

Configuration Management and Documentation	Document Type	Document Number	Date
 	Detailed Specification (DS)	F-P-SFR-0001	2026-08-01
			Page 1 of 20

Technical Specification – Design, Manufacture, Supply and Installation of the Liquid Nitrogen (LN₂) Transfer Line System for the Super-FRS Experiment Area

Project: FAIR – Super-FRS Experimental Gas System (GSI
Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt)

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Document History

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V001	Dr. Maximilian Schuett	2026-08-01	2026-08-01	First Release – restructured into the official FAIR Detailed Specification template (F-FO-CMD-en-0009_DS_Template-V010) and translated into English, based on the original German LV draft (Stand 30.06.2026).
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Configuration Management and Documentation	Document Type Detailed Specification (DS)	Document Number F-P-SFR-0001	Date 2026-08-01
 			Page 2 of 20

Abstract

PSP-Code: 2.14.22.62. AID: [to be assigned]. This specification defines the technical requirements for the design, manufacture, supply, and installation of a vacuum-insulated liquid nitrogen (LN₂) transfer line connecting the LN₂ storage tank area to the HI/DESPEC preparation rooms and to the experimental stations FHF1 (Base Scope) and FHF2 (Optional Scope) in the Super-FRS experiment area at FAIR/GSI, Darmstadt.

Configuration Management and Documentation 	Document Type Detailed Specification (DS)	Document Number F-P-SFR-0001	Date 2026-08-01
			Page 3 of 20

Table of Contents

1. Purpose and Classification of the Document.....	5
2. Abbreviations, Terms and Definitions	6
3. Scope of the Technical System.....	7
3.1. System Overview	7
3.2. Scope of Delivery	10
3.2.1. Base Scope	10
3.2.2. Optional Scope (FHF2) – callable at the Company’s discretion	10
3.2.3. Company-furnished Items and Interfaces	10
3.3. Spare Parts and Maintenance Plan.....	11
4. System Specification	12
4.1. Technical Requirements for System Components.....	12
4.1.1. Transfer Lines	12
4.1.2. Supply Points (Valve Boxes)	12
4.2. Functional Requirements (Parameter List)	12
4.2.1. Transfer Lines and Transfer Line Bundles	12
4.2.2. Supply Points (Valve Boxes)	14
4.3. Interfaces	14
4.3.1. Interface between Transfer Lines and Supply Points.....	14
4.3.2. Interface to Building L0321A	14
4.3.3. Interface to the External Route and Existing Conduits.....	15
4.4. System Environment and Constraints	15
5. Procedure.....	17
5.1. Design Phase	17
5.1.1. CDR (Conceptual Design Review)	17
5.1.2. FDR (Final Design Report)	17
5.2. Production Phase.....	17
5.3. Installation Phase.....	17
6. Quality Assurance, Tests and Acceptance.....	18
6.1. Quality Assurance System of the Contractor	18
6.2. Factory Acceptance Test (FAT)	18
6.3. Site Acceptance Test (SAT)	18
7. Documentation	19
8. Related Documents	20

Configuration Management and Documentation 	Document Type Detailed Specification (DS)	Document Number F-P-SFR-0001	Date 2026-08-01
			Page 4 of 20

List of Tables

Tab. 1: List of abbreviations.....	6
Tab. 2: Overview of the main parameters.	12
Tab. 3: Length and scope overview.	13
Tab. 4: Overview of all documentation.....	19

List of Figures

Fig. 1: Building overview.....	7
Fig. 2: Schematic overview of the LN ₂ transfer line system [HP1.1]. The branch to FHF2 (point C to L1, cf. Fig. 4 and Fig. 5) is Optional Scope; all other branches shown are Base Scope.....	8
Fig. 3: Example of a supply point (valve box).	9
Fig. 4: Construction corridor ("Bauraum") – part 1.	13
Fig. 5: Construction corridor ("Bauraum") – part 2.	14
Fig. 6: External route from the building connection to the nitrogen tanks.	15

Configuration Management and Documentation 	Document Type Detailed Specification (DS)	Document Number F-P-SFR-0001	Date 2026-08-01
			Page 5 of 20

1. Purpose and Classification of the Document

This specification defines the technical requirements for the tender of a transfer line for liquid nitrogen (LN₂, 77 K, 1.3 bara, 25 l/min) connecting the liquid nitrogen storage tank to the laboratories and preparation rooms in the Super-FRS (SFRS) building.

The specification distinguishes between the Base Scope and the Optional Scope (see Section 3.2). Commercial and contractual aspects of the tender – including separate pricing, delivery time, call-off period and conditions for the Optional Scope, and the treatment of the Optional Scope in the bid evaluation – are defined in the separate procurement documents prepared by Purchasing and are not part of this technical specification.

Configuration Management and Documentation	Document Type	Document Number	Date
	Detailed Specification (DS)	F-P-SFR-0001	2026-08-01
			Page 6 of 20

2. Abbreviations, Terms and Definitions

Tab. 1: List of abbreviations.

Abbreviation	Meaning
AD 2000	German pressure equipment code ("AD 2000-Regelwerk")
AN / Contractor	Auftragnehmer – the contractor awarded this specification
AG / Company	Auftraggeber – GSI/FAIR, as the issuing company
bara	bar absolute
BANF	Bestellanforderung – internal purchase requisition
CDR	Conceptual Design Review
DARL	Datenaustauschrichtlinie – Data Exchange Guideline (FAIR)
EDMS	FAIR Engineering & Document Management System (release/approval system)
FAIR	Facility for Antiproton and Ion Research, Darmstadt
FAT	Factory Acceptance Test
FDR	Final Design Review
FHF1 / FHF2	Experimental stations downstream of the Super-FRS (designation per GSI/FAIR nomenclature); FHF2 is Optional Scope, see Section 3.2.2
GSI	GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt
HBO	Hessische Bauordnung – Building Code of the State of Hesse
HI/DESPEC (HISPEC/DESPEC)	High-resolution In-flight SPECTroscopy / DEcay SPECTroscopy – experiment collaboration name
K	Kelvin
LC	Lean Construction
LHe / LOX	Liquid Helium / Liquid Oxygen
LN ₂	Liquid Nitrogen
PED	Pressure Equipment Directive 2014/68/EU
SAT	Site Acceptance Test
SFRS / Super-FRS	Superconducting Fragment Separator
SiGeKo	Sicherheits- und Gesundheitsschutzkoordinator – site health & safety coordinator
W&M	Werk- und Montage (-planung) – Contractor's shop/fabrication and installation planning documents

Note: abbreviations of internal or legacy origin (e.g. "W&M") are given with their commonly understood meaning in German engineering practice and can be confirmed or amended by the Company's project team if required.

Configuration Management and Documentation	Document Type	Document Number	Date
FAIR GSI	Detailed Specification (DS)	F-P-SFR-0001	2026-08-01
			Page 7 of 20

3. Scope of the Technical System

3.1. System Overview

FAIR (Facility for Antiproton and Ion Research) is being built on the campus of GSI Helmholtzzentrum für Schwerionenforschung GmbH in Darmstadt, east of the existing GSI accelerator facility, which will be used as a pre-accelerator.

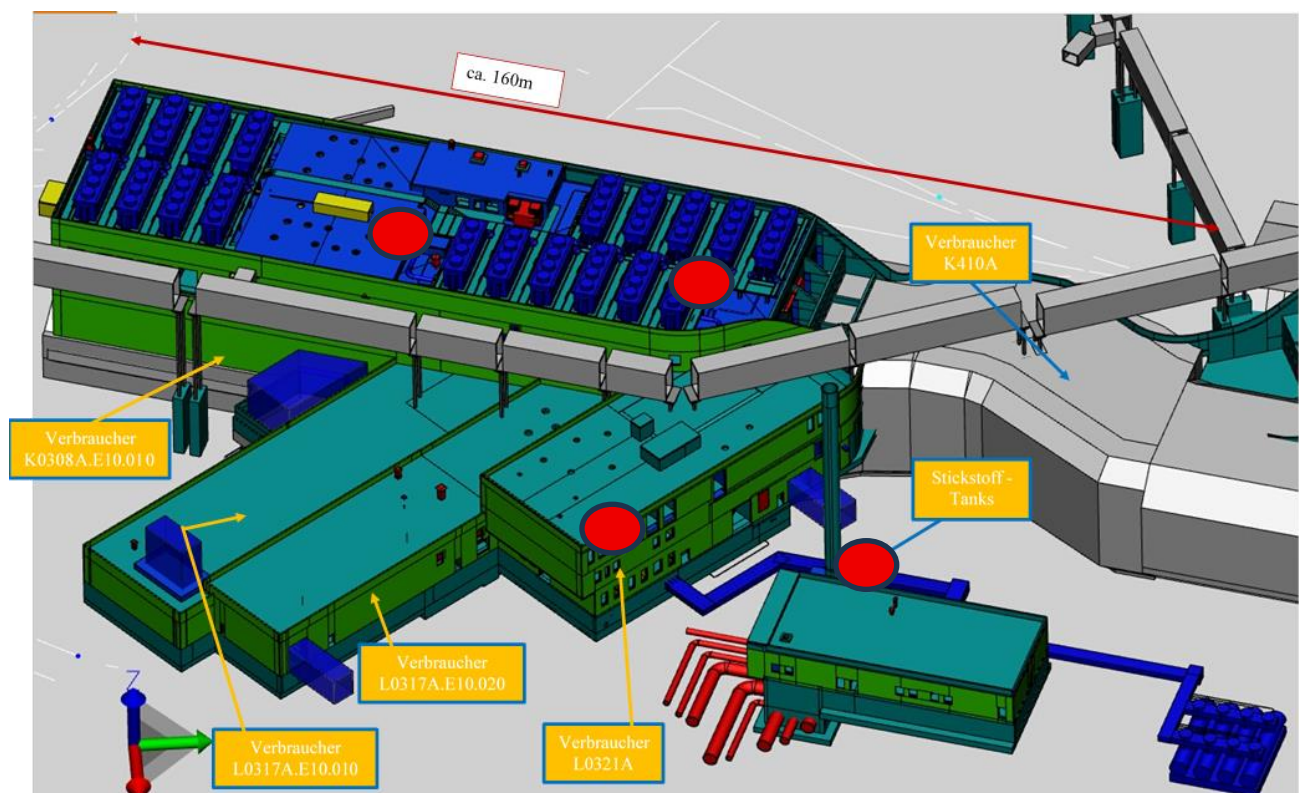


Fig. 1: Building overview. Red dots indicate the approximate installations points in the context of the whole building complex. For details see plans and descriptions below.

For the experimental gas system of the Super-FRS (Superconducting Fragment Separator) and its experimental areas a liquid nitrogen transfer line is required to connect the tank area in front of building L0321A to (cf. [Fig. 1](#)):

- the HI/DESPEC laboratory and preparation rooms (room L0321A.E30.008) – Base Scope;
- the experimental station FHF1 (room K0410A.E10.10) – Base Scope;
- the experimental station FHF2 (room K0308A.E10.10) – Optional Scope (see Section 3.2.2).

A cryogenic plant with two LN₂ tanks is being erected separately and is not part of this specification. A dedicated, separately shut-off outlet from these tanks supplies the consumers described here. The existing tray – if constructed in time - from the tanks to the building entrance may be reused for connecting the outdoor tanks with the building. Further details to be clarified after contract closing.

From the tanks, lines are routed into the buildings and further to the hand-over points of the consumers, using main lines and branch connections as appropriate; the routing and construction corridors (“Bauraum”) planned by the Company shall be observed (see Section 4.3 as well as [Fig. 4](#) & [Fig. 5](#)).

Configuration Management and Documentation	Document Type	Document Number	Date
 	Detailed Specification (DS)	F-P-SFR-0001	2026-08-01
			Page 9 of 20

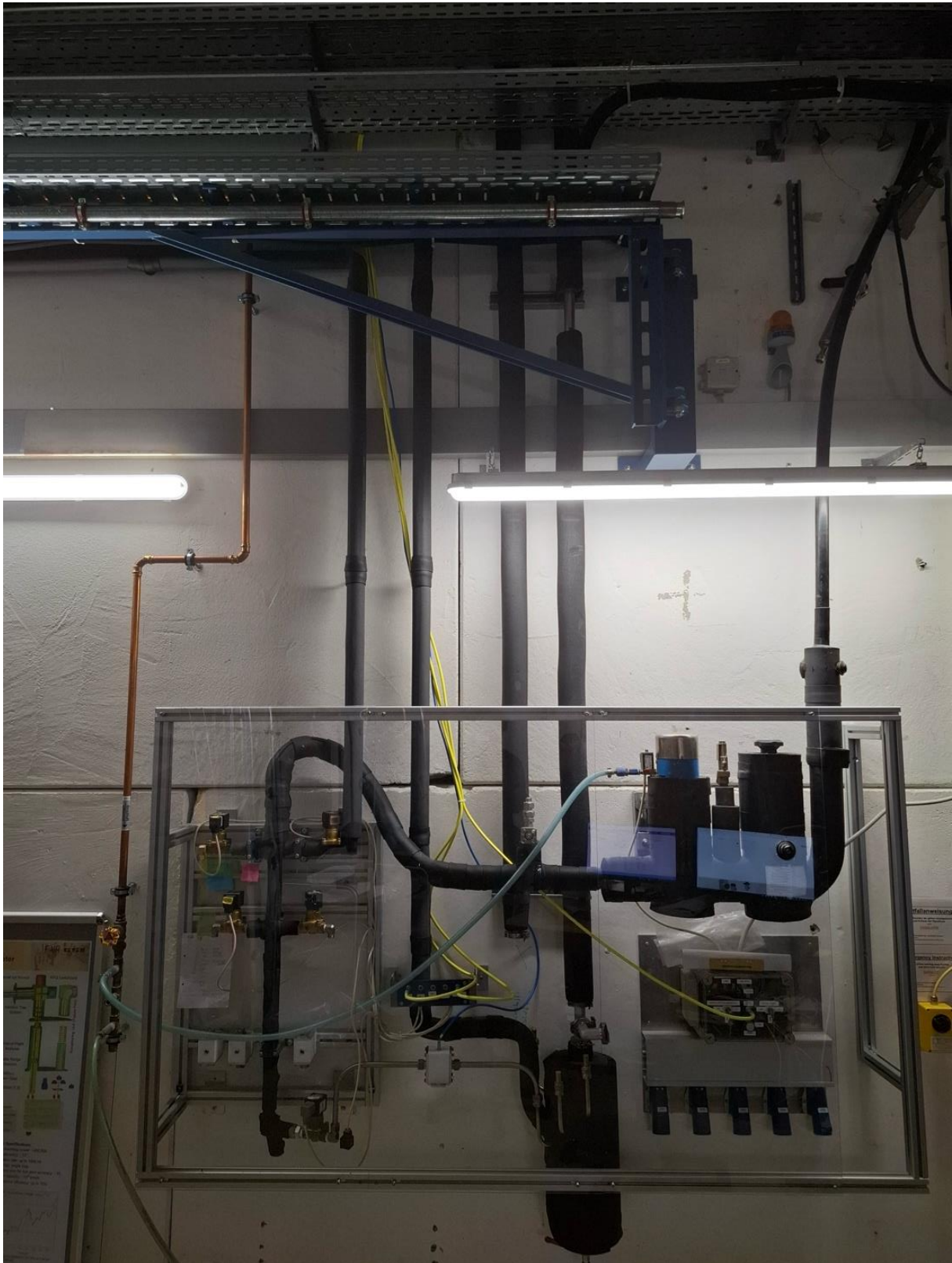


Fig. 3: Example of a supply point (valve box).

Configuration Management and Documentation	Document Type	Document Number	Date
	Detailed Specification (DS)	F-P-SFR-0001	2026-08-01
			Page 10 of 20

3.2. Scope of Delivery

This section defines the scope of services to be delivered by the Contractor. The Base Scope (Section 3.2.1) is the scope of the main contract. The Optional Scope (Section 3.2.2) is technically defined in this specification but shall only be delivered and installed following a separate, written call-off by the Company. The commercial treatment of the Base Scope and the Optional Scope – separate pricing, delivery time of the option, call-off period/deadline, form and conditions of the call-off, and inclusion or exclusion of the Optional Scope in the bid evaluation – is defined in the procurement documents prepared by Purchasing and is not part of this specification.

3.2.1. Base Scope

- Development, engineering and design of the LN₂ transfer line, including pressure-drop, mass-flow and heat-input calculations (Section 4).
- Manufacture and factory testing (FAT, Section 6.2) of the transfer line, comprising: outdoor building connection, tank area to Bldg. L0321A (point A), approx. 20 m; building penetration to the HI/DESPEC laboratory (A–D2, via B, C; s. [Fig. 4Fig-4](#)), approx. 100 m; connection to FHF1 (B–H6, via H, s. [Fig. 5Fig-5](#)), approx. 80 m – in total approx. 200 m of vacuum-insulated LN₂ transfer line (see length table, Section 4.2.1).
- Supply and delivery of the transfer line to site, including all required test and shipping documentation.
- Installation on site, including fixed points, sliding bearings and the compensation concept for thermal contraction (Section 4.1.1), and connection to the two supply points D2 (s. [Fig. 4Fig-4](#)) and H6 (s. [Fig. 5Fig-5](#)), each comprising a manual valve, a safety/pressure-relief valve, and a solenoid valve for 24 V control voltage (Section 4.1.2).
- Sizing and positioning of the branch/T-piece at point C such that the later installation of the Optional Scope (Section 3.2.2) is possible without modification of the Base Scope line.
- Site Acceptance Test (SAT, Section 6.3) after installation.
- All Base Scope documentation listed in Section 7.

3.2.2. Optional Scope (FHF2) – callable at the Company's discretion

- Extension of the transfer line from point C to L1 (via D, E, F, H4; s. [Fig. 4Fig-4](#) and [Fig. 5Fig-5](#)), approx. 120 m, to connect the experimental station FHF2.
- Supply point at L1, comprising a manual valve, a safety/pressure-relief valve, and a solenoid valve (24 V control voltage), equivalent in design to the Base Scope supply points (Section 4.1.2).
- The associated design, manufacture, supply, installation, testing (FAT/SAT) and documentation for this branch, on the same technical basis as the Base Scope.
- To be delivered and installed only following a separate written call-off by the Company; the Optional Scope shall not be executed as part of the Base Scope order.

3.2.3. Company-furnished Items and Interfaces

- The cryogenic plant with the two LN₂ tanks (erected separately) and its dedicated, separately shut-off outlet.
- The route (“Trasse”) to the building entrance is currently being planned by the experimental gas planning firm. After contract closure it needs to be discussed to potentially use the same route being reused for connecting the outdoor tanks.

Configuration Management and Documentation	Document Type	Document Number	Date
	Detailed Specification (DS)	F-P-SFR-0001	2026-08-01
			Page 11 of 20

- Where agreed with the experimental gas system planner, existing conduits inside the buildings currently installed for the (ambient-temperature) experimental gas lines, which may be reused for the LN₂ supply instead of installing dedicated new conduits.
- Disconnection of the existing coupling at the interface point (location and method to be agreed during the optional site visit, Section 5.1.1).
- Control and wiring of the solenoid valves at the supply points (the control system itself is not part of this Contract).
- Galvanized mounting rails and anchor plates along the route (Section 4.4).

3.3. Spare Parts and Maintenance Plan

No spare parts and no maintenance plan are required under this Contract, as no maintenance services are foreseen for this scope. It should be made sure that the insulation vacuum is kept for the whole time of operation (20 years).

Configuration Management and Documentation	Document Type	Document Number	Date
 	Detailed Specification (DS)	F-P-SFR-0001	2026-08-01
			Page 12 of 20

4. System Specification

4.1. Technical Requirements for System Components

4.1.1. Transfer Lines

- Process line material: low-carbon austenitic stainless steel (e.g. 1.4306, 1.4541, 1.4429, 1.4404, or equivalent).
- Outer pipe (vacuum insulation jacket): stainless steel. To protect the transfer line against mechanical damage, the outer pipe should be provided with an additional outer jacket of plastic or similar material.
- The transfer line shall be evacuated ex-works (insulation vacuum) and delivered under a slight positive pressure on the process line side.
- The Contractor shall design and provide evidence for the fixed points, sliding bearings, and the compensation concept for the thermal contraction of the line.
- Heat load into the line shall not exceed 0.2–0.5 W/m at 77 K.
- Based on the current estimate, an inner diameter ≥ 30 mm is expected; the Contractor shall verify the sizing by means of a pressure-drop calculation (Section 4.2.1).

4.1.2. Supply Points (Valve Boxes)

- At each hand-over point, one electrically actuated valve (solenoid, 24 V control voltage), one manual valve and a safety valve shall be provided, together with a standard connection (e.g. plug-in coupling or screw connection).
- No special connection is required for venting/exhaust; The exhaust lines are not part of this scope.
- S. [Fig. 3](#) for an example of a supply point.
- Control and wiring of the solenoid valves is not part of this Contract (Company-furnished, Section 3.2.3).

4.2. Functional Requirements (Parameter List)

4.2.1. Transfer Lines and Transfer Line Bundles

Tab. 2: Overview of the main parameters.

Parameter	Value
Medium	Liquid nitrogen (LN ₂)
Tank pressure	1.3 bara
Flow rate	25 l/min
Isolation Vacuum	Durability min. 15 years
Minimum residual pressure at the farthest consumer	≥ 1.1 bara
Nominal operating temperature	77 K
Building ambient temperature, normal operation	18 °C – 24 °C

Configuration Management and Documentation	Document Type	Document Number	Date
FAIR GSI	Detailed Specification (DS)	F-P-SFR-0001	2026-08-01
			Page
			13 of 20

Building ambient temperature range to be accommodated in case of HVAC failure	0 °C – 40 °C (LN ₂ supply shall remain ensured)
Permissible heat load	0.2 – 0.5 W/m at 88 K
Expected inner diameter	≥ 30 mm (to be confirmed by Contractor's pressure-drop calculation)
Design / test pressure	20 bara
Maximum integral helium leak rate	1 × 10 ⁻⁸ (mbar·l)/s

Tab. 3: Length and scope overview.

Description	Route (schematic)	Length	Scope
Outdoor building connection, tank area to Bldg. L0321A	Tank area – A	20 m	Base Scope
Building penetration to HI/DESPEC laboratory	A – D2 (via B, C)	100 m	Base Scope
Connection to FHF1	B – H6 (via H)	80 m	Base Scope
Connection to FHF2	C – L1 (via D, E, F, H4)	120 m	Optional Scope

Total Base Scope length ≈ 200 m; total length including the Optional Scope ≈ 320 m. The branch/T-piece at point C shall be sized by the Contractor to allow the later addition of the Optional Scope branch without modifying the Base Scope line (Section 3.2.1).

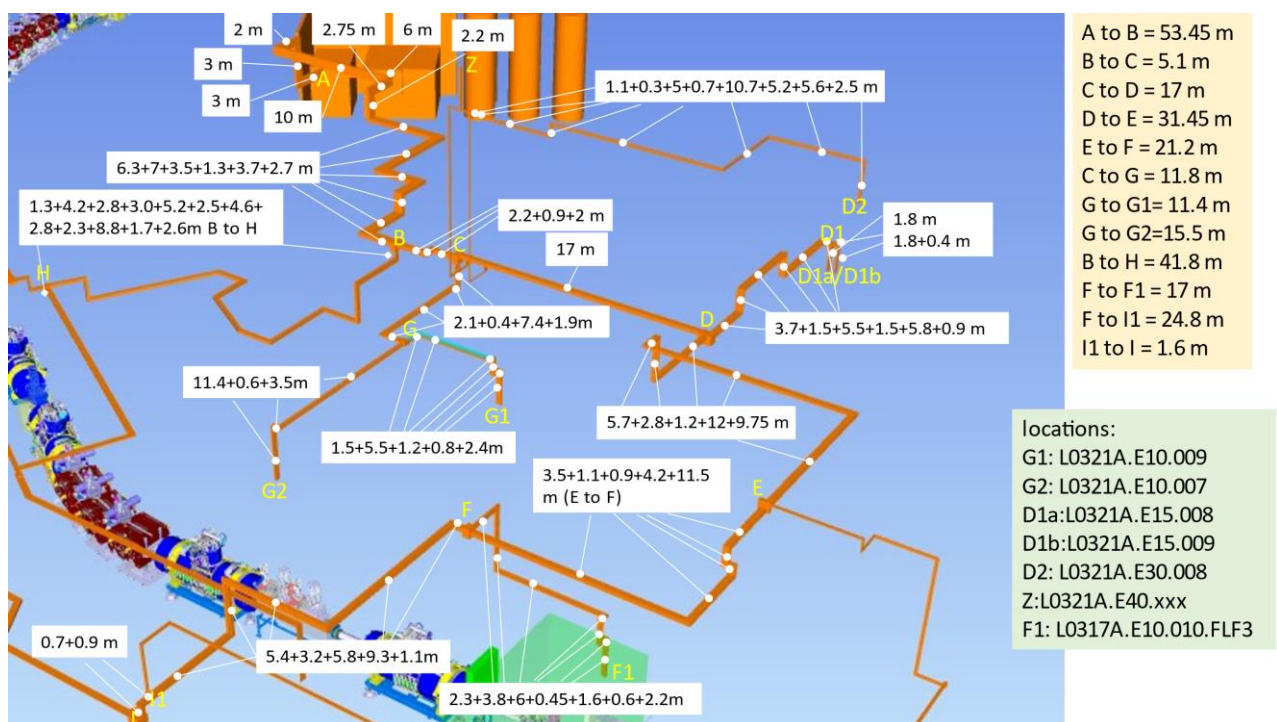


Fig. 4: Construction corridor ("Bauraum") – part 1.

Configuration Management and Documentation 	Document Type Detailed Specification (DS)	Document Number F-P-SFR-0001	Date 2026-08-01
			Page 14 of 20

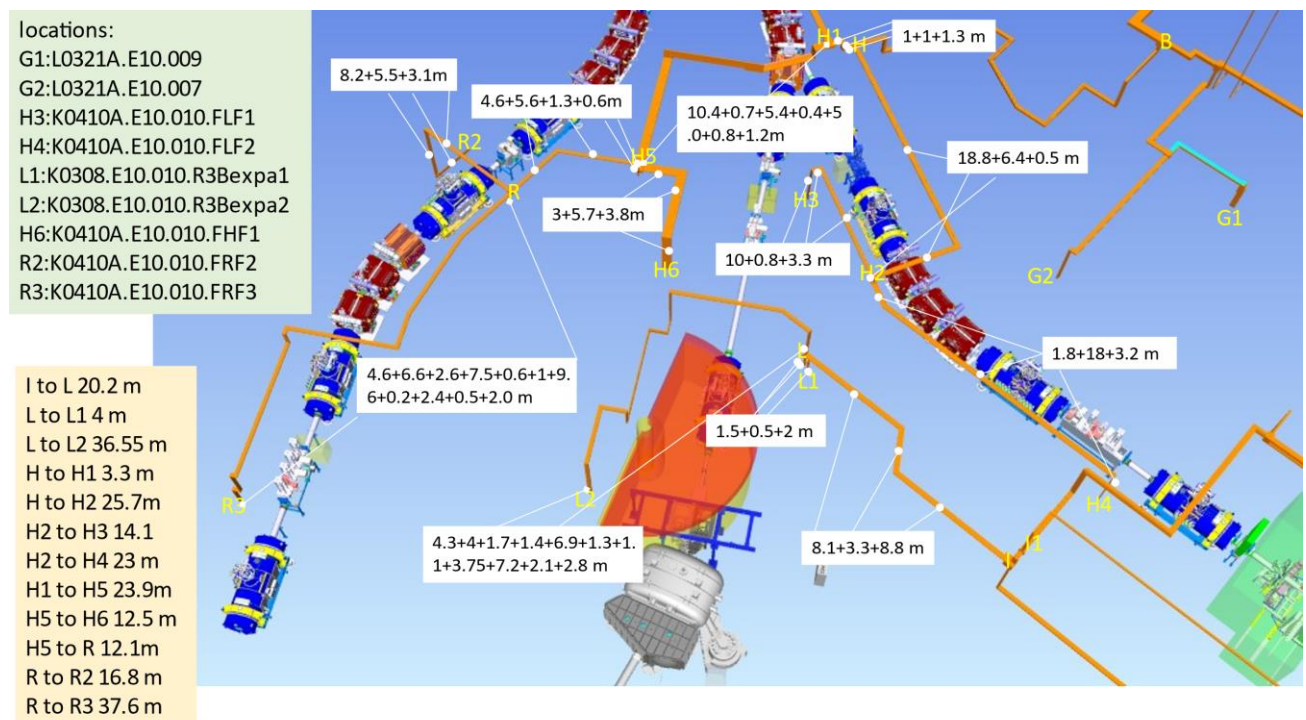


Fig. 5: Construction corridor (“Bauraum”) – part 2.

4.2.2. Supply Points (Valve Boxes)

Each supply point (D2, H6 – Base Scope; L1 – Optional Scope) comprises one manual valve, one safety/pressure-relief valve, and one solenoid valve (24 V control voltage); sizing and materials as per Section 4.1.2.

4.3. Interfaces

4.3.1. Interface between Transfer Lines and Supply Points

At each hand-over point, the interface comprises a manual valve, an electrically actuated valve, and a standard connection (Section 4.1.2). The existing coupling (Company-furnished) is disconnected at a location and by a method to be agreed with the Contractor during an optional site visit prior to contract award (Section 5.1.1).

4.3.2. Interface to Building L0321A

The building penetration point is located at position “A”. Core drilling, openings, slots, etc. required for the line installation shall be checked by the Contractor against the documents provided and included in the Contractor’s own shop and installation planning documents (“W&M”). Required changes or extensions shall be coordinated with the trades concerned; the need shall be registered in good time using the application for execution of a penetration (see site handbook). The application, together with the required detailed planning documents and the confirmations of the trades involved that they have no objection to the requested core drilling, shall be submitted for approval to the

Configuration Management and Documentation 	Document Type Detailed Specification (DS)	Document Number F-P-SFR-0001	Date 2026-08-01
			Page 15 of 20

Company's site supervision in accordance with the "Approval of Contractor Core Drilling" workflow, before the intended date of use. Once approved by the Company, the Contractor marks the location and position of the penetrations on site; the Company then executes the penetrations themselves.

4.3.3. Interface to the External Route and Existing Conduits

The existing route from the building connection to the nitrogen tanks may be reused (Figure 6). Along the construction corridor shown in Figures 4 and 5, conduits for the (ambient-temperature) experimental gas lines are already installed; these are not part of this tender. Subject to agreement with the installer, these existing conduits may also be used for the LN₂ supply, so that no dedicated conduits need to be installed for the LN₂ line.

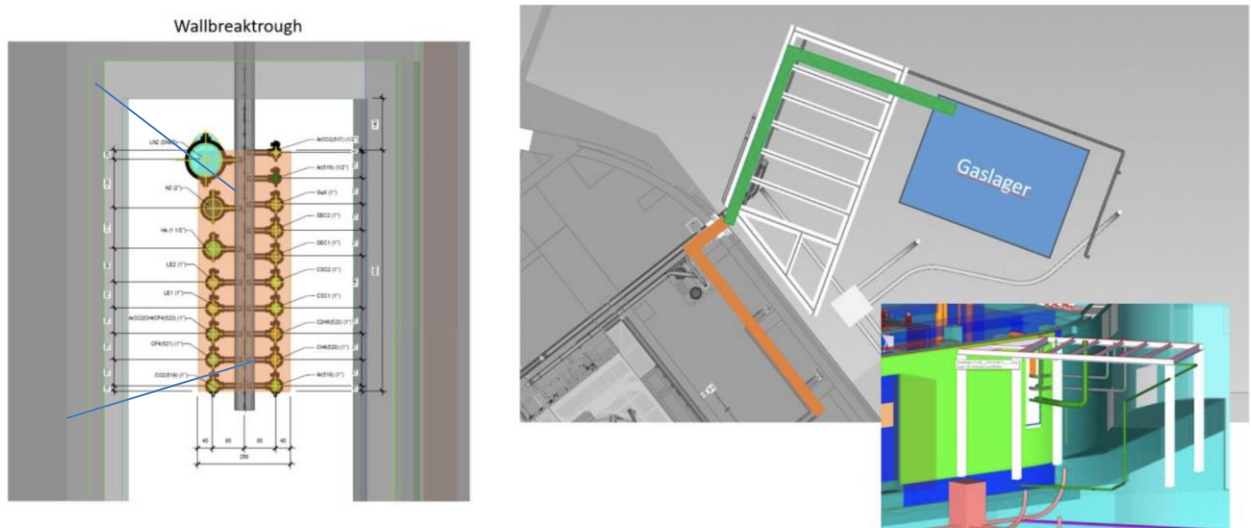


Fig. 6: External route from the building connection to the nitrogen tanks.

4.4. System Environment and Constraints

- Site and legal framework: the Hessian Building Code (Hessische Bauordnung, HBO) applies to the FAIR construction site. All requirements of the HBO must be observed so that public safety and order – in particular life, health, and the natural environment – are not endangered, and so that public-law provisions and the instructions of the building supervisory authorities are complied with (§ 3(55) HBO). Each company is responsible for the proper execution of the works it has undertaken and, to that extent, for the proper setup and safe operation of the site; the required evidence and documents on the construction products and methods used – including, for CE-marked products under Regulation (EU) No. 305/2011, the Declaration of Performance – shall be provided and kept available on site (§ 58 HBO). The person entrusted with site management (HBO site manager) shall ensure that the works are executed in accordance with public-law requirements and shall issue the necessary instructions (§ 59 HBO); the instructions of the HBO site manager shall be strictly followed. (Non-binding translation; the German HBO text remains legally authoritative.)
- Access and site logistics: site access routes for vehicles are shown in the site traffic plan. Hardened surfaces are provided by the Company so that access by semi-trailers or similar, and the setting-up of a mobile crane for assembly, is possible at the various work areas. Close coordination between the Contractor and the Company, as well as site supervision, is required in good time before execution. A site facility area is available by arrangement with

Configuration Management and Documentation	Document Type	Document Number	Date
 	Detailed Specification (DS)	F-P-SFR-0001	2026-08-01
			Page 16 of 20

site logistics; the site traffic plan and, in particular, the internal site logistics handbook shall be observed.

- Site induction: before entering the site, an induction by the site safety and health coordinator (SiGeKo) is required, with the corresponding documents to be presented in accordance with the site regulations (see Section 8, Related Documents).
- Fire protection during construction: see the fire protection concept, Annex B537.
- Core drilling and fastenings: loads and, where applicable, static and dynamic forces introduced by the installed system into building components (ceilings, walls, structural elements, etc.) require that supports, fastening points, and machine foundations are only executed in agreement with the structural engineer. Drilling and anchor work shall only be carried out where fastening to existing mounting rails is not possible and shall be kept to a minimum. Drilling into load-bearing structures without prior reinforcement scanning is limited to a maximum depth of 25 mm; where deeper drilling is required, a reinforcement scan is mandatory. No steel reinforcement may be cut, and anchors shall not exceed 30 mm in diameter. Where drilling/openings, temporary fastenings, supports, built-in items, or other damage to reinforced-concrete elements become necessary during construction, they shall be removed without residue and any resulting defects/holes shall be closed with matching material. Galvanized mounting rails and anchor plates are provided by the Company in the route areas for fastening conduits and components.
- General workmanship requirements: only approved metal anchors shall be used to fasten components; anchors shall be drilled, not driven. Metal anchors with positive expansion are required for anchor connections carrying more than 50 N per anchor and for all ceiling fixings. Equipment installed on base frames or raised-floor mounting frames shall be erected so stably and securely, using bolted connections, that no additional fastening to walls or ceilings is required. Within buildings, components shall only be transported using transport aids with solid-rubber or air-filled wheels. All component surfaces shall be permanently corrosion-protected by hot-dip galvanizing, appropriate to their intended use; after galvanizing, no further processing that reduces the corrosion protection is permitted. Constructions shall be designed to avoid points where rust can initiate. Dirt, oil, and grease films, as well as moisture, shall be thoroughly removed immediately before each protective coating is applied.
- Quality documentation timing: test certificates, manufacturer data sheets, and approvals for the materials and components to be installed or temporarily provided by the Contractor shall be submitted to the Company in good time, and in any case at least 14 calendar days before the start of execution, as evidence of their suitability and quality.
- Lean Construction (LC): the installation sequence shall be coordinated in a weekly Lean Construction meeting (1× per week, 1 hour); attendance is mandatory.
- Schedule [open item – to be confirmed]: installation is targeted to be completed by the end of Q3 2027.

Configuration Management and Documentation	Document Type	Document Number	Date
 	Detailed Specification (DS)	F-P-SFR-0001	2026-08-01
			Page 17 of 20

5. Procedure

5.1. Design Phase

5.1.1. CDR (Conceptual Design Review)

Prior to contract award, a site visit is possible upon request. The Contractor shall submit in writing, prior to contract award, a proposal for the routing of the line, including the calculations for the sizing of the line (pressure drop, mass flow, heat input), and a drawing of the line including its interfaces. During the site optional visit, the location and method for disconnecting the existing coupling (Company-furnished) shall also be defined. The delivery date shall be fixed prior to contract award.

5.1.2. FDR (Final Design Report)

The design documentation (FDR) and the risk assessment shall be delivered before the start of the installation works, at the latest 12 weeks after contract commencement, and shall be approved by the Company.

5.2. Production Phase

Following approval of the design (Section 5.1.2) and confirmation of the delivery date (Section 5.1.1), the line may be manufactured (see Section 6.2, Factory Acceptance Test).

5.3. Installation Phase

Before delivery of the line, a date for its installation shall be agreed between the Company and the Contractor. All required verification documents shall be submitted to the Company in advance. All installation-relevant building dimensions, as well as the transport and assembly conditions, shall be verified by the Contractor on site. The general site constraints and execution requirements set out in Section 4.4 (in particular regarding core drilling, fastenings, fire protection, and Lean Construction) apply throughout the installation phase.

Configuration Management and Documentation	Document Type Detailed Specification (DS)	Document Number F-P-SFR-0001	Date 2026-08-01
			Page 18 of 20

6. Quality Assurance, Tests and Acceptance

6.1. Quality Assurance System of the Contractor

All surfaces coming into contact with the process medium shall be free of water, hydrocarbons, or other contamination. Process lines shall be delivered under a slight positive pressure of nitrogen (approx. 1.1 bara). The Contractor shall provide a certificate demonstrating that the components have been designed and tested in accordance with AD 2000 and the Pressure Equipment Directive 2014/68/EU (PED); the Pressure Equipment Directive shall be observed. The line shall be subjected to a pressure test at 20 bara, which shall be documented in writing. An operating manual shall be supplied in accordance with the applicable legal and technical requirements. If the equipment is classified as PED Category 0 (sound engineering practice), no CE declaration of conformity under the PED shall be issued.

6.2. Factory Acceptance Test (FAT)

The transfer line shall be pressure-tested in accordance with AD 2000. The transfer line shall be leak-tested and shall not exceed an integral helium leak rate of 1×10^{-8} (mbar·l)/s. A test protocol and vacuum verification shall be prepared by the Contractor; documentation of the insulation vacuum is also part of the FAT.

6.3. Site Acceptance Test (SAT)

The delivery and installation shall be checked for damage and completeness. In addition, a pressure test shall be carried out after installation, together with a functional test of all valves.

Configuration Management and Documentation 	Document Type Detailed Specification (DS)	Document Number F-P-SFR-0001	Date 2026-08-01
			Page 19 of 20

7. Documentation

Unless internal FAIR requirements or project-specific documentation guidelines state otherwise, this specification and the technical project documentation to be submitted by the Contractor shall be prepared in English. Where individual, statutorily required documents must additionally be provided in German, this is indicated for the relevant document below. Requirements for file formats, naming, revisioning, metadata, and hand-over shall be aligned with the applicable FAIR EDMS and data-exchange guidelines (see Section 8, Related Documents).

Tab. 4: Overview of all documentation.

Document	Format	Language	Submission / Status
Routing proposal for the line	PDF	EN or DE	Before contract award (CDR, Section 5.1.1)
Design calculation (pressure drop, mass flow, heat input)	PDF	EN or DE	Before contract award (CDR); confirmed at FDR
Technical drawing of the line, incl. interfaces	PDF (+ native CAD on request)	EN or DE	Before contract award (CDR); updated at FDR
Design documentation (FDR) and risk assessment	PDF	EN or DE	Before start of installation, at the latest 12 weeks after contract commencement; subject to Company approval
3D Model	STP	EN or DE	Upload into the DMU model
Material certificates, manufacturer data sheets, approvals	PDF	EN or DE	At least 14 calendar days before start of execution
Certificate: design and testing per AD 2000 and PED 2014/68/EU	PDF	English (+ German if legally required for use in Germany)	Before FAT
Pressure test and leak test protocol	PDF	EN or DE	Before / at SAT
Vacuum verification / insulation vacuum documentation	PDF	EN or DE	With FAT protocol
Operating manual, including safe installation, commissioning, operation, shutdown, inspection, and maintenance instructions	PDF	English (+ German if legally required for use in Germany)	Before SAT and final hand-over

Configuration Management and Documentation 	Document Type Detailed Specification (DS)	Document Number F-P-SFR-0001	Date 2026-08-01
			Page 20 of 20

8. Related Documents

[1] B225_Baustellenhandbuch.pdf	Construction Site Handbook.pdf
[2] B250_Baulogistikhandbuch.pdf	Construction Logistics Handbook.pdf
[3] B252_Baustellenordnungsplan.pdf	Construction Site Regulations Plan.pdf
[4] B230_Baustellenordnung.pdf	Construction Site Regulations.pdf
[5] B257_Handbuch Innere Baulogistik.pdf	Internal Logistics Handbook.pdf
[6] B510_Baubeschreibung.pdf	Construction Description.pdf
[7] B240_Vorbemerkungen Ökologie.pdf	Ecology Guidelines.pdf
[8] FAIR Vergabeordnung	FAIR Tender Regulations
[9] EDMS 2383347	Technical Guideline for Welding Practices