ANNEX B32: ROOM TEMPERATURE VACUUM LEAK TESTING

1. INTRODUCTION

During operation, the cold mass contains superfluid helium at 1.9 K and is bounded by evacuated enclosures. These enclosures include the so-called **insulation vacuum, beam vacuum cold bores** and **heat exchanger tube**.

Before its entry into service, each dipole cold mass shall undergo extensive testing. Included in the test program, is verification of the leak tightness of the cold mass enclosures under operational conditions. As a **provisional acceptance test**, the cold mass shall undergo **room temperature leak testing**.

2. GENERAL DESCRIPTION OF THE TESTS

The objective of the room temperature leak test is to measure the helium leak rates of the cold mass, cold bores and heat exchanger. The leak test shall be made by measuring the helium concentration in each of the evacuated enclosures upon pressurisation of the cold mass or heat exchanger. The helium concentration shall be measured using a **mass spectrometer leak detector**. The test shall be performed in accordance with international (or national equivalent) leak testing standards. The leak tightness measurements shall be made during the safety pressure tests. For information, the test pressures are as follows:

Cold mass	2.6 MPa
Heat exchanger	0.5 MPa (internal pressure)

3. SCOPE

This specification is for **final room temperature leak testing** of dipole cold masses before their cold operation. It describes the item to be tested and defines the equipment, the preparations, the procedure and the quality assurance documentation. Acceptance will be declared under the following conditions:

Cold mass to insulation vacuum	$\leq 1\cdot10^{-10}$ Pa·m^3/s
Cold mass to beam vacuum cold bores	$\leq 1\cdot10^{-11}$ Pa·m^3/s
Cold mass to heat exchanger	$\leq 1\cdot10^{-6}$ Pa·m^3/s
Heat exchanger to insulation vacuum	$\leq 1\cdot10^{-10}$ Pa·m^3/s

Note: all leak rates are given at 20 °C with enclosure at test pressure (helium at 100%)

4. EQUIPEMENT REQUIRED FOR THE TEST (SEE FIGURE B32.1)

4.1. General

The equipment used for leak testing of the cold mass enclosures shall be compatible with clean vacuum systems. No internal or external contamination of the cold mass, cold bores or heat exchanger shall result from the tests.

4.2. Vacuum vessel

The vacuum vessel shall be clean to high vacuum standards. Sealing of the end flanges may be achieved using elastomer o-rings. The free volume inside the vacuum vessel together with the pumping speed of the principal pumping group will strongly influence the leak testing time constant. The vacuum vessel design shall be compatible with the requirements of the pressure test

4.3. Turbomolecular pumping group 1 & 2

The pumping groups shall consist of a turbomolecular pump in series with an oil sealed rotary backing pump. To avoid oil back streaming via the turbo in the event of electrical failure, the connecting manifold between the two pumps shall have a normally closed electromechanical valve. In addition, the backing side of the turbomolecular pump should be equipped with a valve system to enable a helium leak detector to be connected. The input manifold on the turbomolecular pump shall be equipped with suitable vacuum gauges.

4.4. Rough pumping group

The rough pumping group shall be suitable for the repeated pumping of the vacuum vessel enclosure in the pressure range of 0.1 MPa to 10 Pa. A suitable pump would be a oil-sealed rotary pump. To avoid oil back streaming in the event of electrical failure, the connecting manifold between the pump and the vacuum vessel shall have a normally closed electromechanical valve.

4.5. Auxiliary pumping group 1 & 2

The auxiliary pumping group shall be suitable for repeated pumping of large enclosures containing helium gas. The pump will be required to operate in the range 0.1 MPa to 10 Pa. A suitable pump system would be an oil sealed rotary pump dedicated for this use. To avoid parasitic helium signals, the pump shall not exhaust into the ambient air of the test area.

4.6. Vacuum pressure gauges

The vacuum gauges on the vacuum enclosure shall cover the range 0.1 MPa to 10^{-3} Pa nitrogen equivalent. Suitable gauges would be the thermal conductivity (Pirani) gauge and cold cathode ionisation (Penning) gauge combination.

4.7. Helium Leak detector 1, 2 & 3

The leak detectors shall have a sufficient sensitivity to enable the leak tightness values mentioned in Section 2 to be measured.

4.8. Calibrated helium leak

The calibrated helium leak shall be in the range 10^{-8} to 10^{-10} $Pa{\cdot}m^3/s$ and have a clearly marked test date.

4.9. Chart recorder

Chart recorders (or an on-line data acquisition system) shall be used to record the leak detector and pressure measurement signal for the complete duration of the test. Each step of the leak test shall be clearly identified.

4.10. Pressurised helium circuits

The equipment required for the pressurisation of the cold mass and heat exchanger helium circuits shall conform to international (or national equivalent) safety requirements. To avoid contamination of the test area with helium, the circuits shall be of all metal construction.

5. PREPARATIONS

All components used for closing the vacuum envelope shall have been cleaned and individually leak tested to a sensitivity compatible for the subsequent leak test.

The assembly may take place only in a clean dust-free closed area. No machining operations may take place in or close to this assembly area. Areas used for cryogenic operations with abnormal helium concentrations in the ambient air shall be avoided.

Before assembly, all vacuum sealing surfaces should be visually inspected for damage and contamination.

The seals of the test vacuum vessel and all connections to the principal pumping group and leak detectors shall be elastomer O-rings. If the required leak testing sensitivity cannot be achieved, it may be necessary to use metal seals.

The cold mass, cold bores and heat exchanger envelopes within the vacuum vessel envelope shall be of an all-metal construction, including the seals at all de-mountable flanges. Oil or grease shall not be used on any of these seals. Pre-testing of metal sealed joints on the cold mass is advised before final assembly of the vacuum vessel end flanges.

6. LEAK TEST PROCEDURE

The leak tests shall be performed in accordance with international (or national equivalent) leak testing standards (e.g. EN, DIN, AFNOR, etc.) by accredited personnel. If the former and the latter conditions are not satisfied, a detailed leak test procedure shall be submitted for CERN approval before the commencement of leak testing activities.

A typical leak test sequence could be as follows (see Figure 1):

- Install cold mass in vacuum vessel,
- Evacuate vacuum vessel, cold mass, heat exchanger and cold bores,
- Pressurise cold mass (measure leak rate to insulation vacuum, heat exchanger and cold bores),
- Depressurise and evacuate cold mass,
- Pressurise heat exchanger (measure leak rate to insulation vacuum),
- Depressurise and evacuate heat exchanger,
- Vent all volumes to dry nitrogen gas,
- Remove cold mass from vacuum vessel,
- Install protection covers on cold bores, heat exchanger and cold mass flanges.

7. RESULTS AND DOCUMENTATION

A detailed leak test report for each dipole cold mass shall be submitted before provisional acceptance can be declared. The following documentation shall be supplied with each report:

a) A copy of the chart recorder output(s), with all steps of the leak test identified, *b)* A data sheet/computer readable file with the following information:

- Cold mass supplier name,
- Contract number,
- Cold mass serial number,
- CERN leak test technical specification employed,
- Name and qualification of personnel performing the tests,
- Place of the test,
- Date of the test.

And for each enclosure:

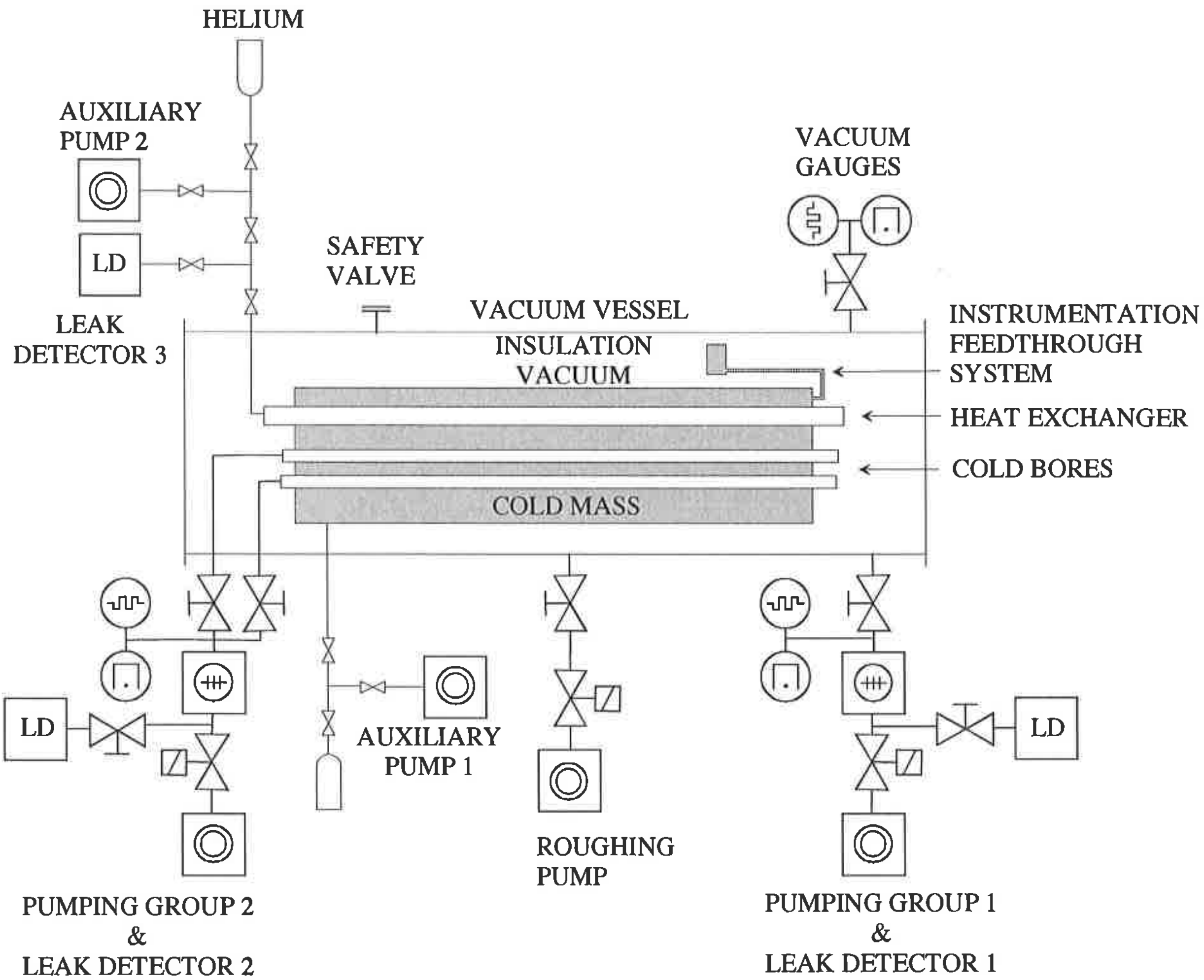
- Name of enclosure under test,
- Leak tightness requirement,
- Leak test method,
- Description of leak test equipment,
- Size of calibrated leak,
- Measured signal of the calibrated leak,
- Measured residual signal of the evacuated enclosure,
- Smallest readable signal,
- Estimated volume of the evacuated enclosure,
- Measured time constant of evacuated enclosure,
- Helium pressure employed,
- Measured signal during the test,
- Calculated smallest detectable signal,
- Conformity/Non-conformity.

The leak test report shall also include all anomalies, corrective actions, repetitions of tests, and correspondence with CERN.

In the event of leak, a non-compliance procedure shall be opened as described in Section 8.2.6. CERN will be contacted for approval on the proposed corrective action.

Fig. B32.1: Dipole cold mass leak testing typical test setup

<u>LEAK TEST SEQUENCE:</u> COLD MASS TO INSULATION VACUUM
COLD MASS TO HEAT EXCHANGER
COLD MASS TO COLD BORES
HEAT EXCHANGER TO INSULATION VACUUM



IMPORTANT:
THE CIRCUITS TO PRESSURE THE COLD MASS AND HEAT EXCHANGER SHOW ONLY THE COMPONENTS THAT ARE REQUIRED TO EXECUTE THE LEAK TESTING.
THE RELEVANT SAFETY STANDARDS FOR PRESSURISED CIRCUITS MUST BE APPLIED.