11±1	2106	0,656	0,465	1897	1885±20	1752	508,3	1542
	KBS313R1	2013-02-22	11,0	11±1	2086	0,64	0,48	1879	1885±20	1732	508,7	1526
	KBS313R3	2013-02-20	10,8	11±1	2107	0,652	0,462	1901	1885±20	1732	502,5	1540
	KBS313R9	2013-02-22	11,0	11±1	2107	0,657	0,465	1898	1885±20	1748	508	1540
	KBS313R5	2013-02-21	11,1	11±1	2109	0,665	0,465	1898	1885±20	1744	506,6	1535
	KBS313R4	2013-02-21	10,8	11±1	2100	0,644	0,467	1895	1885±20	1722	503,5	1547
	KBS313C2	2013-02-19	17,3	17±1	2070	0,835	0,576	1764	1753±20	2588	500	2056

Red are outside the requirement

Block and pellets

Component	Block No	Date of comp,	water content (%)	wc requirement (%)	Bulk density (kg/m3)	Degree of sat,	Void ratio	Dry density (kg/m3)	Dry density requirement (kg/m3)	weight (kg)	Height (mm)	Weight machined (kg)
Distance block (outer)	KBS313C30	2013-08-01	20,1	21±1	2058	0,896	0,622	1714	1712±20	2594	504,9	2469
	KBS313C23	2013-07-31	20,4	21±1	2058	0,906	0,627	1709	1712±20	2604	507,1	2471
	KBS313C19	2013-07-30	20,2	21±1	2072	0,916	0,612	1724	1712±20	2660	514,7	2473
	KBS313C18	2013-07-30	20,2	21±1	2072	0,916	0,612	1724	1712±20	2660	514,7	2476
	KBS313C14	2013-07-29	19,5	21±1	2084	0,913	0,594	1744	1712±20	2606	501,2	2473
	KBS313C26	2013-07-31	20,4	21±1	2061	0,909	0,624	1711	1712±20	2604	506	2470
	KBS313C15	2013-07-30	19,9	21±1	2083	0,921	0,6	1738	1712±20	2606	501,1	2471
Transition block	KBS313C9	2013-02-19	21,4	21±1	2070	0,943	0,63	1705	1712±20	2588	501,3	2482
	KBS313C17	2013-07-30	19,3	21±1	2073	0,894	0,599	1738	1712±20	2658	513	2472
	KBS313C13	2013-07-29	20,8	21±1	2080	0,941	0,615	1721	1712±20	2608	502,4	2476
	KBS313C24	2013-07-31	20,5	21±1	2051	0,9	0,634	1702	1712±20	2604	508,9	2469
	KBS313C16	2013-07-30	20,7	21±1	2083	0,942	0,611	1725	1712±20	2612	502,3	2476
	KBS313C27	2013-07-31	20,4	21±1	2058	0,904	0,626	1710	1712±20	2608	507,6	2473
	KBS313C12	2013-07-29	20,6	21±1	2079	0,935	0,613	1724	1712±20	2600	501,3	2469
	KBS313C7	2013-02-19	20,9	21±1	2073	0,935	0,621	1715	1712±20	2600	502,4	2479
Pellets												8047

Red are outside the requirement

Effects of machining

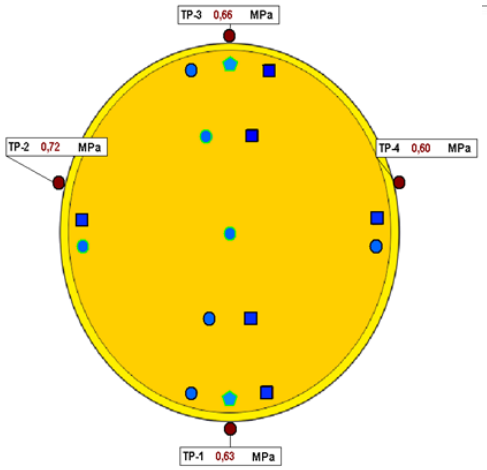
- Some of the blocks that had dry densities within the requirements after manufacturing were found to have a dry density above the requirements after machining, example is given below followed by summarized data

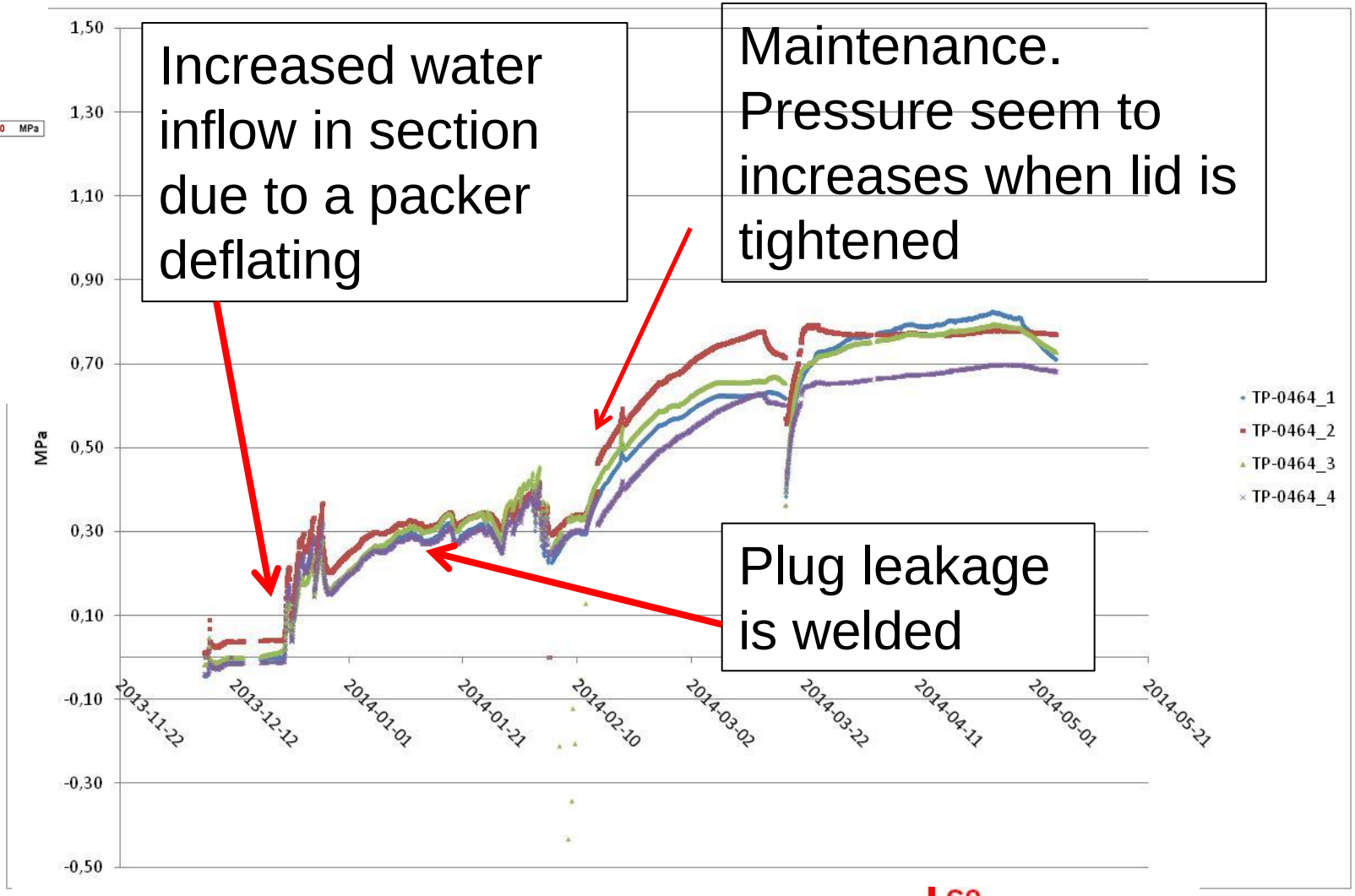
Block No	Dry density requirement (kg/m3)	Dry density before machining (kg/m3)	Dry density after machining (kg/m3)
KBS313R2	1885±20	1903	1910
KBS313R3	1885±20	1901	1913
KBS313R4	1885±20	1895	1916

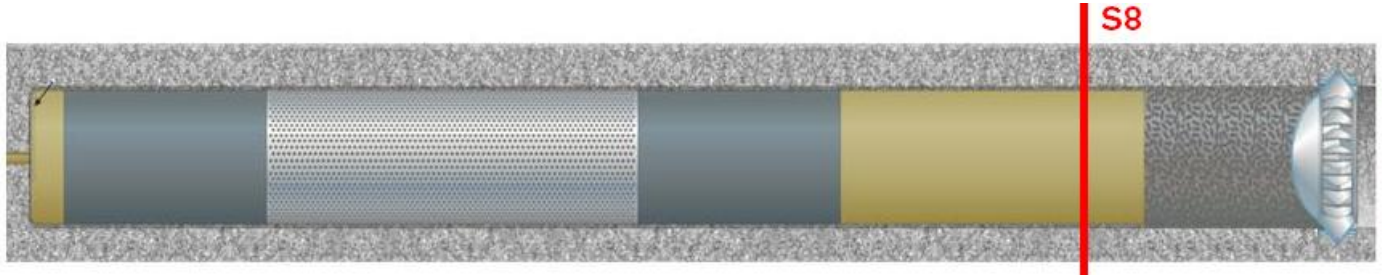
Block type	Number of blocks	Average Dry density (kg/m^3)	STDEV Dry density (kg/m^3)	Requirement dry density (kg/m^3)
Ring shaped	10	1900	10.9	1885±20
Distance block	22	1728	9.2	1712±20

Reason: the outermost part of the block likely has a lower density which is machined off

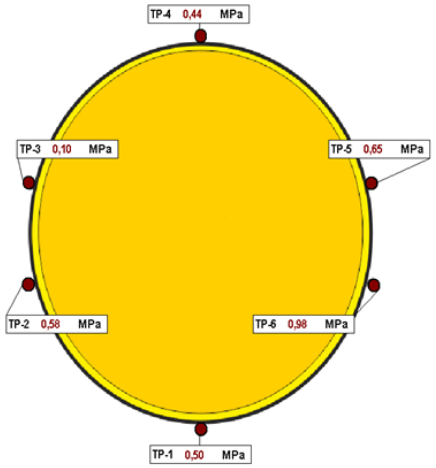
Total pressure on rock, transition block section

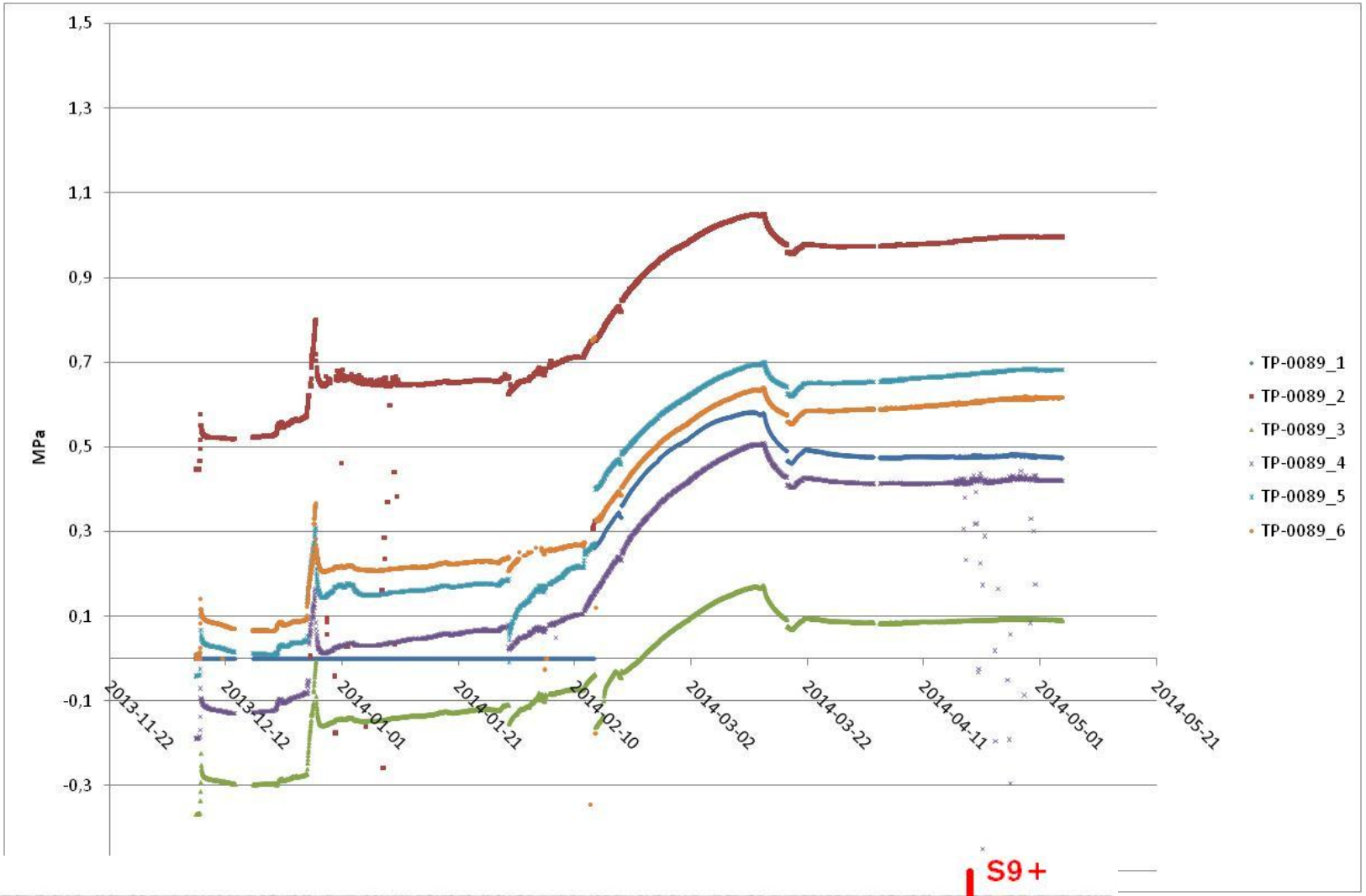


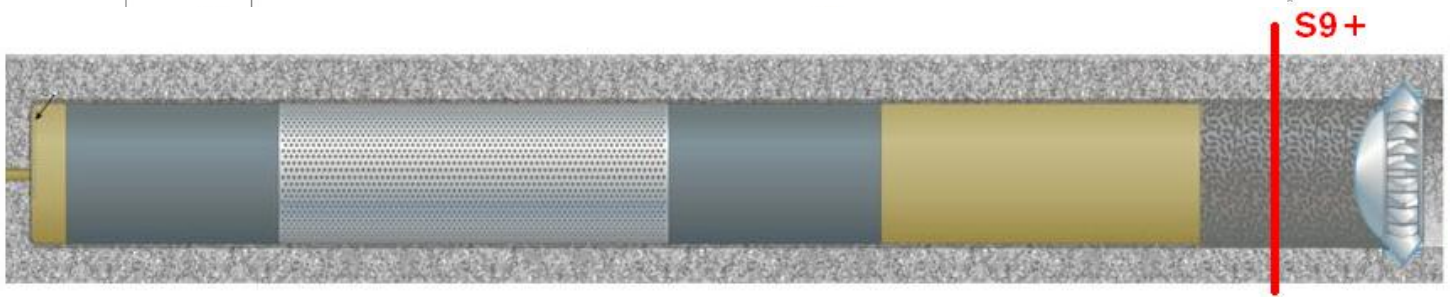




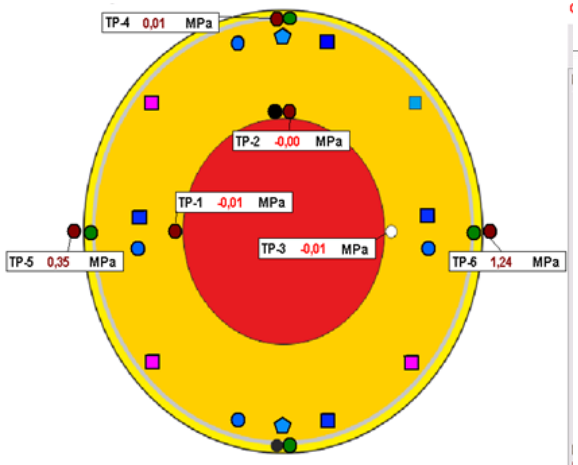
Total pressure against rock, pellets section

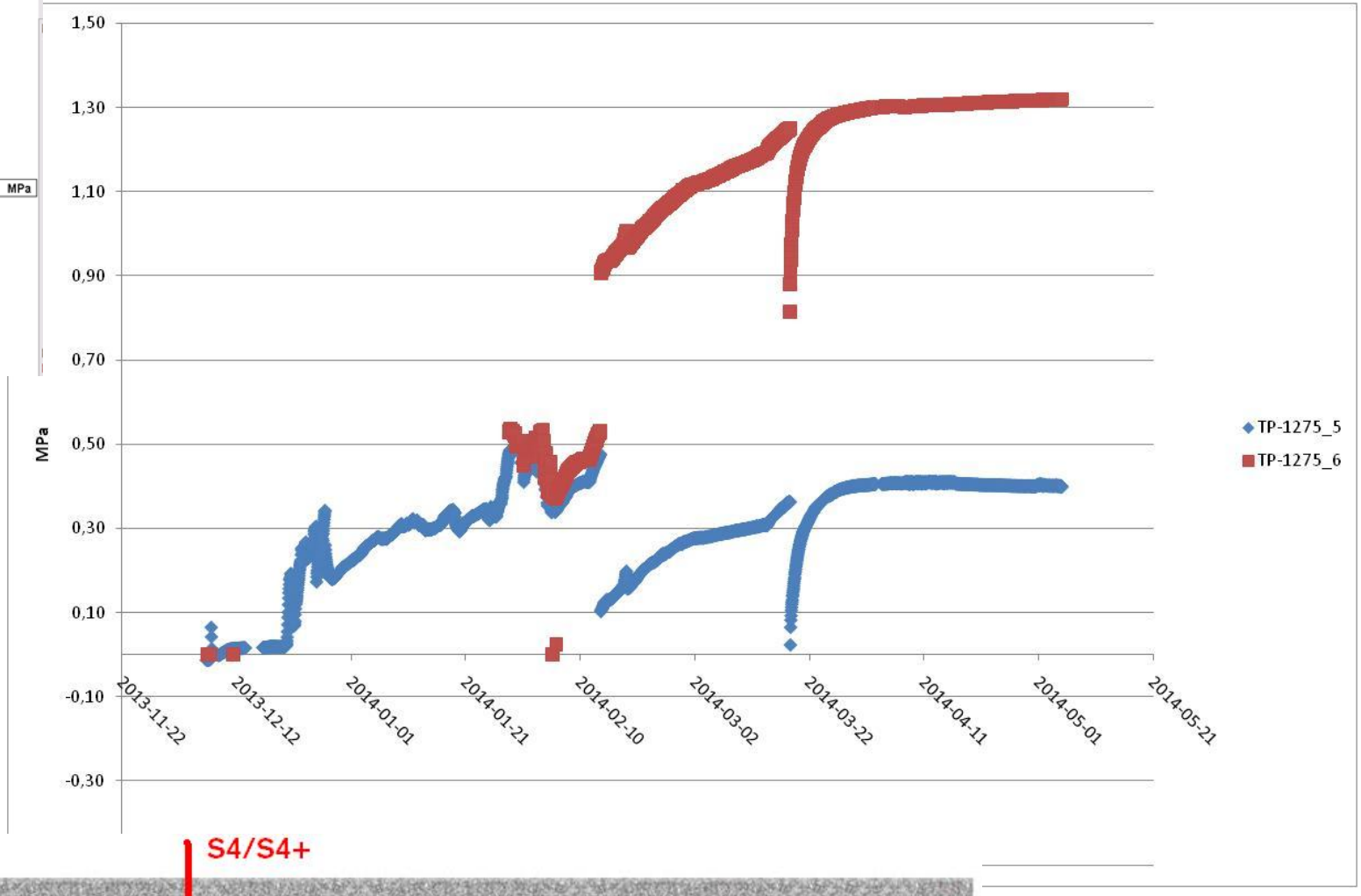


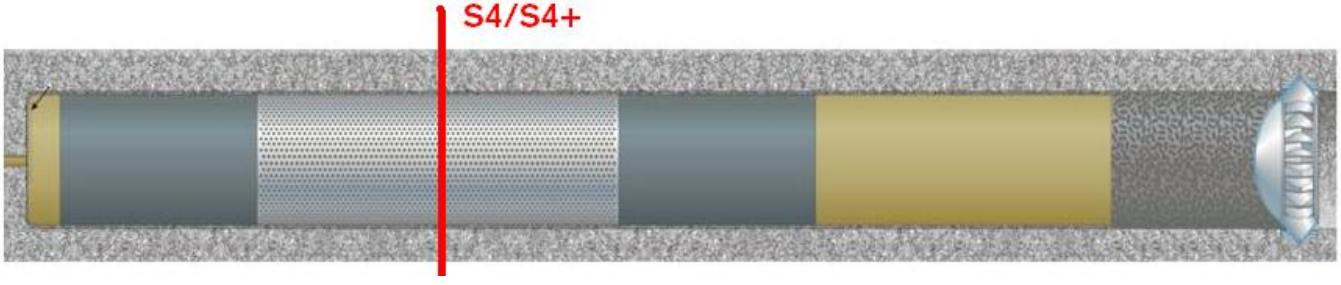




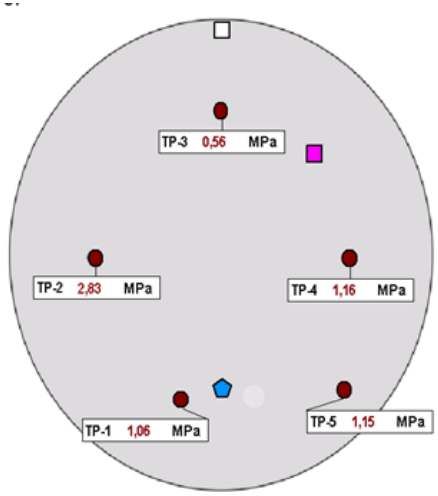
Total pressure on rock, Supercontainer section

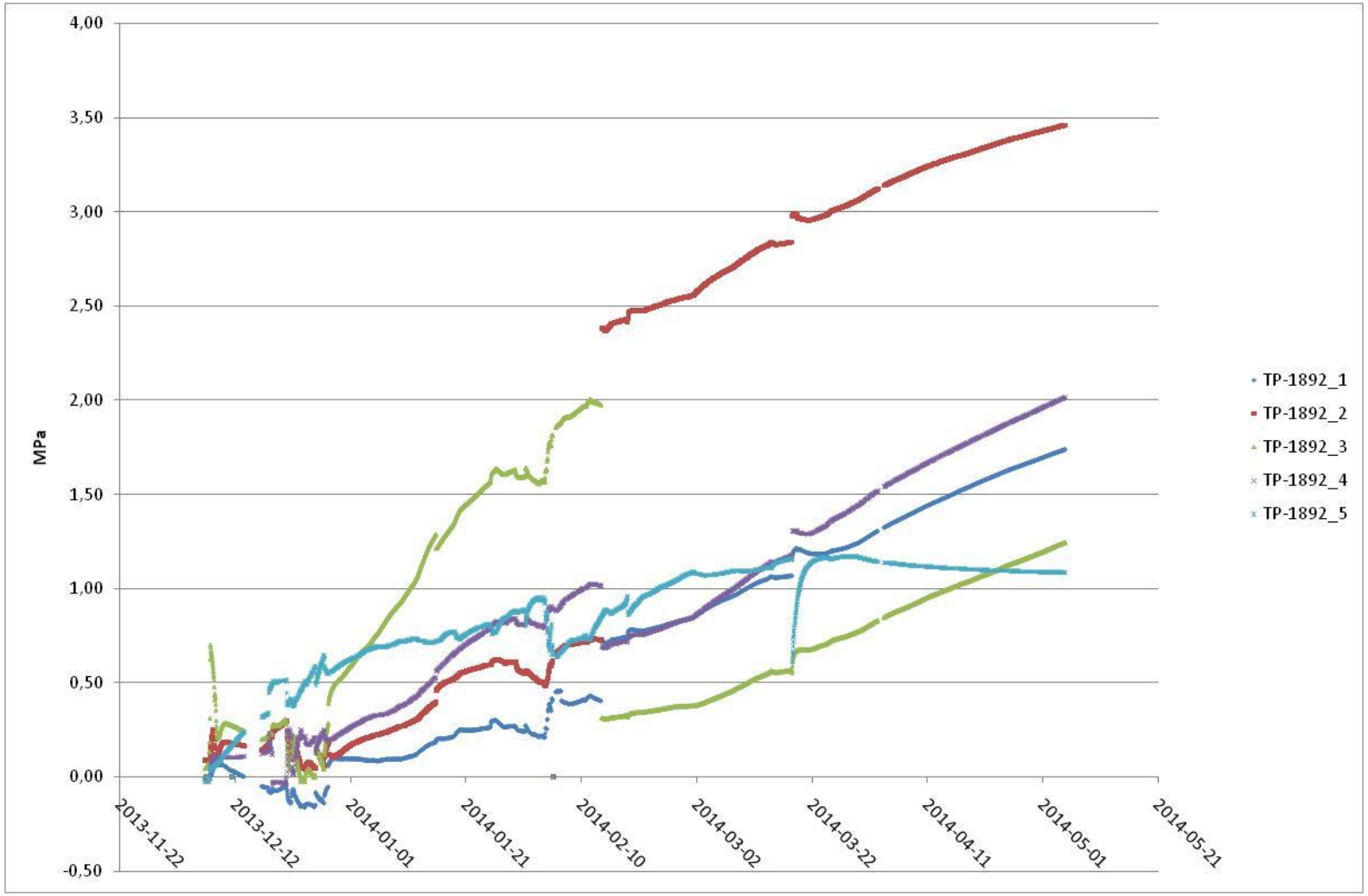


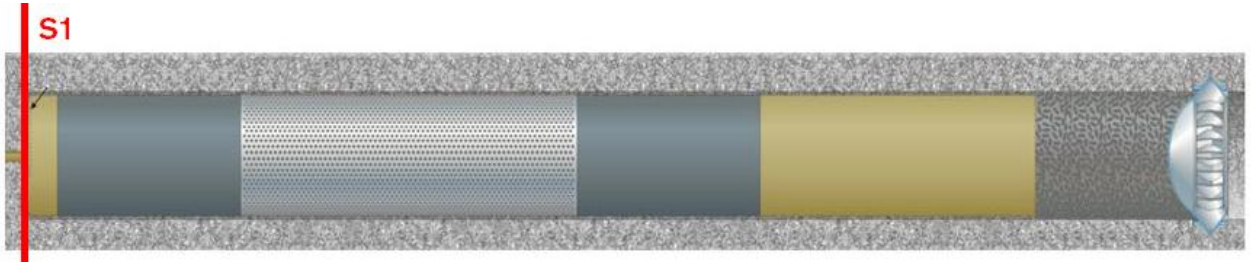




Total pressure on rock, drift front







WP 4 Deliverables and schedule

- Two deliverables have been technically reviewed and updated, SKB quality review is initiated(control of technical review process)
  - *P-14-07 KBS-3H D 4.1. Manufacturing of buffer and filling components for the Multi Purpose Test*
  - P*-14-08 KBS-3H D 4.2. Deposition machine upgrades during the Multi Purpose Test*
- Next deliverable to be done during 2014, P*-14-xx KBS-3H D 4.3. Preparations, assembly, installation and initial monitoring of the Multi Purpose Test*
- Schedule: Monitoring, data assessement and reporting to be continued during 2014.

End of presentation

Any questions?

DAWE (Drainage, Artificial Watering and air Evacuation) selected as KBS-3H reference design

- Reference design selected to define the way forward for KBS-3H:
  - Basis for technical development, planning, safety analysis, radiation protection and work on environmental influence.
- **Drainage:** inclination of drift ensures drainage of inflowing water
- **Artificial Watering:** short pipes through the plugs are used to artificially fill the compartments with water, effectively ensuring quick initial swelling of the buffer.
- **Air Evacuation:** the air is evacuated during water filling

KBS-3H geometrical requirements on the deposition drift

Issue	Requirement	Justification
Length	< 300m	The repository layout shall be similar to KBS-3V. The length is considered to be feasible from a construction and operational point of view. However, optimisation of this length will be necessary after the KBS-3H technology has been demonstrated.
Diameter	1,850 + 5 mm	The drift diameter is based upon operational as well as thermal heat flow and buffer density considerations.
Inclination	2º ± 1º	A positive inclination is a prerequisite for water drainage.
Deviation of pilot hole	< 2m from the nominal position at a distance of 300 m	A minimum distance between the drifts of 36 m has been adopted in thermal dimensioning of the repository layout for the 40 m layout alternative, see Section 7.1.
Diameter variation	≤10mm	The void outside the supercontainer must be kept within these tolerances to ensure acceptable buffer density and swelling pressure after saturation
Steps	≤ 5mm	Full-scale laboratory tests have verified that the emplacement equipment can move properly in the drift for steps of up to 5mm.
Roughness	≤ 5mm	Full-scale laboratory tests have verified that the emplacement equipment functions properly for a roughness up to 5mm.
Straightness (waviness or deviation from the centre line	± 10 mm over a length of 6000 mm	The centre line deviation must be kept within small tolerances to prevent the supercontainer from contacting the rock surface during transport in the drift.

Reference buffer material

Design parameter	Nominal design [wt-%]	Accepted variation [wt-%]
Montmorillonite content	80-85	75-90
Sulphide content	Limited	< 0.5
Total sulphur content (including the sulphide)	Limited	< 1
Organic carbon	Limited	< 1

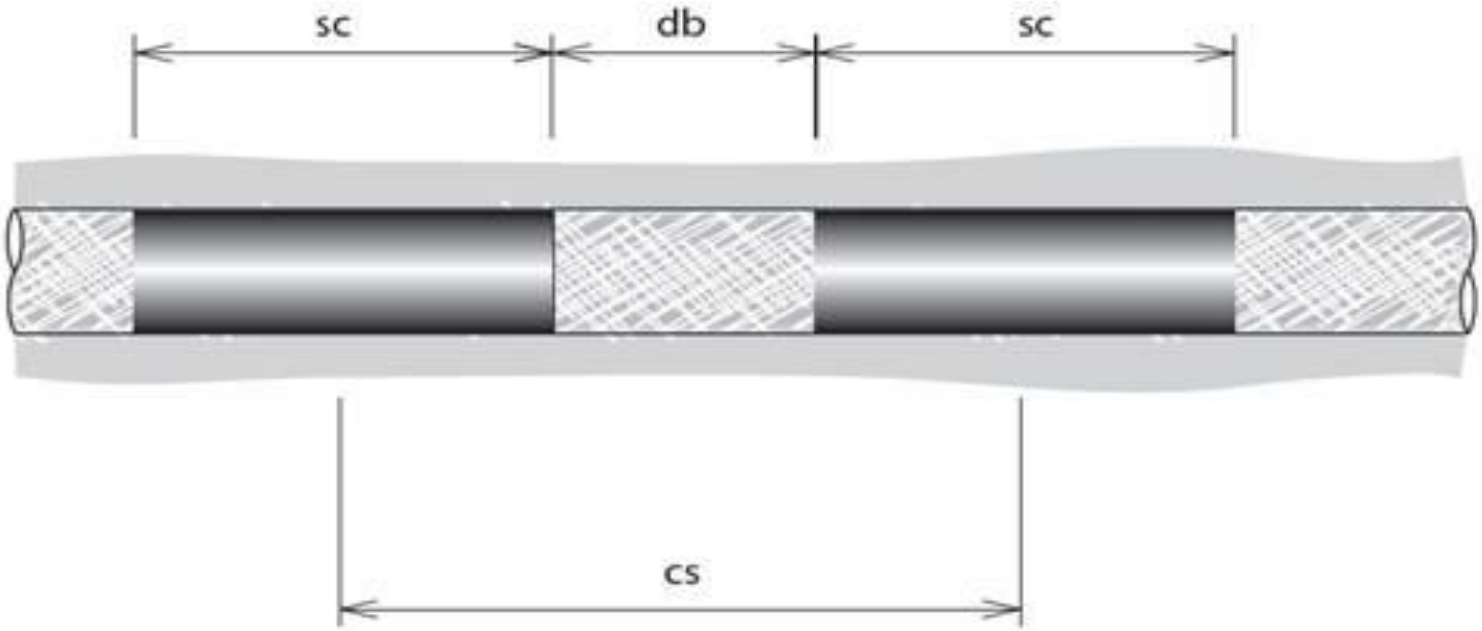
Reference buffer blocks inside the supercontainer

Design parameter	Nominal design	Accepted variation
Solid bocks inside the supercontainer		
Dry density (kg/m^3)	1,753	±20
Water content (%)	10	±1
Dimensions (mm)	Height: 350 Outer diameter: 1,740	±1
Ring shaped blocks inside the supercontainer		
Dry density	1,885	±20
Water content (%)	11	±1
Dimensions (mm)	Height: 1,211 Outer diameter Ti: 1,744 (Outer diameter other metals: 1,740) Inner diameter: 1,058	±1

Reference buffer block outside the supercontainer (distance blocks).

Design parameter	Nominal design	Accepted variation
Solid blocks outside the supercontainer (distance blocks)		
Dry density (kg/m^3)	1,712	±20
Water content (%)	21	±1
Dimensions (mm)	Height: 500 Outer diameter: 1,765	±1

Distance block length, Olkiluoto



	Canister spacing *cs* (m)	Distance block *db* (m)
LO 1 & 2	7,2	2,875
OL 1 & 2	9,0	3,475
OL 3	10,6	4,625

Distance block length Forsmark

	2.9 W/mK	3.57 W/mK
40 m	7.9 [1)]	6.5 [2)]
30 m	8.6 [3)]	7.2 [4)]

1) This canister spacing corresponds to a **distance block with a length of 2.34 m**

2) This canister spacing corresponds to a **distance block with a length of 0.94 m**

3) This canister spacing corresponds to a **distance block with a length of 3.04 m**

4) This canister spacing corresponds to a **distance block with a length of 1.64 m**

A summary of four different canister spacings and corresponding distance block lengths for Swedish spent fuel canisters with respect to deposition drift spacing and thermal conductivity of bedrock.

MPT Illustrations