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PROCEDURE

HL LHC INNER TRIPLET MAGNETS

METROLOGICAL CONTROLS & MEASUREMENTS FOR THE VACUUM VESSEL

Abstract

A number of metrological controls and checks need to be carried out during the construction and assembly of the inner triplet magnets. Based on the experience with the existing triplet magnets, this document summarizes the different measurements needed during the construction and assembly of the magnets. This is not an exhaustive procedure for the construction, but gives the minimum measurements required to ensure the conformity and compatibility with the existing systems.

TRACEABILITY

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1 OBJECTIVE

This procedure describes the minimum metrological measurements to be carried out during during the vacuum vessel construction and assembly.

1.1 Vacuum vessel measurements & controls

1.1.1 Inputs

Pre-requisites for this step are:

- Design values & fabrication drawings
- Laser Tracker
- Corner Cube reflectors in 0.5” and 1,5” diameter
- Stable reference network around the Cryostat
- Retroreflector holders welded on the cryostat (provided by CERN)
- Microsoft Excel template report (provided by CERN)

1.1.2 Description

In order to ensure the conformity and compatibility of the vacuum vessel a number of features need to be measured and controlled. In particular the:

- Cold feet support posts
- Cold feet interface flanges
- Jack interfaces
- Fiducial positions
- Extremity flanges
- FSI interfaces (feedthrough)

The reference system for the metrological controls is defined as follows:

The Y-axis of the coordinate sytem is defined by the center of the cryostat extremity flange on the Non-IP side towards the center of the cryostat extremity flange IP-side (two jack interfaces). The Z-Axis is defined as the normal of the best fit plane of the two extremity support post flanges. The origine is the center of the cryostat extremity flange on the Non-IP. And the X axis is perpendicular to both forming a right hand cartesian system.

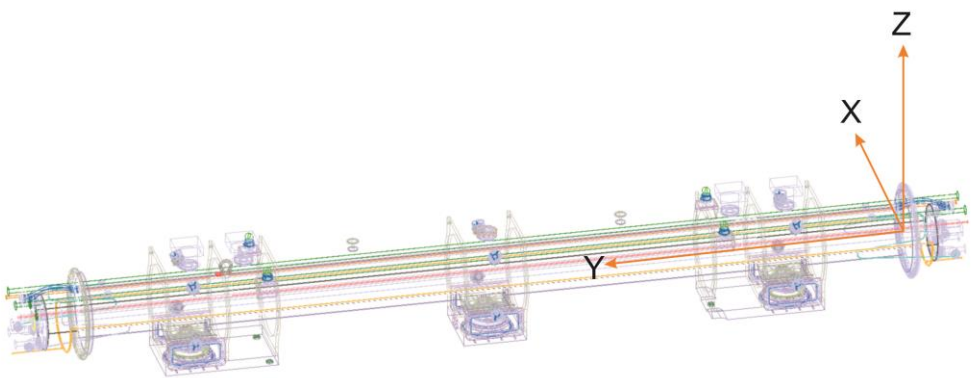

Figure 1: Cryostat Reference Frame

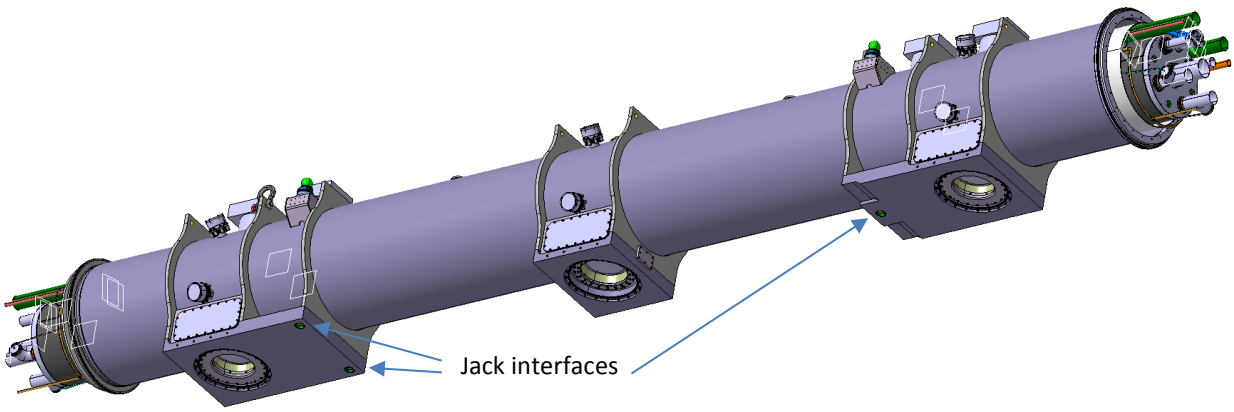

Figure 2: View of the jack interfaces below the Cyrostat

2 MEASUREMENTS

In order to get the needed accuracy, the measurements shall be made with a Laser Tracker. The cryostat must be supported by its jacks in the final configuration. A minimum of seven stations will be needed in order to realise the measurements. The reference cylinder and the reference plane as shown in Figure 6 and Fugure 7 need to be measured from underneath the cryostat what means an installation of the cryostat in a quite high position in order to be able to set up the instrument below. In addition to these references, the fully installed cold feet supports shall be measured in its final configuration as a circle from inside the cryostat. In order to do this, the cold feet support needs to be installed after the references on the cryostat flanges have been measured. The cold feet support is measured as a circle in dynamic mode on top of the composite support.

The RMS of the bundle adjustment for all stations should not exceed 30 µm. A sufficiently robust network of minimum 12 common points need to be established around the setup and 12 auxillary fiducials need to be tack welded onto the cryostat. The nominal positions of the fiducials will be given in a table in a separate document. Each fiducial should be observed from at least 2 stations. The position of the four primary fiducials are critical for the future permanent monitoring system. At this assembly stage a precise positioning with respect to the coldmass can not be ensured. Therefore the primary fiducials will be positioned after the fiducialisation measurement which will transfer the magnets axis to the coldmass reference points and the 12 auxillary fiducials.

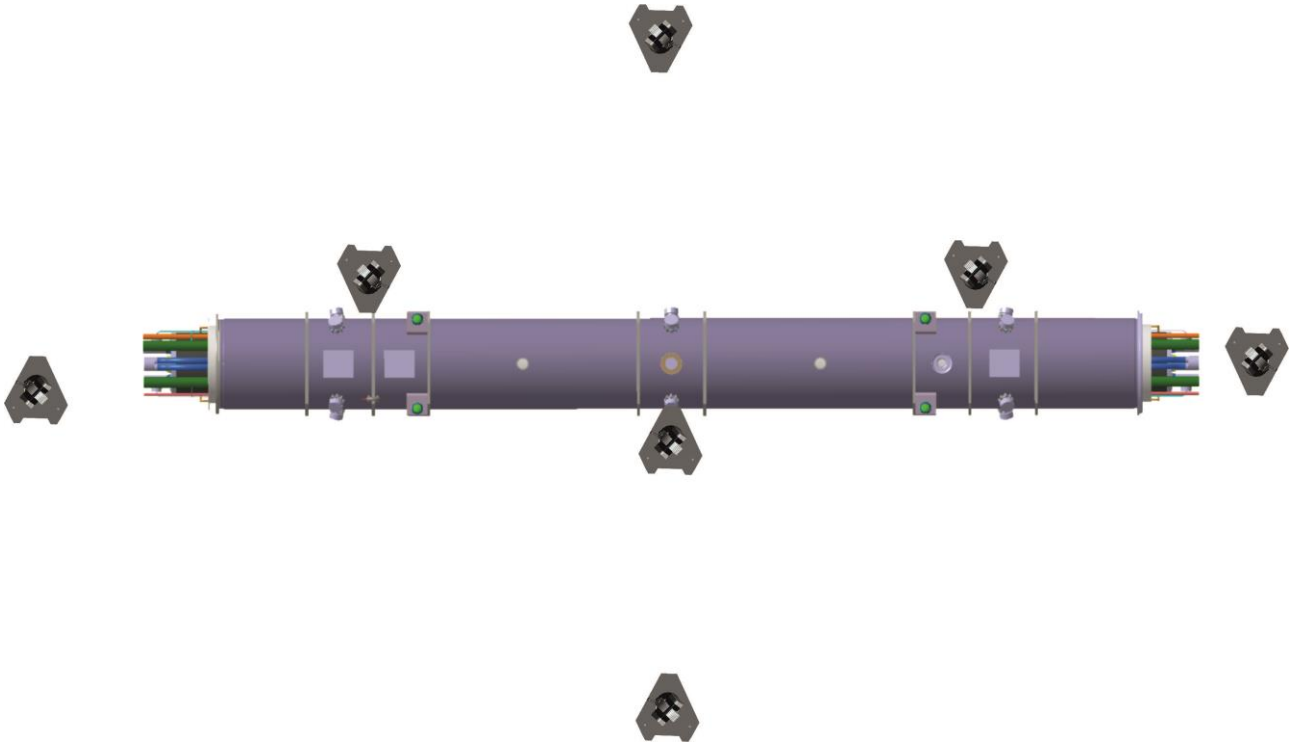

Figure 3: Proposal for measurement setup

2.1 Extremity Flanges

The extremity flanges are measured on the welded flange outside diameter as shown in Figure 4 and Figure 5. The measurements of the flanges shall be made in dynamic measurement mode with space separated acquisition points of 1mm distance all around the flanges. This allows to evaluate the form deviation along with the centers and orientation of the flanges.

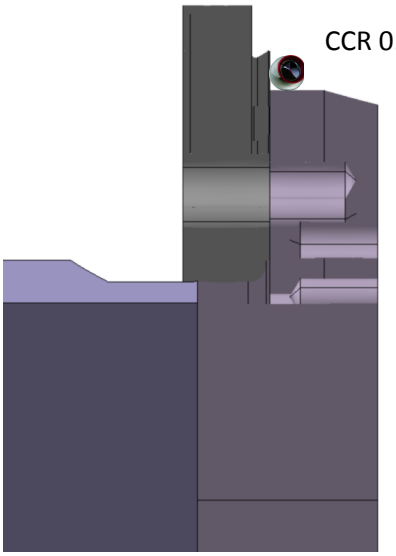

Figure 4: Non-IP side Cryostat Flange

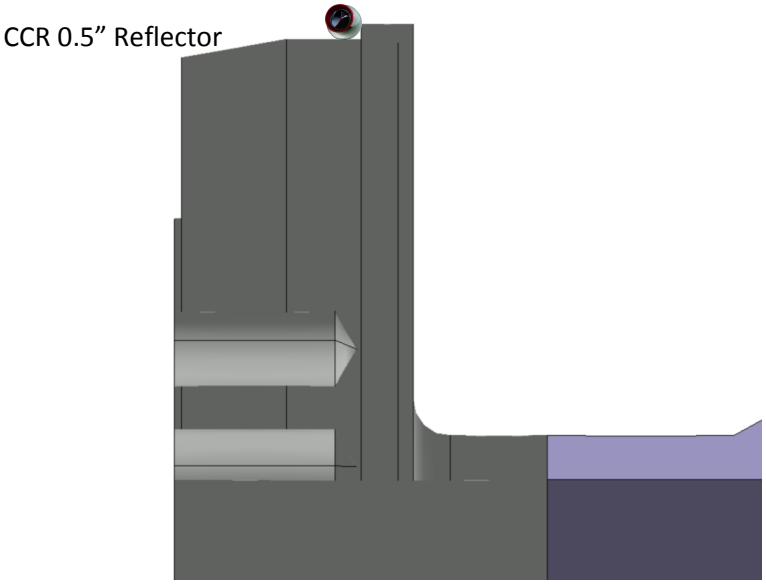

Figure 5: IP side cryostat flange

2.2 Cold Feet supports

The measurement of the support post flanges shall be made in dynamic measurement mode with space separated acquisition points of 1mm distance all around the flanges. This allows to evaluate the form deviation along with the centers and orientation of the flanges. The Figure 6 and 7Figure show the details of the support post flange to be measured. The contact surface will be the lower surface of the flange measured as a circle. This will be measured with a reflector support using a 6mm shank diameter, 10mm planar offset and a CCR 0.5” reflector as it can be seen in Figure Figure .

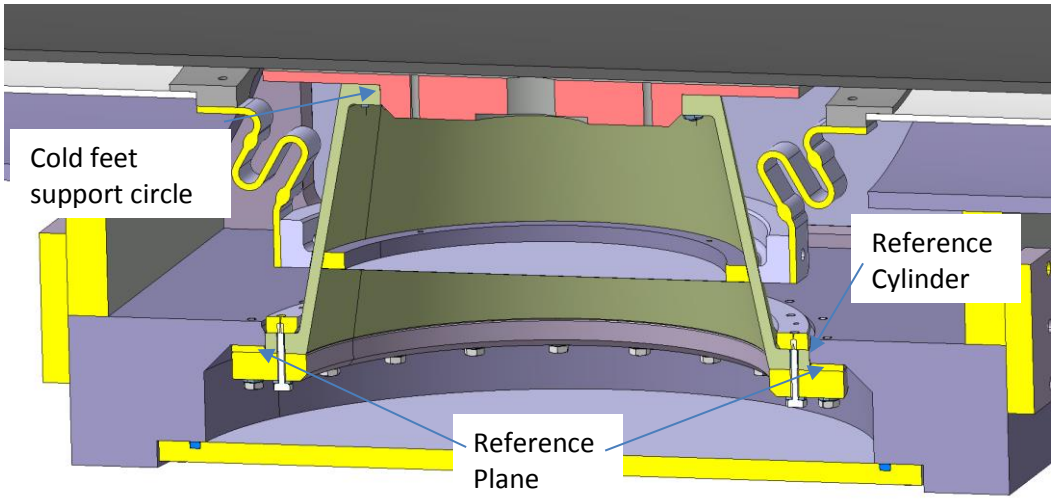

Figure 6: Section of Central Support Post

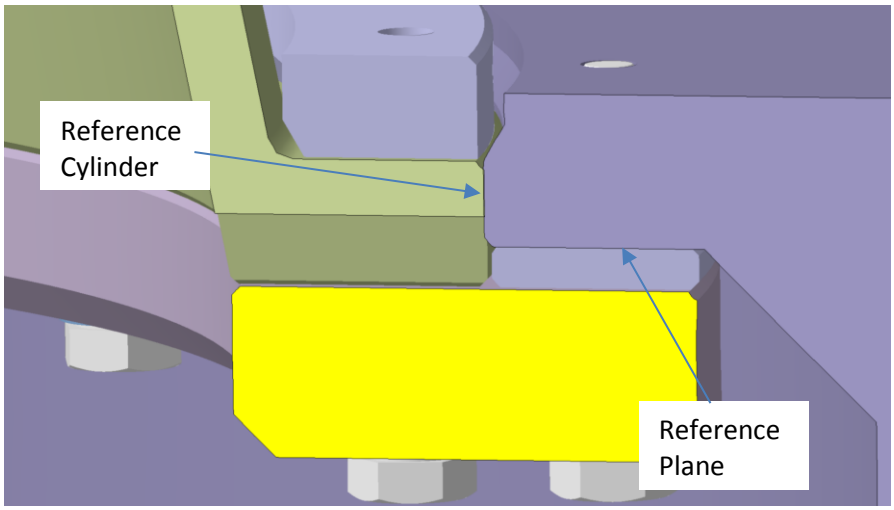

Figure 7: Detail of support post

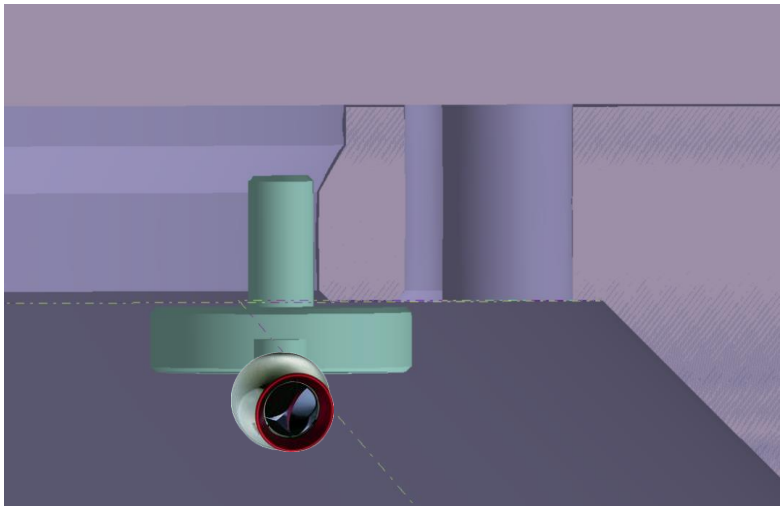

Figure 8: Reflectorholder in contact with flange surface

2.3 Jack interfaces

The jack interfaces need to be measured while they support the cryostat in its final configuration. The only way of doing this is to measure the circle of the jack head with either a CCR 0.5” reflector or a probing device connected to the laser tracker.

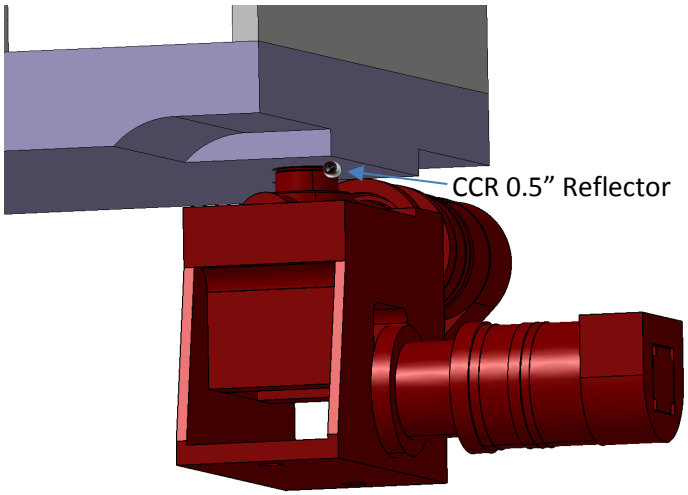

Figure 9: Jack interfaces to be measured

2.4 FSI Feedthrough flanges

The position of the 12 feedthrough flanges shall be measured as a circle in dynamic measurement mode with space separated acquisition points of 1mm distance all around the flanges. This allows to evaluate the form deviation along with the centers and orientation of the flanges. The measurements will be made with a reflector support using a 6mm shank diameter, 10mm planar offset and a CCR 0.5” reflector.

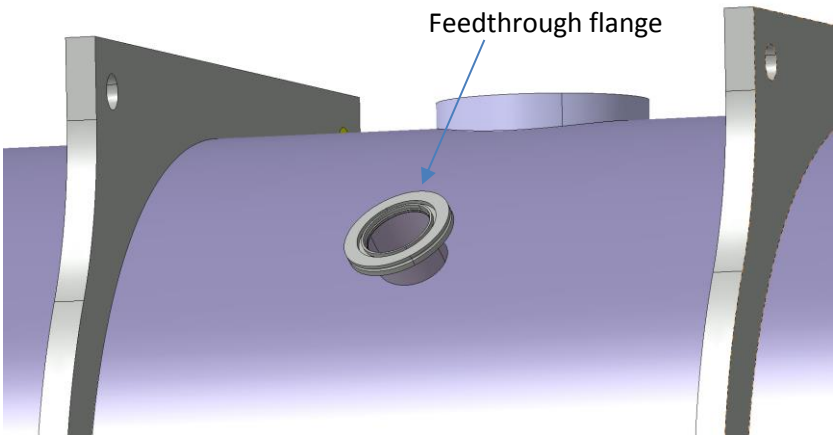

Figure 3: Feedthrough flange to be measured

2.4.1 Outputs

The report should be made using the provided Microsoft Excel template. All reflector offsets should be set correctly already in the measurement job and compensated when calculating the plane and circular features. The report should contain all needed results, measurement and fit precisions.
The results are grouped in the following way:

- Generals / Meta Data
  - Metadata (Operator, Object ID, Date etc.)
  - Instrument
  - Meteorological conditions
  - Network points
  - Bundle adjustment
- Cold feet support posts
  - Position of the three support post flange centers (cryostat & assembled composite support)
  - Deviation of the support post flange centers to a straight line (cryostat & assembled composite support)
  - Orientation of the three support post flanges (cryostat & assembled composite support)
  - Form deviation (planar and circular) of the three support post flanges (cryostat & assembled composite support)
  - Coplanarity of the the support post flanges (cryostat & assembled composite support)
- Jack Interfaces
  - Position of the 3 jack interfaces
- Extremity flanges
  - Position of the vacuum vessel extremity flanges
  - Orientation of the vacuum vessel extremity flanges
  - Form deviation (planar and circular) of the vacuum vessel extremity flanges
- Fiducial reference cups
  - Position of all fiducial reference cups
  - Auxillary fiducials on Cryostat
- FSI monitoring Flanges
  - Position of the FSI monitoring flange centers
  - Orientation of the FSI monitoring flanges

3 ANNEX(ES)

Microsoft Excel Report Template