



Technical Guideline

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Acceptance Test for Cryostat Vacuum Vessels

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1. Scope

- 1) This document defines requirements and tests to be executed for the acceptance test of insulation vacuum vessels and rigid tube-like insulation vacuum shells 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 any other purpose as aforementioned. It is also NOT related to the test of completed cryogenic modules as listed above.
- 3) This document shall NOT represent an inspection process description in terms of the relevant standards for welding inspection.

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) The unit *bara* defines the absolute pressure in bar.

3. Codes and Standards

- 1) DIN EN ISO 4287 [8] is defining the terms of surface texture, necessary for testing the surface quality of sealing surfaces.
- 2) AD 2000-Technical Bulletin HP 30 [9] defines the requirements and procedure for pressure testing of the vacuum vessel.
- 3) AD 2000-Technical Bulletin HP 512 [10] defines a template to be used for documenting the pressure test.

4. Basic Requirements

4.1. Surrounding conditions

- 1) The acceptance test must be performed in a clean, low dust and dry surrounding.
- 2) The general light conditions at the working place must be adequate for visual inspections.
- 3) The surrounding conditions in terms of operation safety for pressure testing are defined in [9].

4.2. Required Documents

- 1) All documents and certificates must be available on site at the date of testing.
- 2) All documents and certificates as defined in [2] must be available.
- 3) Printed copies of all technical drawings, relevant for the cryostat vacuum vessel to be inspected, must be prepared. Only copies of drawings with a valid release note of the contracting entity are admitted.
- 4) The set of drawings must provide at least the following information:
 - complete assembly configuration,
 - all main dimensions,
 - all relevant test dimensions,
 - all relevant form and position tolerances,
 - complete welding definition.
- 5) A testing protocol showing at least the content as defined in 6.1 must be prepared prior to the test procedure being executed.
- 6) 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.

4.3. Required Equipment and Media

- 1) A set of appropriate and well calibrated measurement tools for geometrical measurements at the cryostat must be prepared.
- 2) A calibrated roughness tester for measurement of R_a and R_z as defined in [8] must be available.

- 3) A full set of gaskets and blanking flanges for closing all openings of the vacuum vessel. The blanking flanges must not show any component potentially leaking, e.g. an electrical feed through.
- 4) Lint-free technical tissues and lint-free gloves.
- 5) An additional light source with high illuminance (e.g. gooseneck lamp) must be available.
- 6) Air pistol providing oil free compressed air.
- 7) Nitrogen gas from a compressed gas cylinder with pressure regulator ($p_{\max-out} \geq 2$ bara).
- 8) A suitable port flange with calibrated pressure gauge with drag indicator ($1 \text{ bara} \leq p_{\max} \leq 2 \text{ bara}$, accuracy class 0.6) and vacuum tide valve. The valve must show a leak rate less then the maximum allowed leak rate for a single leak as defined in [7].
- 9) A suitable digital camera for photographic documentation must be available.

5. Checks and Tests

- 1) Within the acceptance test procedure at least all tests and checks as defined in the chapter 5.1 to 5.9 must be executed.
- 2) Furthermore all security-related properties, as found out within a corresponding hazard analysis for the cryostat vacuum vessel, must be proven in detail.
- 3) After finishing the tests, a volume which was evacuated during testing processes shall be vent with dry gaseous nitrogen by applying a slight over pressure (max. 0.3 bar over pressure).

5.1. Document and Certification Check

- 1) The completeness of all documents and certificates as defined in [2] must be checked and documented.
- 2) In case of serial tests for a class of objects identical in construction, a copy of the confirmation; by the contracting entity; of completeness of the following documentation is sufficient:
 - a set of technical drawings with release note of the contracting entity,
 - a set of technical drawings of tooling and equipment for production and testing with release note of the contracting entity,
 - engineering documentation as described within the specification related to the relevant object,
 - documentation of safety relevant calculations,
 - documentation of a hazard analysis associated to the relevant object,
 - process description of all welding processes applied,
 - operation manual according to [1],
 - calibration certificates of the measurement instrumentation in use.
- 3) Documentation not in common must be checked separately for each entity.



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- 4) In case of documents missing, the acceptance test must be declared as failed but being finished if possible.
- 5) In case of documents of safety relevance are missing, tests concerning affected components (5.7 Safety System Test, 5.8 Pressure Test) must NOT be performed and the acceptance test must be unconditionally declared as failed.

5.2. Cursory inspection

- 1) All entities building the vacuum vessel it self must be checked at least for
 - Completeness,
 - correct orientation,
 - visible damages,
 - visible deformationsand any other obvious or visible non-conformities related to the drawings.
- 2) The application and content of the label plate as defined in [5] must be checked.
- 3) In case of any non-conformity the test must be declared as failed.

5.3. Welding Inspection

- 1) All relevant welding related documentation and certifications must be checked for completeness in detail.
- 2) The existence and basic correctness of all welding in terms of [3] and [4] must be checked compared to the drawings.
- 3) All welding must be checked for cleanliness. No oxide films inside the vacuum vessel are allowed.
- 4) Accumulations of welding beads must be registered and documented.
- 5) Inner gaps, caused by unavoidable welding from outside must be inspected carefully for compliance with [3] and [4].
- 6) In case of any non-conformity, inner oxide films or any contamination the test must be declared as failed.

5.4. Cleanliness Test

- 1) For cleanliness test see [6].
- 2) In case the cleanliness test is failed, the acceptance test must be declared as failed.

5.5. Sealing Surface Inspection

- 1) All sealing surfaces and cutting edges (for CF flanges) must be checked for visible scratches and damages.
- 2) In case of scratches or damages the test must be declared as failed.
- 3) All sealing surfaces must be checked with a roughness tester in at least 5 distributed and representative positions.



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- 4) In case of sealing surface quality doesn't meet the specified qualities the test must be declared as failed.

5.6. Dimensional Tests

- 1) The dimensional tests, performed within the quality tests during production must be checked for completeness.
- 2) In case of incomplete documentation the test must be declared as failed.
- 3) Functional dimensions and positions of the most important interfaces e.g.
 - flanges,
 - support structures,
 - conveying interfacesmust be cross checked.
- 4) In case of non-conformity with the existing documentation, the test must be declared as failed.

5.7. Safety System Test

- 1) In case the cryostat in its fully equipped configuration is identified as pressure equipment of the class I or higher in terms of 97/23/EC the test of the relevant safety system must be executed according to [9] and [10].
- 2) The procedure described as follows must NOT be applied for cryostats with burst disk safety systems for the insulation vacuum volume. In case of a burst disk safety system the relevant documentation must be checked for completeness.
- 3) In case of the cryostat in its fully equipped configuration is identified not as pressure equipment in terms of 97/23/EC the procedure as follows must be performed.
- 4) The safety system must be tested for any detectable blocking. In case of blocking, the acceptance test must be defined as failed.
- 5) All flanges must be closed with adequate gaskets and blanking flanges. The port flange with pressure gauge and valve must be installed properly.
- 6) With use of the drag indicator pressure gauge the maximum response pressure of the safety system must be determined 5 times.
- 7) In case the measured response pressure once exceeds the value as defined (with respect to the allowed tolerances) within its certificate, the acceptance test must be declared as failed.
- 8) The response pressure must be determined again after finishing the vacuum test, when ventilating with gaseous Nitrogen over the port flange. The response pressure must not exceed the defined value with respect to the defined tolerance.

5.8. Pressure Test

- 1) The pressure test must be performed as defined in [9] for tests with gas-pressure only. For pressurising Nitrogen must be used.
- 2) In case of the pressure test was failed, the acceptance test must be declared as failed.

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5.9. Vacuum Test

- 1) NO Vacuum test must be executed in case the cleanliness test (see 5.4) is failed.
- 2) For vacuum testing see [7].
- 3) In case the vacuum test is failed, the acceptance test must be declared as failed.

6. Documentation

- 1) Any measured values, detected failures, faulty entities or other non-conformity must be documented in writing and also photographic if possible.
- 2) All described checks and tests must be documented in a testing form agreed with the contracting entity.

6.1. Testing Protocol Requirements

- 1) The testing protocol must show comprehensible structure and content documenting each single test executed.
- 2) The following information must 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 must be documented at least with
 - device identification,
 - serial number,
 - date of last calibration,
 - used measuring range.
- 4) All tests, described in the chapter 5 must 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,

- photographs of non-conformities (if applicable),
 - single ratings,
 - full test rating
- in clearly separated chapters.

- 5) The pressure test described in chapter 5.8 must be documented using the template described in [10].
- 6) All defined tests and procedures must be signed by the executing personnel.
- 7) A conclusion page must indicate the all over test result clearly. In case the full acceptance test failed, a brief explanation must be stated.
- 8) The protocol must be crosschecked and signed by a person, responsible for the product quality of cryostat vacuum vessels.
- 9) The original testing protocol must be handed out to the contracting entity.
- 10) A digital version must be stored in EDMS following the relevant guidelines for EDMS access and usage. The EDMS storage must be agreed with contracting entity.

6.2. Photographic documentation

- 1) Wherever the visual inspection of entities was showing a non conformity, a photography clearly documenting the situation must be taken.
- 2) In case of deformations, scratches, visible contaminations etc. an adequate scale must be shown for comparison within the picture.

7. References

- [1] Directive 97/23/EC, European parliament and the council of the European Union, <http://eur-lex.europa.eu>, 1997
- [2] Technical Guideline No. 10.8e: Documentation and Certificates for Cryostat Vacuum Vessels
- [3] Technical Guideline No. 3.1e: Constructive Design of Welding Seams for Vacuum Chambers
- [4] Technical Guideline No. 3.17e: Design of thick-wall Vacuum Chambers
- [5] Technical Guideline No. 10.7e: Cryostat Label Plates
- [6] Technical Guideline No. 7.18e: Testing Surface Cleanliness of High Vacuum components
- [7] Technical Guideline No. 7.19e: Vacuum Testing of Cryostat Vacuum Vessels
- [8] DIN EN ISO 4287:2009-11; Surface texture: Profile method - Terms, definitions and surface texture parameters; Deutsches Institut für Normung e.V.; Beuth Verlag GmbH; Berlin; Germany; 2009
- [9] AD 2000-Technical Bulletin HP 30, Durchführung von Druckprüfungen; Verband der TÜV e. V.; Beuth Verlag GmbH; Berlin; Germany; 2009
- [10] AD 2000-Technical Bulletin HP 512, Schlußprüfung und Druckprüfung; Verband der TÜV e. V.; Beuth Verlag GmbH; Berlin; Germany; 2009