TOWARDS THE THIRD GENERATION OF TTF CRYOMODULE

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Abstract

We present here the status of the design of the cryostats for the TTF. The first cryomodule, built by Zanon has been assembled and cooled down. Second and third have been built after a substantial revision of the design to lead to a significant cost reduction. Third generation cryomodule design is in progress with new substantial changes to improve its mechanical behavior and to introduce possibility of fixed coupler solution.

Introduction

TTF cryomodule design is coming to its third generation introducing improvements to solve aspects and problems pointed out by the assembling of first cryomodule and the fabrication of second and third. Guidelines and solutions have been changed through each step of the design till coming to the actual, that should accomplish requirements of Tesla 500.

First Cryomodule

First cryomodule was design[1] as a prototype to study the technology and the possible solutions to build a reliable structural support and thermal shielding for the acceleration system of TTF. Figure 1 shows cross section at post and at cavity regions. Three post have been placed to minimize deformation of the gas return pipe over the load of cavities and quadrupole[1]. The two thermal shields, made of aluminum, are divided in three parts, a roof and two lateral panels kept together by screws. Large section copper braids assure the heat transfer between cooling pipe and shield where they are fixed by screws[2]. To assure the good heat contact with the differential dilatation of copper and aluminum springs and Indium foils have been used. Braid-cooling design, even if interesting from a thermo-mechanical point of view, it was responsible for many problems in the construction phase and lead to a very expensive cryostat.

The shield panels have been linked together by aluminum screws and insert. More then 1000 inserts to fix all the panels. In order to assure a good thermal link an Indium foil has been placed between the panels surfaces[1].

Too strict and bad posed tolerances on the definition of the structural components took hard machining and alignment, resulting in a cryostat not corresponding to geometrical requirement. This cause assembly procedure to be long and full of in loco adjustment .

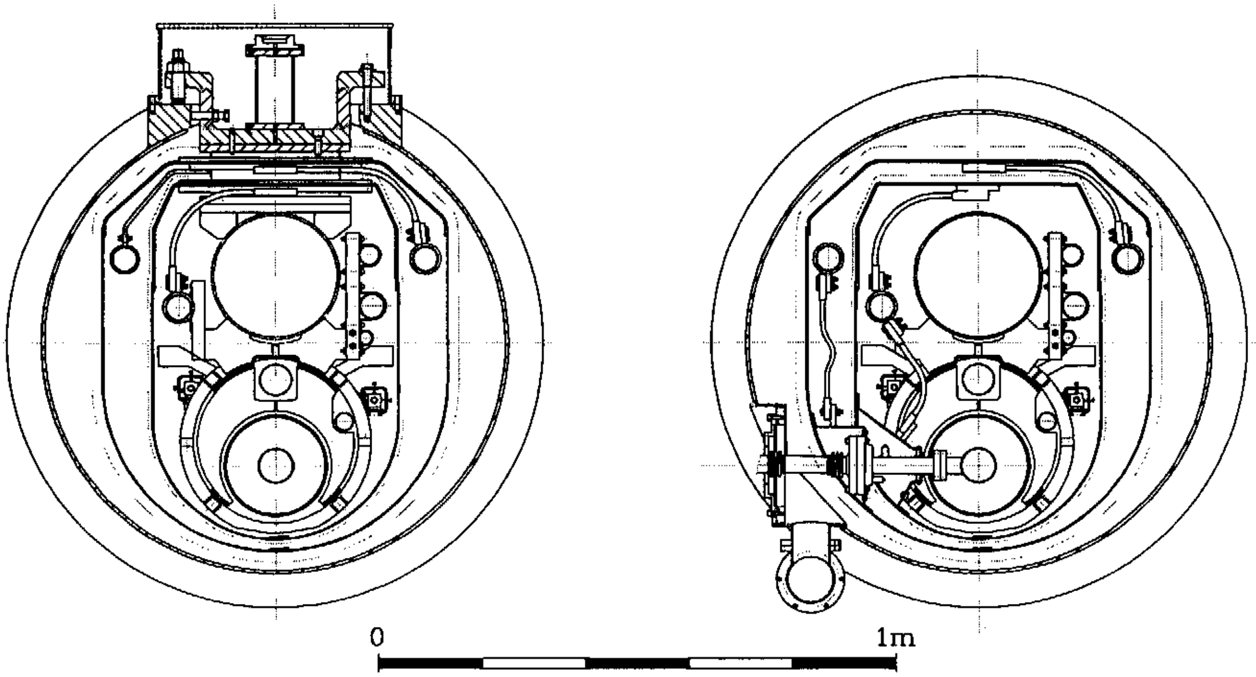

Fig.1 - First Cryomodule cross section at post and at cavity region. Cooldown of the shields is done by copper braids and screws connected to 4K and 70K helium pipe. Shields are kept together by aluminum screws.

Second generation cryomodule (module #2 to #3)

The experience gained during the design and the commissioning of the first cryostat suggested new solutions to improve the mechanical and thermal design. In particular, a different shield cooling method has been employed (see figure 2 and figure 3).

Causes for the high cost of first cryomodule design was identified in different aspect but principal were copper braids, because expensive and labor intensive, and shields panel connection by aluminum screws and inserts. In this sense the most important improvement was the new design of the thermal shields[3]. Cooling pipes were directly welded to the aluminum shield. This solution simplified the technical design of the entire cryomodule but indicated the needed to find a way to avoid stress and deformation during cooldown which could damage the shields. Solution found also prevents the typical deformation induced by welding procedure making easier the production pre-alignment.

Shields will be welded through small aluminum fingers (figure 3) that strongly reduce the resistance section of the joints, preventing possible damage during the cooldown procedure[3].

Another improvement comes from new alignment procedure and tolerances system. The He Gas Return Pipe tolerances were relaxed to 5 mm (standard high quality welded pipe), including straightness. When all ancillary components and supports have been welded, a 14 m milling machine is used to machine the upper three suspension post flanges, to produce the reference axis. As shown in figure 3, during all fabrication steps the HeGRP can be easily referenced to its previously defined axis, by means of pins, according to the desired precision.

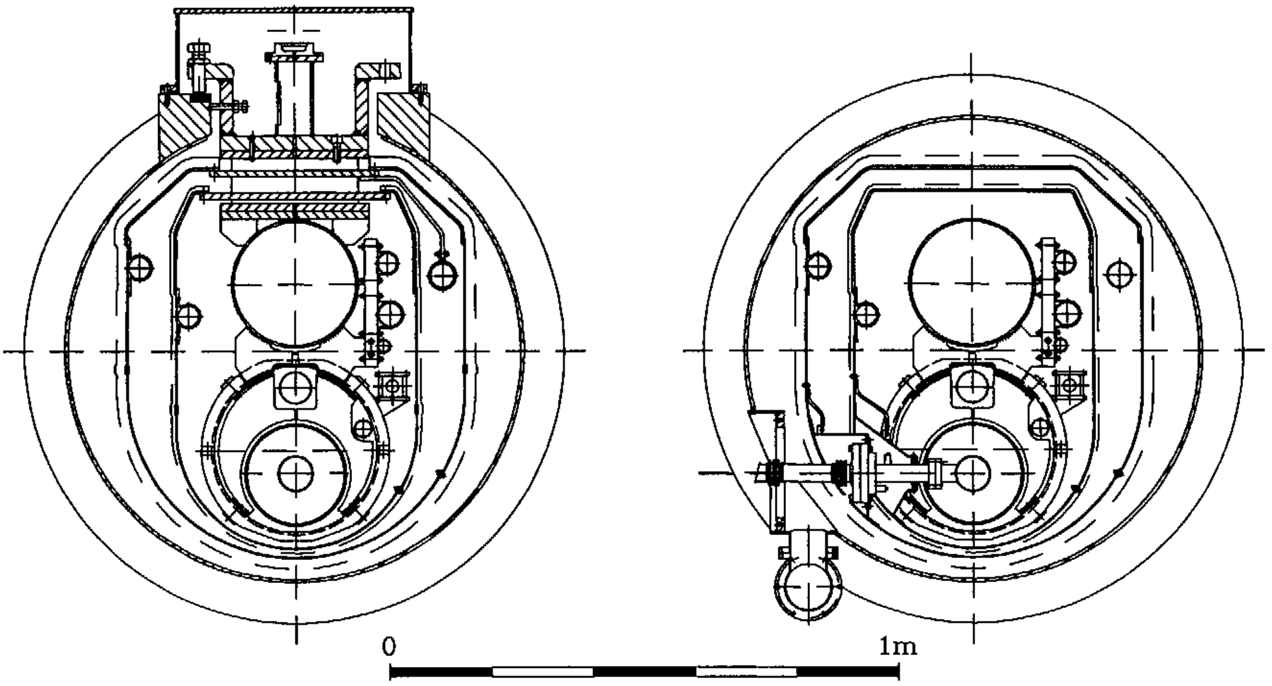

Fig. 2 - Second cryomodule generation (Cryomodule 2 –3). Shields are welded to Helium cooling pipe by small fingers that prevent deformation and high stresses

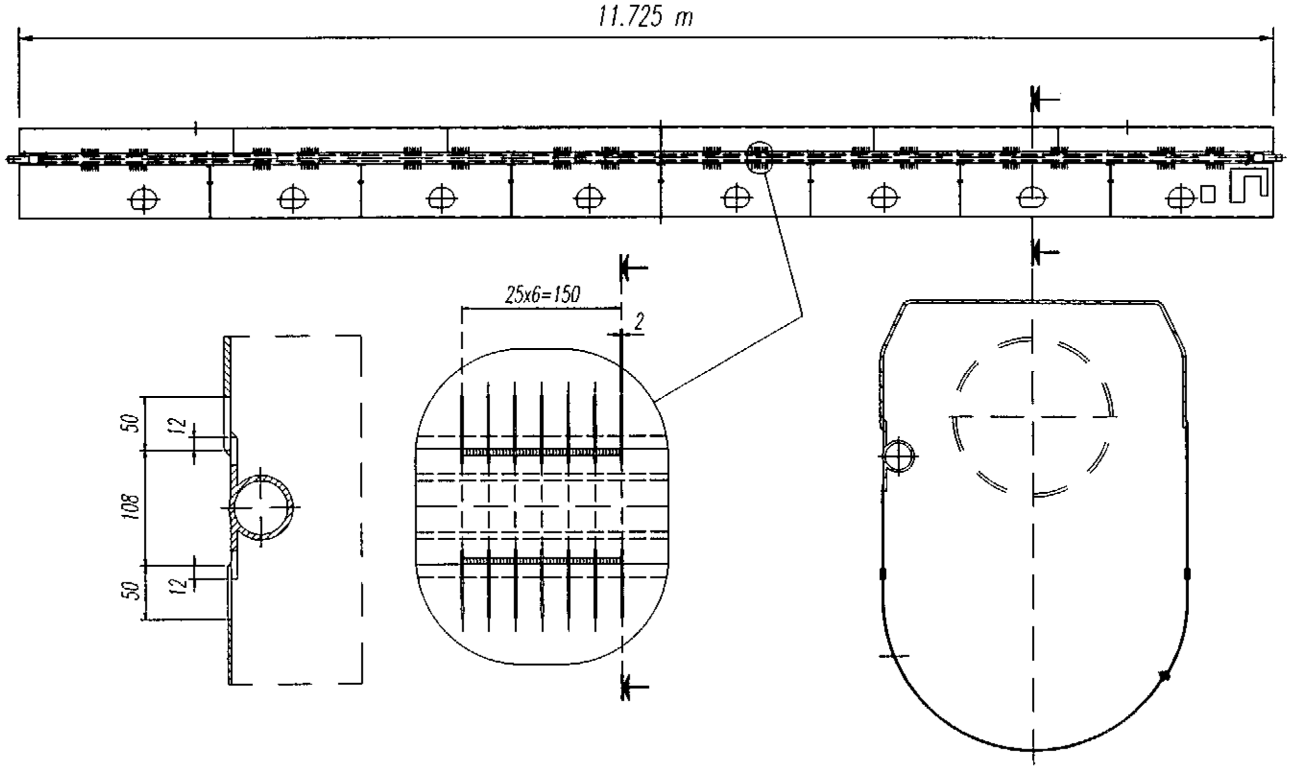

Fig. 3 - The finger welding scheme of the shields. The weld between roof and panel is done at Desy during the final assembly

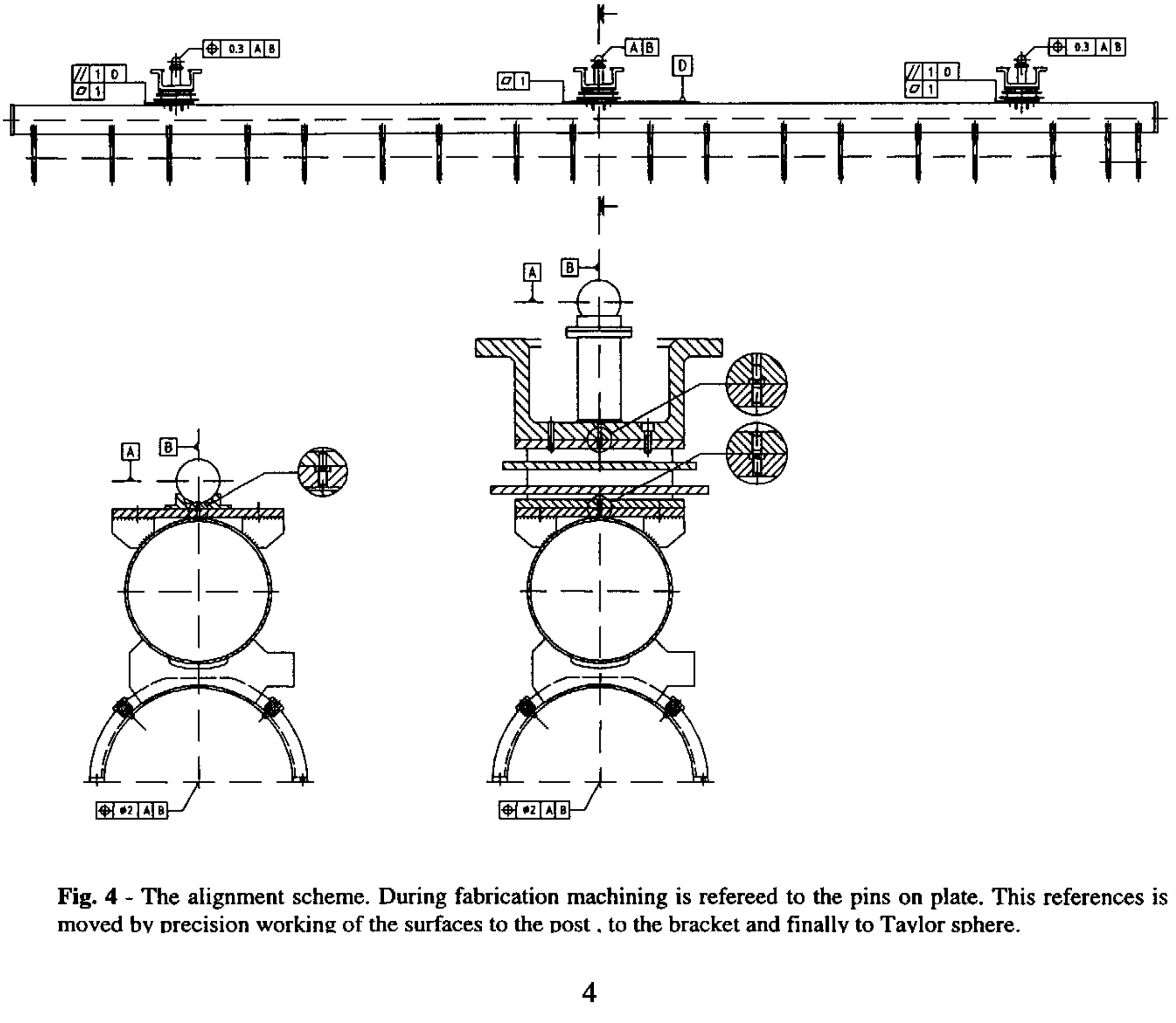

Fig. 4 - The alignment scheme. During fabrication machining is refereed to the pins on plate. This references is then moved by precision working of the surfaces to the post , to the bracket and finally to Taylor sphere.

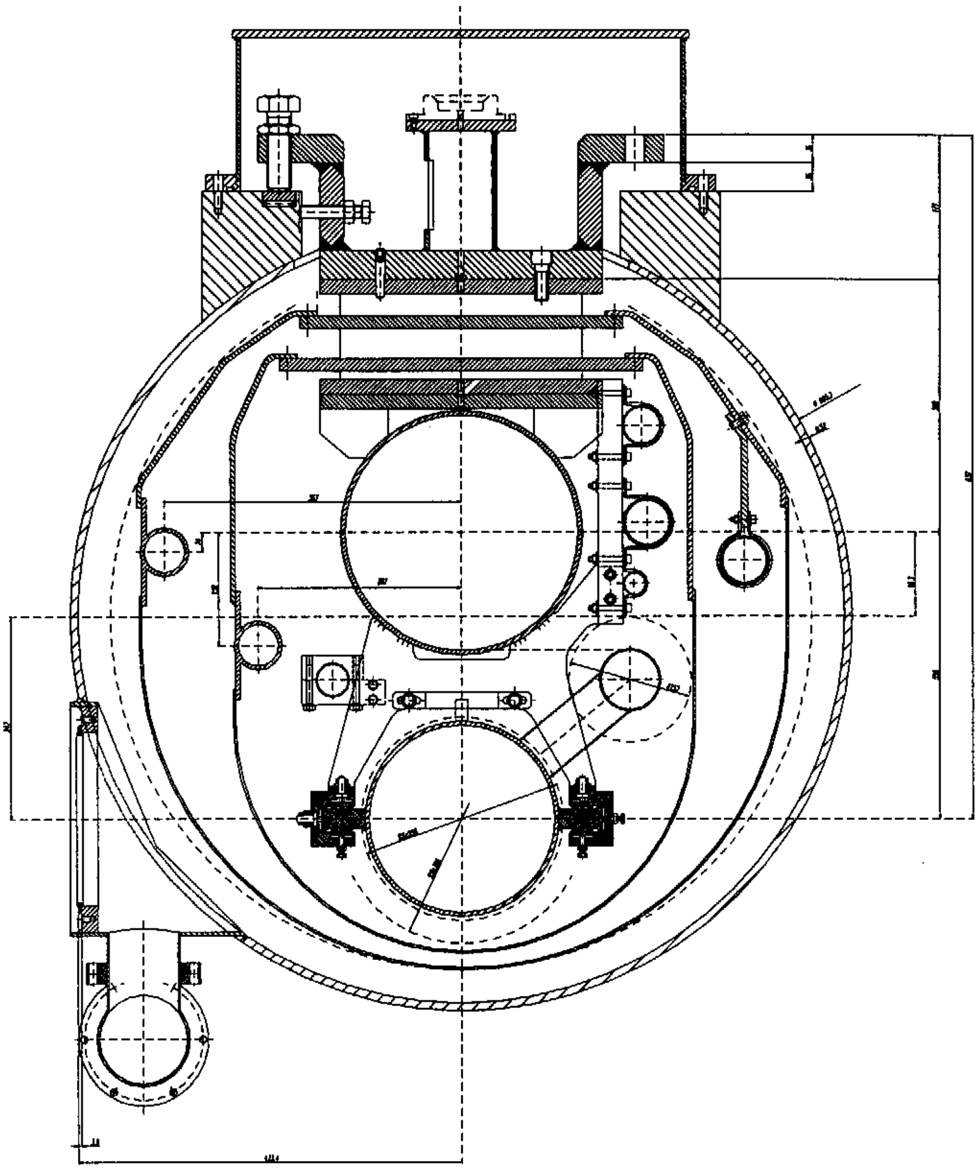

Fig. 5 - Third generation cryomodule cross-section. The vacuum vessel diameter has been reduced and components have been redistributed.

These cryomodule have been fabricated at Zanon with a cost reduction of a factor 2.5 with respect to the first prototype cryostat.Third Generation Cryomodule (modules #4 to #8)

This should be the last step in the development of cryomodule design toward TESLA500. Using experience from previous fabrication and assembling some guidelines have been identified to define actual design. In figure 5 a plot of the new cross section shows main chances.

In order to reduce cost for mass production, the diameter of the vacuum vessel has been reduced to a standard "pipeline " tube. This has involved a redistribution of parts inside the cryostat reducing distance to minimum acceptable. Only HeGRP and cavity have been considered "immobile" due to their structural and physical function.

A wire position monitoring[4] during the cooldown of cryomodule #1 let the online analysis of movement of the cold mass and pointed out the unexpected movement of the end of the Gas Return Pipe, probably due to lateral forces by endcap and feedcap, that changed more then desired the position of the quadrupole.

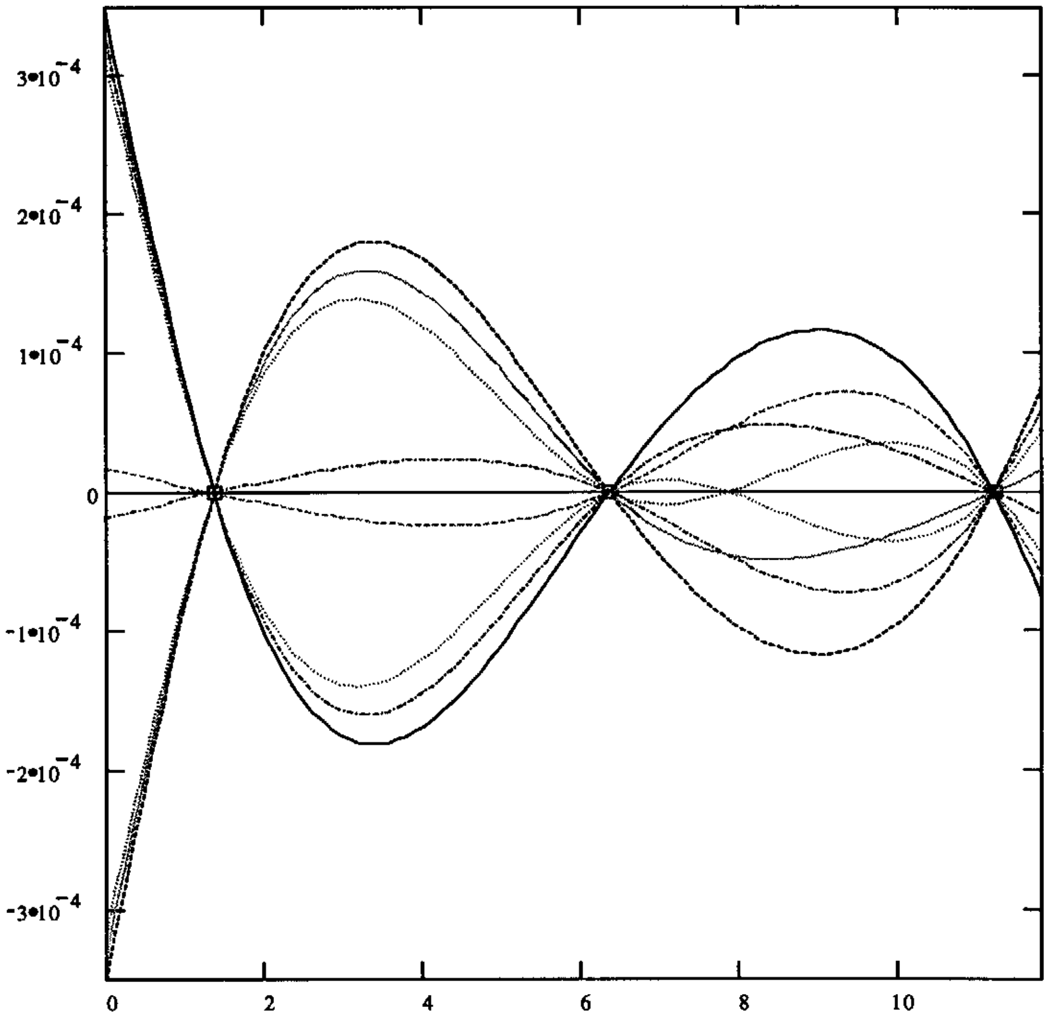

Fig. 6 - Displacement (m) of the HeGRP due to lateral 1000N forces. Curves show different combination of direction. Quadrupole is very closed to post so its movements are reduced to few cents of millimeter.

In order to improve the stiffness of the system in the region of the quadrupole, the lateral posts have been moved to extreme position, compatible with mechanical assembling requirements. This has increase the static deformation of the pipe from 0.2mm to 0.3mm but as remarkably reduced movement of quadrupole under lateral forces as can be see in figure 6.

Another interesting point is the possibility to introduce fixed coupler solution and in the future, as soon as they will be ready, superstructures. This new solution requires the position of active element to be longitudinal free, so cavity and quadrupole have to slide during the cooldown with respect to the supporting HeGRP. To achieve this objective cavity and quadrupole support has been changed as can be see in figure 7. The new proposal introduce a supporting block with a rolling plate that slides over cavity supports. Misalignment between cavity plate and support plate can may produce cavity vertical or lateral movements during the cooldown so tolerances have been imposed to assure that plates supporting cavities to be aligned to bean line. Also friction between cavity reference plate and support is critical so a test bench is running at LASA to check friction efficiency of the rolls in vacuum and at cryogenic temperatures.

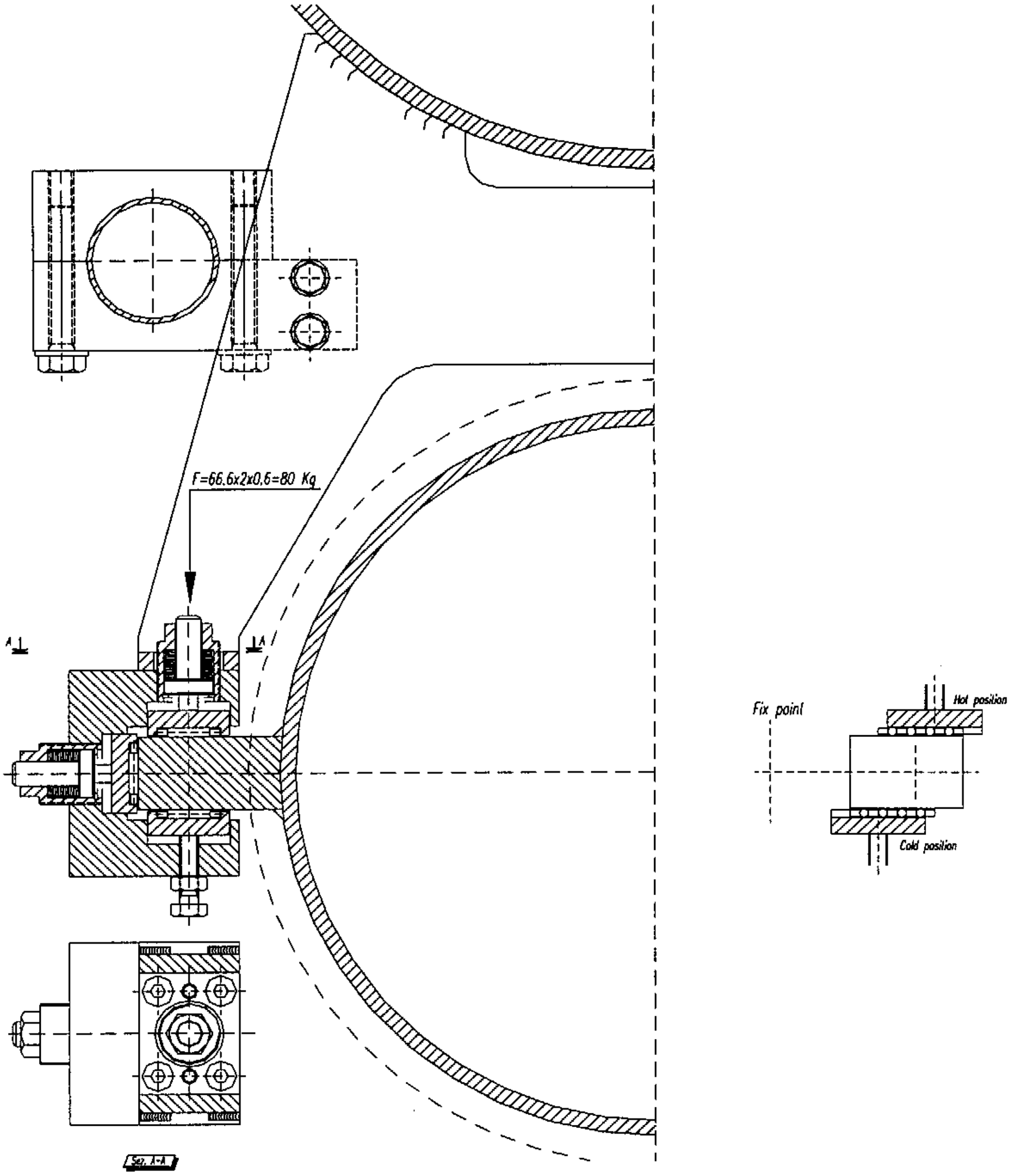

Fig. 7 - The new joint keeps cavity longitudinally free. It lets cavity support run over on auto leveling rolls. This solution doesn't require too high precision in the fabrication of the blocks supporting the cavity

We have changed the shape of coupler cones to a "simpler" one that can be easily machined. Cones are cooled by small copper braids fixed directly on the helium pipes welded to the shield. To respect the new dimension of the vacuum vessel shields shape have been quite changer to respect the 50mm stay clear region from the vacuum vessel. Helium pipes have been moved to let the finger welding during the assembling.

Continuing in the philosophy of decreasing costs and simplifying the design, tolerances have been all verified with requirements to reduced them only to required ones. Where possible standard pipe has been used.

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References

[1] C. Pagani, et al.; CONSTRUCTION, COMMISIONING, AND CRYOGENIC PERFORMANCES OF THE FIRST TESLA TEST FACILITY (TTF) CRYOMODULE, in Proc. Of the 1997 CEC/ICMC, Portland, to be published in Adv. in Cryo. Eng.

[2] D.Barni, C.Pagani, P.Pierini, M.Todero, COOLDOWN SIMULATION FOR TESLA TEST FACILITY CRYOSTAT, in Proc. Of the 1997 CEC/ICMC, Portland, to be published in Adv. in Cryo. Eng.

[3] C.Pagani, D.Barni, M.Bonezzi P.Pierini, J.G. Weisend II, DESIGN OF THE THERMAL SHIELDS FOR THE NEW IMPROVED VERSION OF THE TESLA TEST FACILITY (TTF) CRYOSTAT, in Proc. Of the 1997 CEC/ICMC, Portland, to be published in Adv.in Cryo.Eng..

[4] D.Giove, A.Bosotti, C.Pagani, G.Varisco, A MICROSTRIP BASED POSITION SYSTEM FOR THE ALIGNMENT OF THE TTF CRYOSTAT , in Proc. Of the 1995 Part. Accel. Conf. Dallas, May 1-5 1995, p 2093;