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WP3 - PRELIMINARY TEST OF FORCED CASING DIGGING

CONTENTS

1. Purpose

This document gives the results of the excavation test for the HAT1601 cell head insert, which was performed in ANDRA's underground laboratory from 14-16 June 2011. This test was part of Phase 2 of the "HLW cells" Programme Unit.

2. Summary of test objectives

In the current design, the HLW cell head has a metal sleeve (called the "insert"). During disposal-cell operations, the insert houses a connecting sleeve with a thermal expansion joint which provides continuity between the disposal-package sliding track and the useful part of the cell.

A device for opening and closing the cell is fitted onto the insert at the drift end. With regard to assembling the fixed frame of the shutter (or the seat of the operating plug) onto the cell head, some of the solutions that are being considered rely on a mechanical connection onto the insert. These solutions depend on the suitability of the insert, and its coupling with the ground, to take up the forces (masses and torques) inherent to these assembly modes and to the operating modes of the two systems (shutter or operating plug).

The objectives of the "insert" technology test are the following:

a) Demonstrate the feasibility of driving in a metal cell-head insert over a length of 10 m;

b) Testing the ability of the insert to take up various types of force (tension, bending and torsion) for at least 6 months after insertion into the rock.

This document only covers point a).

3. Test configuration

3.1 Drilling-equipment characteristics

The system was comprised of the following sub-assemblies:

- A directional drilling machine,
- A mucking screw that rotates in a pipe, to carry spoil away from the drill head,
- A driving system, located in the work drift,
- An electro-hydraulic generator to power the system,
- An active management and guidance system for the drilling machine,
- A control panel.

All the drilling equipment was essentially the same as that used during phases 1 and 1b, with just a few modifications (mainly to the cutting wheel) which were needed for excavating a larger diameter.

Drilling and spoil-removal operated without fluid.

Rotational torque was transmitted to the head via the mucking screw, avoiding the need for a drive unit at the front of the machine.

Figure 1 is a schematic diagram of the drilling machine inside the initial sleeve inserted into the rock.

The cutting wheel had three arms fitted with self-sharpening bits and blades. The tooling at the extremities was fitted onto pivoting plates so that the drill head could be removed by reversing the rotation from the drilling direction. The excavation diameter was 791 mm.

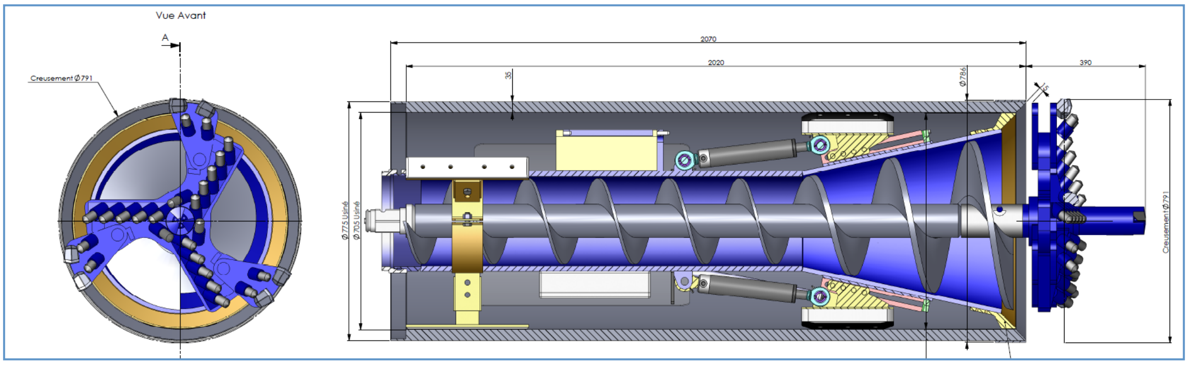

Figure 1 Drilling machine schematic diagram

The drill head had a tapered screw-section extension which provided a mechanical connection with the mucking screw to ensure both drive and spoil removal.

This active part of the drill head was housed in a conical structure which had three functions:

- Guiding and stabilising the drill head thanks to a thickened, reinforced, precision-ground screw flight,
- Providing continuity of spoil transfer to the mucking screw,
- Providing, via the conical shape of the pipe, a bearing surface for the guide pads to direct the drill head.

A flexible metal protection barrier prevented significant penetration of spoil via the annular space between the front end of the cone and the inner wall of the sleeve.

At the back of the cone, four hydraulic jacks fitted with pads that bore onto a slider were used to adjust the position of the drill head axis with respect to the borehole axis.

Spoil removal was provided by a 280 mm diameter auger that rotated inside a 323.9 mm external-diameter steel pipe. This removal system was centred on the drilling axis.

3.2 Insert sleeve-section characteristics

The sleeve sections that comprise the insert were made from rolled, longitudinal-welded, S235 steel sheets. The dimensions of each sleeve are as follows:

- outside diameter: 775 mm (i.e. giving an 8 mm annular space);
- thickness: 35 mm;
- useful length: 2 m.

The insert was driven into the cell as excavation progresses. The sleeve sections were welded together.

3.3 Location of cell HAT1601 and instrumentation used

The insert test was performed in the GAN drift at the junction initially planned for excavation of a 40 m long cell. The cell, referred to as HAT1601, is directed along the major horizontal stress (N155°E) and it is specified that it be slightly rising (1°).

Two peripheral boreholes (ALC1614 and ALC1615) for measuring interstitial pressure were drilled in February 2010 (see Figure 2). Each borehole is fitted with a hydrogeology multi-packer system (with 3 chambers for borehole ALC1614 and 5 chambers for borehole ALC1615). The distance from each chamber to the drift wall is specified in Figure 2. The dimensions and directions of the boreholes are as follows:

- ALC1614 → ∅ = 76 mm, length = 30 m, direction: N159°E and 4.5° rising,
- ALC1615 → ∅ = 76 mm, length = 30 m, direction: N155°E and 8° rising.

The distances from borehole ALC1615's first two measurement chambers to the wall of cell HAT1601 are 1 m and 1.4 m respectively.

In addition to these peripheral measurements, a 3D scan of the insert was performed after excavation.

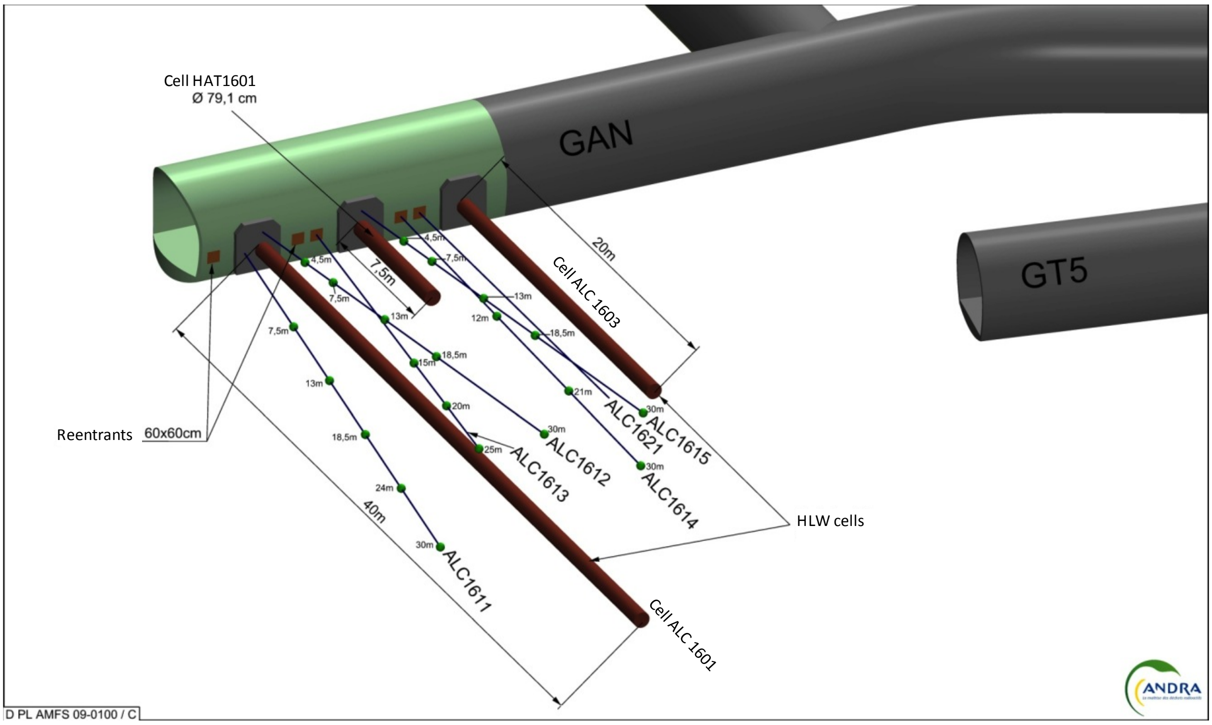

Figure 2 *Position of cell HAT1601 and the peripheral boreholes*

4. Excavation operations

Excavation began on the 14 June 2011. Figure 3 shows the first sleeve, with the drilling machine inside, positioned on the driving station just before excavation began. Excavation was halted on the 16 June 2011 as the insert was jammed in the rock. A total of four sleeve sections had been inserted, i.e. 8 m distributed as follows:

- 7.13 m in the rock itself,
- 25 cm in the junction concrete,
- 62 cm outside the rock, jutting into the drift.

The cutting face was 30 cm ahead of sleeve section 1.

Daily site reports are summarised in Appendix 1.

Figure 3 *Sleeve section 1 positioned on the driving station*

Figure 4 shows the end of sleeve section 4, jutting out 62 cm into the drift. This length should mean that it is possible to perform the mechanical loading tests planned for later.

Figure 4 *The end of sleeve section 4 at the end of excavation*

At the end of drilling, the thrust applied to sleeve section 4 had reached 1,350 kN. After a 5 hour pause[1], sleeve section 5 could not be inserted into the rock as the (1,600 kN) thrust limit of the drilling equipment had been reached. The curves in Figure 5 show the changes in total thrust applied onto the sleeve sections, and the thrust and torque applied at the cutting wheel, as a function of excavation progress. Note that the thrust on the insert started to increase rapidly from sleeve section 3 onwards. The mean drilling speed was 20 mm/minute with acceptable point speeds of around 35-40 mm/minute.

[1] Time required to install and weld sleeve section 5.

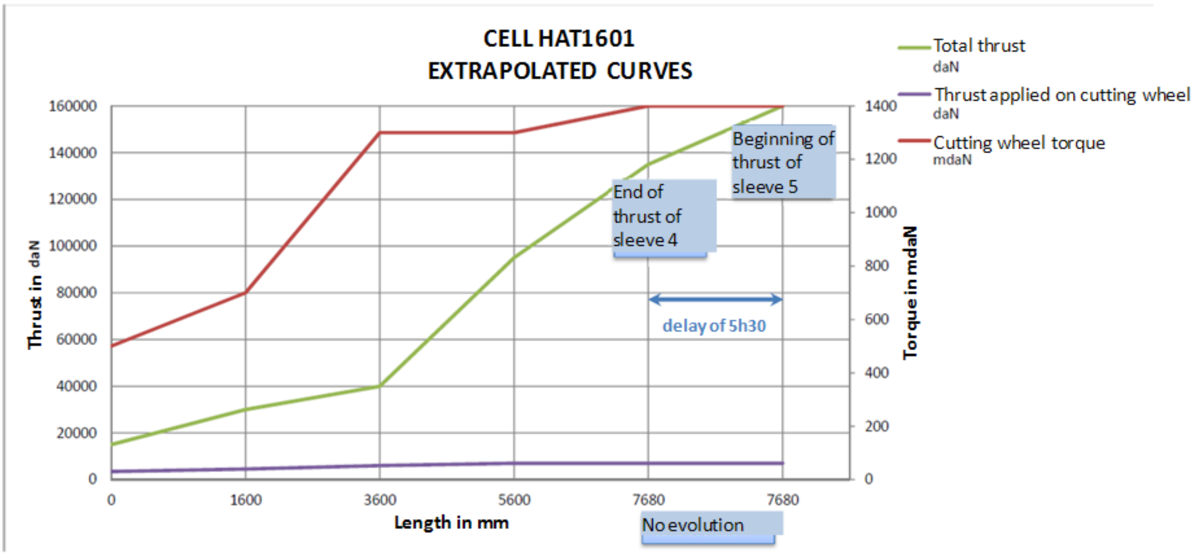

Figure 5 *Changes in the various forces applied as a function of excavation progress*

It should be noted that decimetre-sized argillite blocks with a thickness of 20-40 mm quickly appeared in the removed spoil.

5. Hydro-mechanical impact of insert excavation

Given the length of cell HAT1601, only two chambers of borehole ALC1615 (located in the vertical plane above the cell) measured an excavation impact, which caused a sudden drop in hydraulic pressure (see Figure 6).

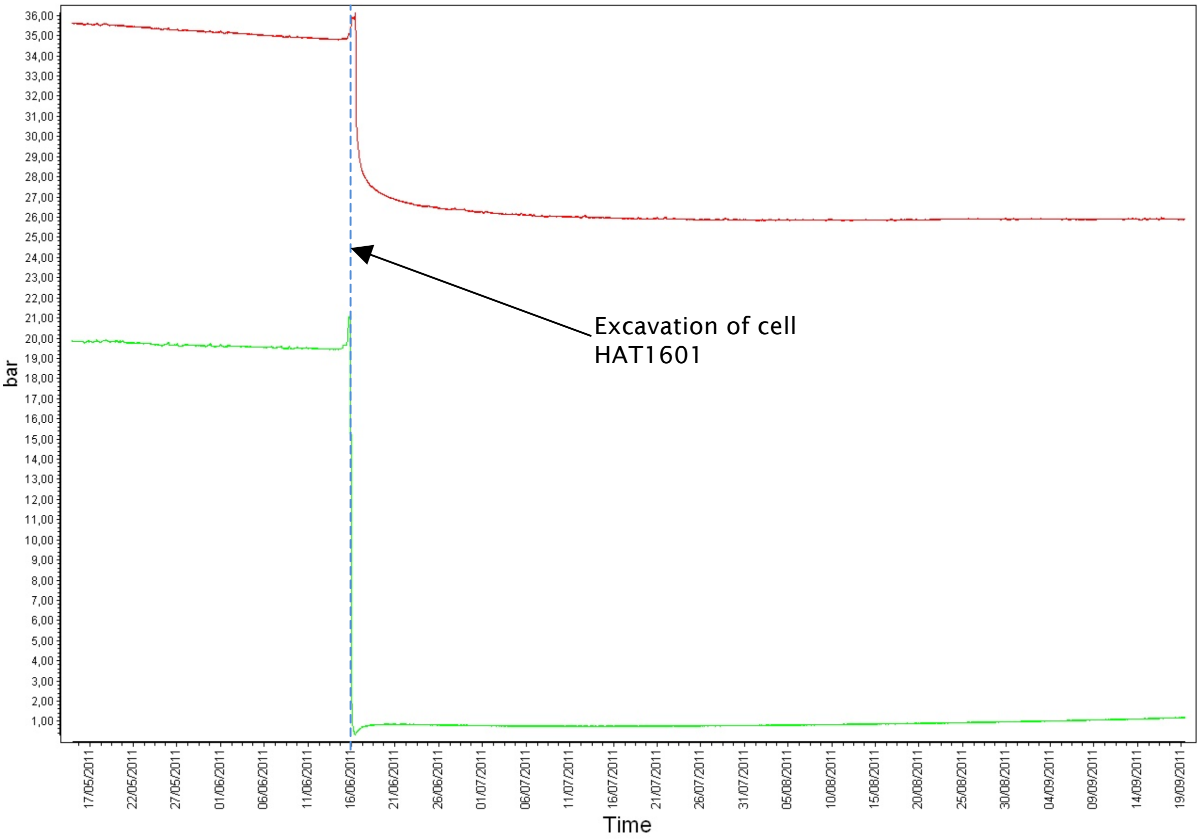

Figure 6 *Influence of cell HAT1601 excavation on the interstitial pressure in borehole ALC1615: chambers at 4.5 m from the drift (green) and 7.5 m (red)*

For comparison, Figure 7 shows the changes in the interstitial pressure measured in phase 1b in borehole ALC1612 during excavation of 40m-long sleeved cell ALC1601. The relative positions of the measurement chambers with respect to the cell were identical in both cases.

The pressure in the chamber 4.5 m from the drift (i.e. 1 m from the theoretical position of the cell's wall) dropped to atmospheric pressure. This result is identical to that obtained in phase 1b, during excavation of cell ALC1601 (see Figure 7).

The chamber located 7.5 m from the drift (i.e. 1.4 m from the theoretical position of the wall of cell HAT1601) detected a pressure drop of approximately 9 bar. It should be remembered that the length of cell HAT1601 is only 7.5 m, which explains that difference with the loss of hydraulic pressure measured at the same relative position during excavation of cell ALC1601 (27 bar, see Figure 7).

In all cases, the pressure drop was preceded by a slight overpressure of approximately 1.5 bar.

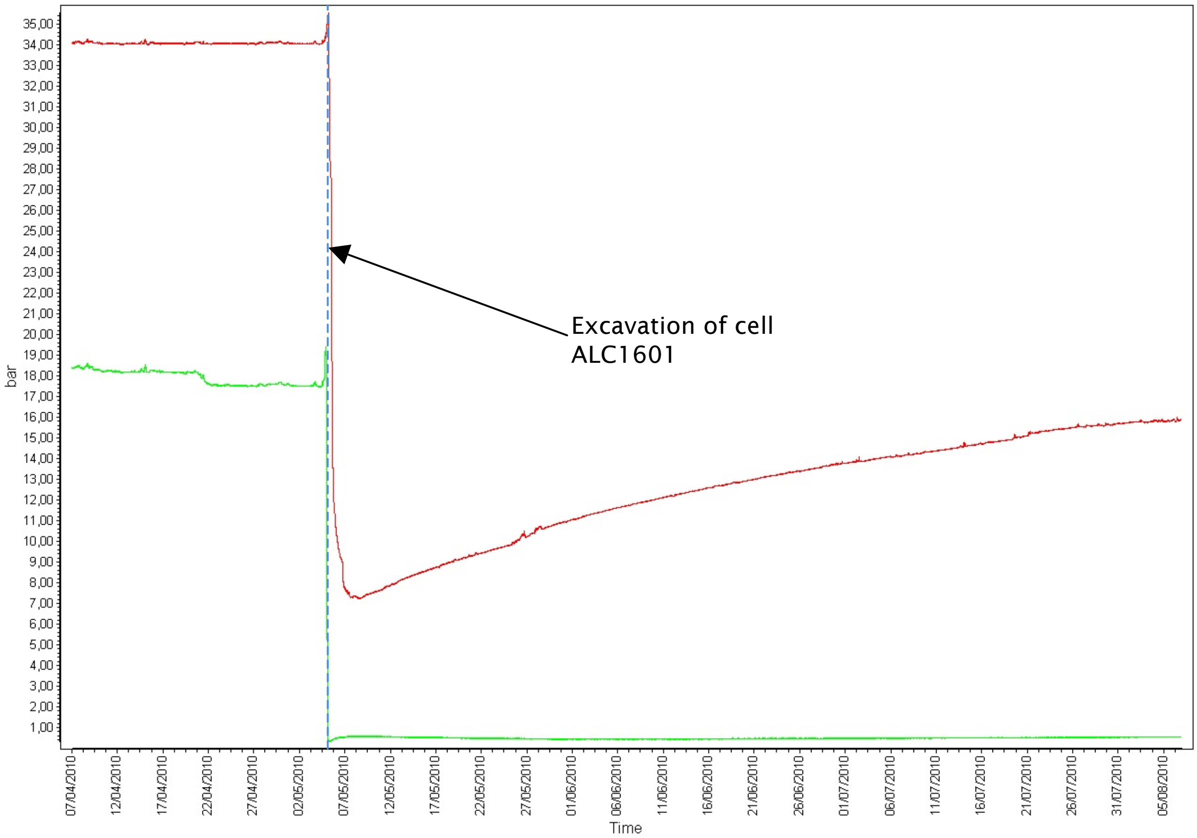

Figure 7 *Influence of cell ALC1601 excavation on the interstitial pressure in borehole ALC1612: chambers at 4.5 m from the drift (green) and 7.5 m (red)*

6. 3D scan of the insert

A 3D scan was performed on 4 July 2011 inside the insert installed in cell HAT1601 (see Figure 8). The exact incline of the cell is +0.63° and its overall deviation in the horizontal plane is less than 10 cm. These results comply with the specifications (vertical and horizontal deviations less than 1°).

Figure 9 shows the deviations for each sleeve section of the insert, in both horizontal and vertical planes. The deviation is defined as the discrepancy at the real axis of the insert (the axis passing through the centre of the near end of sleeve section 4 and that of the far end of sleeve section 1).

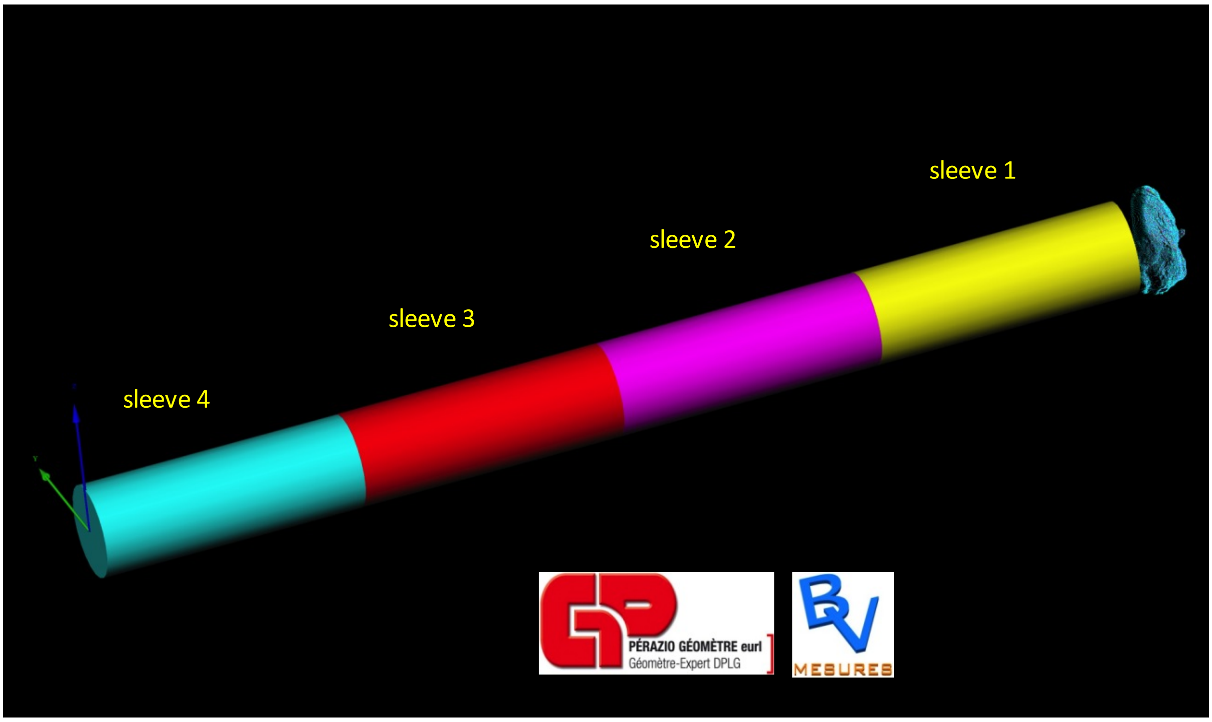

Figure 8 *3D scan of the inside of the insert – sleeve section 1 is the first sleeve section driven into the rock*

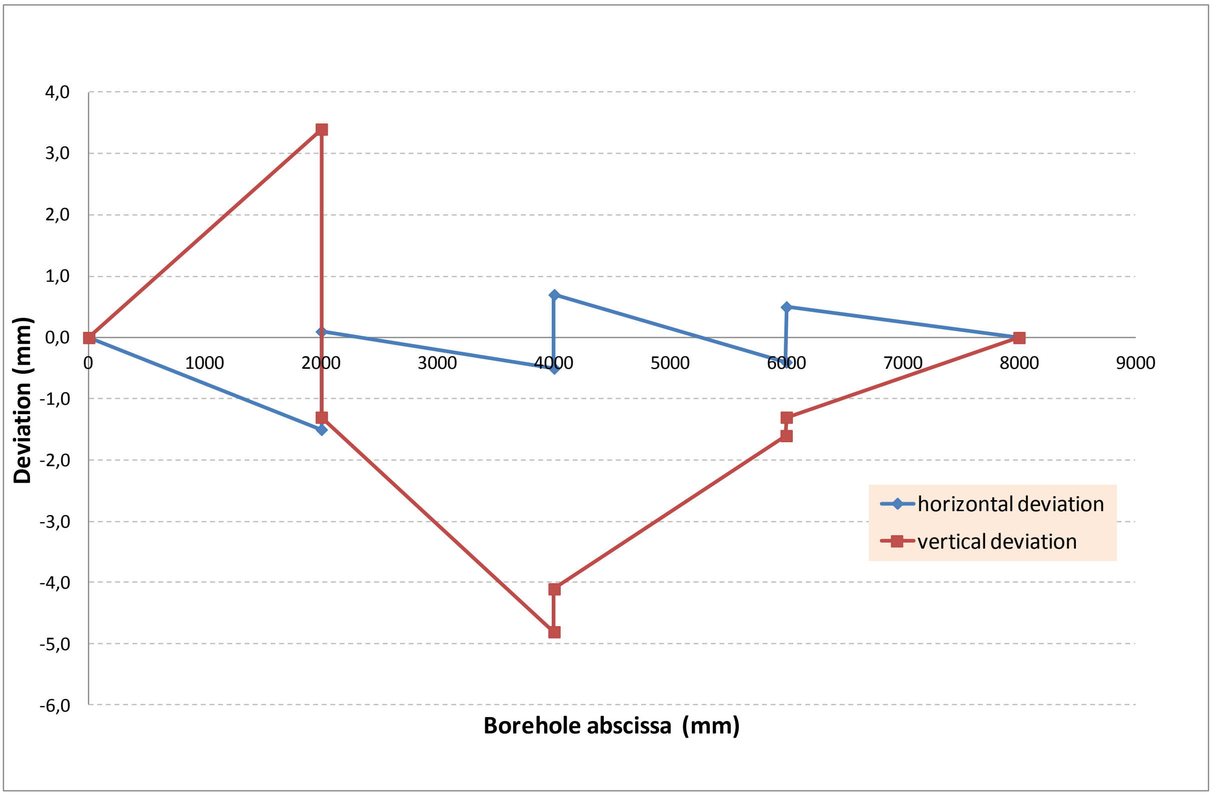

Figure 9 *Horizontal and vertical deviations for each sleeve section of the insert*

7. Conclusion

The result of the insert test (jamming after 7.5 m for an initial 8 mm annular space) means that the dimensions can be specified for the cell that will be excavated in Phase 3 of the “HLW cells” Programme Unit (heated cell). To minimise the risk of the insert jamming, the length of the cell head has been set at 6 m, with an annular space of between 10 and 12 mm. Figure 10 shows the planned design.

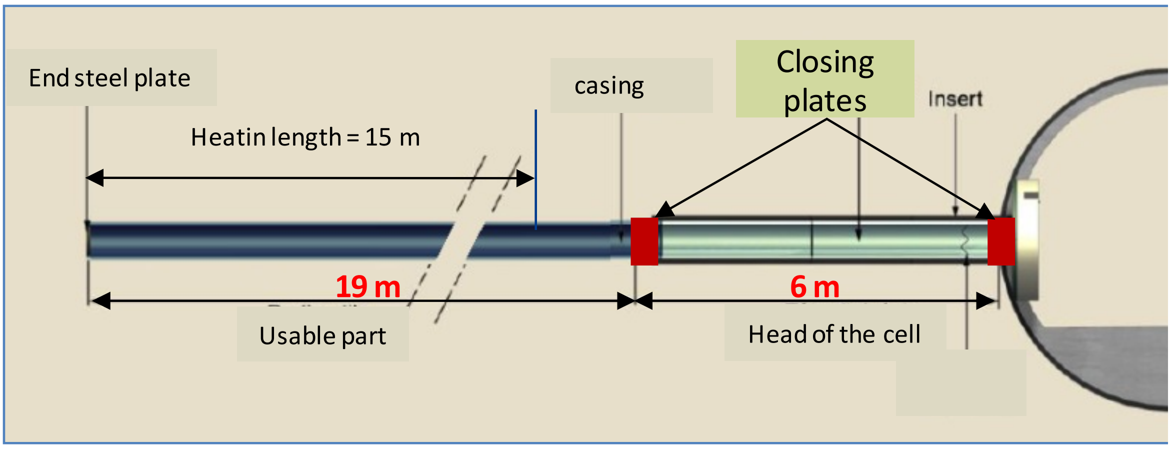

Figure 10 Dimensions of the cell for Phase 3 of the “HLW cells” Programme Unit