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This Project has received funding from the European Union's European Atomic Energy Community's (Euratom) FP7 under grant agreement n°269905, the LUCOEX project.

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DELIVERABLE (D-N°:D2:04)

WP2 - Full-Scale Emplacement (FE) Experiment

Report on the Construction, Testing and Commissioning of the Emplacement Equipment

Author(s):
Heinz Jenni (Rowa Tunnelling Logistics AG, Wangen (SZ), Switzerland
Sven Köhler (Nagra, Wettingen, Switzerland)

Issue date of this report: **13.05.2015**

Start date of project: 01.01.11 End of project: September 2015

Project co-funded by the European Commission under the Seventh Euratom Framework Programme for Nuclear Research &Training Activities (2007-2011)		
Dissemination Level		
PU	Public	PU
RE	Restricted to a group specified by the partners of the LUCOEX	
CO	Confidential, only for partners of the LUCOEX project	

EURATOM

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1. Glossary

Term	Meaning
FE Experiment	Full-Scale Emplacement Experiment
GBM	Granulated bentonite mixture
Heater	Test container with heater unit
LUCOEX	Large Underground COncept EXperiments
Mock-up test	Test of the backfilling machine in a 1:1-scale tunnel model
Nagra	National Cooperative for the Disposal of Radioactive Waste

2. Abstract

The Full-Scale Emplacement (FE) Experiment at the Mont Terri Rock Laboratory is a full-scale heater test in a clay-rich formation. It simulates the construction, waste emplacement and backfilling of a spent fuel (SF) / vitrified high-level waste (HLW) repository tunnel.

One of the aims of the FE Experiment is the investigation of backfilling procedures for underground conditions. This is also Nagra’s participation in the EC co-funded 'Large Underground COncept EXperiments' (LUCOEX) project.

Based on the experience from the Engineered Barrier ("EB") experiment (Kennedy & Plötze, 2003) and the ESDRED project (Plötze & Weber, 2007), a new prototype backfilling machine with five horizontal auger conveyors was developed for the FE Experiment (see Figure 1).

This prototype was used to backfill a horizontal tunnel with a diameter of 2.5-3 m with dry granulated bentonite mixture (GBM) as tightly as possible. According to the Swiss high-level waste disposal concept, this material had to be backfilled with an overall bulk dry density of at least 1,450 kg/m^3.

The GBM was delivered to the prototype machine in big bags.

After emptying the big bags into a hopper, the prototype machine transported, emplaced and compressed the GBM into the tunnel using five auger conveyors simultaneously.

Figure 1 *The prototype machine with five auger conveyors (seen on the left side) developed for backfilling the horizontal FE tunnel with granulated bentonite mixture as tightly as possible. The longest auger is 8.5 m long, bringing the machine length with the big bag transport trolley to 17 m in total*

During the backfilling procedure, the augers were filled up (see Figure 2, left) and remained in the GBM slope in order to build up a backfilling pressure. This pressure pushed the material up to 70 cm upwards after leaving the augers, filling gaps and overbreaks in the tunnel ceiling.

During this process, the prototype was held in place by hydraulic brakes which had to hold a force of up to approx. 32 kN.

By means of sophisticated controls, many parameters, such as the auger force, rotation speed, reaction force or braking force, and therefore the backfilling speed or bulk emplaced density, could be monitored and controlled (see Figure 2, right).

Figure 2 *The front end of one auger conveyor filled with a Fuller type granulated bentonite mixture (GBM) is shown on the left; the screw diameter is approx. 25 cm.*
The control panel for the setting of machine parameters, such as screw turning speed and brake force, is shown on the right

During several preliminary and mock-up tests (one shown in Figure 3), some of which were 1:1-scale, the prototype was extensively tested and optimised. It was transported to the test site at the Mont Terri Rock Laboratory and commissioned as planned and anticipated.

An average bulk emplaced dry density was achieved that clearly met the target dry density.

The advantage of this method is its flexibility regarding tunnel shape and obstacles (such as the containers). Together with the Fuller type GBM, which does not need special care during handling, except for keeping it dry, this method is – once developed – robust and fairly easy to use.

Figure 3 *The newly developed backfilling machine being tested in a 1:1-scale tunnel model in an offsite workshop. The 1 m diameter dummy heater can be seen in between the augers*

3. Introduction

3.1 Task formulation/project aims

In 2014, Nagra started a large-scale test (Full-Scale Emplacement [FE] Experiment) at the Mont Terri Rock Laboratory with the primary purpose of exploring the effects of the heat-producing waste on the coupled thermal/hydraulic/mechanical ("THM") long-term behaviour of the surrounding rock.

A second objective was to demonstrate the technical feasibility of the emplacement of spent fuel containers (here only test containers) and subsequent backfilling of a repository tunnel with granulated bentonite following the Nagra reference concept.

To this end, a 50-metre long test tunnel in line with the Nagra reference concept in cross-sectional geometry and essential supporting elements was excavated in the Opalinus Clay (Daneluzzi et al. 2012)

Three test containers (“heaters”) of corresponding geometry, acting as heating elements, were introduced consecutively into this tunnel, which was subsequently backfilled with granulated bentonite.

The engineering and demonstration components of the FE Experiment are part of Nagra's participation in the EC co-funded 'Large Underground COncept EXperiments' (LUCOEX) project and therefore receive funding from the European Atomic Energy Community's Seventh Framework Programme (FP7) under grant agreement no. 269905.

3.2 Main objectives of the backfilling process

The main objectives of the FE backfilling are:

- To demonstrate the technical feasibility of spent fuel/high-level waste (SF/HLW) emplacement (by means of dummy container emplacement) and subsequent backfilling of the emplacement test tunnel with granulated bentonite mixture following the Swiss reference concept for a deep geological repository.
- To achieve a realistic backfilling of granulated bentonite mixture (GBM) with respect to the reference case in order to provide realistic conditions for the THM processes and the capability for numerical modelling validation.
- To achieve a target dry density of 1.45 t/m^3 or higher for the entire bentonite backfill.
- To achieve a homogeneous composition of the backfilled GBM (avoid segregation).

3.3 Integration into the overall FE Experiment

The FE Experiment aims to cover various aspects of the emplacement of spent fuel/high-level waste (SF/HLW), such as the emplacement tunnel construction, production of bentonite-based blocks and a pellet mixture, production of heater elements simulating the shape and heat output of disposal containers for spent fuel, as well as the construction and use of prototype emplacement and backfilling equipment.

Besides this, multiple aspects concerning different monitoring and numerical modelling issues are also addressed, as shown in Fig. 4.

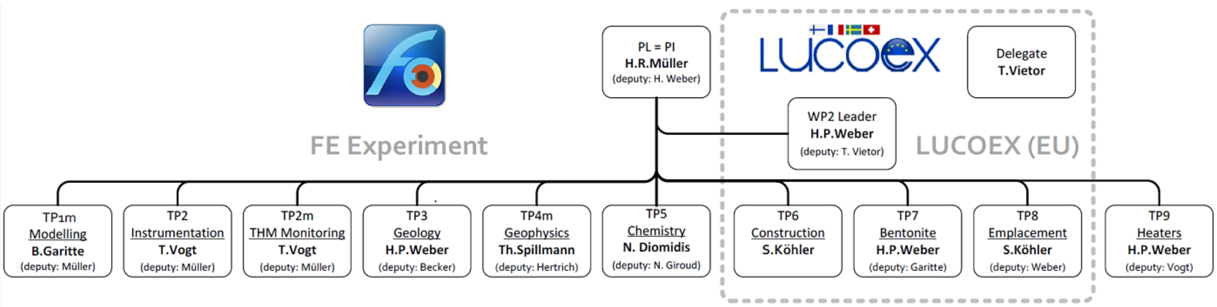

Figure 4 Organisation chart of the FE Experiment

4. Task structure

4.1 Overview of main activities

The process workflow consisted of the following main activities:

- Project start
- Coordination and approval of instrumentation and emplacement system interfaces
- Practical planning
- Design review, approval of practical planning
- Big bag test (interface)
- Detailed practical planning
- Production
- Factory assembly
- Factory test runs
- Factory acceptance test
- Building of the system and the model tunnel for mock-up test 1
- Implementation of mock-up test 1
- Adjustments and optimisations
- Implementation of mock-up test 2
- Acceptance of mock-up test
- Dismantling
- Transport
- Rail system on-site assembly
- On-site assembly, commissioning and training (crane)
- On-site assembly (ventilation and dedusting systems)
- On-site assembly, commissioning and training (feeding wagon/backfilling machine)
- Acceptance
- Commencement conditions for backfilling operation
- Emplacement and backfilling operation

The execution, production and test run planning, as well as the design of the complete emplacement and backfilling systems, including the auxiliary elements (crane, rails and ventilation), was carried out by Rowa Tunnelling Logistics AG, Leuholz 15, CH-8855 Wangen.

4.2 Composition/elements of the emplacement and backfilling systems

The emplacement system consists of the following components:

- Feeding wagon with top-mounted transport structures
- Backfilling machine with top-mounted auger system
- Rail system
- Crane in FE-A niche
- Data capture for backfill density quality control
- Ventilation and dedusting systems

4.3 Destination location in the Mont Terri Rock Laboratory

The Mont Terri motorway tunnel is situated in the Jura Mountains in north-west Switzerland. It is part of the “Transjurane”, the National Highway N16 connecting Belfort (France) with the National Highway network of Switzerland (Figure 5). The motorway tunnel is 3,900 m long and connects Porrentruy and Delémont. It has been open to public traffic since the end of 1998.

The Mont Terri Rock Laboratory is located adjacent to the Reconnaissance Gallery (now the Security Gallery). It can be reached through the Access Gallery in the south, and then through the Security Gallery (Figure 6).

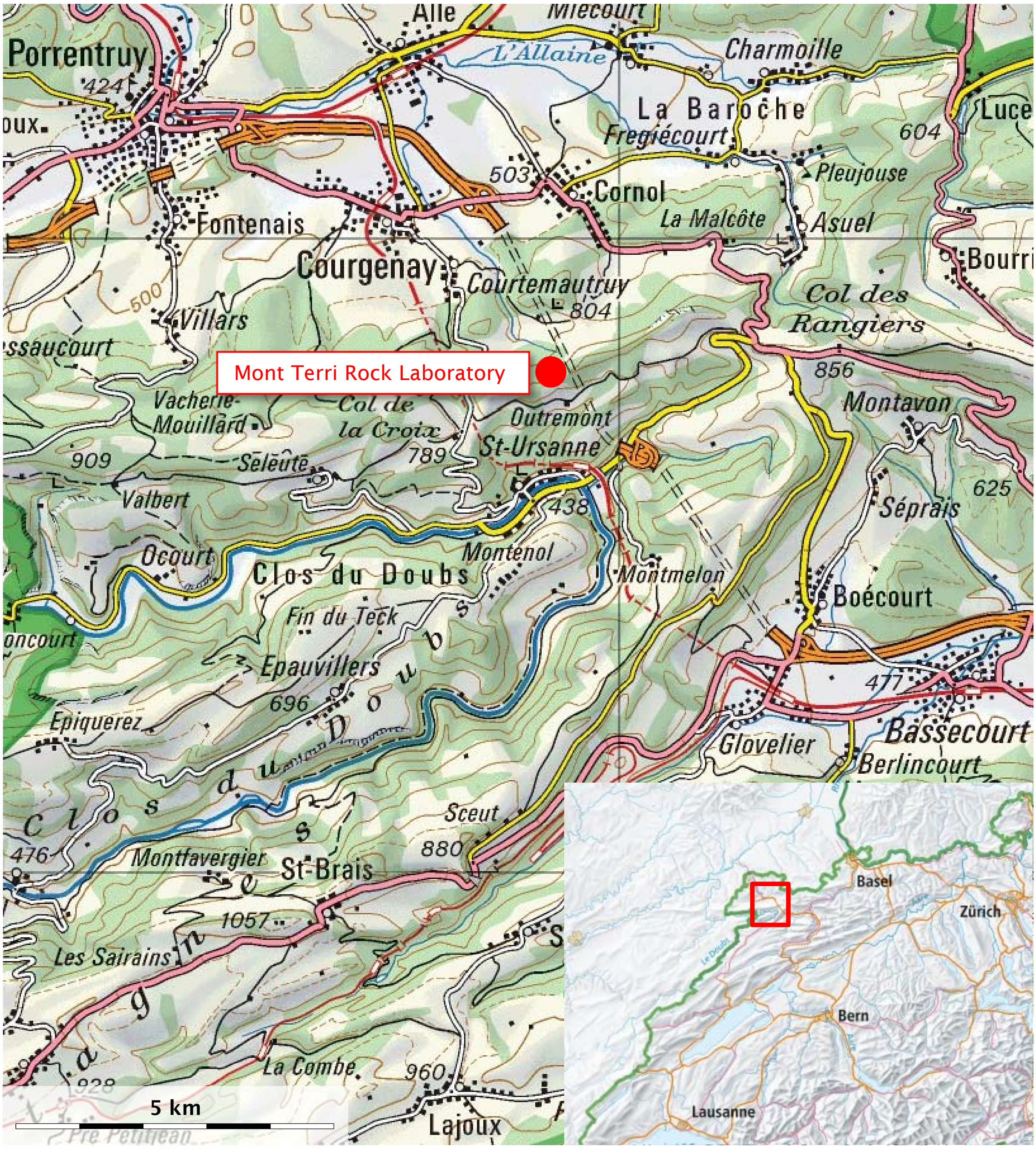

Figure 5 *The geographic position of the Mont Terri Rock Laboratory (map data: swisstopo)*

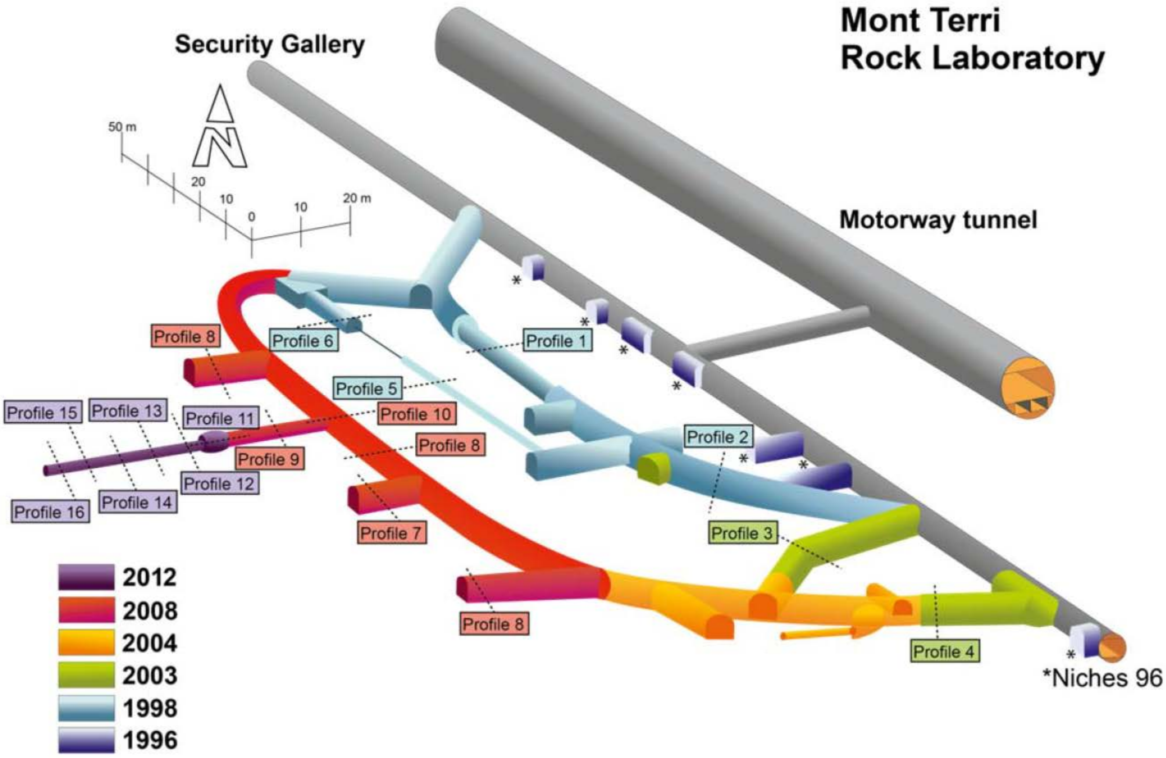

Figure 6 *Perspective view of the Mont Terri Rock Laboratory*

5. Conceptual pre-design

5.1 Boundary conditions

5.1.1 FE tunnel geometry

The FE-A niche and FE tunnel were built exclusively for the FE Experiment. The FE-A niche dimensions were especially optimised for the needs of the emplacement system. The 50-metre long FE tunnel is based on the Swiss reference concept for spent fuel/high-level waste (SF/HLW) repository tunnels.

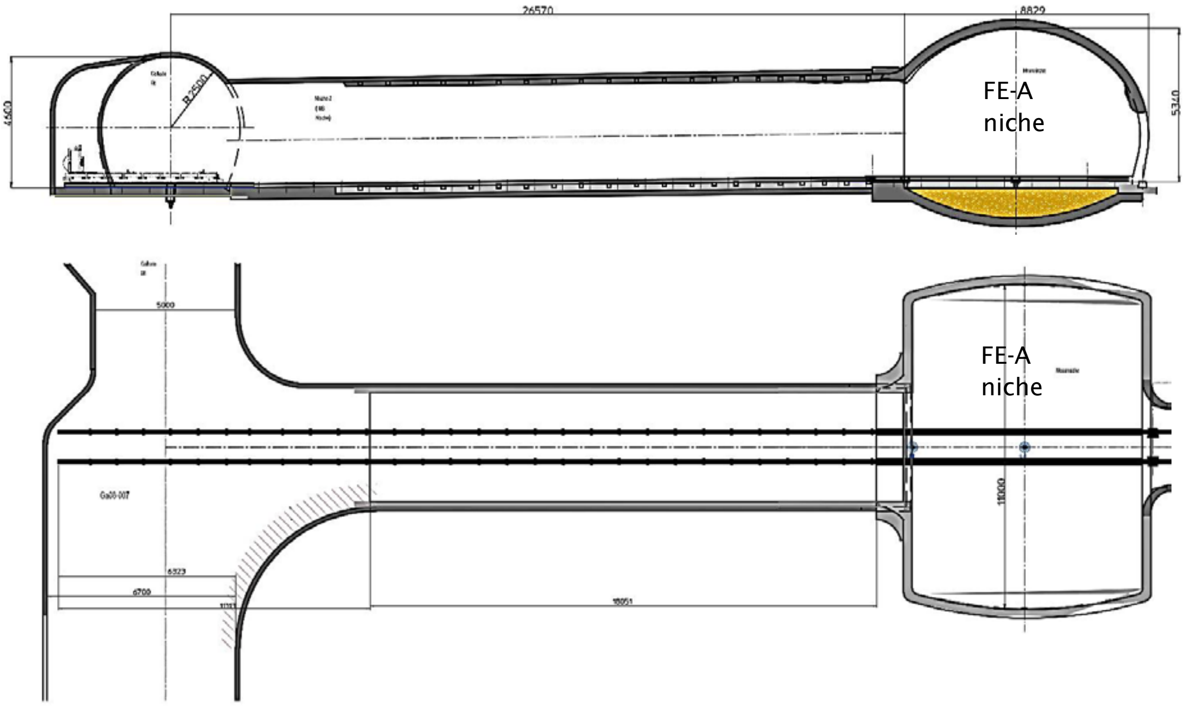

Figure 7 *Front view /top view of Gallery 2008 up to the FE-A niche*

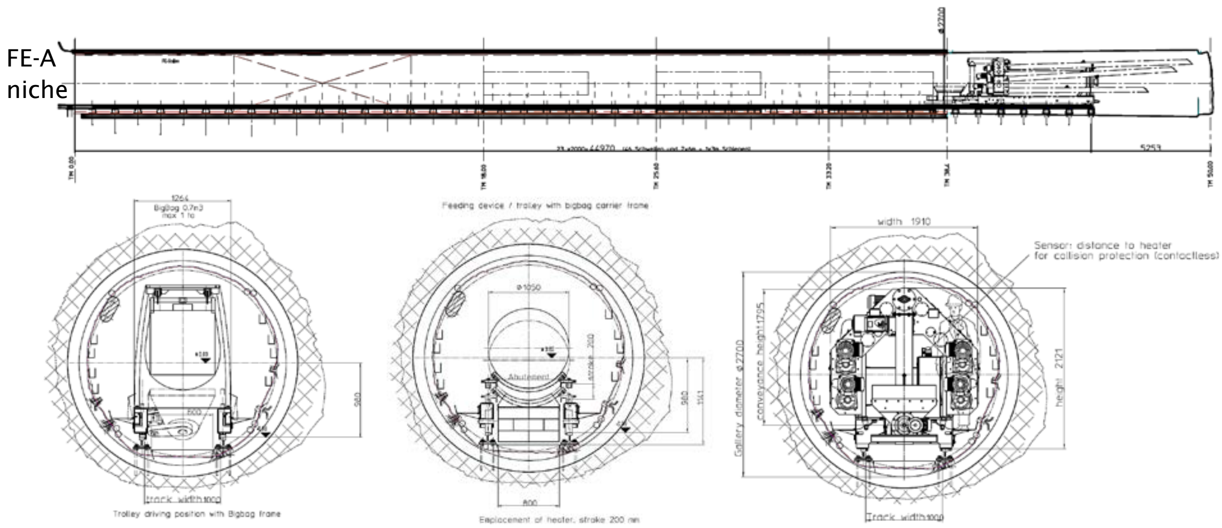

Figure 8 *Sectional views of the FE tunnel (see Daneluzzi et al. (2014) for tunnel construction related issues)*

5.1.2 Interfaces with instrumentation task

The following figure 9 shows the positioning of instrumentation profiles for long-term measurement and monitoring of heaters, gaps and bentonite block pedestals, which are additional geometric or operational restrictions on the backfilling process. (Note: The instrumentation of the FE Experiment is not part of LUCOEX.)

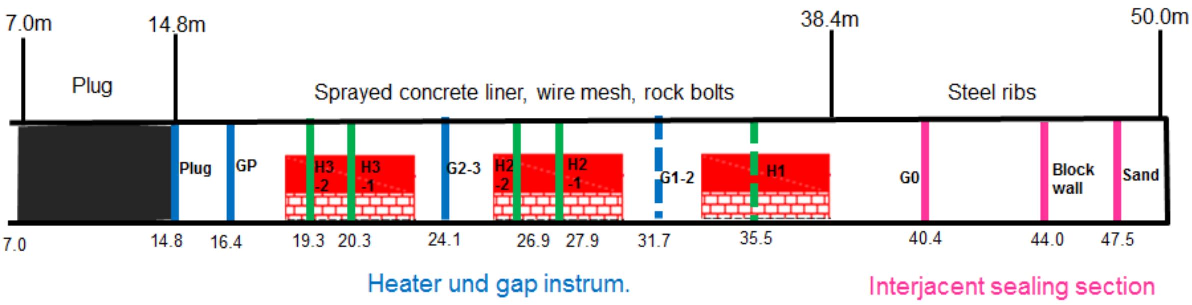

Figure 9 Bentonite and heater monitoring locations

5.1.3 Bentonite block pedestal

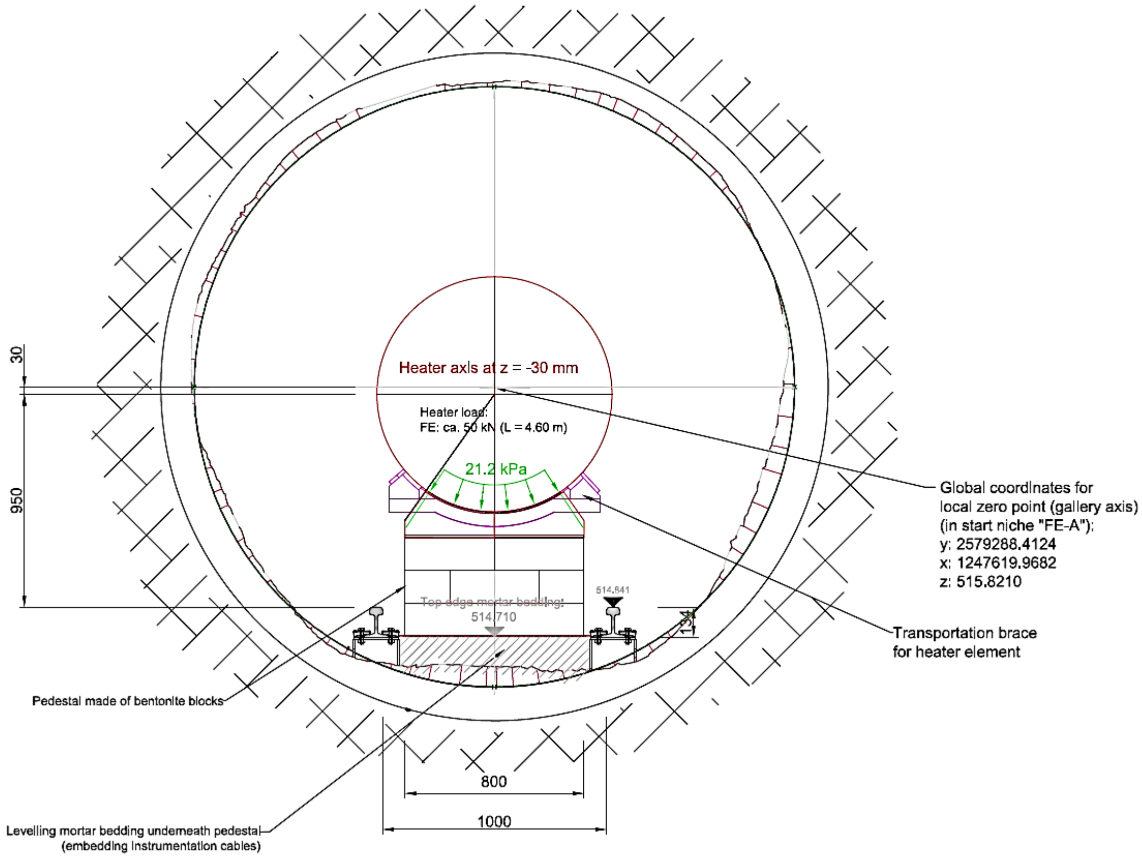

Figure 10 Cross-section of the FE tunnel with bentonite block pedestal, heater and rails

Deviating from the reference concept for a deep geological repository, the heater element block pedestal was assembled manually prior to the emplacement of the heaters and instrumented with measuring sensors.

The pedestal consists of two differently shaped, highly compacted bentonite block types:

- rectangular units (approx. 24 kg)
- units with a rounded support surface for one heater element (approx. 12 kg)

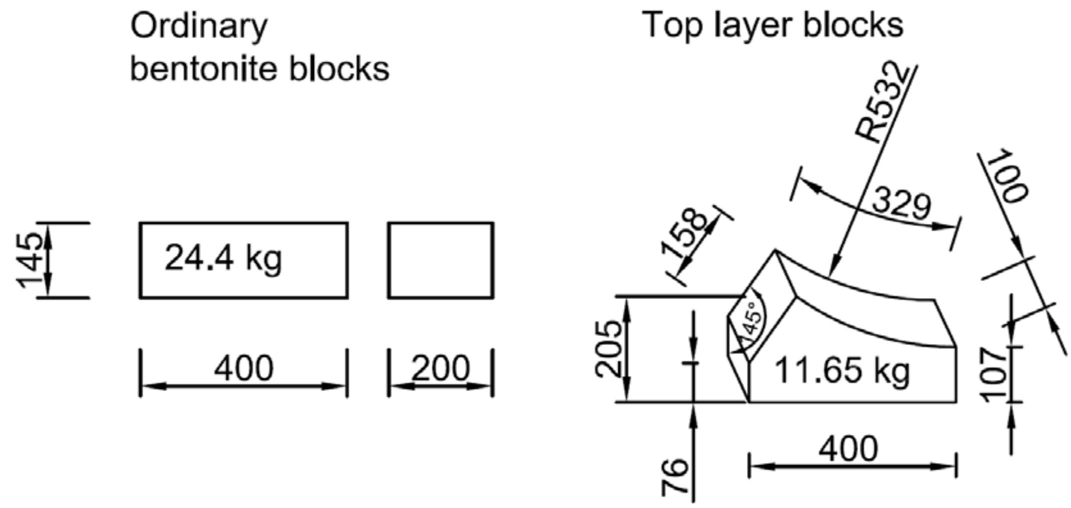

Figure 11 *Shape of ordinary (left) and rounded top layer (right) blocks*

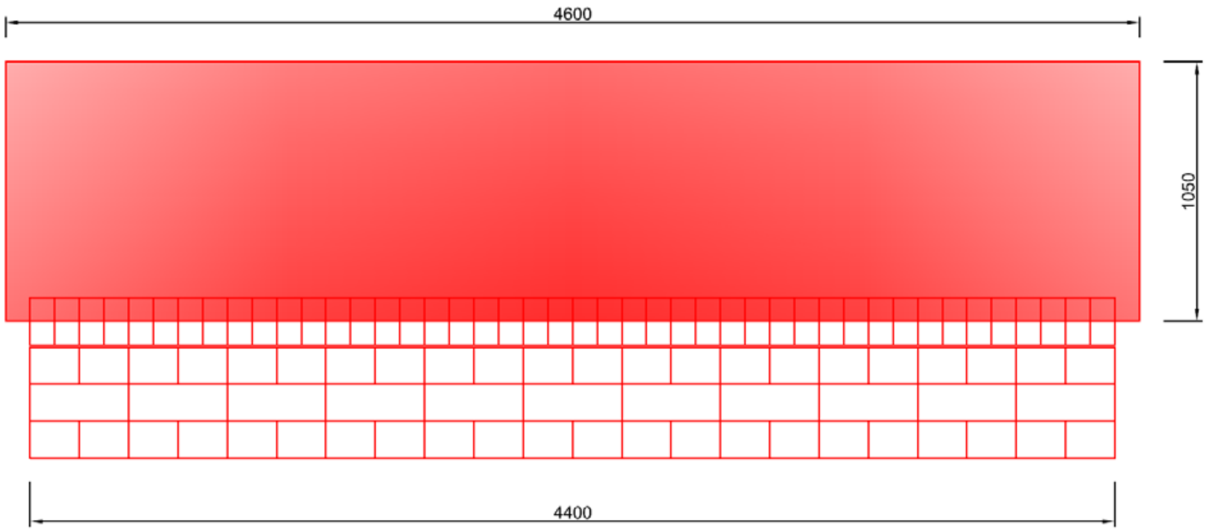

Figure 12 *Side view of a heater resting on a bentonite block pedestal composed of the two block types*

5.1.4 Heater dimensions

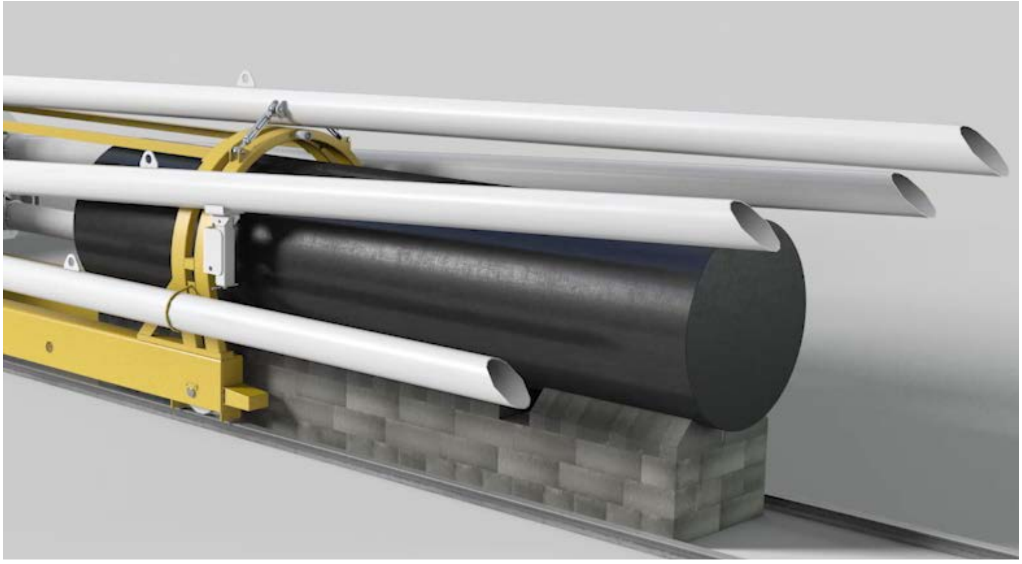

Figure 13 Heater

The heaters are a key component of the FE Experiment. They constitute an important interface for the sub-projects Emplacement System, Bentonite Block Pedestal and Instrumentation. The design parameters for both the emplacement system and the entire project are derived from the geometric properties and weight of the heaters.

The heaters have the following dimensions:

Length: 4,600 mm

Diameter: 1,050 mm

Weight: approx. 6 t

5.1.5 QC measures for backfill

The following parameters are measured and recorded for backfill density QC measures:

- amount of bentonite conveyed
- reaction force of the two brake cylinders
- power consumption, torque and speed of each auger
- backfill volume per section (geodetic measurement using laser scan)

5.2 Requirements on the emplacement and backfilling systems

Various methods for introducing the bentonite backfill material were tested during the conceptual design for a deep repository for radioactive waste. Conveyor belts or pumps and pneumatic systems were discarded due to heavy dust production and the impossibility of mechanical compaction. Another criterion was void space filling at points where material could not be placed directly or by gravity, e.g. overbreaks from tunnelling, some of which are located behind a simple reinforcement mesh head protection.

Auger conveyors can meet all the listed requirements. However, in previous experiments with auger conveyors, the operating conditions of the machines were not systematically recorded. Some of the parameters, such as the importance of compaction properties during the backfilling process and the backfill grain distribution, could only be identified by the tests performed, e.g. the Engineered Barrier experiment "EB" (Kennedy & Plötze, 2003), the ESDRED project (Plötze & Weber, 2007), the HE-E experiment (Teodori & Gaus, 2011), the Gas Permeable Seal Test (GAST) (Rüedi et al., 2012).

5.3 Specifications

5.3.1 Backfilling equipment specifications

The table below lists the main elements of the backfilling equipment and its key requirements.

System component	Requirements
Feeding wagon *For drawing, see annex 3*	• Transport of the bentonite block pedestal • Transport and placement of the heater • Transport of the big bags (4 bags of approx. 1 t each) • Heater weight: max. 6 t • Rail system slope: max. 1% • Track width: 1,000 mm • Transportable inside the Mont Terri Rock Laboratory • Adapted to the effective geometry of the FE tunnel in the Mont Terri Rock Laboratory
Backfilling machine *For drawing, see annex 1*	• Complete, homogeneous filling of the FE tunnel in the Mont Terri Rock Laboratory, with the backfill material (granulated bentonite mixture) having the highest possible bulk density of 1.45 t/m^3 • Five horizontal auger conveyors (HFS), operated with frequency inverters • Option of separate disassembly of each auger • Auger adjustability according to drawing 10731-100B • Material (bentonite) needs to be conveyed over a distance of 7.6 m in one journey (backfilling trajectory) • Reliable material supply and distribution to the augers • Track width: 1,000 mm • Transportable inside the Mont Terri Rock Laboratory • Adapted to the effective geometry of the FE tunnel in the Mont Terri Rock Laboratory
Crane in FE-A niche *For drawing, see annex 5*	• Feeding wagon transfers, handling of heaters, bentonite block pedestals and other materials • Used for on-site assembly • Lifting capacity: max. 6 t • 2 trolleys • Transportable inside the Mont Terri Rock Laboratory • Adapted to the effective geometry of the FE-A niche in the Mont Terri Rock Laboratory

5.3.2 Bentonite specifications

In a complex production process, the filling material was prepared from a specific mixture of dried, highly compacted bentonite pellets.

The following filling material specifications were relevant for the efficient operation of the backfilling machine:

Granulation	< 15 mm
Dry bulk density	approx. 1.45 t/m^3 (loose)
Special feature	free flowing, non-abrasive

5.4 Pre-testing for basic design

Stepwise studies were undertaken (Jenni, 2013) in order to investigate and prepare, respectively, the site specific boundary conditions, such as site access and logistics, as well as predefining the dimensions of the FE experimental tunnel and the "FE-A" start niche. Finally, the general design with five horizontal screw conveyours (also called "augers") was suggested and justified as a basis for principal decisions for the backfilling technology.

As parameters for conventional auger use could only be applied to a limited extent, a pre-test had to be carried out. This refers to backfill material properties as well as to the compacting and reaction forces of the conveyor equipment. The pre-test dealt with the acquisition of emplacement equipment layout parameters by using the auger equipment from the ESDRED project (Plötze & Weber, 2007). The detailed planning of the backfilling system, i.e. the auger layout and the process technology control, is based on the data obtained from this pre-test (Köhler & Garitte, 2015).

5.5 Auxiliary elements

5.5.1 Crane in the FE-A niche

A gantry crane in the FE-A niche was used to transfer the different top-mounted structures, as well as other loads transported by the feeding wagon, such as:

- transport bases for pedestal blocks
- pallets with pedestal blocks
- heaters (with intermediate frame)
- big bag frame

as well as to lift the feeding wagon itself off the rails and put it into its parking position on the left side of the FE-A niche (to allow the backfilling unit to cross).

☞ For the crane design and implementation at Mont Terri, see annex 5

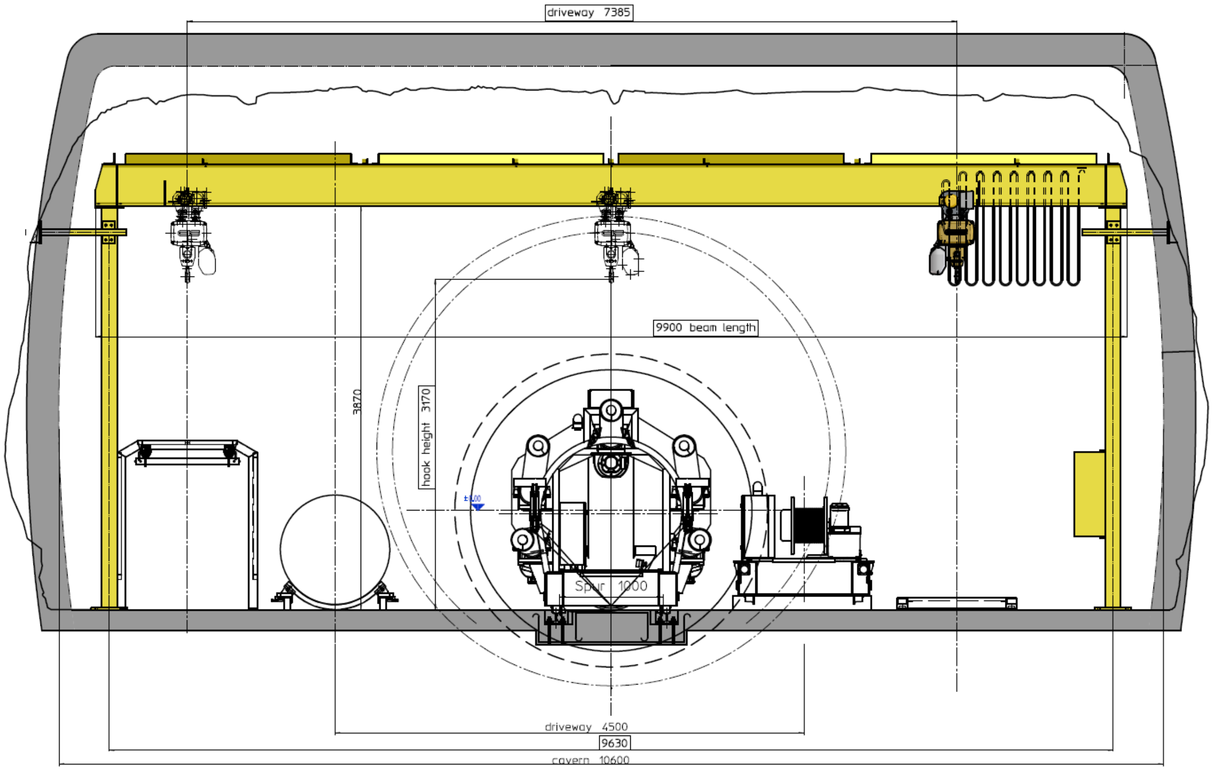

Figure 14 *View of the gantry crane*

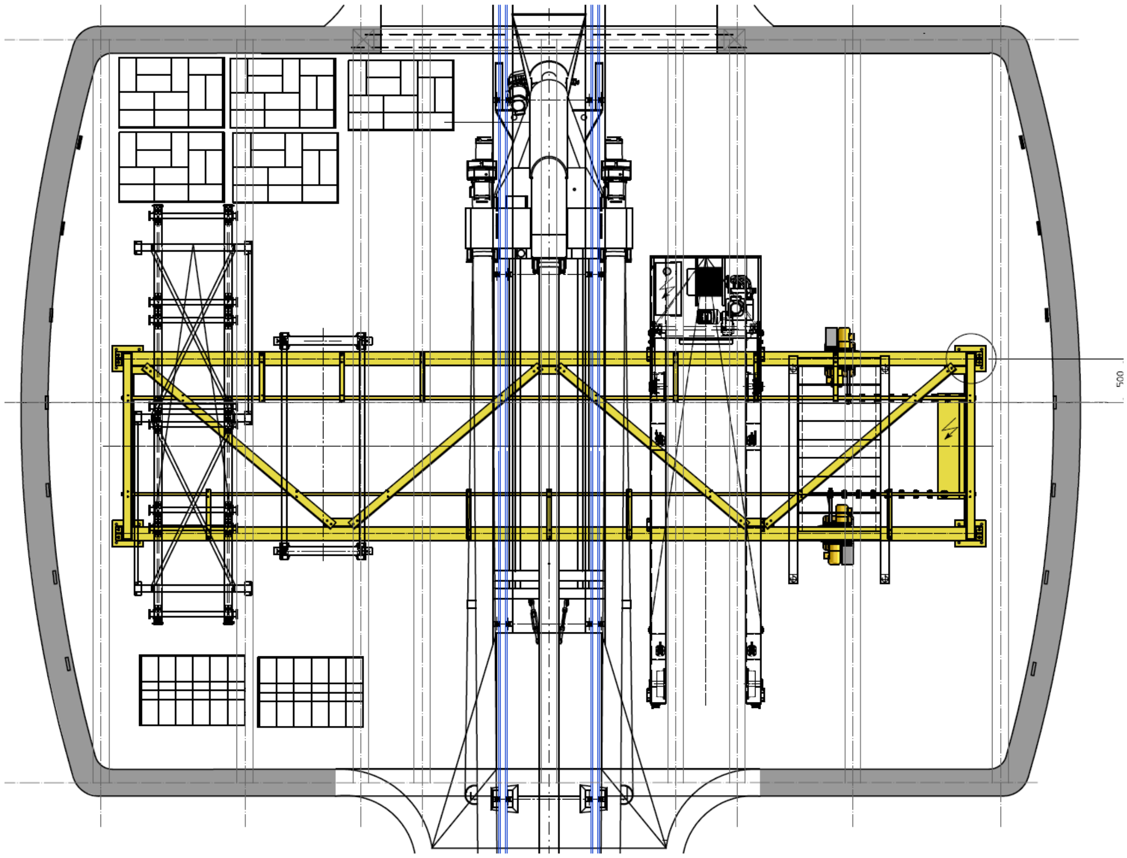

Figure 15 *Top view of the gantry crane*

5.5.2 Rail system

The backfilling machine travels on rails which have been laid from Gallery 08 to the operating location in the FE tunnel.

☞ For the rail design and implementation at Mont Terri, see annex 6

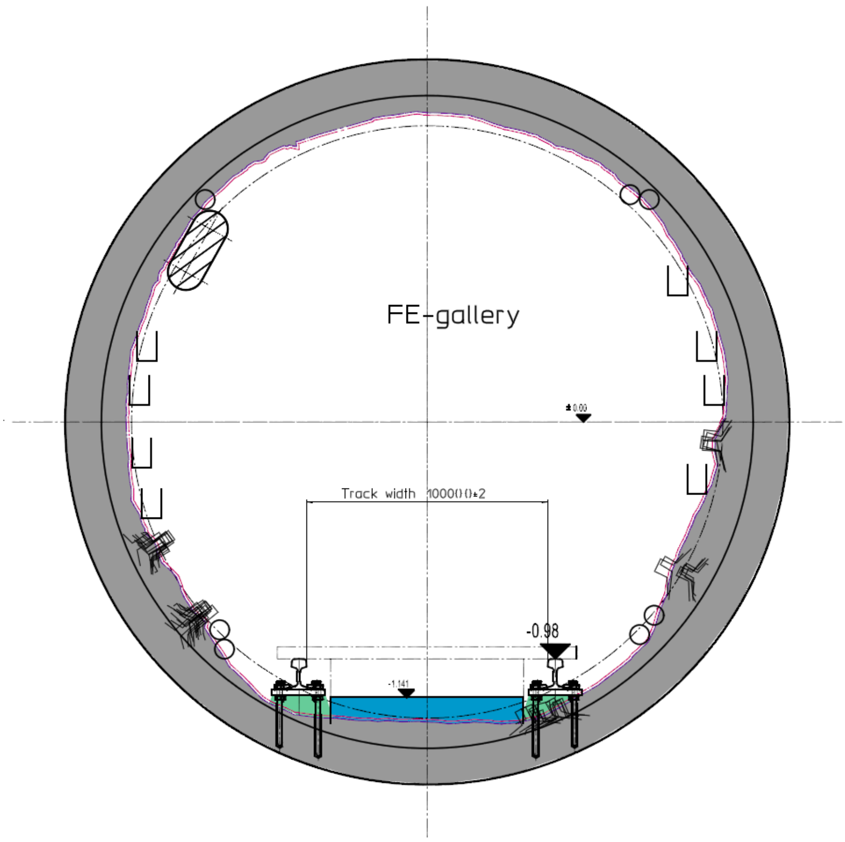

Figure 16 Rail system

5.5.3 Ventilation and dedusting

A dedusting system was installed in Gallery 08 for dust removal from the backfill area.

An air compressor was also provided for filter cleaning of the dedusting system.

The ventilation ducts had to be dismantled progressively, following the backfilling process.

☞ For the ventilation and dedusting design and implementation at Mont Terri, see annex 7

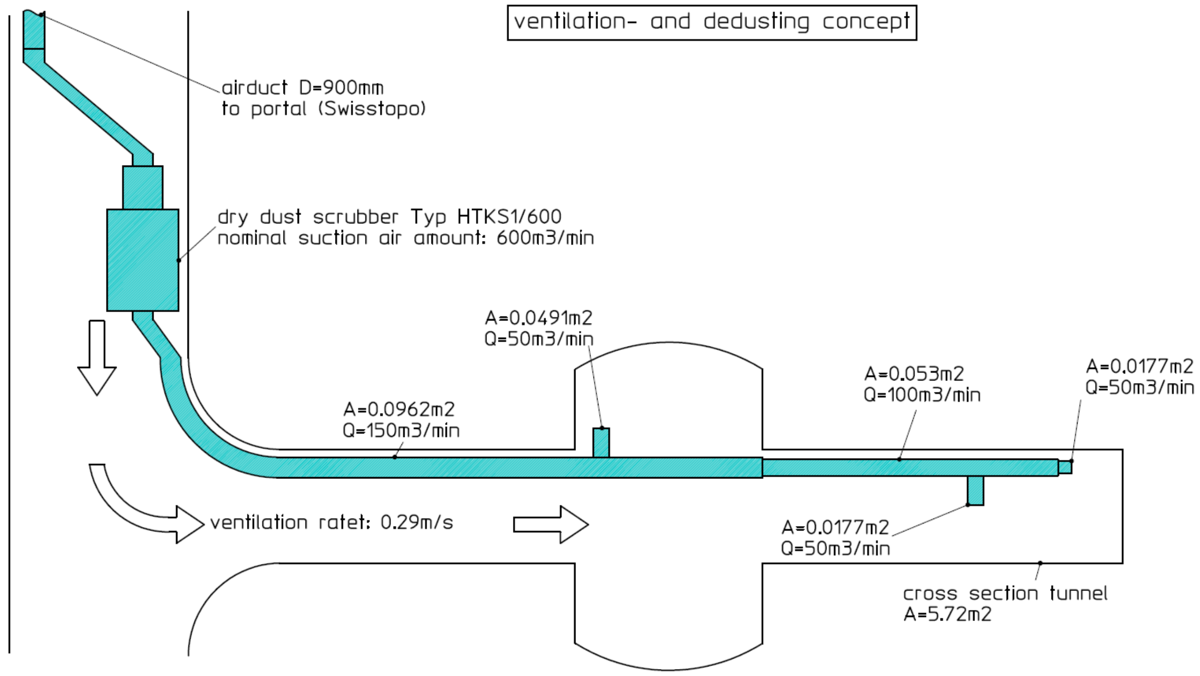

Figure 17 Ventilation and dedusting concept

6. Emplacement and backfilling system design

6.1 Usage Agreement

To ensure that the delivered system met the requirements of the customer, the supplier (Rowa Tunnelling Logistics AG) drafted a Usage Agreement (basis for the planning, design and operation of the system) which was coordinated with Nagra.

This Agreement described the intended use by Nagra and the backfilling concept for which the Rowa system was designed. The Usage Agreement formed the binding basis for the planning, design and operation of the system.

6.2 Functions

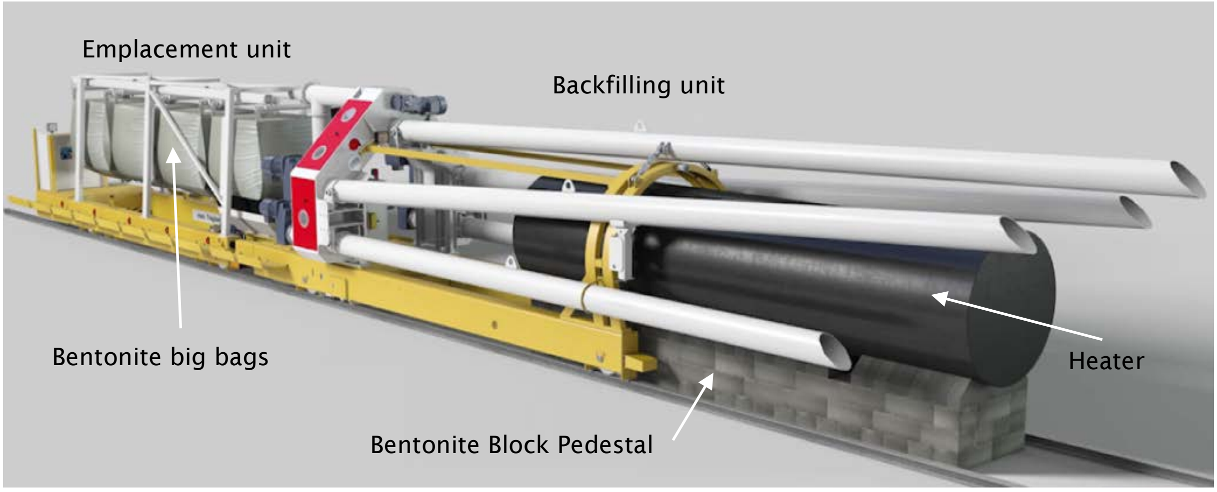

Figure 18 *General layout of the emplacement and backfilling systems*

Essentially, the tasks of the delivered system comprised:

1. Transport of the bentonite blocks for the heater pedestals with the rail-bound feeding wagon. Installation was carried out manually.
2. Transport of the heaters with the feeding wagon and their positioning on pedestals by means of a hydraulic lifting unit.
3. Delivery of the granulated bentonite in big bags from Gallery 08 to the backfilling machine, using the feeding wagon.
4. Granulated bentonite backfilling of the heaters with maximum compaction using the backfilling machine.
5. Material and equipment handling in the FE-A niche with the gantry crane.
6. Ventilation and dedusting of the tunnel system.

☞ See also the backfilling machine general layout drawing in annex 1 and FE Experiment stage plan in annex 2

6.2.1 Task 1: Transport and installation of the bentonite stacks

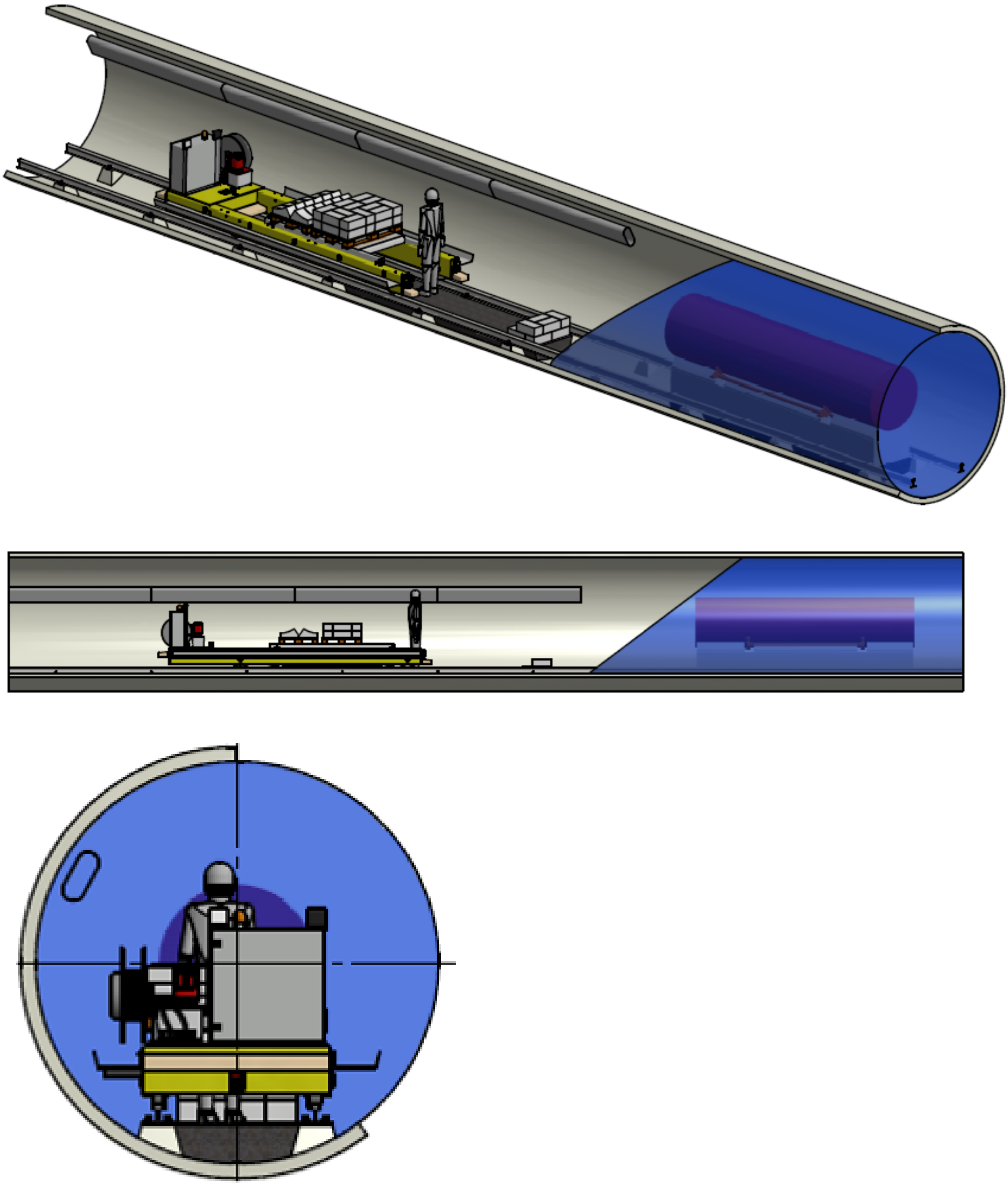

Figure 19 Task 1: Transport of a bentonite stack with the feeding wagon and installation as a pedestal for the heater

The feeding wagon, which is equipped with a transport base, takes the bentonite stacks to the mounting site.

The bentonite blocks are mounted manually to form a pedestal for the heater.

6.2.2 Task 2: Transport and positioning of the heater

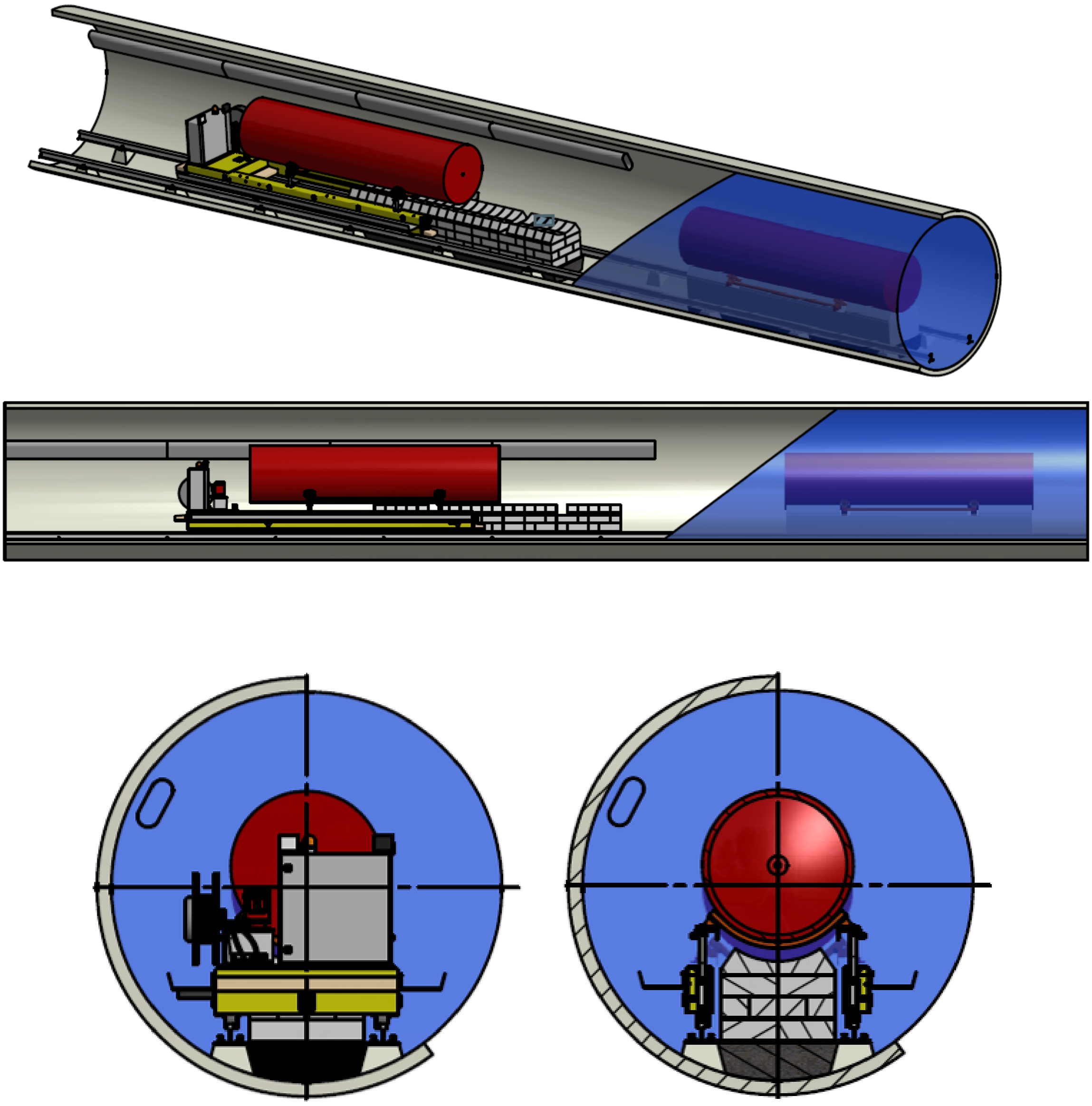

Figure 20 *Task 2: Transport of a heater with the feeding wagon and its positioning on the pedestal*

The feeding wagon takes the heater, which rests on an intermediate frame, to the installation site.

The heater, together with the intermediate frame, is lifted hydraulically. The feeding wagon then travels on, until the heater can be deposited on the bentonite block pedestal. The intermediate frame is then dismantled by hand.

6.2.3 Task 3: Granulated bentonite mixture supply process

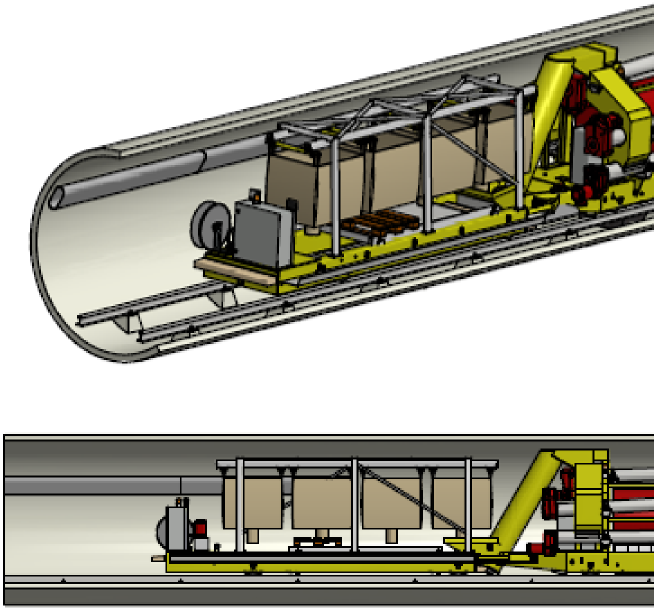

Figure 21 *Task 3: Granulated bentonite being supplied in big bags with feeding wagon*

The feeding wagon, equipped with a special support frame for four big bags, supplies the backfilling machine with granulated bentonite.

The granulated material in the front big bag is discharged into the feed hopper of the auger system. The four big bags of each batch are emptied one after the other. The feeding wagon then runs back to Gallery 08 and brings four new big bags. In the meantime, the backfilling process is stopped.

6.2.4 Task 4: Backfilling

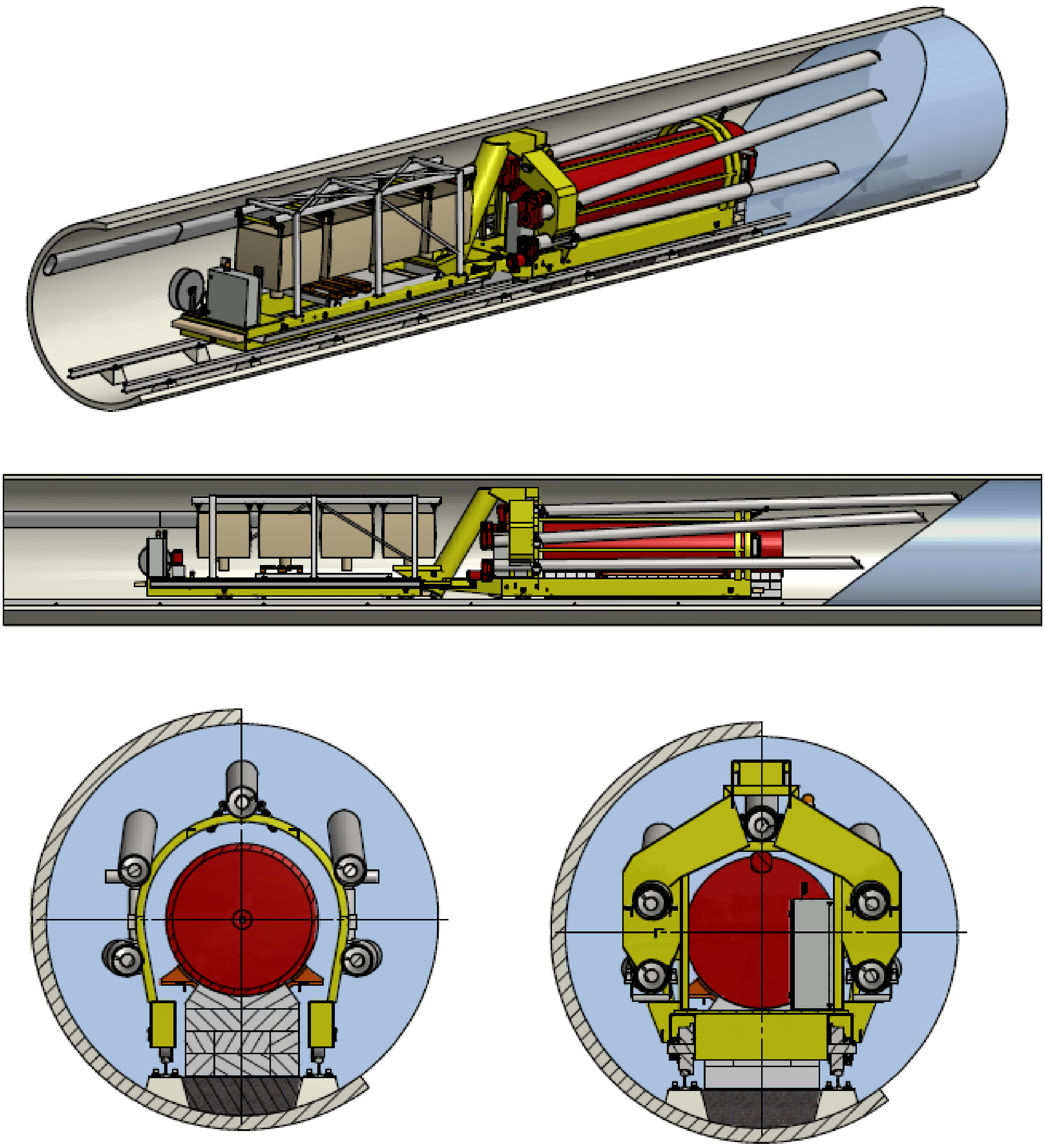

Figure 22 Task 4: Backfilling with the backfilling machine

The auger system mounted on the backfilling unit is used to continuously backfill the entire FE tunnel, including the installed heaters, with granulated bentonite, following a backwards direction from the tunnel end up to the tunnel start next to the FE-A niche.

In this stage, the backfilling unit and the feeding wagon with the top-mounted big bag frame are mechanically and electrically linked to each other and together form the backfilling machine.

6.3 Components

6.3.1 Feeding wagon

Figure 23 Feeding wagon

The wagon chassis consists of a sturdy steel frame with four flanged wheels.

The control cabinet, the hydraulic unit and the spring-driven cable reel are mounted on the rear end of the chassis.

The design of the feeding wagon frame is forked, so that the heater can be moved over the pedestal previously installed in the FE tunnel.

The feeder is powered by a 1.1 kW offset geared motor with frequency inverter that drives the rear axle. The axle then transmits the torque via a roller chain on both the left and right hand sides to the sprockets on the flanged wheels.

The lifting unit integrated into the chassis consists of four hydraulic cylinders with a 200 mm stroke. When the cylinders are extended, the intermediate frame that carries the heater is raised and can then be positioned over the pedestal.

The hydraulic unit with an output of 3 kW is mounted on the platform at the rear end of the feeding wagon.

Each cylinder is operated separately by four hand lever valves on the hydraulic unit.

Electrical installation

The control cabinet is installed on the platform at the rear end of the feeding wagon.

The cabinet door is equipped with a USB plug connection. During the backfilling process, data can be transferred from the data logger through this port to a USB flash drive and processed for calculation of the backfill density.

Long travel of the feeding wagon is operated by the operator walking behind the feeding wagon via a cable-connected remote control. The lifting cylinders are activated individually by means of four hand lever valves on the hydraulic unit.

Power to the control cabinet is supplied through a spring-driven cable reel on the feeding wagon with 55 m maximum unwinding length.

6.3.2 Wagon-mounted transport systems

The feeding wagon is used for transporting different types of loads depending on the stage of the emplacement process. Accordingly, the crane in the FE-A niche must be used to install the corresponding systems on the feeding wagon.

Transport base for bentonite pedestal blocks

The bentonite blocks for the pedestals are transported on pallets. To this end, the transport base must be mounted on the chassis.

Figure 24 Transport base for bentonite pedestal blocks

Heater intermediate frame

The heater is placed on the feeding wagon, together with the intermediate frame.

The heater is lifted hydraulically, together with the intermediate frame, then moved over the bentonite stack and set down. The frame is equipped with a horizontal alignment to allow correct placement of the heater on the pedestal.

Figure 25 *Transport of heater with intermediate frame*

Big bag frame

For the transport of the granulated bentonite required for backfilling, a suspension frame holding four big bags is mounted on the feeding wagon.

The big bag transport frame is equipped with two rails where the big bags are suspended on sliding suspension yokes.

Figure 26 *Transport of big bags*

Custom-designed big bags were required due to the special space conditions (for dimensions, see annex 8).

6.3.3 Backfilling machine

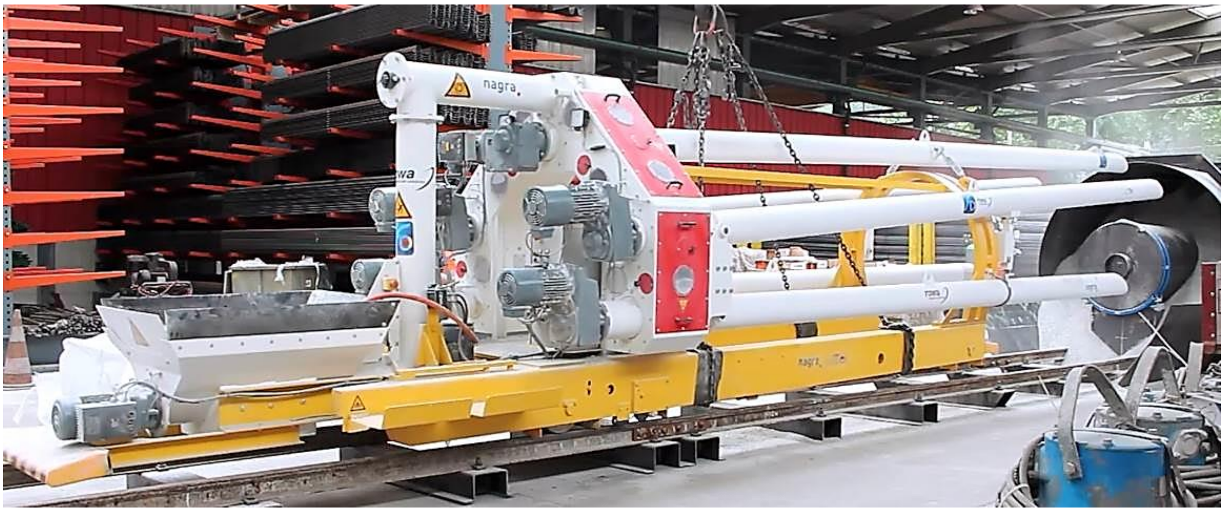

Figure 27 Backfilling machine

The backfilling machine comprises the backfilling unit with the auger system mounted on top. During the backfilling process, it must be additionally linked up with the feeding wagon loaded with big bags, running behind the backfilling unit.

The wagon chassis consists of a sturdy steel frame with four flanged wheels.

The front end of the chassis is equipped with a retaining ring as a support for the augers. The auger system is designed as one complete unit mounted on the wagon. The feed hopper is installed at the rear end of the chassis.

The design of the backfilling wagon is forked, so that the augers can be arranged around the heater previously brought into the test tunnel.

The backfilling wagon is powered by a 1.1 kW offset geared motor with frequency inverter that drives the rear axle. The axle then transmits the torque via a roller chain on both the left and right hand sides to the sprockets on the flanged wheels.

Brake unit

The feeding wagon is equipped with a hydraulic brake cylinder on both the right and left hand sides of its rear end to absorb the reaction force of approximately 32 kN during bentonite infeed. The cylinders are folded down by hand for use, each of them resting on a brake shoe screwed to the rails.

The brake cylinders are powered by the 3 kW hydraulic unit on the feeding wagon.

Figure 28 *Extended brake cylinders*

Auger system

The auger system comprises the feed hopper with discharge auger, the vertical auger and the stuffing auger for feeding the distribution box, the distribution box itself and its 5 discharge augers:

- 1 crown auger
- 1 roof auger, on both the left and right hand sides
- 1 invert auger, on both the left and right hand sides

All augers except the vertical and the stuffing augers are powered by frequency-controlled geared motors.

The torque of the vertical screw is transmitted via a chain drive.

The invert and roof augers can be removed for the sealing process at the end of the tunnel backfilling. The time expended for disassembly and reassembly amounts to 3-4 man-hours per auger.

The following mechanical settings are possible:

- horizontal and vertical adjustment of the crown auger outfeed
- height adjustment of the roof auger outfeed
- adjustments on the deflector plate in the distribution box

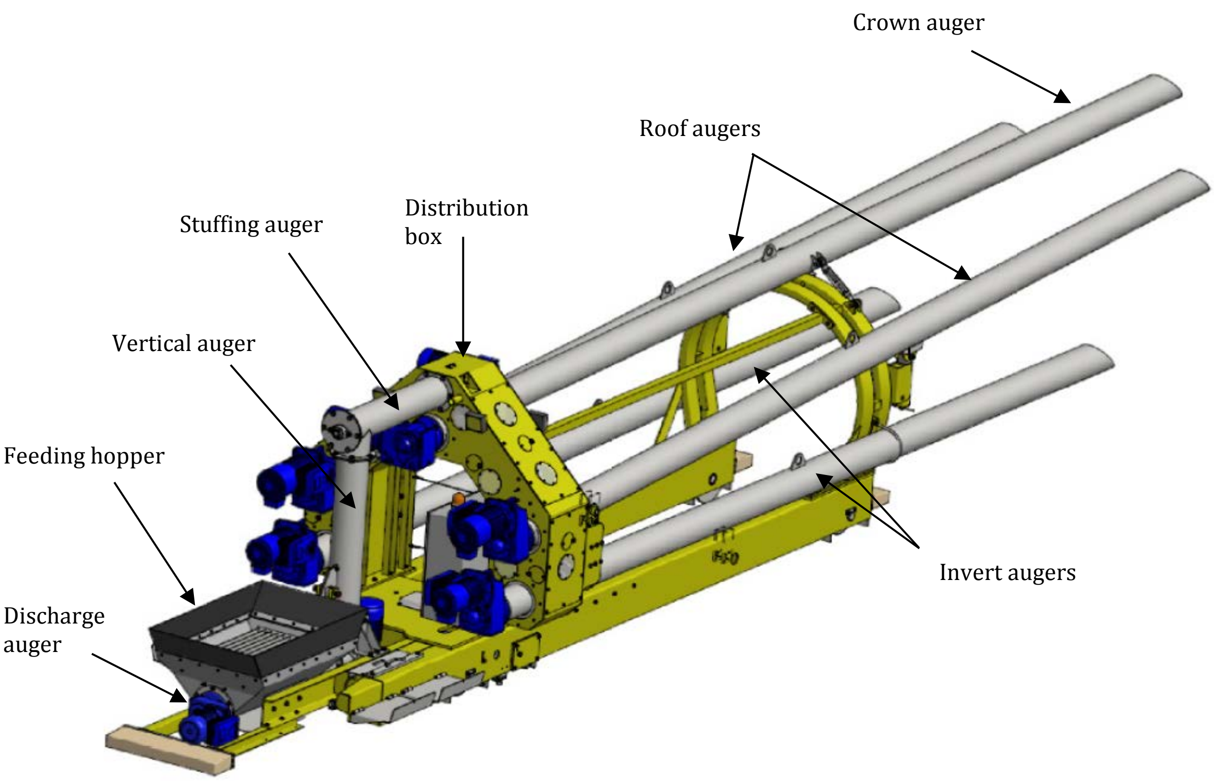

Figure 29 Auger system

Distribution box

The distribution box is equipped with various covered poke holes for loosening product blockages.

Distribution box ventilation (aspiration)

A delimited aspiration space inside the box, with a pipe leading out of the box, allows the air displaced by material infeed to escape from the box.

Eletrical installation

The auger system and brake unit are operated on the touch screen integrated into the front of the feeding wagon control cabinet.

Long travel of the backfilling wagon is controlled, while in standalone mode, by the operator walking behind the wagon using a cable-connected remote control. When working in tandem mode, long travel is controlled via the cable-connected remote control of the feeding wagon.

7. Emplacement and backfilling system manufacturing

7.1 Manufacturing partner

Planning and management for the production of the different components of the emplacement and backfilling systems was carried out by Rowa Tunnelling Logistics AG. The work was performed by appropriately qualified subcontractors in Switzerland and Poland to ensure that the high quality requirements were met.

The specialised company Wirtech AG, CH-3661 Uetendorf, was called in by Rowa for the development and delivery of the complex auger system.

7.2 Pictures of the manufacturing process

The following pictures show different stages of the production process.

Figure 30 Manufacturing of the emplacement unit chassis

Figure 31 *Manufacturing of the backfilling unit chassis*

Figure 32 *Assembly of the auger system*

Figure 33 Manufacturing of the crane frame

8. Emplacement and backfilling system testing

8.1 Auger system testing

The auger system testing was conducted on 18.02.2014 in the facilities of the company Wirtech AG, CH-3661 Uetendorf.

Test objectives

- Auger settings
- Distribution box sealing
- Big bag system operation
- Material distribution in the distribution box
- Electrical control
- Functional test with material
- Measurements of flow rates

The objectives listed above were all tested and shown to be fulfilled.

Figure 34 Testing of the auger system

8.2 Mock-up test 1

Mock-up test 1 was conducted from 05.-16.05.2014 in the facilities of the company Belloli SA, CH-6537 Grono.

The objectives of the mock-up test were:

1. To perform a technology demonstration of the tunnel backfilling with the emplacement system
   a) To check and optimise the functionality of the overall “emplacement system” under realistic conditions.
   b) To check and optimise the control and regulation parameters of the emplacement system, including brake calibration (load test) in the initial phase of the mock-up test.
   c) To check the geometric and process-related interfaces with relevant components of the systems "Instrumentation" and "Heating elements including the bentonite block pedestals”.
   d) To demonstrate the emplacement system operation during visits of external interest groups
2. To test processes and determine time requirements in order to derive the work programme for later application in the Mont Terri Rock Laboratory
3. To carry out quality control of the backfilling: global and local bulk density measurements on the granulated bentonite conveyed into the test rig. For this issue, refer to (Köhler & Garitte, 2015).

For the mock-up tests, a 1:1-scale tunnel model was manufactured and a provisional rail track was laid in the workshop.

Test objectives

Test 1: Backfilling

- Handling of the bentonite material
- Time required, material conveyed per time unit
- Handling and feeding of the big bags
- Effects on the Mont Terri work programme
- Backfill quality control
- Backfill density measurement

Test 2: Emplacement

- Handling of the dummy heater in the emplacement system (heater/wagon)
- Introduction and lowering of the dummy
- Handling of the dummy on the pedestal
- Space in the tunnel
- Other activities without direct interface to the emplacement system (instrumentation and wiring of heaters, bentonite blocks, etc.)
- Effects on the Mont Terri work programme

Test 1: Backfilling

Figure 35 *1:1-scale tunnel model*

Figure 36 Backfilling test inside the 1:1-scale tunnel model

Test 2: Emplacement

Figure 37 *Preparing the emplacement unit*

Figure 38 *The heater (dummy) being loaded onto the emplacement unit*

Figure 39 *Dimension check of heater and abutment*

Figure 40 *Driving into 1:1-scale tunnel model*

8.3 Optimisation

The following adjustments and optimisations were made based on the experience of mock-up test 1:

- The brake system was modified and the brake cylinders were moved from the backfilling wagon to the rear of the feeding wagon
- 2 brake shoes (rail clamps) were manufactured to support the brake cylinders on the rails
- Anti-derailment system (spreader bar and side guides) for heater transport

Figure 41 Spreader bar

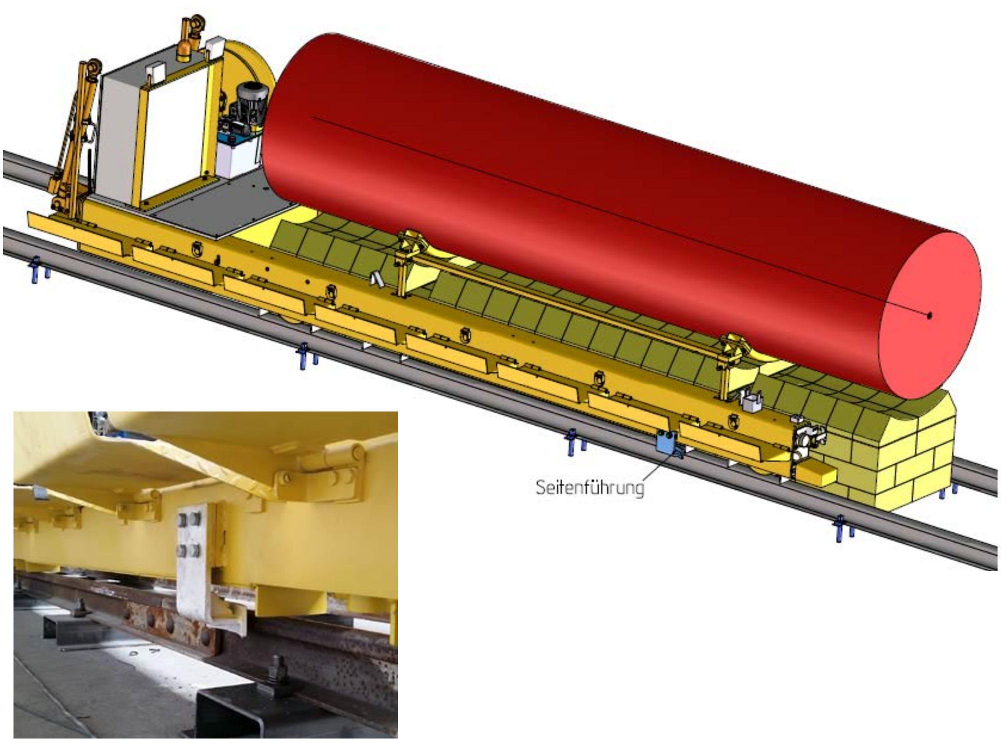

Figure 42 Side guides

8.4 Mock-up test 2

Mock-up test 2 was conducted from 11.-13.08.2014, following the optimisations and also took place in the facilities of the company Belloli SA, CH-6537 Grono.

8.4.1 Implementation of mock-up test 2

Figure 43 Test tunnel with backfilling machine und feeding wagon

Figure 44 All the backfilling auger tubes were equipped with sensors

Figure 45 *Start-up of backfilling process*

Figure 46 *The viewing windows are gradually filled with material*

Figure 47 *Display of the system on the control panel*

Figure 48 Hydraulic brake during the backfilling

Figure 49 Preparing to pull up the next big bag

Figure 50 New big bag being opened

Interruption for conical pile measurement with geometer

Figure 51 View of conical pile in the tunnel

Figure 52 Conical pile measurement with geometer

Figure 53 *The sensors at the ends of the tubes are pushed upwards during backfilling*

Figure 54 *After the geometer measurement, the system is moved into the tunnel again*

Figure 55 *The brake is installed again and the backfilling can be restarted*

Displays of the control panel

Figure 56 Filling level visualisation during the backfilling process

Figure 57 Display showing torque and speed of each auger

Figure 58 *Display showing tunnel metres, rpm, each auger´s workload and the backfilling process reaction force*

Figure 59 *Conical pile measurement with the laser measuring tool*

8.4.2 Conclusions of mock-up test 2

1. The feeding wagon and backfilling machine perform their functions.
2. The modified brake performs its function (required brake force of 32'000 N).
3. The backfilling process could be performed without problems or interruptions.
4. The backfilling process could be performed quickly.
5. The measurement results, especially of the backfill density measurement, show that the requirements relating to density could be met (Köhler & Garitte, 2015).

9. Acceptance and commissioning

9.1 Transport from test location to Mont Terri

A detailed transport schedule was drawn up for the system components. The feeding wagon and the backfilling wagon were transported as fully pre-mounted assemblies from the test location to the Mont Terri site.

The following pictures show the components being unloaded and moved inside the Mont Terri Rock Laboratory tunnel system.

Figure 60 Backfilling machine being unloaded

Figure 61 Backfilling machine being transported inside the rock laboratory

Figure 62 *Backfilling machine being transported inside the rock laboratory*

Figure 63 *Feeding wagon being transported inside the rock laboratory*

Figure 64 Dedusting unit being transported inside the rock laboratory

Figure 65 Ventilator being transported inside the rock laboratory

Figure 66 Crane frame being transported inside the rock laboratory

9.2 On-site assembly and testing

A detailed schedule was drawn up for the on-site assembly and testing.

The crane in the FE-A niche and the rails in the FE access tunnel were installed in an early site assembly stage, so that they could be used for the subsequent installation work.

Figure 67 Rail installation in the FE tunnel

Figure 68 Rail track control measurement

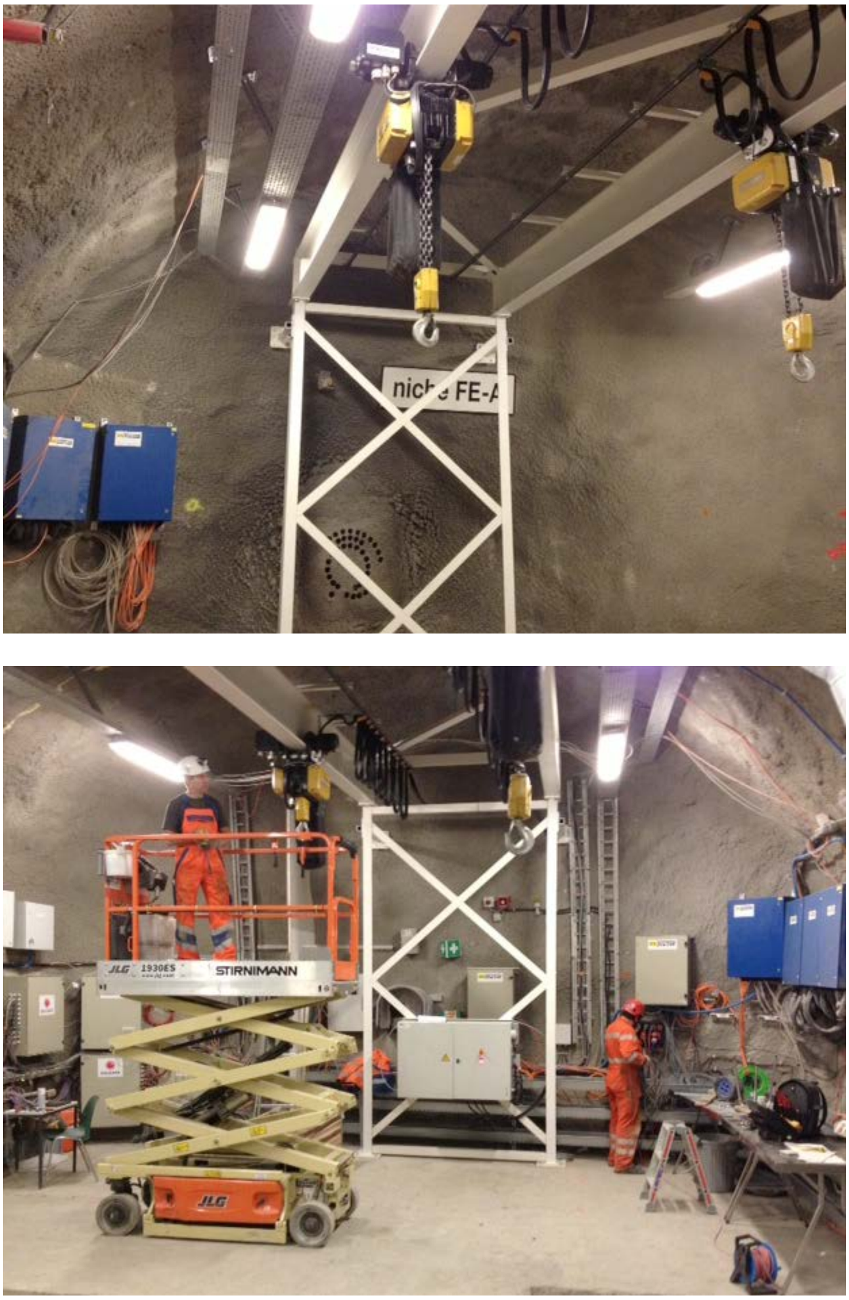

Figure 69 *Crane being assembled in the FE-A niche*

Figure 70 *Crane overload test with test weight (mobile crane 6.2 t)*

Figure 71 Positioning of backfilling unit

Figure 72 Positioning of emplacement unit

Figure 73 *Assembly of ventilation and dedusting system*

9.3 Commissioning

The commissioning of the emplacement and backfilling systems and the practical training of the operating personnel was carried out and recorded successfully on 24.09.2014 in the presence of Nagra representatives.

Figure 74 Feeding wagon with backfilling machine in Gallery 2008

Figure 75 Big bag loading in Gallery 08

Figure 76 *The feeding wagon traveling from Gallery 08 to the FE access tunnel*

Figure 77 *FE tunnel with instrumentation and rails as well as ventilation and dedusting systems*

Figure 78 Backfilling in the FE tunnel

Figure 79 Backfilling machine during the backfilling process

Figure 80 Backfilling quality check

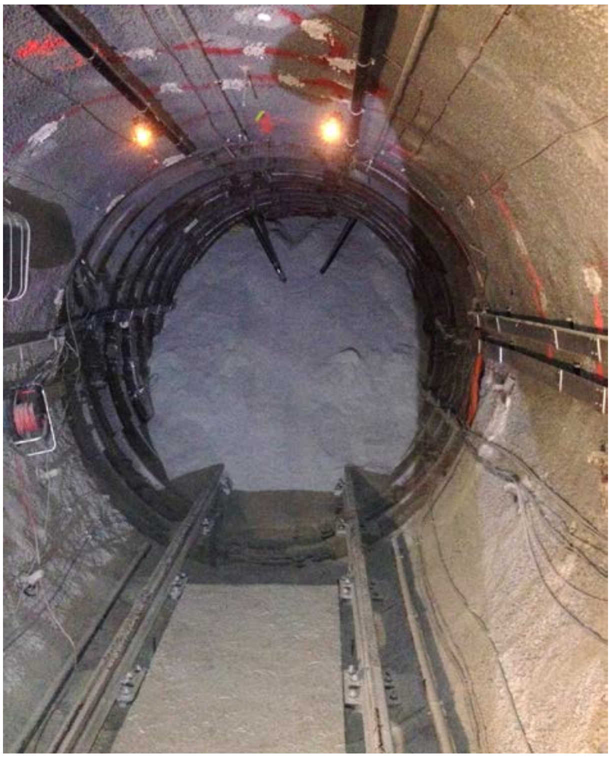

Figure 81 FE tunnel during the backfilling process

Figure 82 *Dedusting duct in the FE tunnel*

Figure 83 *Retracted backfilling machine after the backfilling*

Figure 84 Crane in FE-A niche with ventilation and dedusting units

Figure 85 Ventilation and dedusting ducts in the FE access tunnel

Figure 86 *Dedusting system in Gallery 08*

Figure 87 *Operator training*

Figure 88 Operator training

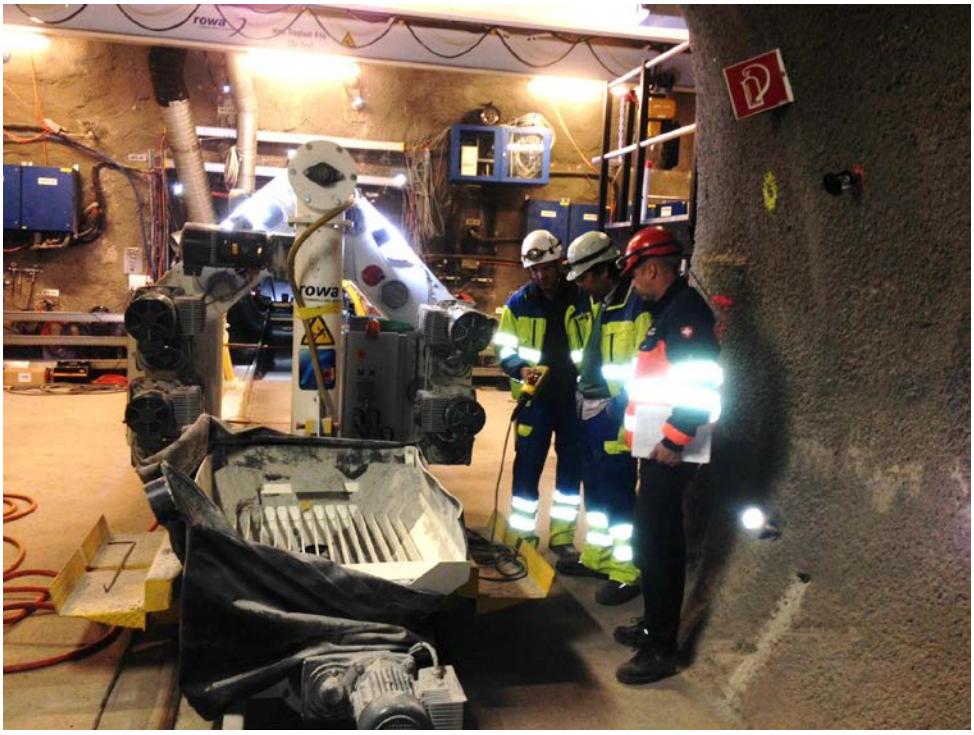

Figure 89 Operator training

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Teodori, S.P., Gaus, I. (2011): Long Term performance ofEngineered Barrier Systems (PEBS) - Mont Terri HE-E Experiment: as-built report. Authors: S.-P. Teodori, I. Gaus, S. Köhler, H.-P. Weber, U. Rösli, P. Steiner, T. Trick, J.-L. Garcià Siñeriz, C. Nussbaum, K. Wieczorek, K. Schuster, J. C. Mayor. Nagra work report NAB 11-25

11. Annex

Annex no.	Contents
1	Backfilling machine general layout drawing
2	Mont Terri experiment stage plan
3	Feeding wagon general layout drawing
4	Backfilling wagon general layout drawing
5	FE-A niche crane general layout drawing (labelling in German)
6	Rail installation general layout drawing (labelling in German)
7	Dedusting system general layout drawing (labelling in German)
8	Big bag dimensions (labelling in German)
9	Safety layout

Annex 1

Backfilling machine general layout drawing

Verfüllvolumen Einlagerungsabschnitt
Backfill volume emplacement section

Verfüllquerschnitt/Backfill cross section	Länge/length	Fläche/area	Volumen/volume
Stollen leer / gallery empty	3.0 m	5.7 m2	17.0 m3
Canister+Auflage / heater+pedestal	4.6 m	4.2 m2	19.3 m3
Netto / net amount			36.3 m3

Index	gezeichnet	geprüft	freigegeben	Aenderungsvermerk
D	7.05.2015 AO	7.05.2015 KaRi	7.05.2015 HJ	aktualisiert
C	18.11.2013 AO	18.11.2013 KaRi	19.11.2013 HJ	Vertragsindex
B	03.09.2013 AO	03.09.2013 KaRi	03.09.2013 HJ	Vertragsindex
A	27.8.2013 AO	27.8.2013 KaRi	28.8.2013 HJ	aktualisiert

Blattgrösse: A1
Gewicht: ...
Massstab: 1:25

FE / LUCOEX
Verfülleinheit/Backfilling device
Experiment Mont Terri

gezeichnet: 20.08.2013	Visum: AO
geprüft: 20.08.2013	Visum: KaRi
freigegeben: 21.08.2013	Visum: HJ

Rowa Tunnelling Logistics AG, CH-8855 Wangen

10731-100 D

Annex 2

Mont Terri experiment stage plan

FE emplacement - Working sequences

05.11.2013 / S. Köhler, H. Jenni, A. Oberberger

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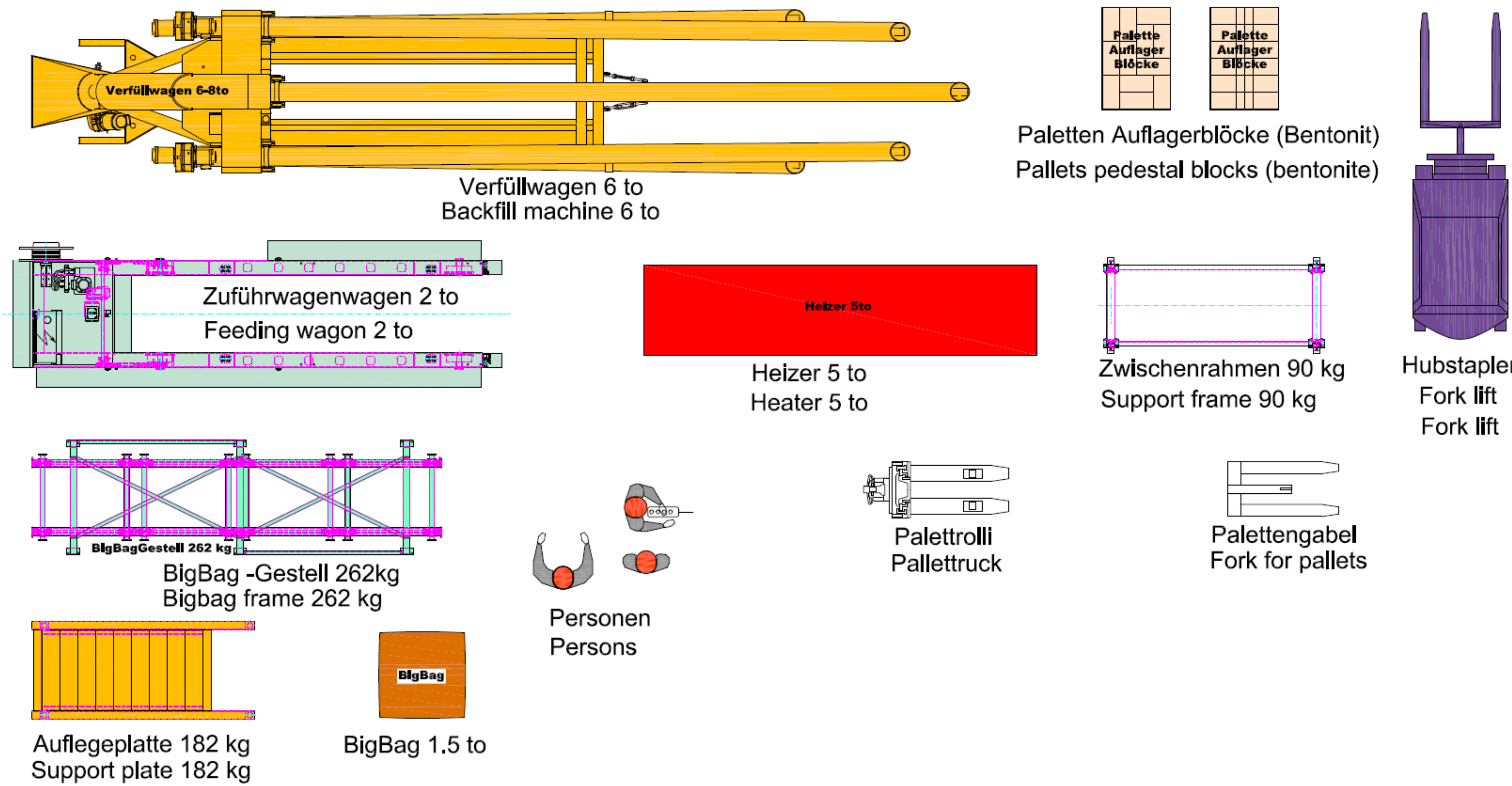
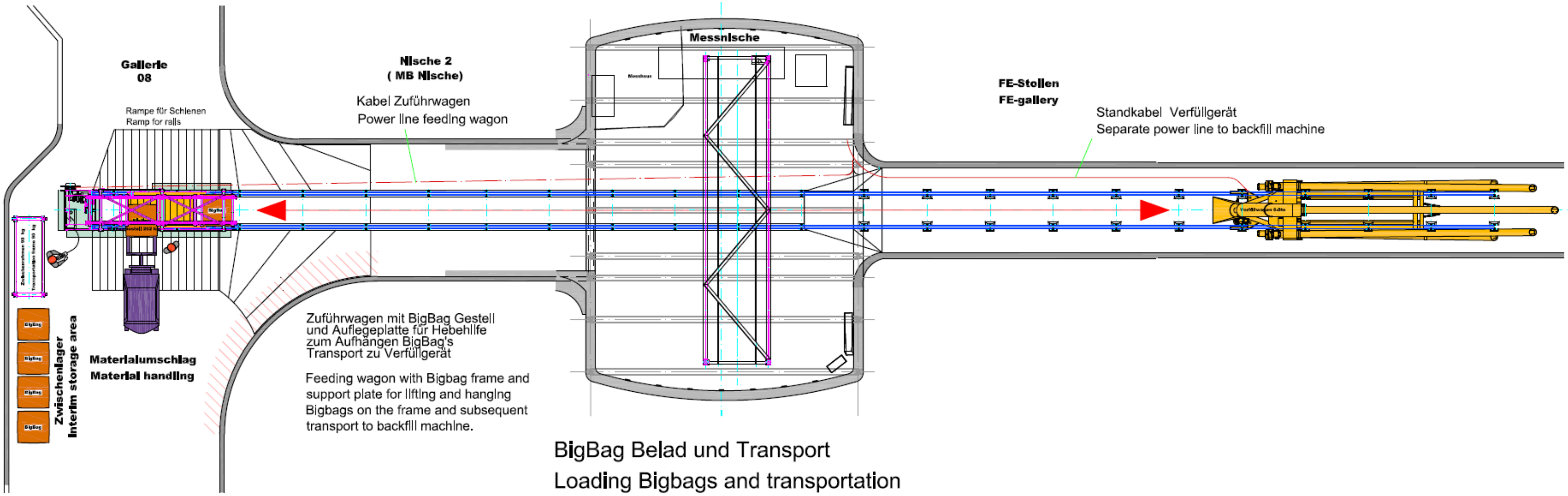
Used symbols



Phase 1: Loading and transportation of bigbags



	Working step	Workers position	Min. number of Workers	Auxiliary devices
1	Backfill machine waiting in FE-gallery, connected to separate power line, ready for operation	None	None	None
2	Feeding wagon in in Ga 08 loaded with 4 bigbags	Ga 08, sidewards to feeding wagon	• 1 driver forklift • 1 operator feeding wagon • 1 worker loading bigbags	• 1 forklift • 1 crane scale

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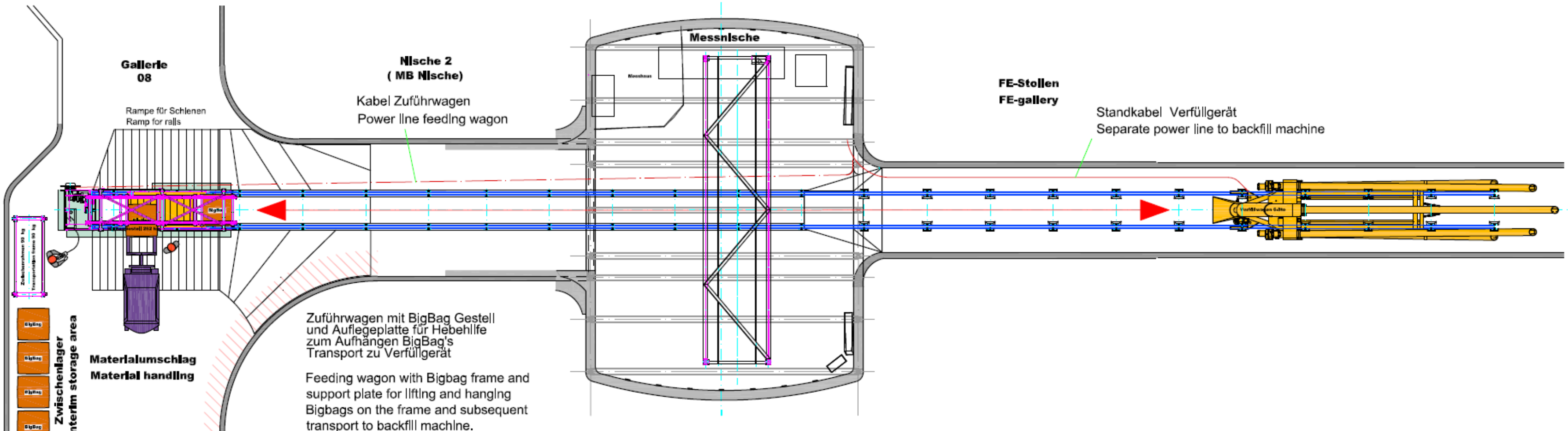
Phase 1: Loading and transportation of bigbags



BigBag Belad und Transport
Loading Bigbags and transportation

	Working step	Workers position	Min. number of Workers	Auxiliary devices
3	Feeding wagon loaded with 4 bigbags moving towards backfill machine	• No person between feeding wagon and backfill machine • Wired operation of feeding wagon • Driveway is surveyed with front sided camera / rear sided monitor screen	1 Operator feeding wagon	none

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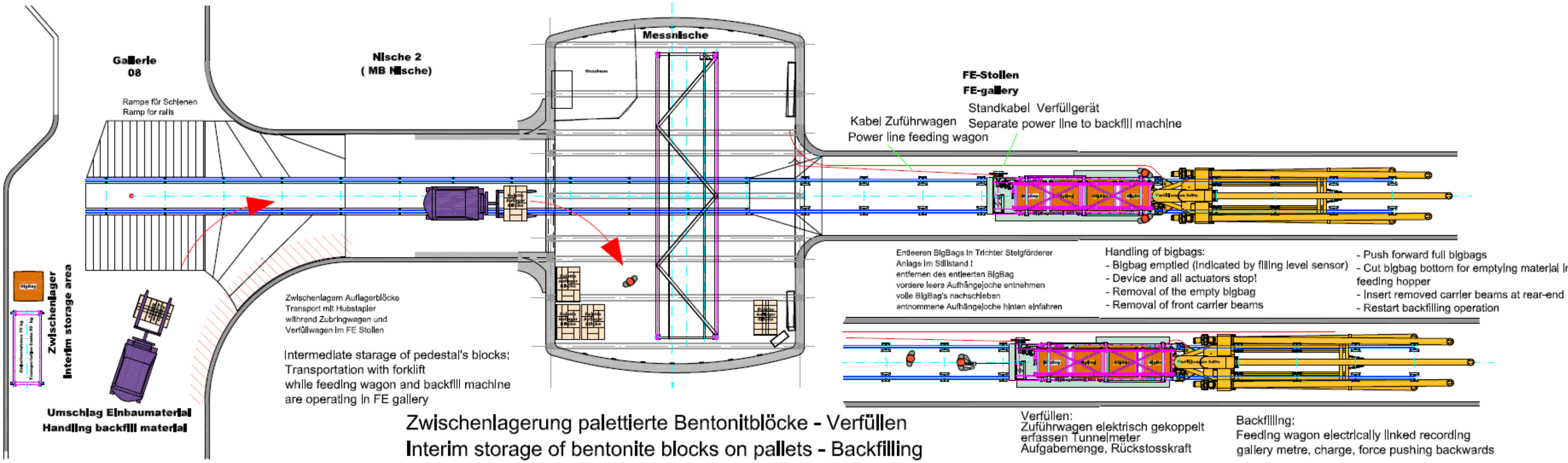
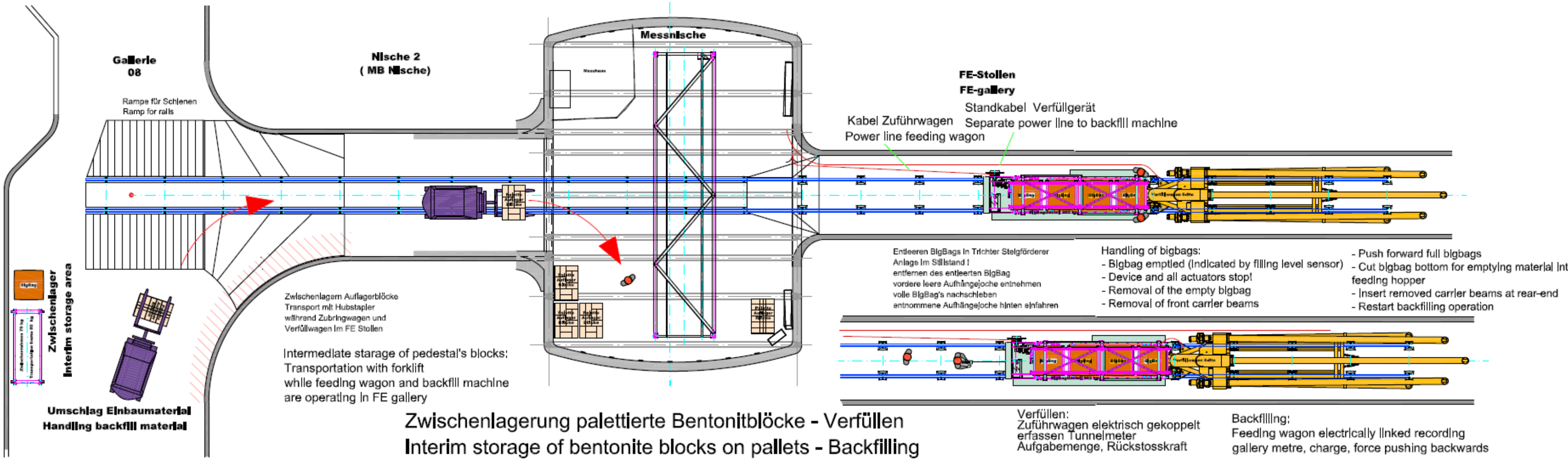
Phase 2: Backfilling
+ interim storage of bentonite blocks in start niche



	Working step	Workers position	Min. number of Workers	Auxiliary devices
1	Feeding wagon and backfill machine are being electrically and mechanically connected in the FE gallery. Backfill machine not operating (standing still!)	• On gangway and platform of feeding wagen • Between feeding wagon and backfill machine	• 1 operator feeding wagon • 1 worker handling bigbags	none
2	Bigbag Nr. 1 is positioned above the feeding hopper, opened (cutting its bottom) and prepared for backfill operation. Backfill machine not operating (standing still!)	• On gangway and platform of feeding wagen • Between feeding wagon and backfill machine	• 1 operator feeding wagon • 1 worker handling bigbags	• Cutting tool for bigbags' bottom

Phase 2: Backfilling
+ interim storage of bentonite blocks in start niche



	Working step	Workers position	Min. number of Workers	Auxiliary devices
3	Workers get off the backfilling facility at rear end of the feeding wagon.	• Rear end of the feeding wagon	• 1 operator feeding wagon • 1 worker handling bigbags	none
4	Preparation for backfill operation and checking for start: • Hydraulic breaks – ok • Electric connection – ok • Display on touch panel – ok • Backfill machine ready for start – ok	• Rear end of the feeding wagon	• 1 operator feeding wagon • 1 worker handling bigbags	none

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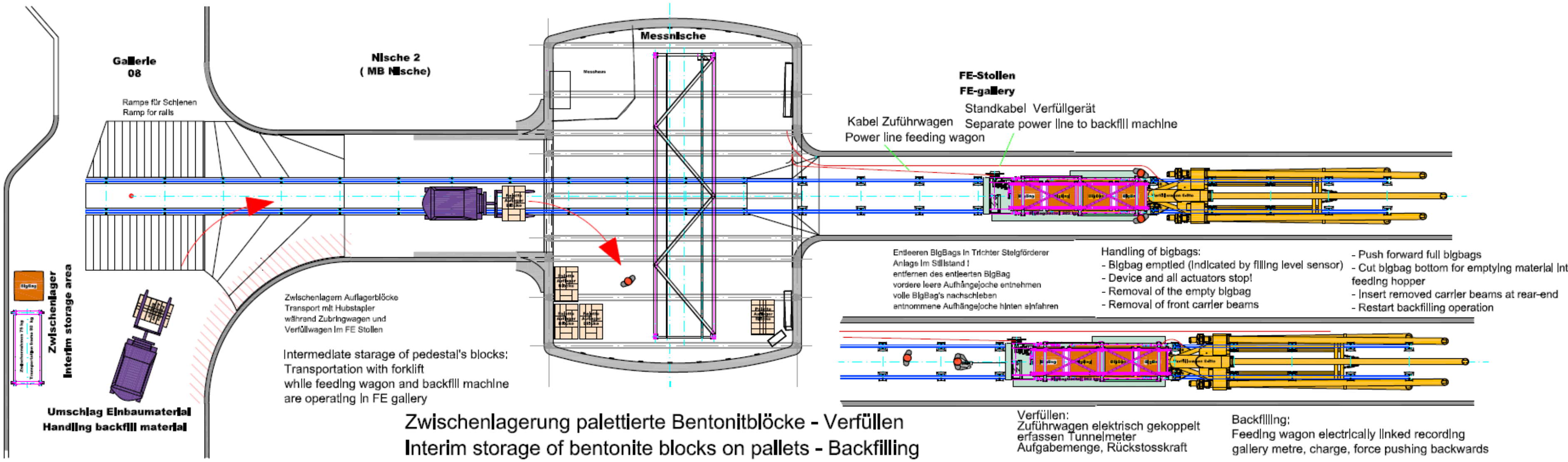
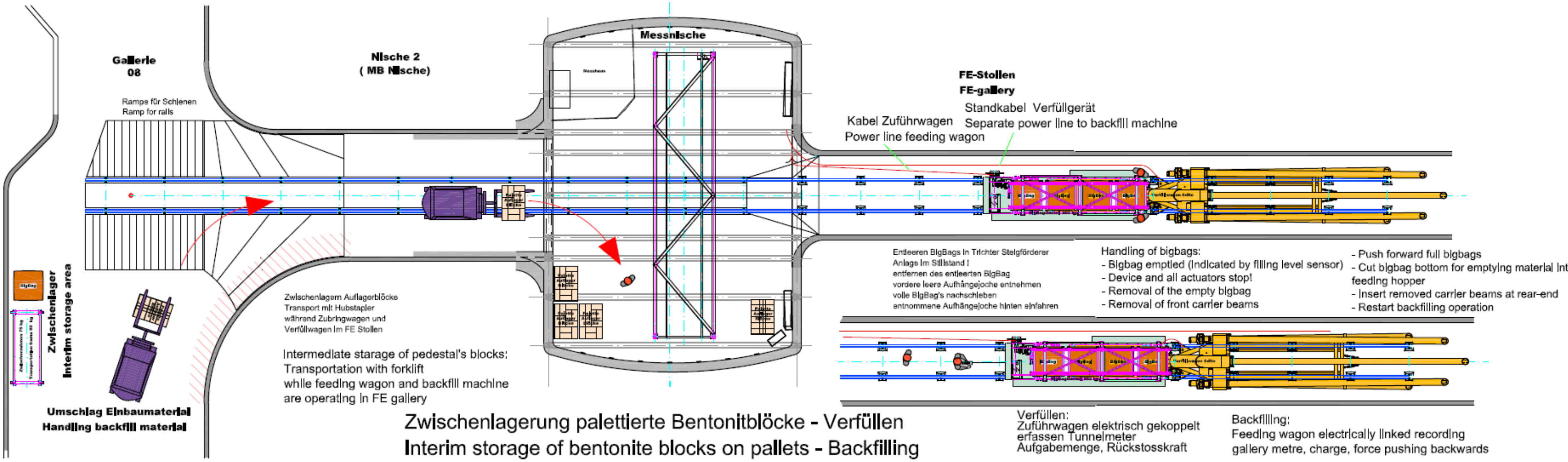
Phase 2: Backfilling
+ interim storage of bentonite blocks in start niche



	Working step	Workers position	Min. number of Workers	Aux. devices
5	• Approval and start backfilling of bigbag Nr. 1 • Check of backfill operation via touch panel display • Manually pull back the separate power line of the backfill wagon with proceeding backfill	• Rear end of the feeding wagon	• 1 operator feeding wagon • 1 worker handling bigbags	none
6	As soon as bigbag Nr. 1 is empty, device stops automatically via a filling level sensor in the feeding hopper	• Rear end of the feeding wagon	• 1 operator feeding wagon • 1 worker handling bigbags	none

Phase 2: Backfilling
+ interim storage of bentonite blocks in start niche



	Working step	Workers position	Min. number of Workers	Aux. devices
7	• Manual removal of empty bigbag Nr. 1 and carrier beams • Position bigbag Nr. 2 over feeding hopper (push other bigbags forward) • Open bigbag Nr. 2 (cut bottom) and prepare for operation • Backfill device not operating (standing still)!	• On gangway and platform of feeding wagen • Between feeding wagon and backfill machine	• 1 operator feeding wagon • 1 worker handling bigbags	Cutting tool for bigbags' bottom

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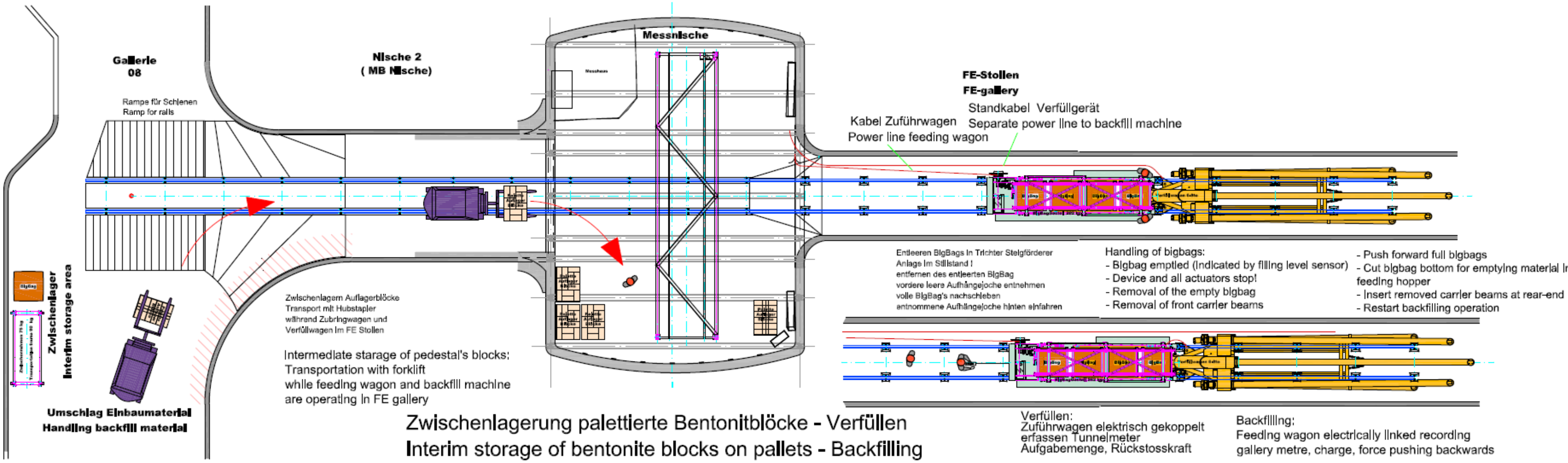
Phase 2: Backfilling
+ interim storage of bentonite blocks in start niche



	Working step	Workers position	Min. number of Workers	Aux. devices
8	Workers get off the backfilling facility at rear end of the feeding wagon.	• Rear end of the feeding wagon	• 1 operator feeding wagon • 1 worker handling bigbags	none
9	Repetition of working steps untill all bigbags are empty.			
10	During backfill operation, pallets with bentonite blocks for next pedestal are transferred into start niche	• Start niche	• 1 operator fork lift	

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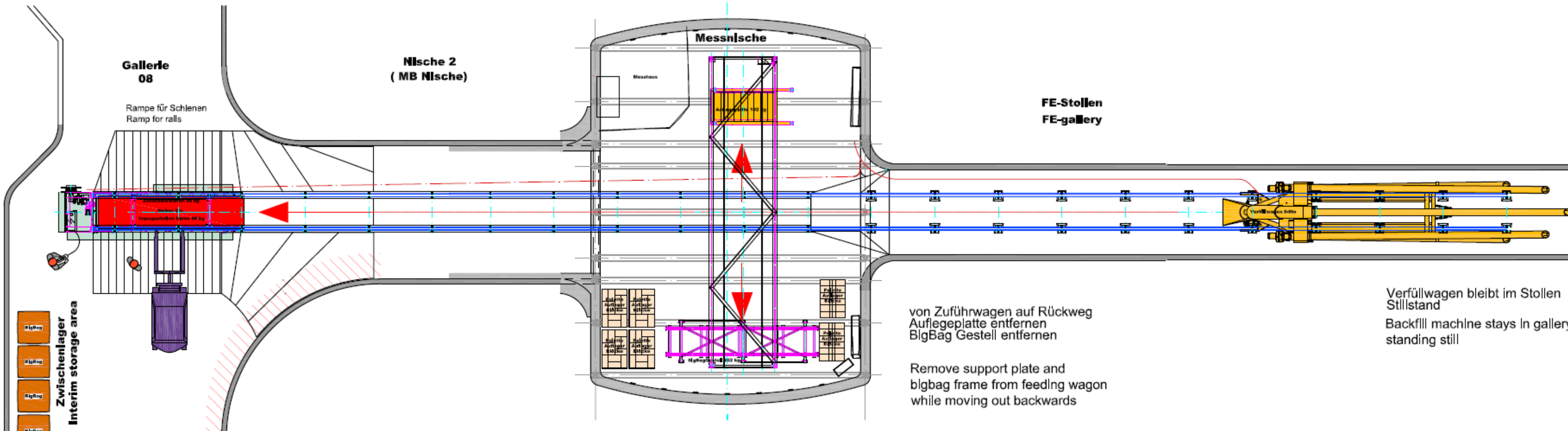
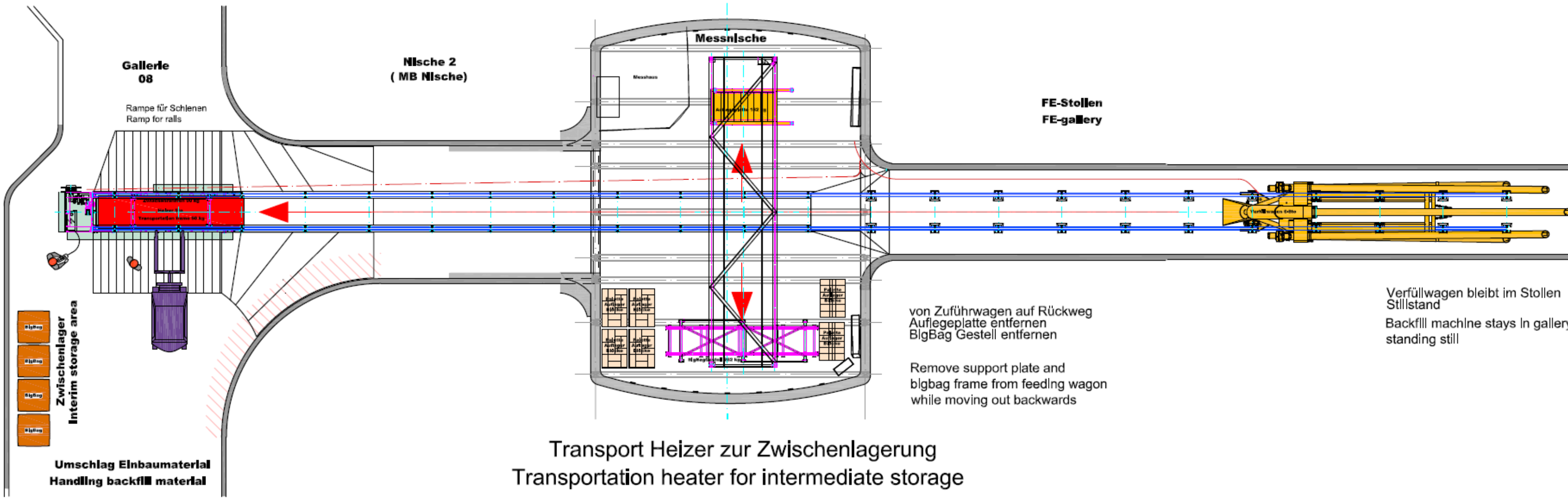
Phase 3: Transport heater to start niche



Transport Heizer zur Zwischenlagerung
Transportation heater for intermediate storage

	Working step	Workers position	Min. number of Workers	Aux. devices
1	• Disconnect feeding wagon from backfill machine • Pause backfill machine	• On gangway and platform of feeding wagen • Between feeding wagon and backfill machine	• 1 operator feeding wagon • 1 worker handling bigbags	none
2	Move feeding wagon to start niche	• Rear end of the feeding wagon	• 1 operator feeding wagon • 1 operator bigbags	none

Phase 3: Transport heater to start niche



Transport Heizer zur Zwischenlagerung
Transportation heater for intermediate storage

	Working step	Workers position	Min. number of Workers	Aux. devices
3	Dismount bigbag frame and support plate from feeding wagon and put them aside in the start niche	• Start niche	• 1 operator crane • 1 worker unloading elements	• 1 gantry crane • Lifting accessories
4	Move feeding wagon to Ga 08 to load the heater	• Rear end of the feeding wagon	• 1 operator feeding wagon • 1 worker loading heater	None
5	Mounting of the support frame onto the feeding wagon	• Ga 08, sidewards the feeding wagon	• 1 operator fork lift • 1 operator feeding wagon • 1 worker loading heater	• 1 Fork lift

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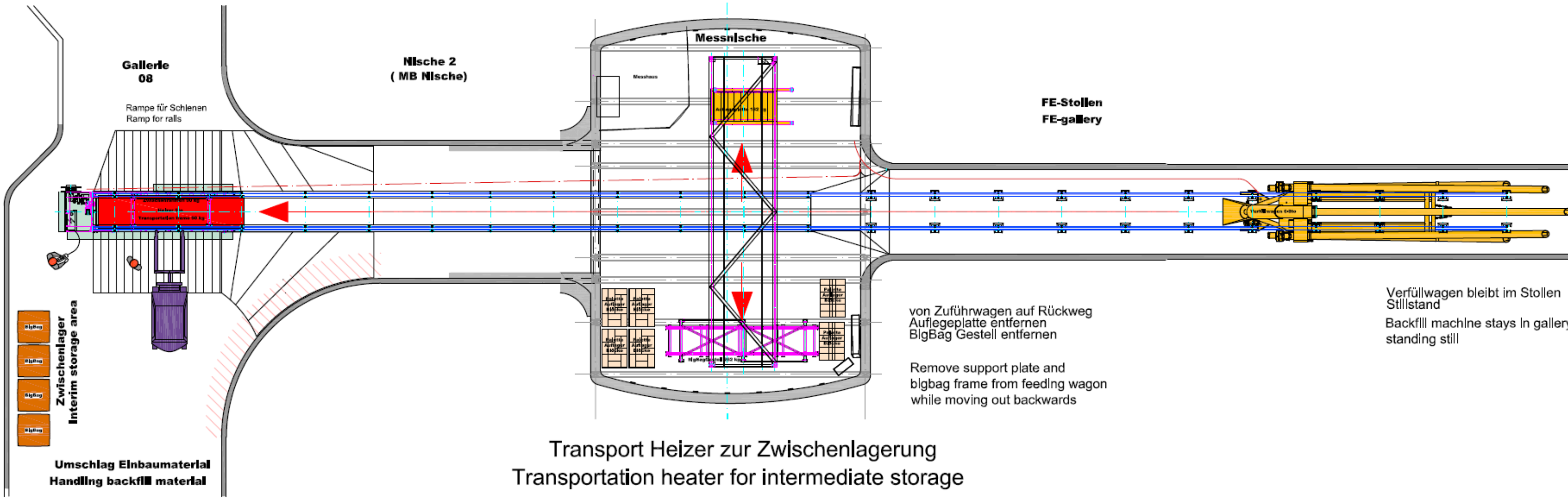
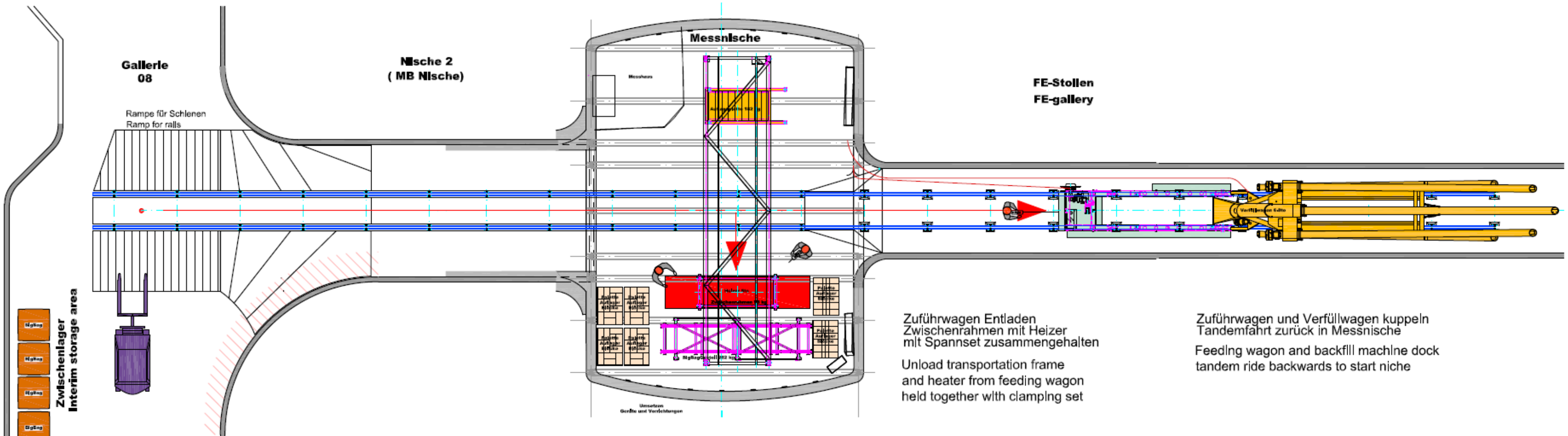
Phase 3: Transport heater to start niche



	Working step	Workers position	Min. number of Workers	Aux. devices
6	Loading and securing of heater on support frame and feeding wagon	• Ga 08, sidewards the feeding wagon	• 1 operator fork lift • 1 operator feeding wagon • 1 worker loading heater	• 1 Fork lift (maybe Manitou?)
7	Move feeding wagon with heater into start niche	• Rear end of the feeding wagon	• 1 operator feeding wagon • 1 operator heater	None

Phase 4: Tandem ride feeding wagon + backfill machine



Tandemfahrt Zuführwagen Verfüllwagen
Tandem ride feeding wagon + backfill machine

	Working step	Workers position	Min. number of Workers	Aux. devices
1	Unload heater with support frame in start niche (intermediate storage)	• Start niche, sidewards feeding wagon	• 1 operator crane • 1 worker unloading	• 1 gantry crane • Lifting accessories
2	Move feeding wagon towards backfill machine	• Rear end of feeding wagon	• 1 operator feeding wagon • 1 co-worker	None

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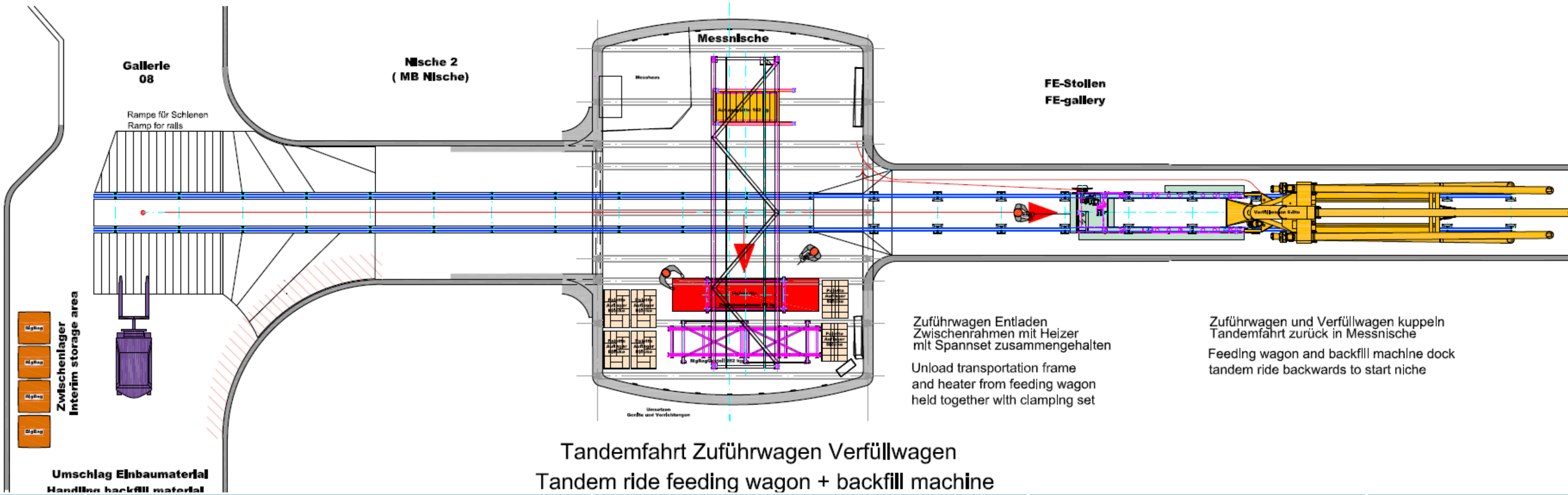
Phase 4: Tandem ride feeding wagon + backfill machine



Tandemfahrt Zuführwagen Verfüllwagen
Tandem ride feeding wagon + backfill machine

	Working step	Workers position	Min. number of Workers	Aux. devices
3	Mechanical and electrical connection of feeding wagon and backfill machnine	• On gangway and platform of feeding wagen • Between feeding wagon and backfill machine	• 1 operator feeding wagon • 1 co-worker	None
4	Disconnect separate power line from backfill machine and tandem ride of both devices until feeding wagon reaches lift-off position in start niche	• Rear end of feeding wagon	• 1 operator feeding wagon • 1 co-worker	None

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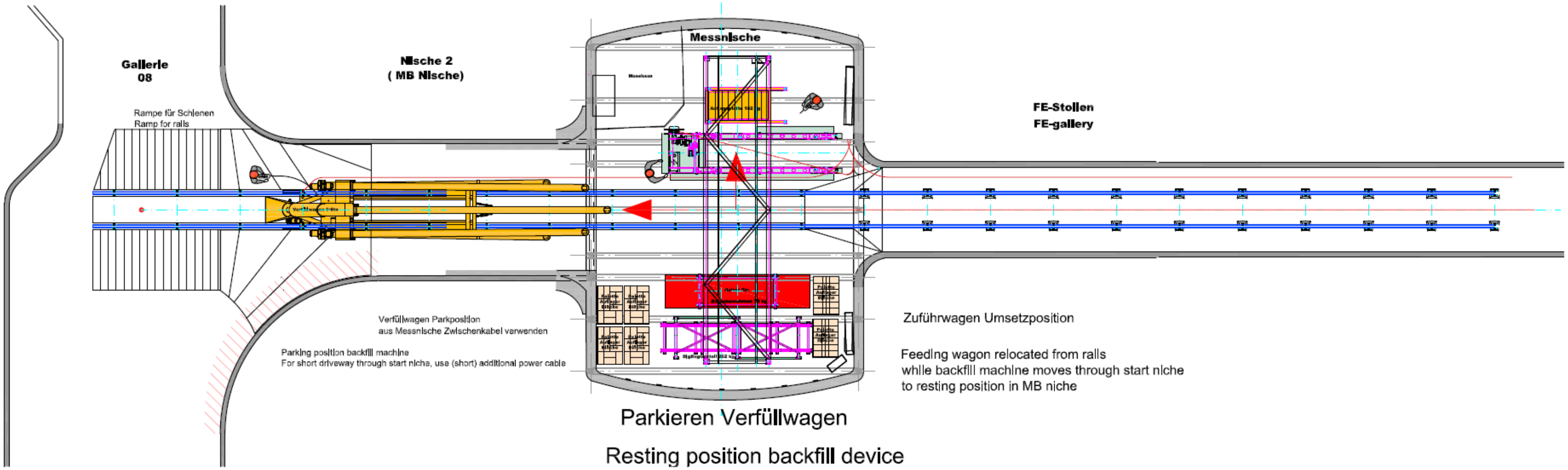
Phase 5: Relocate feeding wagon and backfill machnine for heater emplacement process



	Working step	Workers position	Min. number of Workers	Aux. devices
1	Disconnect feeding wagon from backfill machine (mechanically and electrically) and relocate it with crane to resting position aside the rails in the start niche	• Start niche	• 1 operator crane • 1 operator feeding wagon	• 1 gantry crane • Lifting accessories
2	Supply power to backfill machine via separate short line and move it through start niche to resting position in MB niche	• Wired control at rear end of backfill machine	• 1 operator backfill machine	none

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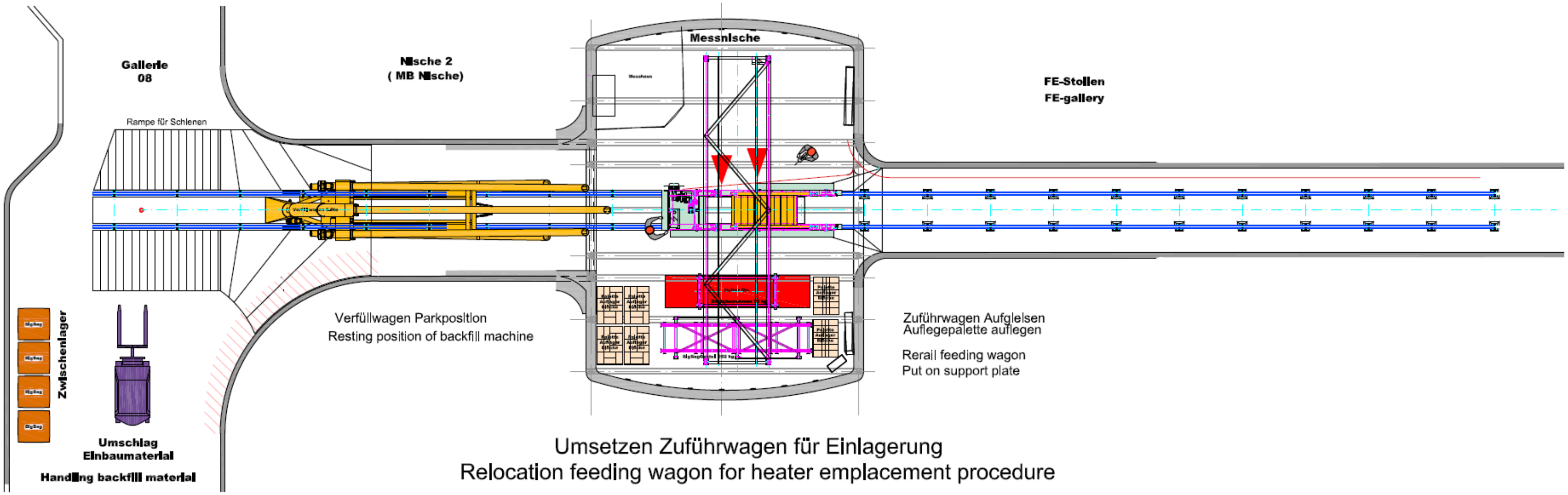
Phase 6: Preparation of feeding wagon for emplacement procedure



	Working step	Workers position	Min. number of Workers	Aux. devices
1	The feeding wagon is rerailed with the crane and the support plate is set down on it	• Start niche, aside feeding wagon	• 1 operator crane • 1 operator feeding wagon	• 1 gantry crane • Lifting accessories

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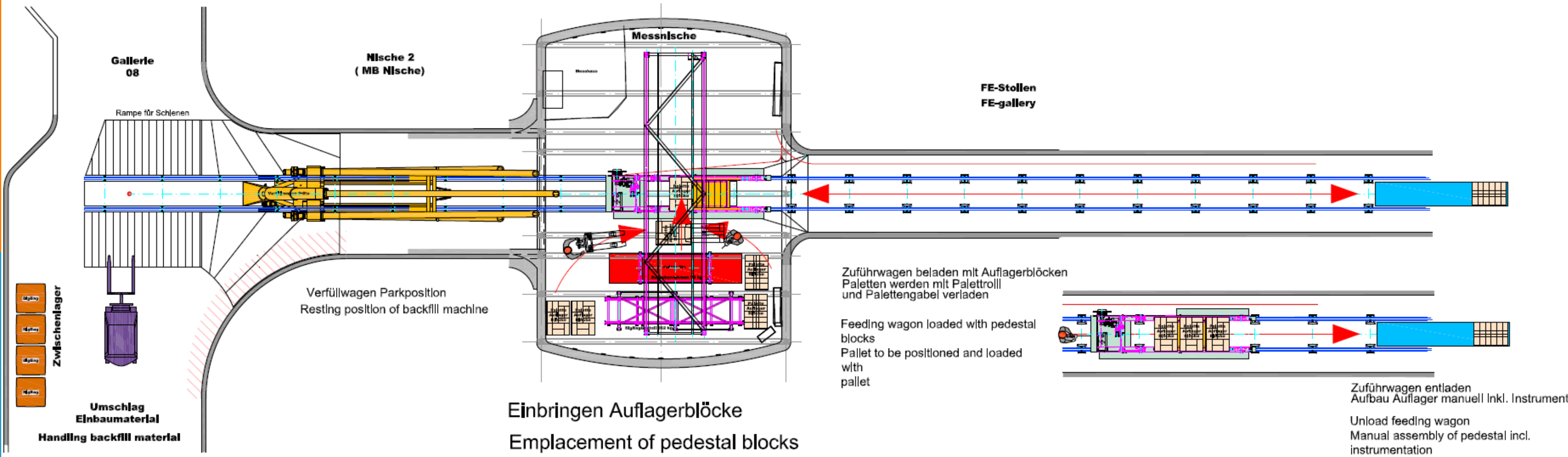
Phase 7: Emplacement of bentonite blocks



	Working step	Workers position	Min. number of Workers	Aux. devices
1	Loading of pallets of bentonite blocks onto the feeding wagon.	• Start niche, sidewards the feeding wagon	• 1 operator crane • 1 co-worker	• 1 gantry crane with fork for pallets • 1 Pallettruck
2	Transfer of loaded feeding wagon to the destination in the FE gallery.	• Wired control at rear end of the feeding wagon • No persons in the FE gallery • Driveway is surveyed with front sided camera / rear sided monitor screen	• 1 operator feeding wagon	None

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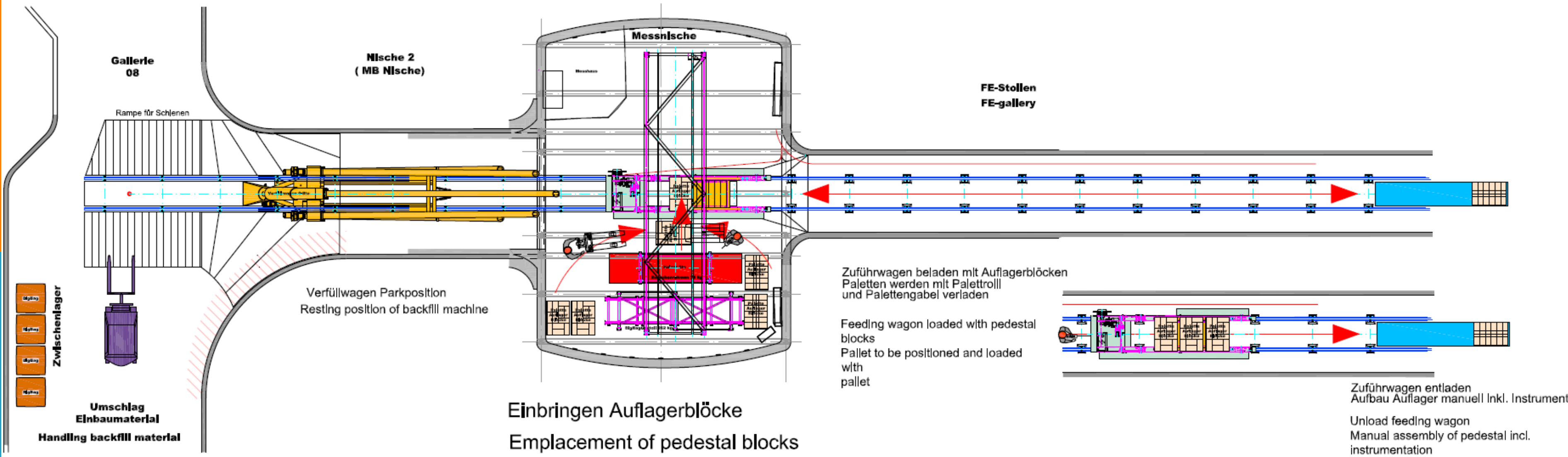
Phase 7: Emplacement of bentonite blocks



	Working step	Workers position	Min. number of Workers	Aux. devices
3	Manual assembly of the bentonite blocks pedestal for the heater incl. instrumentation and cable lining	• Front side of the feeding wagon	• 2 workers	• Special equipment for instrumentation
4	Check and approval of pedestal	• FE gallery	• 1 Nagra supervisor	None

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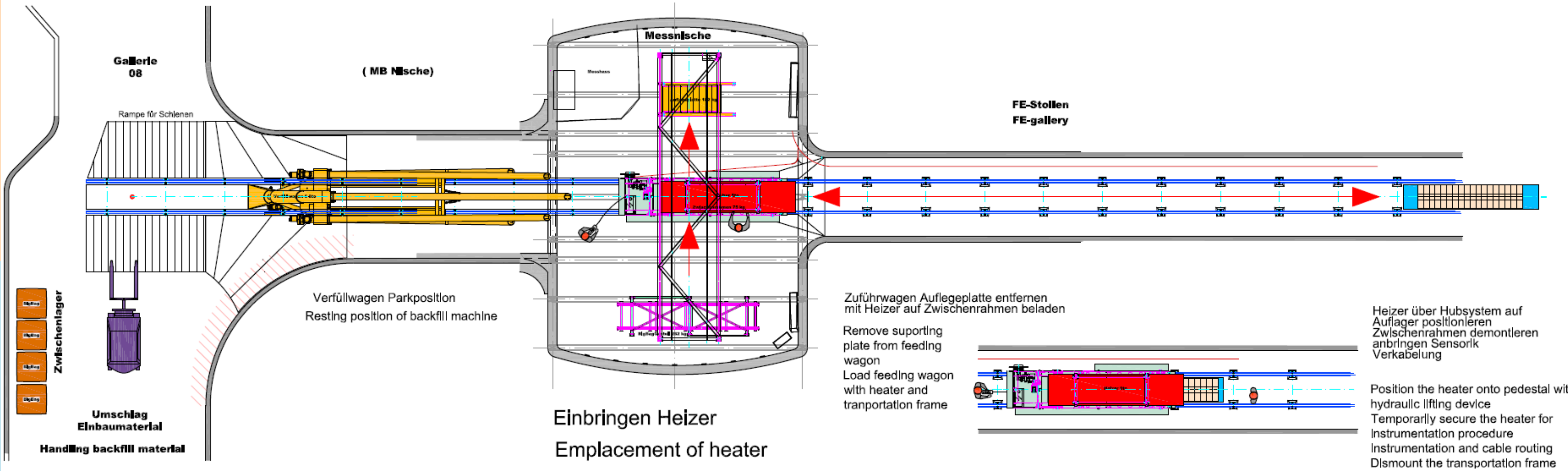
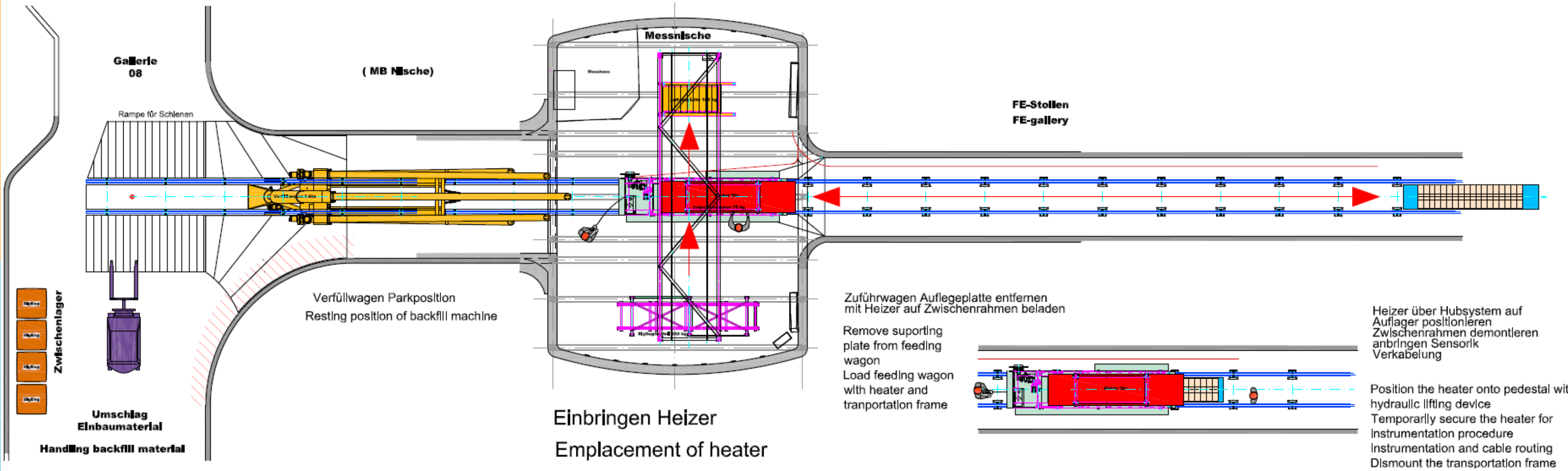
Phase 8: Emplacement of heater



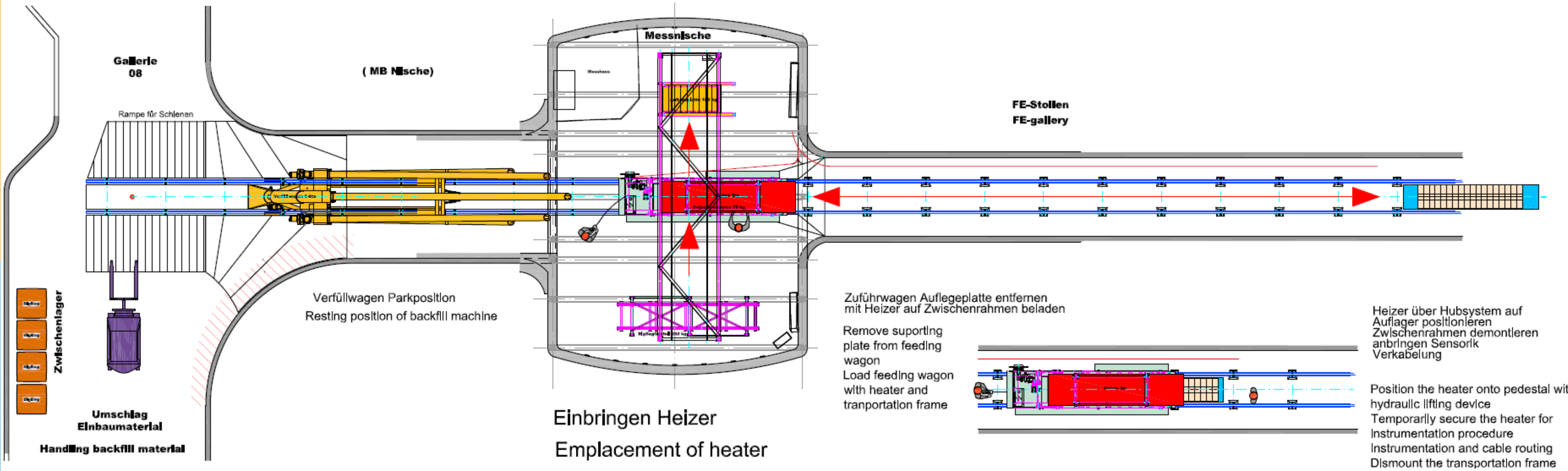
	Working step	Workers position	Min. number of Workers	Aux. devices
1	Move feeding wagon to start niche	• Rear end of feeding wagon	• 1 operator feeding w. • 1 co-worker	• None
2	Put aside support plate	• Start niche	• 1 operator crane • 1 co-worker	• 1 gantry crane with lifting accessories
3	Load and secure heater with support frame onto feeding wagon	• Start niche	• 1 operator crane • 1 co-worker	• 1 gantry crane with lifting accessories

Phase 8: Emplacement of heater



	Working step	Workers position	Min. number of Workers	Aux. devices
4	Move loaded feeding wagon into FE gallery and towards pedestal	• No person between feeding wagon and backfill machine • Wired operation of feeding wagon • Driveway is surveyed with front sided camera / rear sided monitor screen	• 1 operator feeding wagon	• None

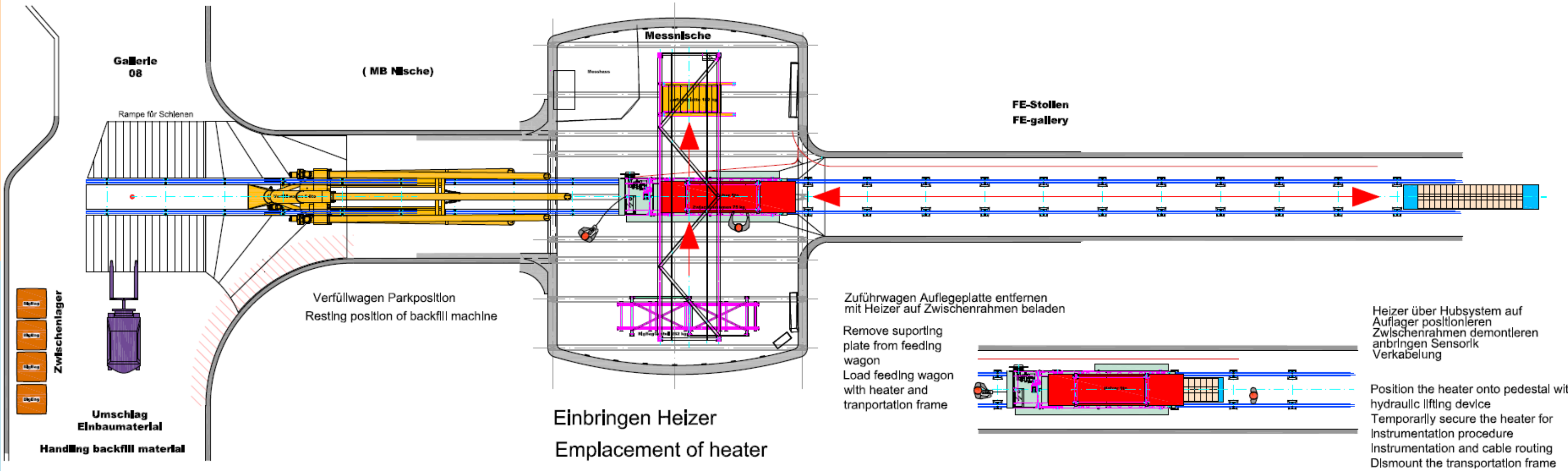
Phase 8: Emplacement of heater



	Working step	Workers position	Min. number of Workers	Aux. devices
5	Position and set down the heater onto the pedestal with hydraulic lifting device	• Front and rear end of feeding wagon	• 1 operator crane • 1 co-worker	• None
6	Check and approval of heater and pedestal position	• FE gallery, next to heater	• 1 construction surveyor • 1 Nagra supervisor	• 1 Survey instrument equipment
7	Temporary securing of heater for heater instrumentation works	• FE gallery, next to heater	• 1 operator feeding wagon • 1 co-worker	• Securing elements

nagra.

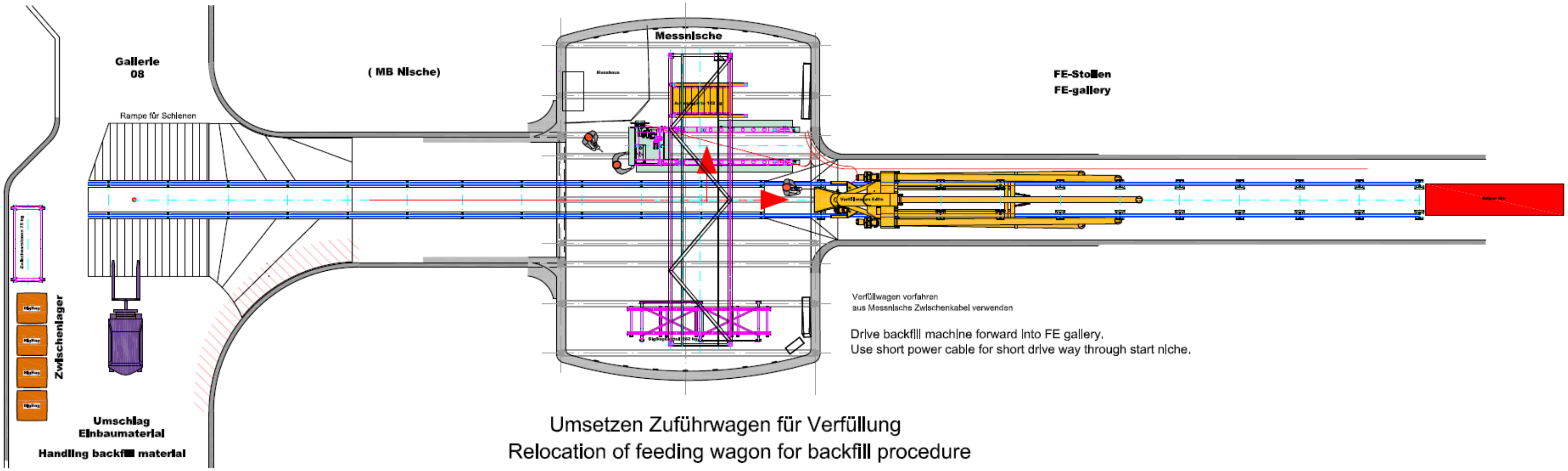
Phase 8: Emplacement of heater



	Working step	Workers position	Min. number of Workers	Aux. devices
8	Instrumentation of the heater	• FE gallery, next to heater	• x instrumentation specialists	• Sensors • Cables • Specific working equipment
9	Disassembly of support frame	• FE gallery, next to heater	• 1 operator feeding wagon • 1 co-worker	• None
10	Move feeding wagon to start niche	• Rear end of feeding wagon	• 1 operator feeding wagon • 1 co-worker	• None

nagra.

Phase 9: Relocation of feeding wagon and backfill machine for backfilling procedure

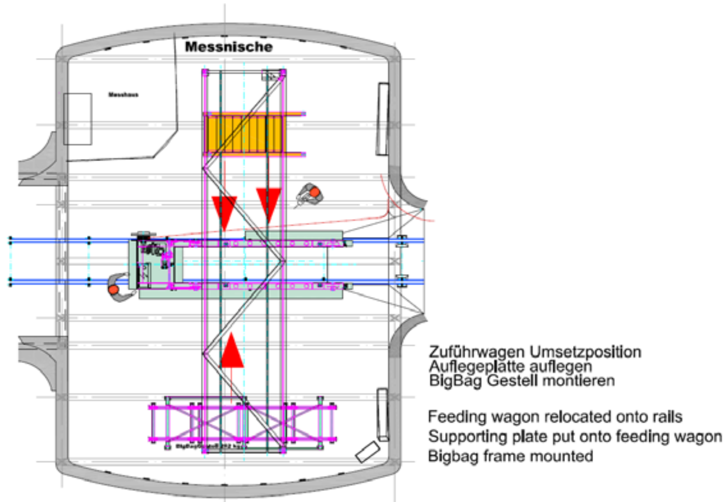


Umsetzen Zuführwagen für Verfüllung
Relocation of feeding wagon for backfill procedure

	Working step	Workers position	Min. number of Workers	Aux. devices
1	Relocate feeding wagon with crane to resting position aside rails in the start niche	• Start niche	• 1 operator crane • 1 co-worker	• 1 crane and lifting accessories
2	Move backfill machine with short power line through start niche to FE gallery entrance. Remove short power line.	• MB niche and start niche	• 1 operator backfill machine • 1 co-worker	• None

nagra.

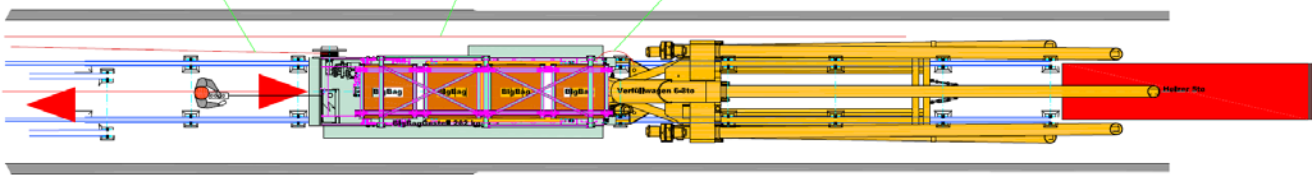
Phase 10: Relocate and reload feeding wagon for backfill procedure



Umsetzen Zuführwagen für Verfüllung
Relocate feeding wagon for backfill procedure

	Working step	Workers position	Min. number of Workers	Aux. devices
1	Rerail the feeding wagon with crane onto the rails in the start niche and mount support plate and carrier frame for bigbags.	• Start niche	• 1 operator crane • 1 co-worker	• 1 crane and lifting accessories
2	Move feeding wagon into Ga 08 in order to load bigbags	• Ga 08, sidewards feeding w.	• 1 operator backfill machine • 1 co-worker loading bigbags • 1 operator forklift • 1 Nagra supervisor	• 1 forklift
3	(→ refer to phase 1) …			

Phase 11: Moving the feeding wagon and the backfill machine in and out of the FE gallery



Ein- Ausfahren Zuführwagen und Verfüllwagen

Driving feeding wagon and backfill machine in and out

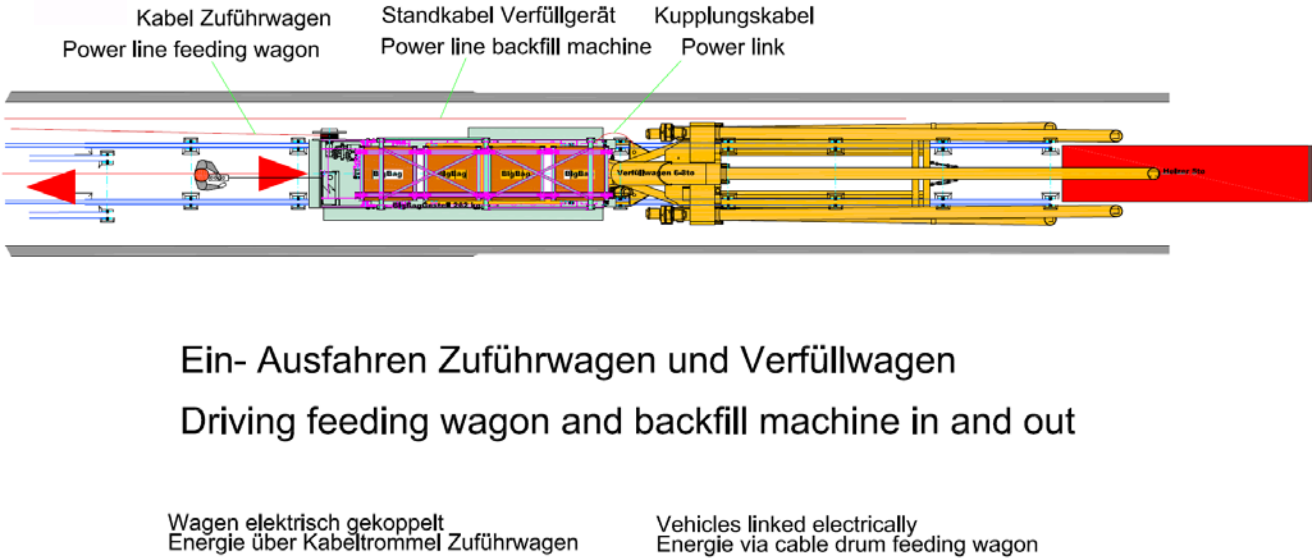
Wagen elektrisch gekoppelt
Energie über Kabeltrommel Zuführwagen

Vehicles linked electrically
Energie via cable drum feeding wagon

	Working step	Workers position	Min. number of Workers	Aux. devices
1	The feeding w. and backfill m. are mechanically and electrically connected.	• FE gallery, rear end of feeding wagon	• 1 operator feeding- and backfill facility • 1 co-worker	• None
2	Tandem ride to the current backfill slope	• Rear end of feeding wagon	• 1 operator feeding- and backfill facility • 1 co-worker	• None

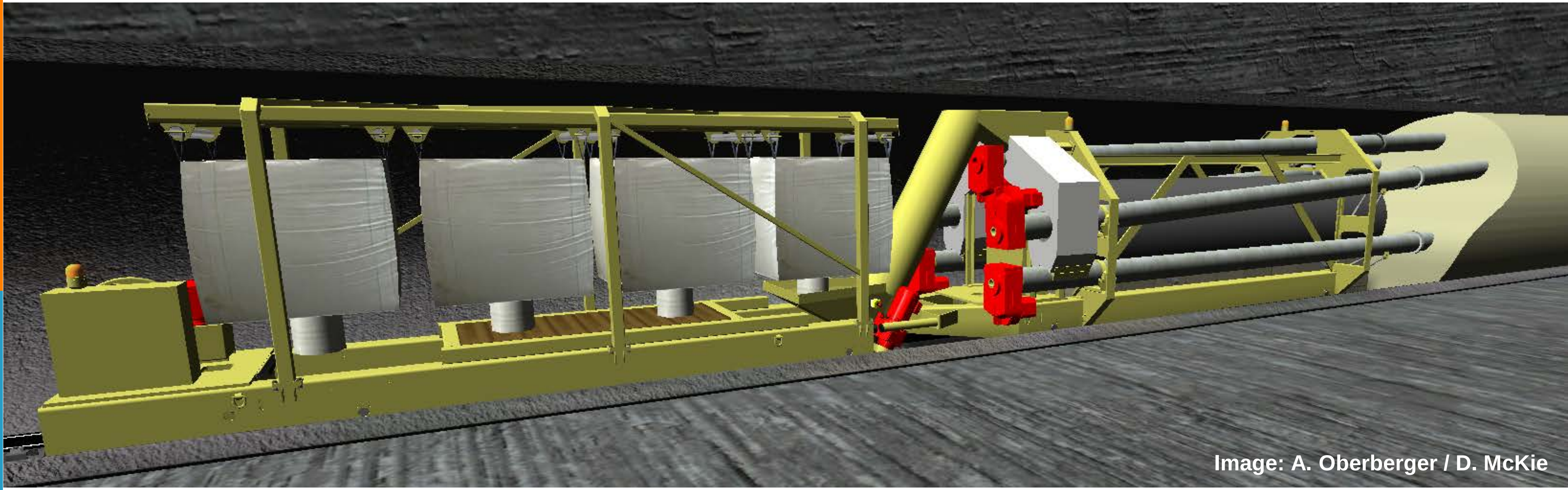
nagra

Phase 11: Moving the feeding wagon and the backfill machine in and out of the FE gallery



	Working step	Workers position	Min. number of Workers	Aux. devices
3	At the backfilling position, the separat power line is connected to the backfill machine	• FE gallery, between feeding w. and backfill m.	• 1 operator feeding- and backfill facility • 1 co-worker	• None
4	Repeat backfill procedure according to phase 2			

In order to mount instrumentation sensors and cable lines just in front of the backfill slope, the feeding- and backfill facility can be driven in and out in this manner at any time. The work instructions for the emplacement and for the instrumentation workers have to comprise the relevant interface considerations.



thank you
for your attention

nagra.

Annex 3

Feeding wagon

general layout drawing

Index	gezeichnet	geprüft	freigegeben	Aenderungsvermerk
C	29.10.2013 AO	29.10.2013 KaRi	30.10.2013 HJ	Aktualisiert, Ausführung
B	03.09.2013 AO	03.09.2013 KaRi	04.09.2013 HJ	Aktualisiert, Vertragsindex
A	26.8.2013 AO	27.8.2013 KaRi	28.8.2013 HJ	Aktualisiert

nagra.

Blattgrösse: A1	Gewicht: 2486 kg
Massstab: 1:1	
gezeichnet: 02.08.2013	Visum: AO
geprüft: 20.08.2013	Visum: KaRi
freigegeben: 21.08.2013	Visum: HJ

FE / LUCOEX
Zuführwagen / Feeding device
Experiment Mont Terri

rowa Rowa Tunnelling Logistics AG, CH-8855 Wangen

10731-200 C

Annex 4

Backfilling wagon general layout drawing

Erforderliche Anziehdrehmomente [Nm]

Verbindung	Grösse / Klasse	M8 geölt	M8 MoS2	M10 geölt	M10 MoS2	M12 geölt	M12 MoS2	M16 geölt	M16 MoS2	M20 geölt	M20 MoS2	M22 geölt	M22 MoS2	M24 geölt	M24 MoS2	M27 geölt	M27 MoS2	M30 geölt	M30 MoS2
Maschinenbau	8.8	26	21	51	42	89	72	215	174	420	340	570	455	725	580	1070	855	1450	1160
	10.9	36	29	72	58	125	101	305	245	590	475	800	640	1020	820	1510	1210	2050	1640
Hochfest	HV	--	--	--	--	120	100	350	250	600	450	900	650	1100	800	1650	1250	2200	1650
Rostfrei	70 (A2)	--		30		50		121		224		318		400		--		--	
	80 (A2)	--		40		67		161		325		400		534		--		--	
Hilti HVA:	HVU+HAS/-R/-HCR	--		35		60		120		260		--		450		650 (HAS)		950 (HAS)	
Lindapter	A,B,D2,LR	--		30		69		147		285		--		491		--		--	
	C1,C2,D1	--		15		35		74		143		--		--		--		--	

MOLYKOTE-Schmierstoff ist grundsätzlich zu bevorzugen und bei rostfreiem Stahl vorgeschrieben

Index	gezeichnet	geprüft	freigegeben	Aenderungsvermerk
B	07.05.2015 AO	07.05.2015 KaRi	07.05.2015 HJ	neue Masse durch ausgelagerte Bremsfunktion
A	16.12.2013 AO	16.12.2013 KaRi	17.12.2013 HJ	neue Masse durch aktuelle Bremsfunktion

nagra.

Blattgrösse: A1
Gewicht: 4950 kg
Massstab: 1:20

FE / LUCOEX
Verfüllwagen
Experiment Mont Terri

gezeichnet: 16.11.2013 — Visum: AO
geprüft: 17.11.2013 — Visum: KaRi
freigegeben: 18.11.2013 — Visum: HJ

Rowa Tunnelling Logistics AG, CH-8855 Wangen

10731-101 B

Annex 5

FE-A niche crane
general layout drawing
(labelling in German)

Index	gezeichnet	geprüft	freigegeben	Aenderungsvermerk
E	19.02.2014 AO	19.02.2014 KaRi	19.021.2014 HJ	aktuelle Version der Einbringmaschienen und Lage eingefügt
D	18.11.2013 AO	18.11.2013 KaRi	19.11.2013 HJ	Ausführung
C	10.10.2013 AO	11.10.2013 KaRi	11.10.2013 HJ	Kran an Scankontur angepasst
B	03.09.2013 AO	03.09.2013 KaRi	03.09.2013 HJ	Vertragsindex
A	23.8.2013 AO	26.8.2013 KaRi	28.8.2013 HJ	aktualisiert

Blattgrösse: A0	Gewicht: 3012 kg
Massstab: 1:20	
gezeichnet: 29.7.2013	Visum: AO
geprüft: 20.8.2013	Visum: KaRi
freigegeben: 21.8.2013	Visum: HJ

FE / LUCOEX
Kran Messnische
Experiment Mont Terri

Rowa Tunnelling Logistics AG, CH-8855 Wangen

10731-300 E

Annex 6

Rail installation
general layout drawing
(labelling in German)

A	19.02.2014 AO	19.02.2014 KaRi	19.02.2014 HJ	Verlegeanfangspunkt 3m geschoben, Teile angepasst
Index	gezeichnet	geprüft	freigegeben	Aenderungsvermerk

Blattgrösse: 420x1841 — Gewicht: 7613 kg — Massstab: 1:50

FE / LUCOEX
Schienenverlegeplan
Ausführungsplan

Mont Terri Project

gezeichnet: 07.02.2014	Visum: AO
geprüft: 07.02.2014	Visum: KaRi
freigegeben: 10.02.2014	Visum: HJ

Rowa Tunnelling Logistics AG, CH-8855 Wangen

10731-604 A

Annex 7

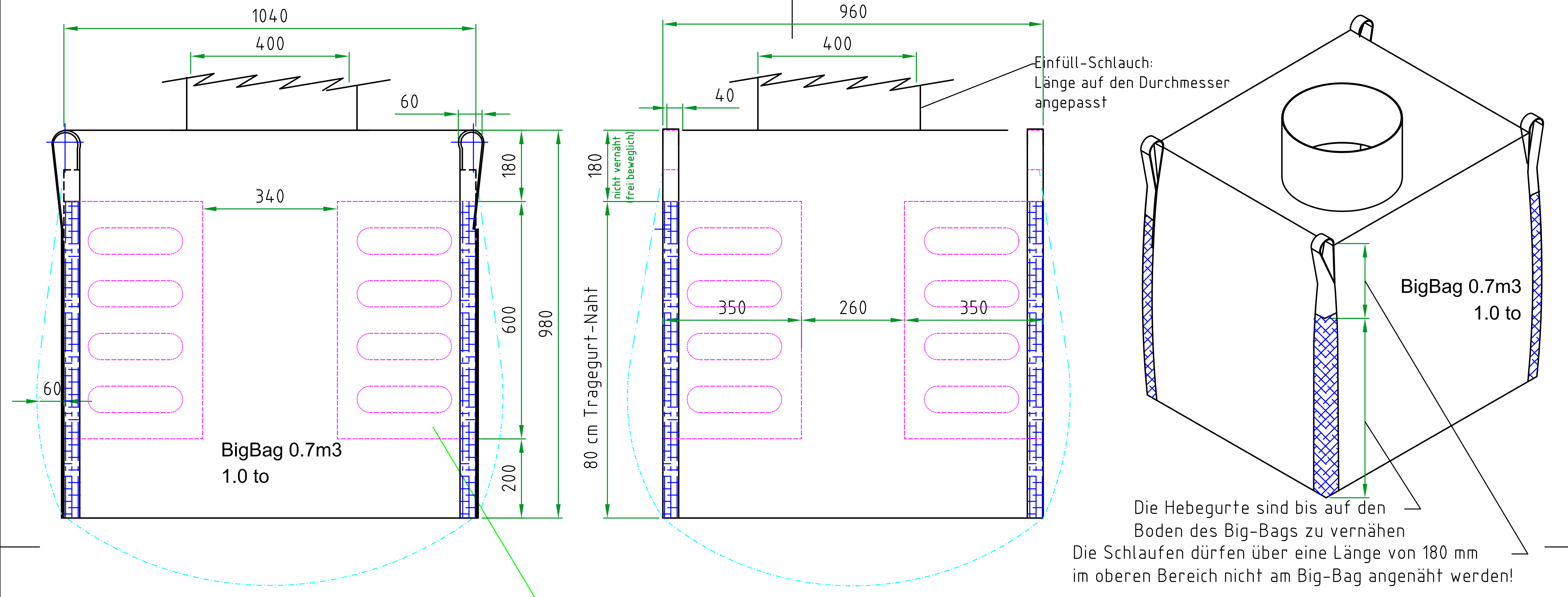
Dedusting system
general layout drawing
(labelling in German)

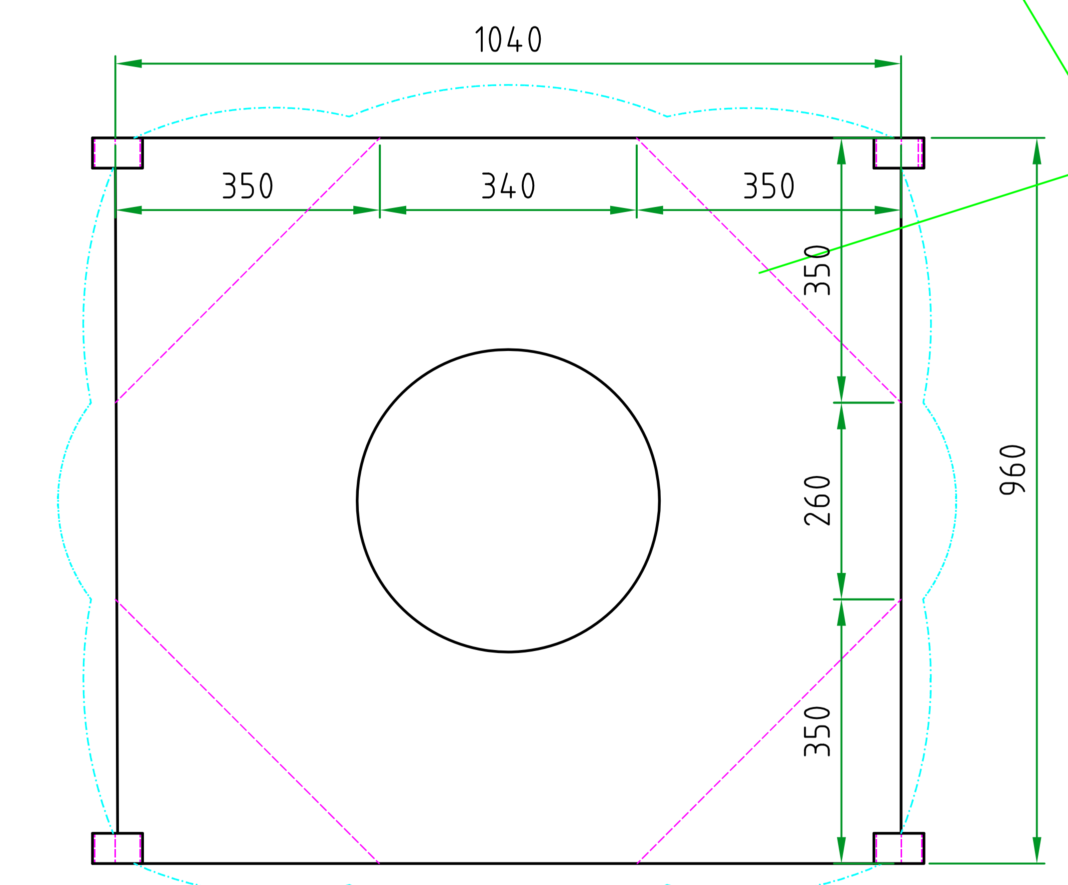

Faltlutte D=900mm bis portal (Swisstopo)
Blechrohr D=700mm
gekürzt auf 723
B-B (1:25)
Querschnitt Messnische
Schnitt A-A 1:10
Detail1 (1:5)
Befestigung Ovalrohr mit Montage-Bügel
Schnitt C-C (1:25)
bestehende Belüftungsleitung Ø250
Neue Entstaubungsleitung Ø350
Reserveansaugstutzen mit Regulierklappe
Absaugleistung Nische: 50m3/min mit Regulierklappe
D=350mm
Absaugleistung: 150m3/min
Absaugleistung Trichter: 50m3/min
Profil 150x385
Absaugleistung: 100m3/min
Absaugleistung Luttenende: 50m3/min
TM 0.00
TM 18.00
TM 25.60
TM 33.20
TM 40.80
TM 50.00
Flexible Spirallutte D=150mm mit Regulierklappe
Flexibler Staubsack verschliessbar
Ventilations- und Entstaubungsschema
Faltlutte D=900mm bis portal (Swisstopo)
Trockenentstauber Typ HTKS1/600
nominale Absaugluftmenge: 600m3/min
A=0.0491m2
Q=50m3/min
A=0.0962m2
Q=150m3/min
A=0.053m2
Q=100m3/min
A=0.0177m2
Q=50m3/min
A=0.0177m2
Q=50m3/min
Wettergeschwindigkeit: 0.29m/s
Querschnitt Stollen
A=5.72m2
Schnitt D-D (1:25)
el. Anschluss
Kabel + Stecker CEE 63/5Pol
(ELB)
el. Anschluss
Kabel + Stecker CEE 16/5Pol
(ELB)
Lufttank 270l
Kompressor
Typ Compair L22
2m3/min
10bar
el. Anschluss
mit Stecker CEE 63/5Pol
(Compair)
el. Anschlusskasten
2x CEE 63/5Pol
1x CEE 16/5Pol
(Swisstopo)
Druckluftanschluss
Ventilator GAL6-100/100
Luftmenge: 250 m3/min
Gesamtdruckdifferenz: 3500 Pa
Antriebsleistung: 2x11kW
Trockenentstauber Typ: HTKS 1/600
nominale Absaugluftmenge: 600 m3/min
Filterfläche: 254 m2
Nebenantriebe: ca. 3kW
Staubkonzentration in der Reinluft: <0.5 mg/m3
zulässiger MAK-Wert: 3 mg/m3
Neue Entstaubungsleitung (Lieferumfang Rowa)
bestehende Belüftungsleitung
Elektro Einspeisung
nagra
FE / LUCOEX
Übersicht Entstaubung
Experiment Mont Terri
10731-148

Annex 8

Big bag dimensions

(labelling in German)





Über Eck verlaufende Versteifungselemente (Innenwandversteifung) mit 4 Öffnungen. Sollen um 15 bis 20 mm (diagonal gemessen) im Untermass gefertigt werden.

Die angegebenen Masse der Aussenabmessungen sind die Maximalmasse. Fertigungstoleranzen (+0, -10 mm) verkleinern diese.

Index	gezeichnet	geprüft	freigegeben	Aenderungsvermerk
Cf	04.04.2014 Khsv	04.04.2014 Fij		Veränderung der Aussenmasse (Breite und Höhe, ohne Traggurt-Länge), Veränderung der vernähten Länge des Traggurts, Entfernen der mittleren Querversteifung
Ce	14.01.2014 Khsv	14.01.2014 Fij		Korrektur der Aussenmasse und entspr. Anpassung Versteifungselemente
Cd	25.11.2013 Khsv	25.11.2013 Fij		Korrektur Querversteifung im Längsschnitt; Ergänzung Vermassung Längsversteifung
Cc	22.11.2013 Khsv	22.11.2013 Fij		Quer liegendes Versteifungselement ergänzt, Einfüllschlauch angepasst, Öffnungen und Masse angepasst
Cb	31.10.2013 Khsv	31.10.2013 Fij		Masse angepasst für Bigbag–Lieferanten
C	15.10.2013 AO	15.10.2013 KaRi	16.10.2013 HJ	Anforderungen aktualisiert gemäss Versuchsresultat
B	02.9.2013 AO	02.9.2013 KaRi	03.9.2013 HJ	Vertragsindex
A	23.8.2013 AO	26.8.2013 KaRi	28.8.2013 HJ	aktualisiert

nagra

LUCOEX

Blattgrösse: A3 297x420	Gewicht: ...		
Massstab: 1:10			
gezeichnet: 19.08.2013	Visum: AO		
geprüft: 20.08.2013	Visum: KaRi		
freigegeben: 21.08.2013	Visum: HJ		

FE / LUCOEX
Abmessungen Big Bag
Experiment Mont Terri

rowa

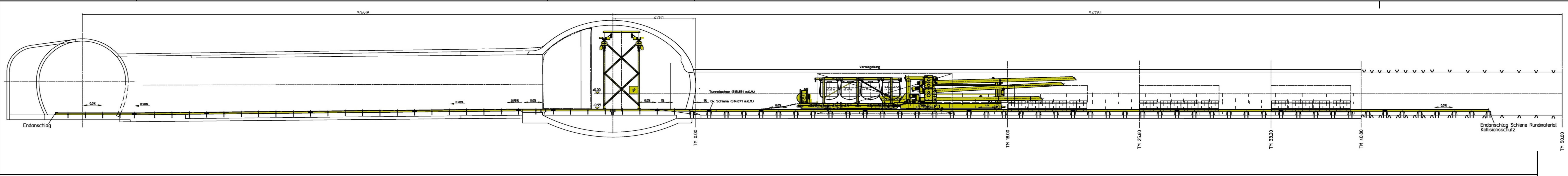
Rowa Tunnelling Logistics AG, CH-8855 Wangen

10731-204 Cf

Annex 9

Safety layout

	Gallerie 08	Nische 2 (MB Nische)	Messnische	FE-Stollen



Brandlasten / Fire level (high / low)	
Manuelles. Feuerlöschsyst. / Manual fire extinguisher	Messnische; Verfüllwagen; Übergabe Positionieren
Fire pro (DSPA) / automatische Löscheinrichtung Elektroschränke	E-Schrank Kran; E-Schrank Zuführwagen; E-Schrank Verfüllwagen
Not-Aus / Emergency stop; Bumper	E-Schrank Kran; Zuführwagen; 2x; Verfüllwagen
Hupe / Horn; Drehlicht / rotary light	E-Schrank Zuführwagen; E-Schrank Verfüllwagen
Kamera / camera	Zuführwagen; Verfüllwagen
Zutrittssperre / access forbidden; Seilzugschalter / rope switch	Zugang zu Verfüllschnecken (Seilzugschalter)
Arbeitsplatzbeleuchtung / Working place lighting	Zuführwagen (2x); Traggestell Verfüllwagen (4x)
Normal- und Notbeleuchtung / normaly and emergency lighting	Gallerie 08; Nische; Nische; Nische; Messnische; Messnische; FE-Stollen; FE-Stollen; FE-Stollen; FE-Stollen; FE-Stollen
Positionsüberwachungssystem / Position control system	Position Messgerät; Messrad; Verfüll-wagen
Kollisionsüberwachung mit Lichtschranke / collisions control system with light beam	Zuführwagen (zu Betonitauflager); E-Schrank Verfüllwagen (zu Heizer)
Elektrokabel; low smoke und halogenfrei / electric cable; low smoke and non halogen	Elektrokabel Kran; Elektrokabel Zuführwagen; Elektrokabel Verfüllwagen
Hydrauliköl; selbsverlöschend und biologisch abbaubar / hydraulic oil; self extinguishing and biologically degradable	Hydr. Öl Zuführwagen; Hydr. Öl Verfüllwagen
Warn-/Hinweisschilder / Warning signs	
Alarm (Blitzlicht/Horn)/ Sicherheitsanweisung wie Rettung/ Telefon Notruf	
Erste Hilfe / First aid; Self preserver; Oxygen measure unit	
Arbeitsfeld Personen dauernd / work field people permanent	Kran Messnische; Vorschrift: Immer mind. 1Person in der Messnische; Verfüllung
Arbeitsfeld Personen Wartung / work field people maintenance	Kran Messnische; Vorschrift: Immer mind. 1Person in der Messnische; Zuführwagen; Förderschnecke
Arbeitsfeld Personen beweglich / work field people movement	Kran Messnische; Vorschrift: Immer mind. 1Person in der Messnische
Zutrittskontrolle durch Swisstopo / access control by Swisstopo	
Arbeitsausrüstung / safety atachment	
Verbote: - Rauchverbot - Ess- und Trinkverbot	

Konzeptfreigabe:
Sie beinhaltet die kundenseitige Genehmigung bezüglich Konzept, Schnittstellen und Vertragskonformität.

[ ] genehmigt ohne Korrekturen
[ ] genehmigt mit Korrekturen/Vorbehalten
[ ] Bemerkungen: ....

Datum: ....
Rowa Tunnelling Logistics AG, CH-8855 Wangen: Kunde: ....
Zuständig: .... Zuständig: ....
Visum: .... Visum: ....

Besprechung mit Swisstopo vom 16.01.2014

	delivery Rowa
	delivery Swisstopo

Index	gezeichnet	geprüft	freigegeben	Aenderungsvermerk

nagra. Mont Terri

Safetylayout

Massstab:	Gewicht:
Gezeichnet: 27.11.2013	Visum: mm
Geprüft: 28.11.2013	Visum: ws
Freigegeben: 28.11.2013	Visum: hj
Artikel:	Format: A3

Rowa Tunneling Logistics AG, CH-8855 Wangen

10731-005a