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NOTE

16T DIPOLE DESIGN OPTIONS STRUCTURAL DATA

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Abstract:

This document summarizes the reference material data and criteria to be considered for the structural design & analysis in the exploration of the different design options of the 16T dipole.

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1. INTRODUCTORY CONSIDERATIONS

There is little experience in how to optimize design criteria for high field accelerator magnets made in Nb_3Sn. These concern the ideal pre-stress conditions to apply before and during powering (in 2D as well as in 3D), the treatment of interfaces (free, glued, with or without friction …), the maximum allowed strain and stress on the coil and the criteria to judge about its distribution in the coil cross section. The criteria and data proposed here are derived from the development program carried out in the US National Laboratories and the ongoing work being performed at CERN mostly on the 11T and the MQXF programs. Data have been compiled with the help of Paolo Ferracin.

2. CRITERIA/ASSUMPTIONS

We assume that all materials are limited by the yield strength, or by the material degradation (coil).

Concerning the ferromagnetic material (low carbon steel), a limit of tensile stress of $\sigma_l < 200$ MPa shall be considered at cold. This limit has to be considered as a prudent design threshold: it may change considerably depending on the exact steel composition and on its treatment.

The stress on the coil can vary considerably depending on the coil spot, in particular the interface conditions between coil and surrounding structure. We assume that the "reference coil pre-stress" in the 2D section is the one at the middle of the cable.

Concerning this last point, we set a baseline design such that the coil is loaded until the nominal magnetic field in the aperture of 16T. This will leave the opportunity, in a model magnet, to explore different configurations of pre-stress, including the ones unloading the coil at a lower field than the nominal one (for example setting an unloading target at 15T).

At the stage of exploring and comparing design options, we will consider that the pole tip is glued to the coil. At a later stage a decision about separate or glued coil will have to be taken: an independent coil can possibly allow the exploration of low pre-stress conditions.

The same for friction, which will be neglected at the level of the exploration of design options. At a later stage the use of a friction coefficient of 0.2 for most surfaces may be considered, but its need in a magnet which will certainly perform some "settling quenches" is still controversial.

3. MATERIAL DATA

Table 1: Material Data for the exploration of 16T dipole design options

Material	**Stress limit (MPa)**		**E (GPa)**		**ν**	**α**
	293 K	4.2 K	293 K	4.2 K*	293 K /4.2 K	293 K→4.2 K
Coil	150	200	EX=52 EY=44 GXY=21	EX=52 EY=44 GXY=21	0.3	X=3.1E-3 Y=3.4E-3
Austenitic steel 316LN	350	1050	193	210	0.28	2.8E-3
Al 7075	480	690	70	79	0.3	4.2E-3
Ferromagnetic iron	180	720	213	224	0.28	2.0E-3
Pole (Ti6Al4V)	800	1650	130	130	0.3	1.7E-3

*In accordance to the experience of the LARP program, we use the same coil elastic modulus at warm and at cold. This may evolve when performing the final design if new data will be available.

X cable side direction (radial in costeta) , Y cable face direction (azimutal in costeta).