MICE Cleaning and Welding Procedure

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1. Purpose

This note describes the cleaning and welding procedure to be used on the MICE absorbers and magnet cryostats. This note also describes the clean condition required for welding that occurs within the MICE assembly area.

2. General

The absorbers that are attached to the MICE shall be designed for internal pressures of 0.68 MPa (6.8 bar or 100 psig). The absorber cryostat vacuum must be designed for a working pressure of 0.2 MPa (2 bar or 30 psi). The absorber and its vacuum vessel are designed in accordance with the ASME pressure vessel code (or the equivalent European of British standard code) for flammable gasses. The vacuum vessel for the RF cavity and the superconducting magnets must be designed as a 0.1 MPa (1 bar or 15 psig) pressure vessel (internal pressure). In addition, the magnet vacuum vessels must be designed for an external pressure of 0.1 MPa (1 bar or 15 psi). The helium cryogenic vessels for the magnets must be designed as a pressure vessel with a working pressure of 0.4 MPa (4 bar or 60 psig) under the ASME pressure vessel code (or the equivalent European of British standard code) for non-flammable gases. Piping must be designed for a working pressure of 2 MPa (20 bar or 300 psig) unless otherwise specified.

The cryogenic system vacuum vessels for the magnets, the vacuum vessel for the RF cavity, and the vacuum vessel for the absorber must be capable of maintaining a vacuum of 10^{-4} Pa (7.5×10^{-7} torr) or lower. The vacuum vessels must also be built to high vacuum standards. The leak tightness of all MICE components is found in Reference [1].

3. Component Cleaning in Preparation for Welding

Before MICE components can be welded, the surfaces of the components shall be cleaned after manufacture and rendered free from and all traces of cutting fluids, grease and other hydrocarbon contaminants. The parts shall be cleaned according to the following procedure recommended by CERN for the LHC [2]:

- The part shall be degreased.
- The part shall be ultrasonically cleaned in a bath of heated alkaline detergent solution.
- The part shall be rinsed immediately with de-mineralized water.
- The parts shall be dried with a flow of dry clean air that shall be maintained until the values of relative humidity monitored at the inlet and exit to the supply channel shall be identical to within 5%.

After cleaning and drying a local wetting test on a visible external surface shall reveal a film of water covering the wetted surface without showing single droplets. After the cleaning of the parts has been completed, they shall be bagged protecting the surfaces from contamination and dust. The parts should be tagged and put into locked storage.

4. Requirements for a Clean Welding Area

The term ‘clean area” refers to the working conditions and special measures that shall be applied to avoid contamination by the usual workshop contaminants such as oil, machine or finger grease, lint, dirt, atmospheric dust, paint and other such contaminants.

A clean area is in separate building or a separate designated room that is not part of a normal workshop. A suitable area of normal workshop space may be adapted as a clean area provided it is completely isolated from the rest of the workshop. A clean area is where the assembly and welding of cryogenic system occurs. The definition of a clean area is defined is the same as for the LHC by CERN in reference [3].

A clean area is a controlled are with the following general specifications:

- The clean area air should be temperature and humidity controlled. The temperature of the clean area should be 20 ºC ±5 ºC (68 ºF ±9 ºF). The relative humidity of the clean area should be 55% ±15%. The air should be changed and filtered to avoid contamination of dust, lint, and other contaminants.
- The floor can be fined screened concrete or equivalent. The floor must be adequately painted or sealed so that the floor is not a source of dust or other contaminants.
- The lighting should be adequate for the process being carried out.
- Heating shall be guarded to avoid the risk of fire.
- The clean area must have adequate controls for the entrance and exit.

Parts manufactured outside the clean area must be inspected, cleaned, and bagged before they can be brought into the clean area.

5. Acceptance of Weld Filler Material

Before manufacturing, the contractor shall provide 10 samples of filler materials he intends to use. These samples shall have a minimum length of 600 mm and shall be accompanied by a certificate indicating origin, grade of alloy, and chemical composition. A MICE designee will check the filler material samples and samples of welds made from that material for hardness,

ductility and magnetic permeability. MICE will give the contractor written notification concerning acceptability of this filler material after these tests are completed.

6. Weld Preparation

The area machined in preparation for welding shall be free from any traces of cutting fluids or contamination in accordance with Section 3 of this report. The machined surfaces shall also be inspected and found to be free of cracks, holes, and porous regions.

7. Welding Methods

TIG, MIG, or plasma welding methods shall be used. All leak-tight welds shall be fully penetrated. The number of weld passes made while welding a component depends on the degree of distortion control needed during the weld process as well as the size of the weld.

Distortion due to welding may be a problem for a number of the welds in the MICE absorbers. It is recommended that the distortion of the welded sections be measured as the welds are being made, so that corrective measures can be taken to reduce the weld distortion of the finished components.

All welds shall be made using a shield gas to prevent the formation of slag and porosity that may interfere with the tightness if the weld. Tubes that are welded must have an inert purge gas flowing through the tube as the weld is being made. Automatic welding techniques (for example, orbital welding) are recommended for welds made on circular pipes and tubes.

General information on applicable welding techniques can be found at the American Welding Society web-site http://www.aws.org. Recommended publications can be found under the following sub-categories:

- General references
- Filler materials
- Piping and tubing
- Qualification and certification
- Welding procedure specification

If manual welding is used, non-destructive tests shall be used on 100 percent of the welds. A dye penetration test should be done on the filled section of a full penetration weld before the surface of the weld is finished. Welds for the absorber body and the absorber vacuum vessel should be non-destructive tested in accordance with the ASME pressure vessel code. All

longitudinal welds in the absorber components must have a radiographic inspection [4] and [5]. The only welds on the absorber that do not require a radiographic inspection are the final close out welds that can not be inspected using radiographic inspection. These welds must be tested using a dye penetration test.

If automatic or orbital welding techniques are implemented on helium piping, then the percentage of non-destructive tests can be relaxed to meet the normal standards for the weld being made. All non-destructive weld tests must be done by a fully qualified welding inspector.

The contractor doing the welding shall provide the MICE designee information on the welding methods that he intends to use for manufacturing the MICE absorbers, the MICE cryostats and vacuum vessels, and all of MICE cryogenic sub-components.

8. Welding Operators

It shall be the contractor's responsibility to maintain the qualification of the welding operators he intends to employ for the contracted work. The contractor shall maintain a permanent record, which shall be made available for inspection by the MICE designee on request. These records shall contain details about these welding operators showing in particular the date of qualification, the qualifying authority, and the results of the tests. The welder making the welds for the MICE absorber assembly and the absorber vacuum vessel assembly must be qualified to do those types of welds. The welders making the welds for the MICE cryostat vacuum vessel and RF vacuum vessel assemblies must be qualified to do those types of welds.

9. Welding Procedure Qualification and Tests

This It shall be the contractor's responsibility to qualify the welding procedures used for the following MICE components. In addition to the standard qualification tests, the contractor shall prepare five samples of the following types of welds:

- orbital welds of 304 stainless steel pipes and pipes made from 6061 aluminum
- 6061 aluminum hydrogen absorber body and magnet cryostat vessel welds that meet the standards of the ASME pressure vessel code for flammable gases
- 304 stainless steel cryogenic vacuum vessel full penetration welds in plates that are from 12 mm to 25 mm thick

The samples, which are at room temperature, shall be visually inspected. The samples shall be thermally shocked by dipping them into liquid nitrogen until the boiling stops. The sample shall be allowed to warm to room temperature while sitting in air. The cold shock shall be

repeated three times per sample. The welds shall be visually inspected. The pipe weld samples shall be subjected to vacuum leak tightness tests according to the standards set for in reference [1].

At any time during the manufacturing period, MICE may require the welding procedure qualification tests to be repeated.

10. References

[1] M. A. Green, "MICE Vacuum Leak Procedure," Note LBNL-10151, 8 Feb. 2006

[2] "Welding Procedures, Qualification, Inspection and Tests of Welds," Annex J2, IT-2593/LHC/LHC, EDMS No. 107609

[3] "Requirements for the Clean Area," Annex J1, IT-2593/LHC/LHC, EDMS No. 107609

[4] "Standard Guide for Radiographic Examination," ASTM publication E94-00, ASTM International, West Conshohoken PA, see http://www.astm.org.

[5] "Practical Reference Guide to Radiographic Interpretation Acceptance Criteria," American Welding Society Catalog number PRG (See the American Welding Society web-site at http://www.aws.org for more information.