



# Technical Guideline

Number

7.19e

B-MT

## Vacuum Testing of Cryostat Vacuum Vessels

Status

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### Contents

|      |                                       |   |
|------|---------------------------------------|---|
| 1.   | Scope.....                            | 1 |
| 2.   | Definitions .....                     | 1 |
| 3.   | Basic Requirements.....               | 1 |
| 3.1. | Surrounding conditions .....          | 1 |
| 3.2. | Required Documentation .....          | 2 |
| 3.3. | Required Equipment and Media.....     | 2 |
| 4.   | Test Preparation .....                | 2 |
| 5.   | Checks and Tests .....                | 3 |
| 5.1. | Document and Certification Check..... | 3 |
| 5.2. | Single He Leak Test.....              | 3 |
| 5.3. | Integral He Leak Test.....            | 3 |
| 5.4. | End Pressure Test .....               | 4 |
| 5.5. | Residual Gas Test.....                | 4 |
| 6.   | Documentation.....                    | 4 |
| 6.1. | Testing Protocol Requirements.....    | 4 |

### 1. Scope

- 1) This document defines the requirements and procedures for the testing of vacuum properties of cryostat vacuum vessels in applications like
  - magnet cryostats,
  - cryogenic supply systems,
  - cryogenic transport systems,
  - cryogenic current lead boxes,
  - auxiliary cryogenic systems within FAIR accelerators.
- 2) This document is NOT related to tubing for conduction of cryogenic media or to beam tube vacuum testing.
- 3) This document is NOT related to any other purpose as aforementioned.

### 2. Definitions

- 1) A *cryostat* in terms of this guideline is a technical system enclosing another technical system to be operated at temperatures far below room temperature (e.g. 4.5K).
- 2) A *cryostat vacuum vessel* in terms of this guideline is a vessel, respectively a vessel like or tube like component, associated to the insulation vacuum volume of a cryostat.

### 3. Basic Requirements

#### 3.1. Surrounding conditions

- 1) The acceptance test shall be performed in a clean, low dust and dry surrounding.
- 2) No contamination with any grease or oil shall be accepted during vacuum testing.

### 3.2. Required Documentation

- 1) A testing protocol showing at least the content as defined in 6.1 must be prepared prior to the test procedure being executed.
- 2) A copy of the calibration certificate of the He – leak tester in use for the tests is required and shall be added to the documentation.
- 3) Quality documentation proving vacuum properties, for all electrical feedthroughs shall be added to the documentation.
- 4) Calibration certificates for the measurement instrumentation in use. None of the calibration certificates must show a date of last calibration older then one year at the date of testing.

### 3.3. Required Equipment and Media

- 1) The following equipment and media is required for the tests
  - calibrated He leak tester with most sensible range of  $1 \cdot 10^{-10}$  mbar\*L/s,
  - vacuummeter with a most sensible range of  $\leq 10^{-7}$  mbar,
  - quadrupole mass spectrometer with
    - faraday cup detector,
    - minimum detectable partial pressure of  $5 \cdot 10^{-12}$  mbar,
    - atomic mass number range of 1 – 100,
  - turbo molecular pump  
pumping speed:  $S \geq 300$  L/s for  $N_2$  @  $p \leq 1 \cdot 10^{-3}$  mbar,
  - roughing pump
  - oil-free vacuum equipment  
(pumps, tubing, valves etc.),
  - suitable oil free tubing, T – fittings and valves,
  - a set of blanking flanges and seals for all flanges not in use during testing,
  - plastic balloon for covering the complete vacuum vessel,
  - gaseous He.

## 4. Test Preparation

- 1) If possible the vacuum vessel shall be tested without any interior.
- 2) In case the a cryostat vacuum vessel shows obvious contamination with e.g. dust, grease, oil or any other solids or liquids the vacuum test shall be declared as failed.
- 3) All flanges not in use for vacuum testing shall be carefully closed by adequate seals and blanking flanges.
- 4) A testing scheme as described in Figure 1 shall be set up.
- 5) The vacuum scheme must be prepared for oil-free vacuum in the cryostat vacuum vessel.

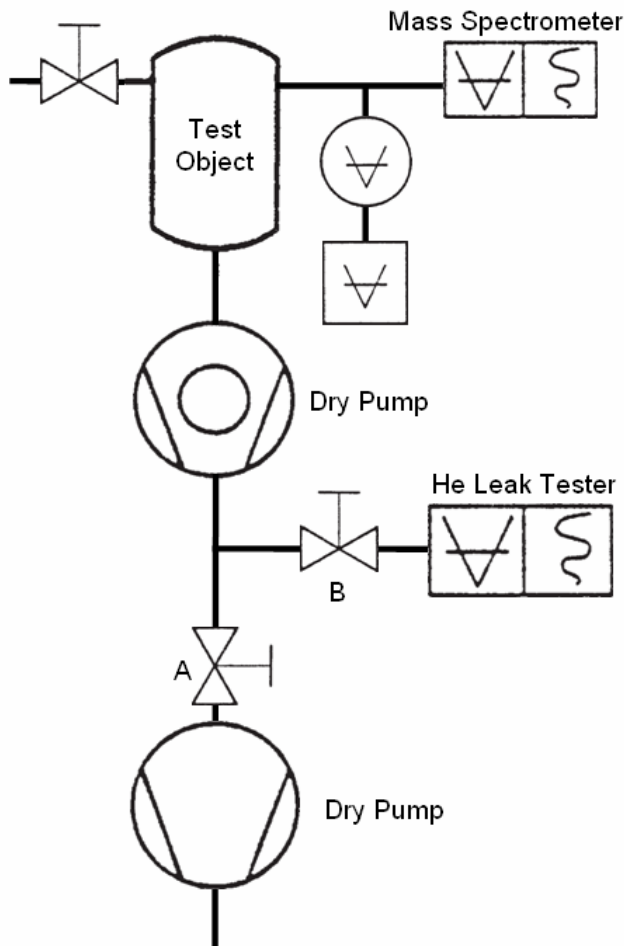


Figure 1: Vacuum testing scheme

## 5. Checks and Tests

- 1) For vacuum testing the tests and checks 5.1 to 5.5 shall be performed following the listed sequence.

### 5.1. Document and Certification Check

- 1) The quality documents for all electrical feedthroughs shall be checked for completeness.
- 2) In case of incomplete documentation, the vacuum test shall be declared as failed.

### 5.2. Single He Leak Test

- 1) For single He leak testing valve B shall be opened and valve A shall be closed.
- 2) All welding seams, flanges and existing feed through shall be tested for leaks separately by applying He gas to the full length of the welding seam respectively the vacuum gaskets and electrical sockets.
- 3) One single detected He-leak must not exceed  $1 \cdot 10^{-9}$  mbar\*L/s.
- 4) In case of one single leak rate at a welding exceeds the defined maximum value, the test shall be declared as failed.

### 5.3. Integral He Leak Test

- 1) For the integral He leak test the vessel shall be covered completely by a plastic balloon permanently filled with gaseous He.
- 2) For integral He leak testing valve B shall be opened and valve A shall be closed.
- 3) The He partial pressure of the residual gas shall be recorded during a testing time of  $\geq 20$  min.
- 4) The integral He leak rate of the vacuum vessel must not exceed  $5 \cdot 10^{-8}$  mbar\*L/s.
- 5) In case of an integral He leak rate exceeds the defined value, the test shall be declared as failed.

#### 5.4. Outgassing Rate Test

- 1) For the outgassing rate test, valve A shall be opened and valve B shall be closed.
- 2) The cryostat vacuum vessel shall reach a maximum surface related outgassing rate of  $q_{out} \leq 5 \cdot 10^{-9}$  mbar\*L/(s\*cm<sup>2</sup>) after  $t_{max} \leq 24$  h.
- 3) In case the outgassing rate is higher then defined, the test shall be declared as failed.

#### 5.5. Residual Gas Test

- 1) The residual gas spectra of the empty cryostat after 24 h of pumping shall show a hydrocarbon percentage < 5% for all residual components with an atomic mass number  $\geq 36$ .
- 2) In case the residual gas spectra shows higher hydrocarbon percentages then defined, the test shall be declared as failed.

### 6. Documentation

- 1) Any measured values shall be documented in writing within a protocol as defined as follows.
- 2) Time dependent measurements shall be recorded diagrams and put to the protocol.
- 3) All described checks and tests shall be documented in a testing form, agreed by the contracting entity.

#### 6.1. Testing Protocol Requirements

- 1) The testing protocol shall show comprehensible structure and content documenting each single test executed.
- 2) The following information shall be at least documented within the cover sheet:
  - Test identification,
  - Address of Company or Institute,
  - Identification of Department,
  - Names of testing personnel,
  - Name of quality testing leader,
  - Date and time,
  - Identification of tested object,
  - Serial number of tested object,
  - Test result,
  - Number of pages (including photo prints).
- 3) The measurement equipment in use shall be documented at least with
  - device identification,
  - serial number,
  - date of last calibration,



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- applied measuring range.
- 4) All tests, described in the chapter 5 shall be documented at least with
    - brief description of testing process,
    - test schemes if applicable (e.g. vacuum scheme),
    - relevant device settings,
    - registered non-conformities,
    - nominal values,
    - measured values,
    - photos of non-conformities (if applicable),
    - single ratings,
    - full test ratingin clearly separated chapters.
  - 5) All defined tests and procedures shall be signed by the executing personnel.
  - 6) A conclusion page shall indicate the all over test result clearly. In case the full acceptance test failed a brief explanation shall be stated.
  - 7) The protocol shall be crosschecked and signed by a person, responsible for the product quality of cryostat vacuum vessels.
  - 8) The original testing protocol shall be handed out to GSI.
  - 9) A digital version shall be stored in EDMS following the relevant guidelines for EDMS access and usage. The EDMS storage shall be agreed with the contracting entity.