Document Title	**Safety devices for SIS100 helium process pipes**
Description	This document specifies the safety devices for the SIS100 process pipes to protect a sextant against excessive pressure increase in case of a sudden loss of vacuum.
Division/ Organization	Commons / Cryogenics
Field of Application	FAIR GmbH and GSI GmbH

Document History

Version	Prepared/Checked by	Date	Date of Release	Comments
V 1.0	T. Eisel, A. Täschner, B. Streicher			First draft
V 2.0	T. Eisel	2020-07-23		No rupture discs considered anymore
V 3.0	T. Eisel, M. Kauschke	2026-08-25		New template, several updates for tendering
V002	T. Eisel	2026-10-22		Scope of delivery adapted with options (demand purchase office), few EDMS comments incorporated

Abstract

In the following the safety relevant information are given for the helium process pipes of SIS100. Basing on this, the safety equipment for the SIS100 sextants, which is attached to the main process headers of the feed box, end box and missing dipole are specified in this document.

This specification is intended to be used for the tendering process.

Further, the information required for the sizing of the safety equipment are described.

PSP codes: 2.8.12.7.1 and 2.8.12.7.2 Safety valves – local cryogenics

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1. Purpose and Classification of the Document

The purpose of this document is to specify the technical requirements for the tendering of the safety equipment attached to the main helium headers of the SIS100 sextants.

Specified are operational characteristics and sizing parameters. Thus, the specification of the safety equipment is a proposal by the Company. The Contractor may propose other solutions, if technical and safety related advantages can be achieved.

The sizing, design, production and usage of the safety equipment has to comply with European directives like the pressure equipment directive 2014/68/EU, (including i.e. DIN EN ISO 4126-1)

This document belongs to the technical part of the contract only. All commercial and organizational conditions are specified in the commercial part of the contract.

2. Abbreviations, Terms and Definitions

Abbreviation	Definition
Company	GSI Helmholtzzentrum für Schwerionenforschung
Contractor	Provider of the safety equipment
EB	End Box
FB	Feed Box
MD	Missing Dipole
SLV	Sudden Loss of Vacuum

3. Scope of the Technical System

3.1. System Overview

The safety valves are used to protect the cryogenic system of SIS100 at FAIR.

The helium inside is at cryogenic temperatures down to 4 K. The helium conditions and geometrical dimensions are described later on in the chapter system specification.

Further, the working and environmental conditions of the safety equipment are summarized later on in this document.

3.2. Scope of Delivery

3.2.1. deliveries by the contractor,

- In total 72 safety devices AND spare parts need to be delivered by the Contractor with the options
  - welding flanges of type “Welding Neck Flange PN40 Type 11 EN1092-1/11”, gaskets and connectors between flange and safety equipment for each equipment according to EN 13480
  - guide tubes in order to direct the outflow to the ceiling according to EN 13480
- Declaration of conformity with European standards, mandatory is the pressure equipment directive 2014/68/EU
- EN10204 3.1 certificate
- Operation manual including handling and mounting instructions, maintenance plan and environmental conditions for operation (including maximum operation pressure), the operation manual need to be in German language
- Testing documentation
- Documentation required for the technical inspection authority including amongst others material and welding certificates, mechanical and hydraulic calculations

3.2.2. deliveries by the company

- Sizing, concept and flange design description

3.3. Spare Parts

It is assumed to have one spare for each type of safety equipment. If the flanges and gaskets cannot be recuperated, these components are assumed to be spare parts to be delivered too.

4. System Specification

4.1. General

The SIS100 synchrotron cryogenic system consists of in total six sextants. Each sextant has at both extremities one Feed Box (FB) and one End Box (EB). At these boxes safety equipment at the five main helium headers will be located. Further, approximately in the middle of the sector (at the Missing Dipoles, abbreviated with MDs) safety equipment is attached to two main helium headers. The helium inside is at cryogenic temperatures down to 4 K. The helium conditions and geometrical dimensions are described later on in this document.

The helium headers must be protected against excessive pressures in case of accidents. The worst case, which is a thermal insulation vacuum break down, is considered for the sizing of the safety equipment.

4.2. Helium headers and conditions

Following helium headers are integrated in the cryogenic system, to which the safety equipment will be installed:

A1 Liquid helium supply for the magnets;

A2 Liquid helium supply for the vacuum chambers;

B Common helium return of A1 and A2;

C Gaseous helium supply for the shield and

D Gaseous helium return of the shield.

An overview about the piping to which the safety equipment will be mounted and the operational conditions are given in Table 1.

Table 1: Flange dimensions and operational conditions of the safety equipment. Flanges of type "Welding Neck Flange PN40 Type 11 EN1092-1/11" are installed at the cryogenic devices.

Process header	Amount of safety equipment	Flange size at the cryogenic device	Operating temperature in K	Operating pressure in bar(a)	Design pressure in bar(a)
A1 He supply magnets	6 12	FB: DN40 EB, MD: DN50	4.5	1.8 *	20
A2 He supply vacuum chamber	18	DN25	4.5	1.8 *	20
B He return magnets + vacuum chamber	12	DN50	4.3	1.1 *	20
C He supply shield	12	DN25	50	18	20
D He return shield	12	DN25	80	17	20

*The operation pressure during cool down is up to 18 bar(a). 50 cool down and warm up cycles over 20 years are assumed.

The pressures are given in absolute values bar(a) compared to the vacuum surrounding the process pipes.

4.3. Parameters and requirements of the safety equipment

According to the pressure equipment directive 2014/68/EU, the momentary pressure surge allowed in the cryogenic process pipes for PN20 is 19 bar(g) * 1.1 = 20.9 bar(g), which equals to 21.9 bar(a).

In case of a sudden loss of insulation vacuum the mass flow released via the safety equipment creates a pressure drop. The pressure drop (resulting in a pressure increase) in the process pipes and attached pipe work towards the safety equipment for an opening of the safety equipment is shown in Table 2. With the above mentioned information, the operating pressure can be derived, see Table 2.

Table 2: Safety equipment sizing parameters

Position	Process header	Pressure drop in bar(a)	Assumed operating / set / popping pressure bar(a) *	Max. mass flow released to atmosphere in kg/s	Helium temperature in K
Feed box	A1	0.5		1	20
&	A2	1.2§	17.7 / 19.7 / 20.7	0.5	20
End box	B	0.2		2	10
	C, D	0.1	18 / 20 / 21.1	0.06	60
Missing	A1	0.5		1	10
Dipole	A2	1.2§	17.7 / 19.7 / 20.7	0.5	20

* These values need to be confirmed/sized by the contractor. The set pressure for A1, A2 and B is assumed to be equal and is defined by A2 due to the highest pressure drop. The contractor shall confirm these assumptions.

§ This pressure drop violates the 3% rule according to AD2000-A2. Thus, a safety device with higher allowed pressure drop would be beneficial.

The added pressure loss for the opened safety equipment shall be small in the order of few mbar only.

The leak rate of the safety valves shall be in the order of equal or better 10^{-3} mbar*l/s. The tightness criterion shall be achieved at 94% of the set pressure or at least at the assumed operating pressure, e.g. 18 bar(a).

4.1. Environment, constraints

The material for the flanges and connectors to the safety valves shall be made of stainless steel and suitable for the described low temperatures. The dimensions of the welding flange and connectors shall fit to safety valve without unnecessary reductions.

Environmental conditions in the SIS100 tunnel will be 12 up to 25 °C of air temperature and 30 to 80 % of relative humidity.

The outlet to the atmosphere shall have a protection against objects that could possibly damage the safety equipment. The protection shall allow, however, a visual inspection if needed. The outflow shall be directed by a bend towards the ceiling. The vertical helium release is beneficial for the process pipe design in terms of reaction forces.

The maintenance interval of the safety valves is assumed to be 5 years.

5. Documentation

All safety equipment shall be delivered with a complete set of documentation, as described in the chapter scope of delivery