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Document Title	Detailed Specification of rectangular blind flanges for the focal plane chambers of the Super-FRS
Description	Rectangular blind flanges for beam-diagnostic insert ports located on the top of the Super-FRS focal-plane chambers.
Division/ Organization	Super-FRS
Field of Application	FAIR GmbH and GSI GmbH

Document History

Version	Prepared/Checked by	Date	Date of Release	Comments
V001	S. Purushothaman	12.03.2025		•
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Abstract

This specification covers the construction, and testing of rectangular blind flanges for beam-diagnostic insert ports located on the top of the Super-FRS focal-plane chambers. The document defines the requirements for the mechanical, vacuum physical, technical, and metallurgical characteristics of the component. The document also stipulates the requirements regarding the dimensions, the testing, and the inspection of the component.

Blind flange type	AID	CID	Blind flange type	AID	CID				
F350	AID:0005401	CID:07000950014	F450	AID:0005403	CID:07000950298				
		CID:07000950021			CID:07000950304				
		CID:07000950038			CID:07000950311				
		CID:07000950045			CID:07000950328				
		CID:07000950052			CID:07000950335				
		CID:07000950069			CID:07000950342				
		CID:07000950076			CID:07000950359				
		CID:07000950083			CID:07000950366				
		CID:07000950090			CID:07000950373				
		CID:07000950106			CID:07000950380				
		CID:07000950113			CID:07000950397				
F390	AID:0005402	CID:07000950120	F550	AID:0005404	CID:07000950403				
		CID:07000950137			CID:07000950410				
		CID:07000950144			CID:07000950427				
		CID:07000950151			CID:07000950434				
		CID:07000950168			CID:07000950441				
		CID:07000950175			F630	AID:0005405	CID:07000950465		
		CID:07000950182					F750	AID:0005406	CID:07000950472
		CID:07000950199			CID:07000950489				
		CID:07000950205							
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Cost account	Total number of items
FAIR-Auftrag 772500	47



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1. Purpose and Classification of the Document

This document defines the built-to-print technical specification for the rectangular blind flanges for beam-diagnostic insert ports located on the top of the Super-FRS focal-plane chambers.

The design authority rests with FAIR GmbH / GSI GmbH (hereinafter referred to as “the Company”). The Company provides the released 3D models, 2D drawings, interface definitions, and boundary conditions forming the contractual design baseline.

The Contractor is responsible for the manufacturing, assembly, inspection, testing, and delivery of the system strictly in accordance with:

- The released drawing package
- This technical specification
- All referenced FAIR Technical Guidelines

This document forms part of the Technical Part of the Contract. Commercial and legal conditions are defined in the Commercial Part of the Contract.

1.1. Manufacturing Design Review (MDR) and Contractor Responsibility


Although this procurement is classified as built-to-print, the Contractor shall perform a comprehensive and independent technical evaluation of the complete design package prior to the commencement of manufacturing. This Manufacturing Design Review (MDR) shall include verification of:

- Completeness and internal consistency of all documentation
- Manufacturability of all components

Any identified inconsistencies, risks, ambiguities, omissions, or potential improvements shall be formally communicated to the Company without delay. Proposed modifications shall be submitted exclusively via the Engineering Change Request (ECR) procedure. No deviations from the released design are permitted without prior written approval from the Company.

Notwithstanding the built-to-print nature of this contract, the Contractor remains fully responsible for achieving all specified functional, safety, mechanical, and vacuum performance requirements. Compliance with released drawings does not relieve the Contractor of responsibility for overall system performance, including the successful completion of the Factory Acceptance Test (FAT).

The Contractor’s obligation to exercise professional engineering diligence applies throughout all project phases, including manufacturing, assembly, testing, and documentation.

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2. Abbreviations, Terms and Definitions

Table 1: Abbreviation, Terms and Definitions.


Abbreviation Term	Definition
FAIR GmbH	Facility for Antiproton and Ion Research GmbH
GSI	GSI Helmholtzzentrum für Schwerionenforschung GmbH
PSP	Project Structure Plan
FAT	Factory Acceptance Test
SAT	Site Acceptance Test
MDR	Manufacturing Design Review
FEM	Finite Element Method
EDMS	Electronic Document Management System
Super-FRS	Superconducting Fragment Separator
NCR	Non-conformity report
ECR	Engineering change request

3. Scope of the Technical System

3.1. System Overview

The beam-diagnostic elements of the Super-FRS use custom rectangular flanges with integrated elastomer seals as the interface to the focal-plane chambers. The top plate of each focal-plane chamber contains corresponding rectangular openings with polished sealing surfaces.

The rectangular blind flanges detailed within the scope of this document are intended to close these rectangular ports of the focal-plane chambers for vacuum testing or to provide a temporary vacuum seal when the diagnostic inserts are removed for maintenance.

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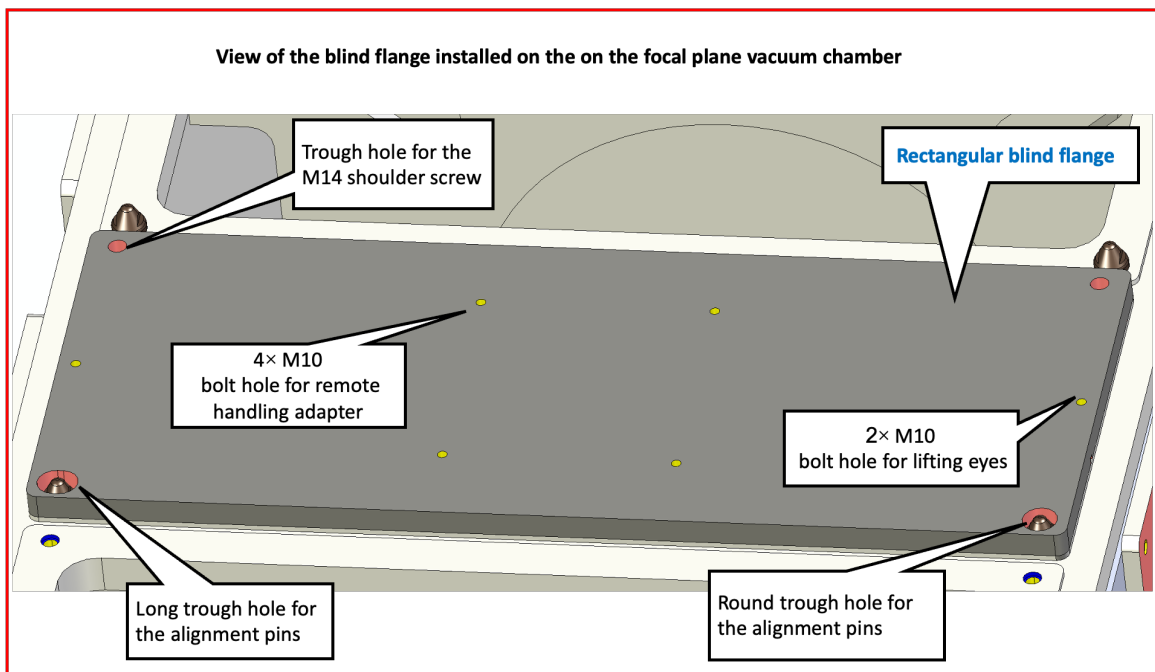
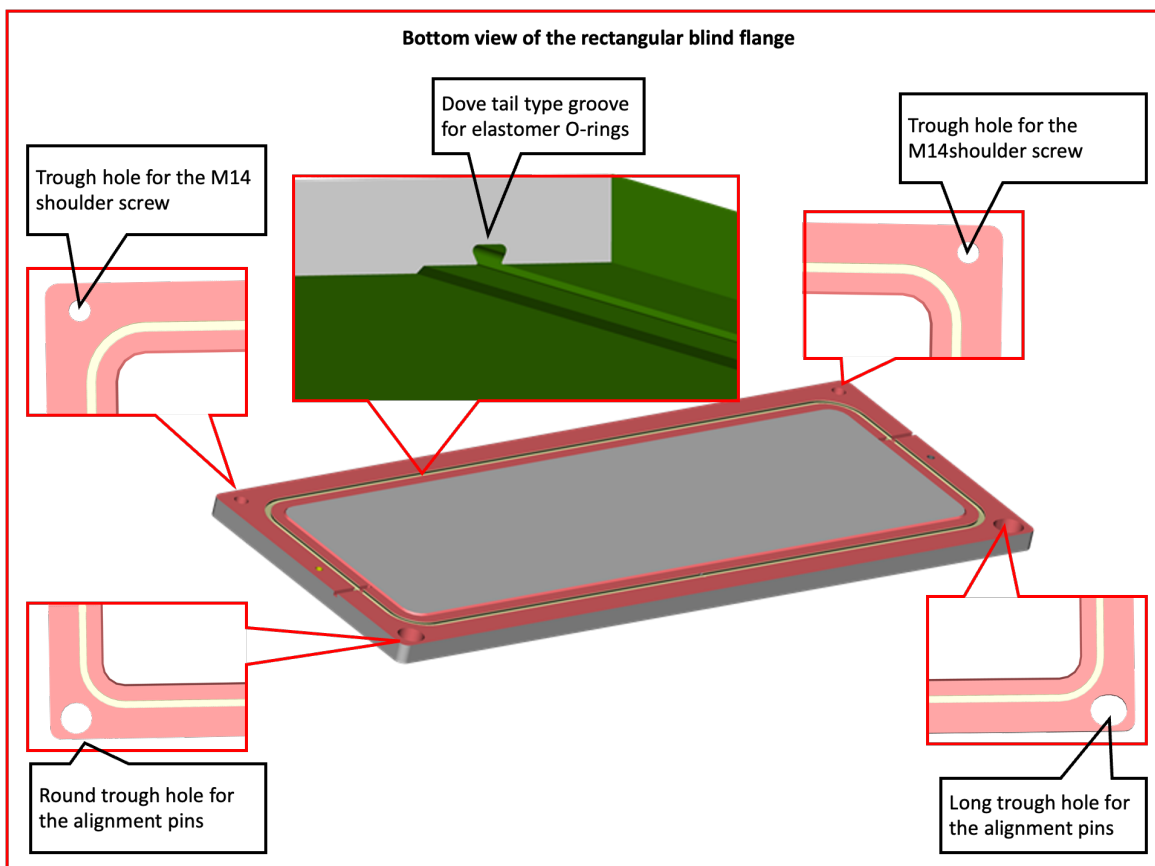



Figure 1: Schematic representation of the general design of the rectangular blind flanges. This design consideration, outlining the general design of the blind flanges, is also applicable to the beam diagnostic flanges.

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3.2. Scope of Delivery

The Contractor shall manufacture, assemble, test, and deliver the system strictly in accordance with the released drawing package and this specification.

The Contractor shall perform a technical review of the provided design documentation prior manufacturing and notify the Company of any identified inconsistencies, risks, or improvement potential. Any proposed modifications require written approval via the Engineering Change Request (ECR) procedure.


1. **The Contractor shall manufacture the flanges in accordance with the drawing sets provided by the Company and listed below.**
2. **Contractor shall deliver the flanges with Elastomer seals made of FKM (Viton®) fluoroelastomer, hardness 70–75 Shore A, suitable for non-baked high-vacuum applications.**

Table 2: List of rectangular aluminum blind flanges for the SFRS focal plane chambers.

#	Fange Type	Attached 2D drawings	count
1	F350	TR-0000050201_-_Blindflansch-810x270-AL.pdf TR-0000050200_-_BG-Blindflansch-810x270.pdf S_TR-0000050200_-_BG-Blindflansch-810x270.pdf	11
2	F390	TR-0000050198_-_Blindflansch-810x310-AL.pdf TR-0000050197_-_BG-Blindflansch-810x310.pdf S_TR-0000050197_-_BG-Blindflansch-810x310.pdf	17
3	F450	TR-0000050193_-_Blindflansch-810x370-AL.pdf TR-0000050194_-_BG-Blindflansch-810x370.pdf S_TR-0000050194_-_BG-Blindflansch-810x370.pdf	13
4	F630	TR-0000049945_-_Blindflansch-810x550-AL.pdf TR-0000050065_-_BG-Blindflansch-810x550.pdf S_TR-0000050065_-_BG-Blindflansch-810x550.pdf	1
5	F550	70013-00-00-470.pdf	3
6	F750	70013-00-00-670.pdf	2

3.3. Spare Parts

The Contractor shall supply two spare sets of elastomer seals for each flange.

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4. System Specification

4.1. Material selection

The flanges shall be manufactured from aluminum alloy EN AW-5083 (material number 3.3547) to construct the blind flanges.

4.2. Vacuum requirements

Operational pressure of the vacuum chamber is $\leq 1 \times 10^{-7}$ mbar. All flanges and sealing interfaces shall be compatible with this vacuum level and shall maintain leak-tight operation.

Table 3: Vacuum requirement of the components.

Criteria	Requirement
The outgassing rate	After 10h of pumping <ul style="list-style-type: none"> ○ $\leq 1 \times 10^{-9}$ mbar l / s.cm²
Integral leakage rate	$< 1 \times 10^{-9}$ mbar·l/s.
Residual Gas Composition	After 24 hours pumping: <ul style="list-style-type: none"> ○ All peaks from masses between 18 and 45 have to be 100 times lower than the peak from mass 18, except peak from masses 28 and 44 ○ All peaks from masses higher than 45 have to be 1000 times lower than the peak from mass 18

5. Procedure


5.1. Overall Procedures

Within an agreed period after contract award, the Contractor shall submit a detailed project schedule covering manufacturing, testing, and delivery phases in accordance with the approved design documentation.

- The schedule shall include at minimum:
- Manufacturing Design Review (MDR)
- Production phase
- Factory Acceptance Test (FAT)
- Delivery (packing and transport)
- Installation and Site Acceptance Test (SAT)

During project execution, the Contractor shall provide a monthly progress report describing:

- Activities completed during the previous month
- Activities planned for the following month
- Deviations from the agreed project schedule, including corrective actions

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The project progress and reports shall be reviewed in regular coordination meetings between the Company and the Contractor.

The Contractor shall complete and submit the “Progress Report Spreadsheet” provided by the Company. This report shall reflect the status of manufacturing, material procurement, major components, cleaning, vacuum testing, inspection activities, and delivery status.

4.2.2 Supporting Documents

- Production/manufacturing process plan
- Inspection and test procedures
- Risk assessment
- Operation Manual (In English and German)
- Installation instructions
- Material test certificates shall be provided in accordance with DIN EN ISO 10204.

5.2. Production Phase

The production shall follow the released process and control plan. Mechanical designs shall follow the rules of Component Reference by the FAIR Technical Guideline F-TG-ZT-3.75e [1].

A QR code tag according to [2] must be attached on the outer surface of the flange, visible after installation. The code to be used will be provided by the Company as a graphic file and contains the CID number. The QR Code can be laser-marked, burnt, etched or engraved directly on the curved flange surface.

The production phase ends with an approval of the factory acceptance tests which will be accompanied by the Company.

6. Quality Assurance, Tests and Acceptance

6.1. Quality Assurance System of the Contractor


Herein, all the measures shall be described in detail or referenced, which ensure that the present specifications will be fulfilled. The complete Quality Acceptance process is written down in *General Specification* [3].

The contractor shall install a quality assurance system which allows quality planning, quality steering, quality measurement and quality improvement. It is important that very close information exchange between contractor and company is ensured. It is the responsibility of the Contractor to ensure that the subcontractors shall follow the required quality assurance system during the manufacturing.

For details see FAIR General Specifications [3].

6.2. Factory Acceptance Test (FAT)

The appointment for the Factory Acceptance Test has to be announced to the Company at least 30 days ahead so that the presence of the firm representatives can be guaranteed. The Contractor provides all tools which are necessary for the acceptance procedure. After the release of the factory

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acceptance test by the Company, the distribution can take place. All FAT tests shall be carefully recorded in protocols. All test documentation shall be submitted to the FAIR GmbH.

FAIR GmbH provides an acceptance certificate (see FAIR Technical Guideline [4]), where all measurements and tests have to be documented. Contractor can use their own protocol if available but this shall be presented in CDR or FDR.

6.2.1. Visual inspection

- The Contractor has to examine the internal and external surfaces of the flanges for any defect, scratch, dirt, contamination or dent.
- The sealing surfaces must be clean and free from any defect.
- The inspection of the components has to be done with special care, in order not to cause any contamination or scratches.

6.2.2. Mechanical acceptance test

The contractor is requested to carry out a Mechanical acceptance test according to Technical Guideline [5]. The check will be done at the contractor site.

The final cleaning of the vacuum component must be done after the mechanical inspection because it includes the check of the vacuum surfaces. If a re-work is necessary after the mechanical inspection, the required tolerances have to be proved again.

6.2.3. Vacuum acceptance test


The Contractor must provide the information of the leak rate, outgassing rate, and the residual gas composition during the vacuum acceptance test (see Section 4.2).

The proof of HV aptitude of the system has to be done in a dedicated HV test setup of the contractor. Inspection and testing shall be performed using properly calibrated measuring and test equipment. Contractor shall make sure that the vacuum system is not contaminated with the hydrocarbons during the acceptance tests. The test procedure is described in detail in FAIR Technical Guideline [6].

- Leak testing shall be performed with a calibrated He leak detector. The integral leakage rate shall be $<1 \times 10^{-9}$ mbar·l/s. The contractor shall provide a proposal for leak test procedure.
- Pump down curve shall be recorded and presented in the FAT report.
- RGA data must be recorded and presented in the FAT report.

6.3. Site Acceptance Test (SAT)

Formal acceptance of the delivered vacuum chamber system shall take place only after successful completion of the Site Acceptance Test (SAT A – Milestone M10 within the General Specification) at the FAIR GmbH site.

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The SAT shall verify compliance of the delivered system with the approved design documentation and contractual specifications.

Any failure identified during SAT shall be rectified by the Contractor in accordance with the contractual conditions. Equipment not complying with the agreed specification may be rejected and returned at the Contractor's expense.

If the system must be returned to the Contractor's premises for repair or modification, the complete Factory Acceptance Test (FAT), as defined in Section 6.2, including all relevant additional tests, shall be repeated prior to redelivery.

6.4. Packaging, Transport and Installation

The shipping and packaging of vacuum components have to follow the FAIR Technical Guideline [7]. The system has to be packed without contamination and damage during packaging.

7. Documentation

No deviations from the approved design are permitted without written approval.

The Contractor shall provide the following documentation, as applicable, in accordance with the approved design documentation and contractual requirements:


- Assembly, installation, and disassembly instructions.
- Risk and hazard analysis covering assembly, transport and installation.
- Maintenance and operational instructions (manual) delivered in both German and English.
- User manual delivered in both German and English.
- Material test certificates in accordance with DIN EN ISO 10204 (3.1 / 2.2 as applicable).
- All documentation, whether electronic or printed, shall become the property of the Company.
- Electronic documentation shall be uploaded to the FAIR web-based data management system (EDMS).
- The Company will provide EDMS access and define the project folder structure.
- Document organization and numbering shall follow FAIR EDMS guidelines and shall be coordinated with the Company.
- All documents requiring approval shall undergo EDMS-based review and release procedures.
- Documentation not properly released and approved in EDMS will not be accepted.

7.1. Non-Conformance Reporting

Any deviation identified during manufacturing, inspection, or testing from the approved design documentation shall be documented in a Non-Conformance Report (NCR) and submitted electronically to the Company for approval prior to implementation.

7.2. Material related Documentation and Certificates

All relevant material certificates of construction materials used for the production of the vacuum chamber which confirm all relevant material properties shall be delivered.
Certificates for the used welding filler shall be delivered.

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Necessary test certificates in accordance with DIN EN ISO 10204: works certificate 2.2 or certificate 3.1.

7.3. FAT documentation

In particular, for FAT documentation the protocol given in the FAIR Technical Guideline [4] can be used if the manufacturer has no own templates. In addition, all documents required by the "Vacuum Properties Acceptance Tests".


7.4. SAT documentation

The protocol of the SAT Part A test (which repeats FAT) shall be prepared in the same way as the FAT protocol according to the FAIR Technical Guideline [4]. If the SAT fails, the SAT record will be delivered to chamber manufacturer with the demand of repair or rework.

8. Related Documents

8.1. Bibliography

- [1] F-TG-ZT-3.75e, "Mandatory: FAIR Technical Guideline, Component Reference," EDMS ID: 1467107.
- [2] F-TG-B-0.5e, "Mandatory: FAIR Technical Guideline, Permanent Labelling of Components "," EDMS ID: 1229368.
- [3] F-GS-PMO-en, "Mandatory: FAIR General Specifications," EDMS ID: 1365092.
- [4] F-TG-V-7.15e, "Recommendation: FAIR Technical Guideline, Record for Factory Acceptance Test (FAT) of Vacuum.," EDMS ID: 1172908.
- [5] F-TG-V-7.1e, "Mandatory: FAIR Technical Guideline, Mechanical Acceptance Test for UHV Components," EDMS ID: 1172905.
- [6] F-TG-V-7.2e, "Mandatory: FAIR Technical Guideline, Vacuum Properties Acceptance Test without Bake-out.," EDMS ID: 1172906.
- [7] F-TG-V-9.1e, "Mandatory: FAIR Technical Guideline, Transport and Packaging of Vacuum Components.," EDMS ID: 1172926.
- [8] F-TG-MDS-de-KRL-V005, "Mandatory: FAIR Technical Guideline, Design Guideline," EDMS ID: 1229367.
- [9] F-TG-B-02e, "Mandatory: FAIR Technical Guideline, Data Exchange Guideline Part 1 (DRL T1)," EDMS ID: 1229366.
- [10] F-TG-B-03e, "Mandatory: FAIR Technical Guideline, Data Exchange Guideline Part 2 (DARL T2)," EDMS ID: 1259954.
- [11] F-TG-QUA, "Recommendation: Guideline for the execution of welding practices for the FAIR project," EDMS ID: 2383347.

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[12] F-TG-B-01e, " MANDATORY: Material Selection and Radiation," EDMIS ID: 1173073.