

# The heating system for the PRACLAY Experiment

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Exchange Meeting  
25 November 2010



# Outline

- Introduction
- Design
- Testing
- Installation
- Conclusions

# Aim

- Heat experimental part of PRACLAY gallery ...
- ... following the defined heating strategy
  - C<sup>te</sup> temperature: 80°C at gallery extrados
  - Progressive heating: 16°C → 80°C
  - During 10 years

## Define requirements of the heating system

- EURIDICE
- NRG (type of heater & general aspects)

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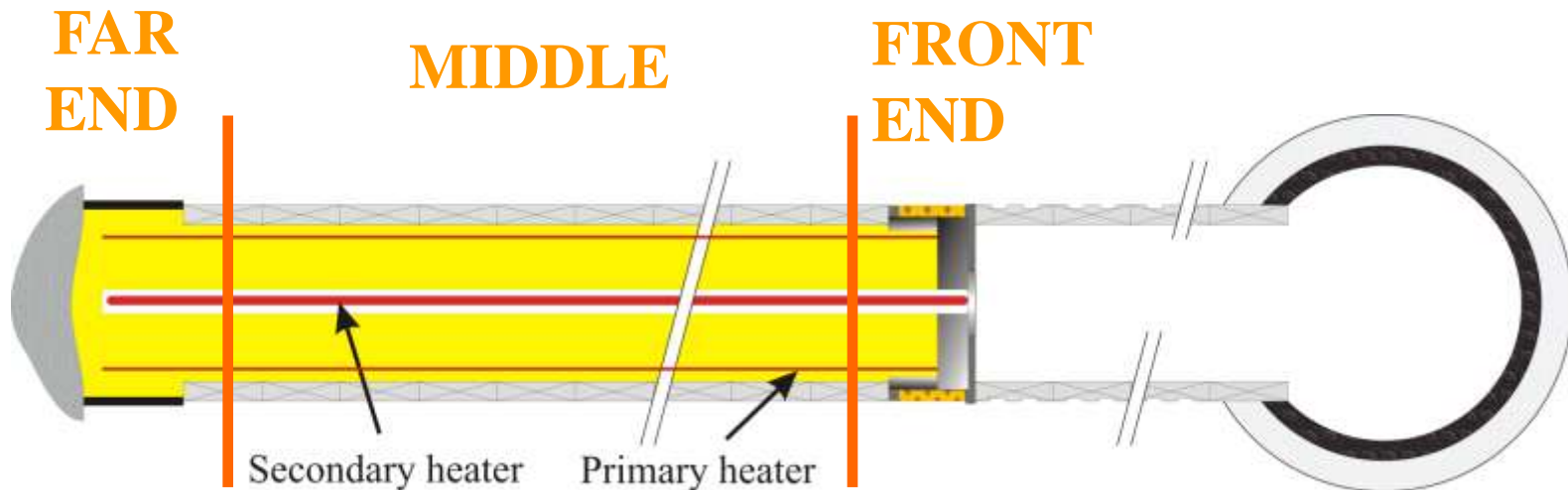
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# Three sections

- Front and far end sections to limit side effects
- Each section is to be controlled separately
- Middle section is the representative part
- Maximise the length of the middle section

## Primary and secondary heating systems



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# Main design requirements for the **heater** fixed by experimental conditions

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- water saturated (up to 35 bar) and hot
- mechanically robust & corrosion resistant
- life cycle overall system > 10 years
- heater at 10 cm from the lining intrados
  - protect concrete lining and instrument cables
- install with 100 % redundancy
- limit number of feed-throughs
- loops parallel to the gallery axis

# Main requirements **control system**

## During start-up

1. Temperature cables  $< 200^{\circ}\text{C}$
2. Max gradient concrete:  $15^{\circ}\text{C}$
3. Temperature difference in middle section:  $< 7^{\circ}\text{C}$
4. Temperature difference total:  $< 10^{\circ}\text{C}$
5. Concrete temperature:  $< 95^{\circ}\text{C}$

## During stationary phase

1. Temperature cables  $< 200^{\circ}\text{C}$
2. Max gradient concrete :  $10^{\circ}\text{C}$
- 3a. Mean temperature middle section:  $80^{\circ}\text{C} \pm 2^{\circ}\text{C}$
- 3b. Local temperature middle section:  $80^{\circ}\text{C} \pm 3^{\circ}\text{C}$
- 4a. Mean temperature total:  $80^{\circ}\text{C} \pm 4^{\circ}\text{C}$
- 4b. Local temperature total:  $80^{\circ}\text{C} \pm 6^{\circ}\text{C}$
5. Concrete temperature:  $< 95^{\circ}\text{C}$

Be able to control secondary heater ( $C^{\text{te}}$  power)

Log heater output & generate alarms

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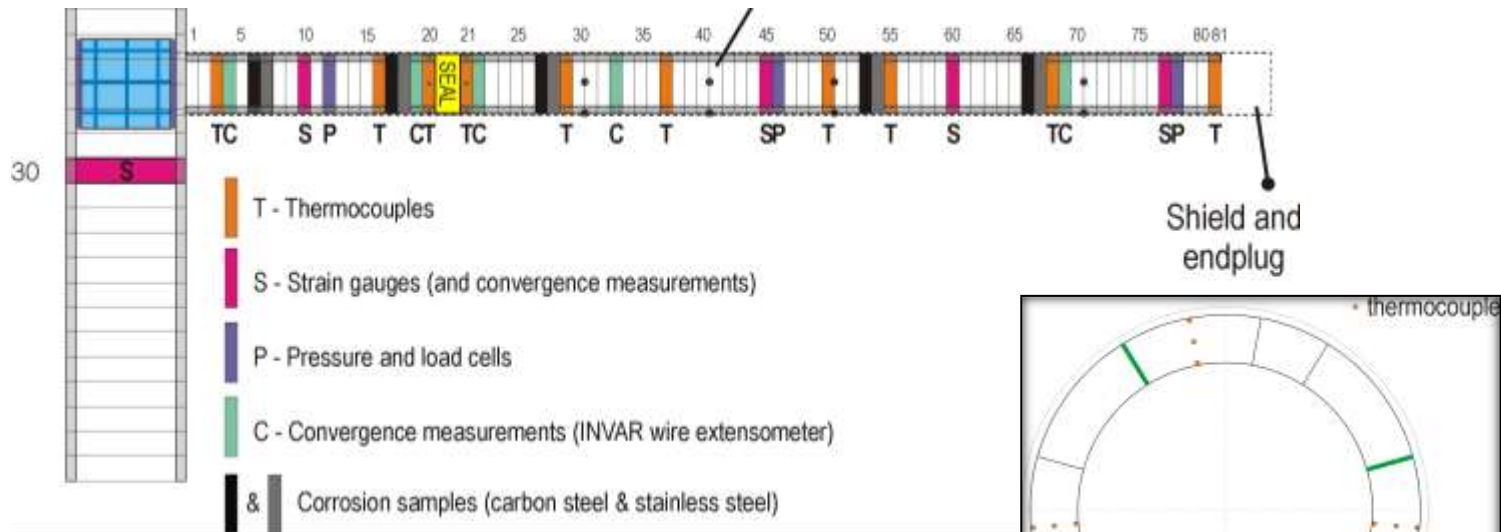
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# Input control system

- 7 lining sections inside the experiment were equipped with thermocouples
- 4 segments in each section
- 3 TC in each segment
  - Use intrados and extrados
- $7 \times 4 \times 2 = 56$  TC



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# Contract by public procurement

- Technical specification described functional requirements
  - Primary heater elements
  - Control system
- Detailed design to be performed by contractant
- Tyco Thermal Controls (Oct 2009)

Secondary heater elements: reuse ESDRED heater

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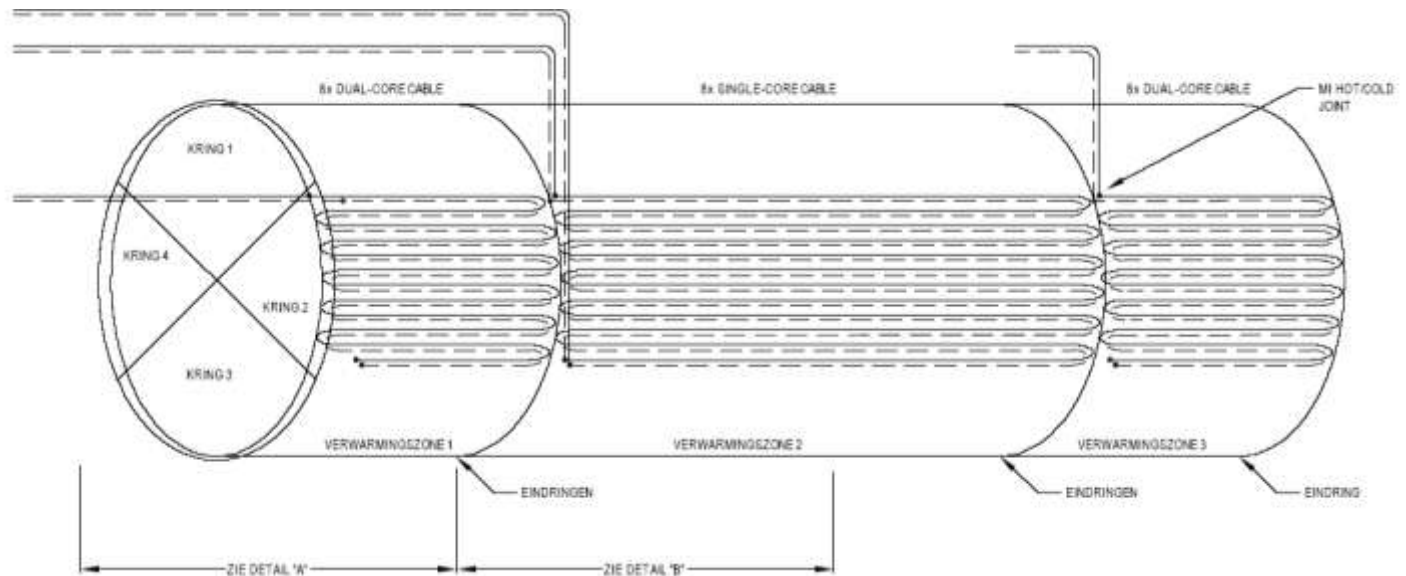
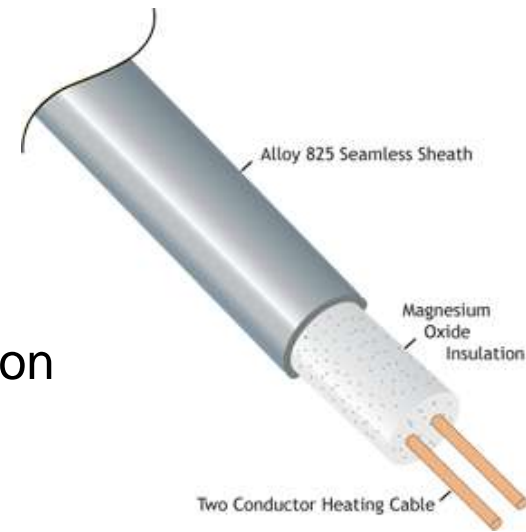
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# Design by Tyco

- Mineral Insulated elements
  - Alloy 825 (Incoloy)
  - Laser welded
- Three sections, four elements per section
  - Power controlled separately
  - 100 % redundant → 24 elements
  - Switched every 24 hours
- Fixed on stainless steel support structures, cables may not touch each other



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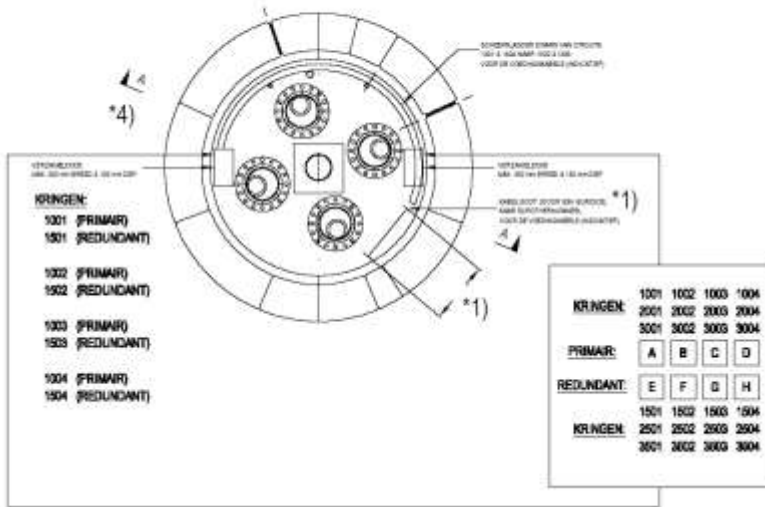
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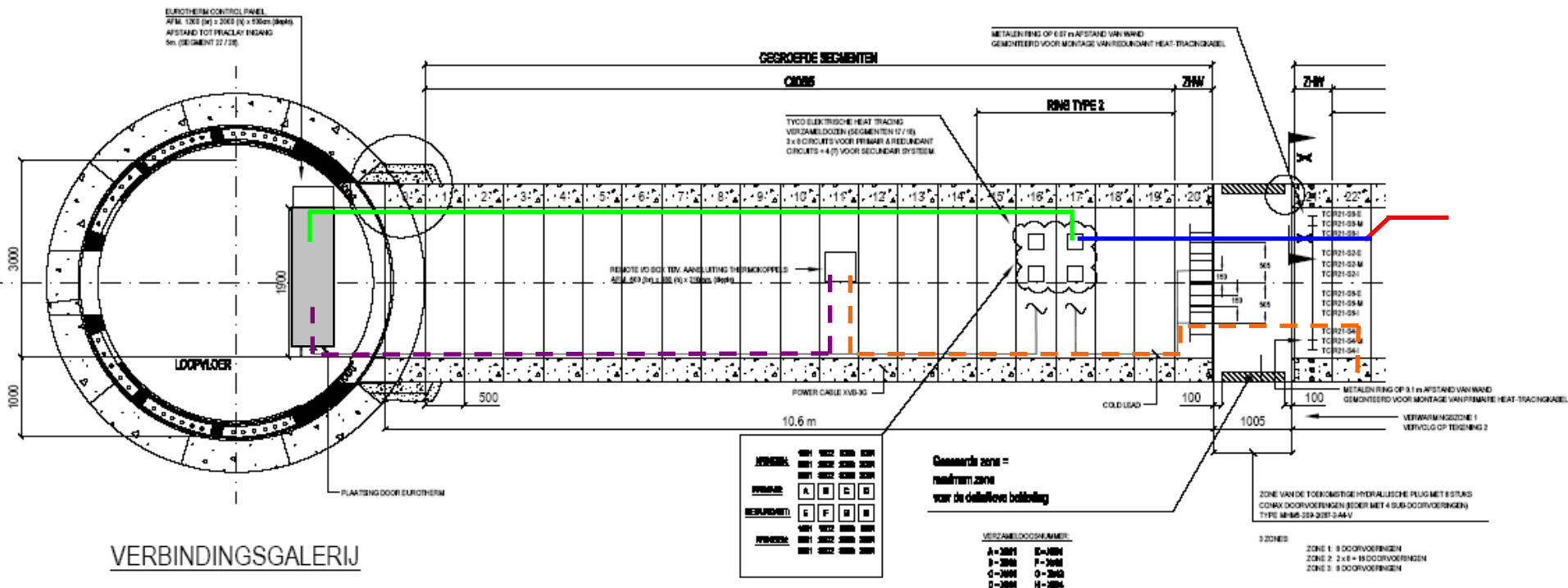
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# Heater - Setup

SCHAAL 1:25  
 INSTALLATIEDETAIL HT JUNCTION BOXES NABIJ HYDRAULISCHE SEAL

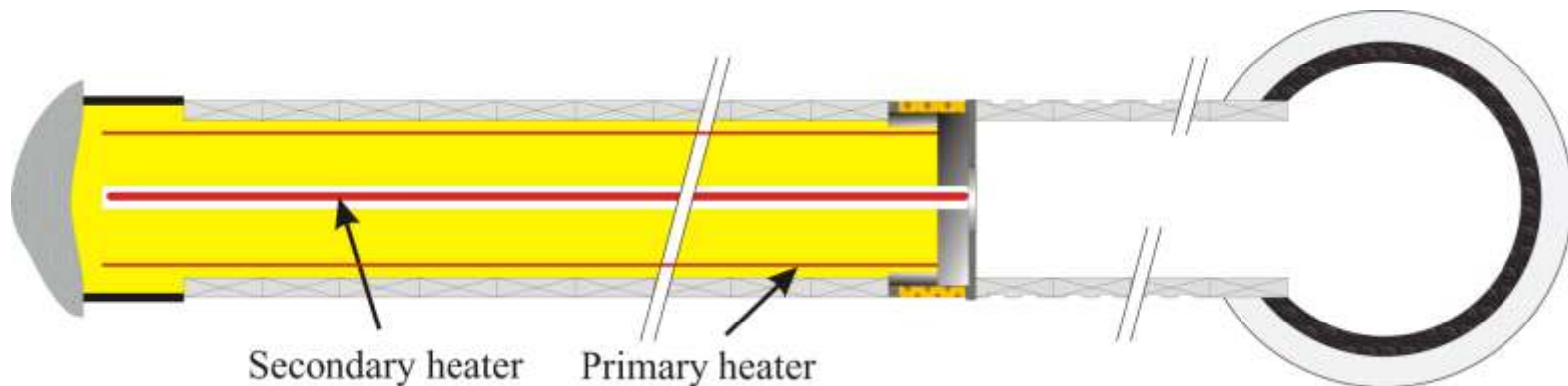


- Heater element & cold lead
- Power cable
- Thermocouple
- Data cable



# Secondary heater

- Re-use ESDRED elements
- Four MI elements
- To be installed in central tube
- Accessible at all times during experiment
- Same control system as primary
- Constant power



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# Dummy element

- Elements are guaranteed up to 30 bar but PRACLAY pressure could reach 35 bar
- Design and manufacturing process are compatible with higher pressures → test
- Stepwise increase of pressure and temperature
- Megger: determine resistance between element sheet and element core ( $> 50 \text{ M}\Omega$ )

<b>Temperature</b>	<b>Pressure</b>	<b>Result</b>
Room temperature	30 bar	$> 200 \text{ G}\Omega$
90°C	30 bar	$> 20 \text{ G}\Omega$
90°C	35 bar	$> 20 \text{ G}\Omega$
90°C	40 bar	$> 20 \text{ G}\Omega$
Room temperature	40 bar	$> 200 \text{ G}\Omega$

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# Installed elements

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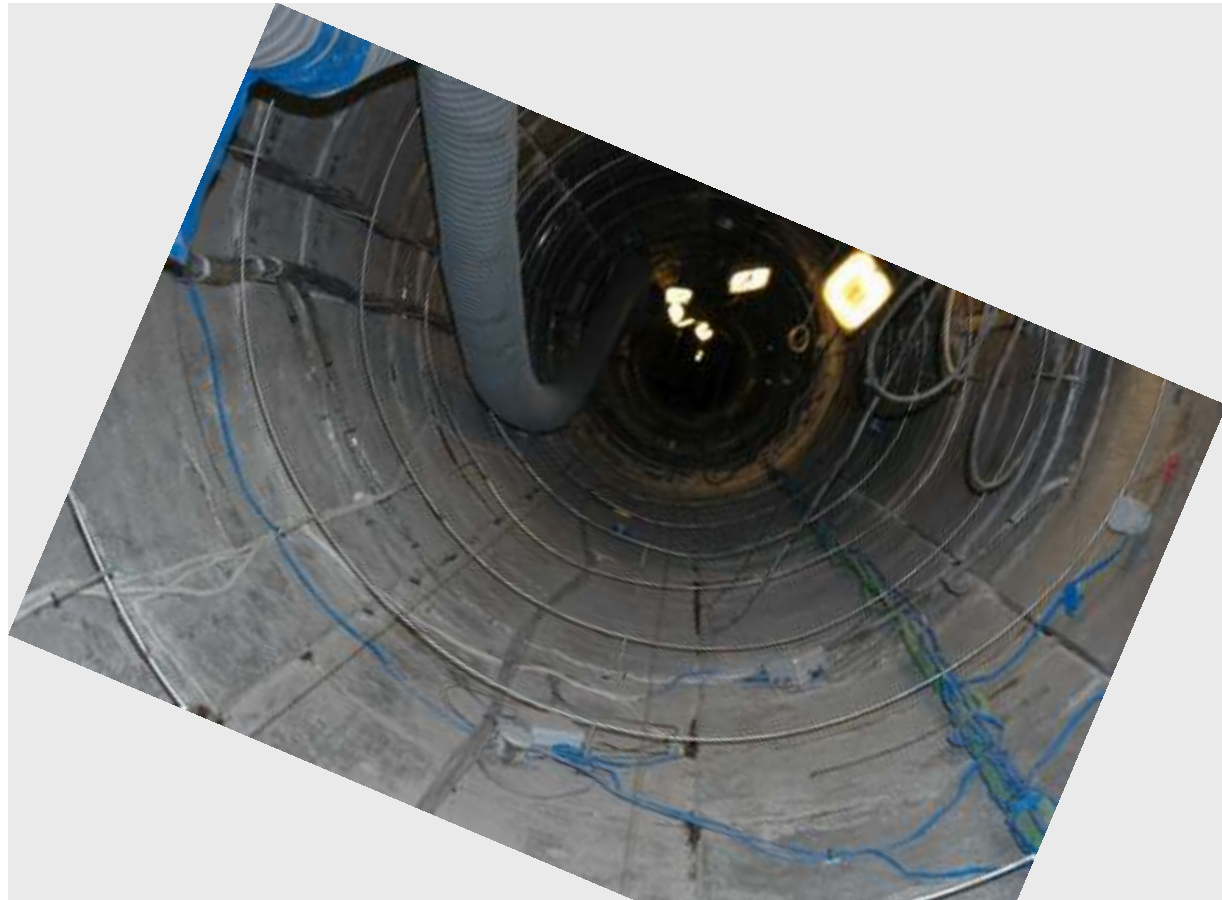
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- Testing (Megger) is performed after each step
  - After production
  - On-site
  - Before installation
  - After installation
- Elements were immersed on-site during testing to detect defects → all OK

# Support structure

- Stainless steel rings
- 10 cm distance from gallery intrados
- Spacing : 1 m



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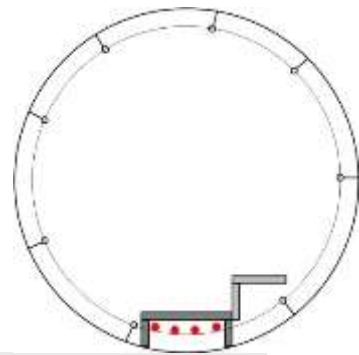
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# Heater phase 1

- Stainless steel cable ties



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# Work platform

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# Heater phase 2

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# Heater connections

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# Control panel

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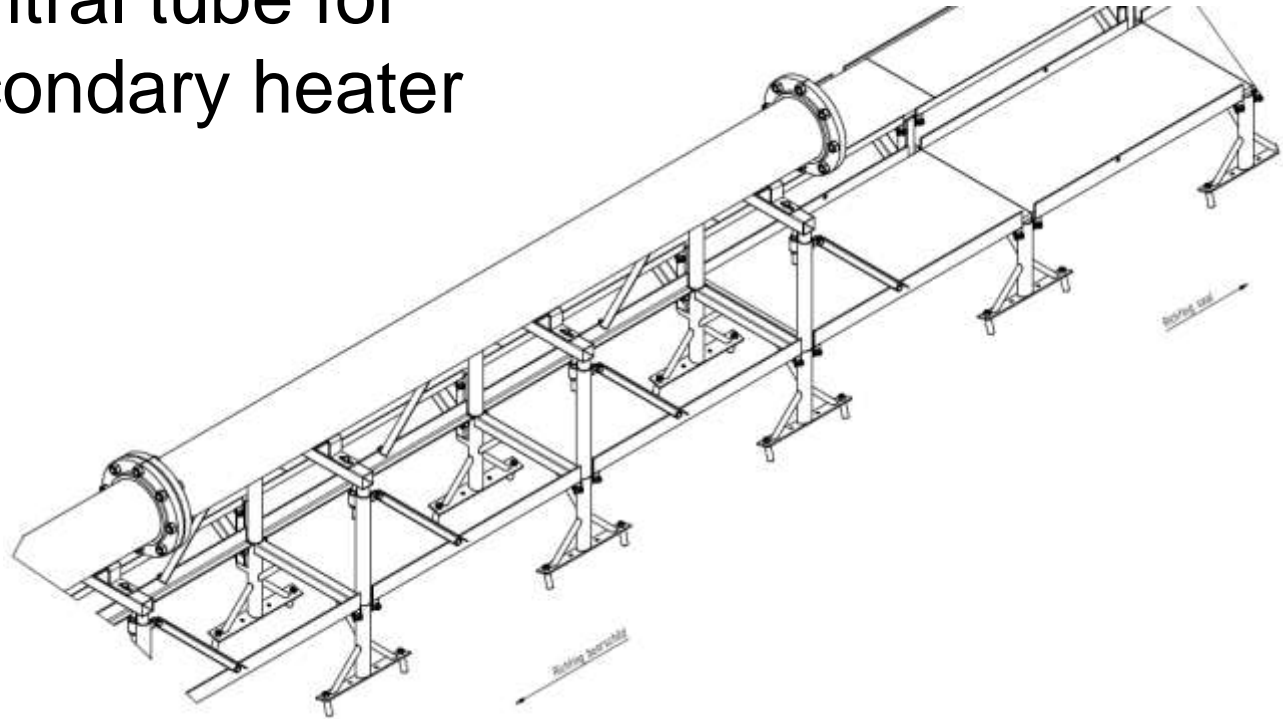
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# Central tube for secondary heater



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# Conclusions

- Primary heater installed and connected to i/o boxes according to design
- Test results on elements were satisfactory

## Future work related to the heater system

- Install control system
- In-situ testing
  - Heater elements
  - Connections
  - Control system
- Install thermocouples on elements
- Install secondary heater
- Switch-on

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Questions?

