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THERMAL CONTRACTION STUDY
(February 27, 1990)

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The bellows in the interconnect region will accommodate the contraction of different magnet components over a range of temperatures. The following is a study of the contraction distances for each bellows design. Also included in this study are some components that do not require bellows.

The maximum contraction for any given bellows will occur over the longest possible component length. A survey of magnet combinations indicates that longest length is between a long dipole and a long dipole/correction element in a standard half cell. According to the Site-Specific Conceptual Design report, the long dipole slot length is 15.815 m and the correction element slot length is 0.5 m. The dipoles are anchored in the middle with the correction element simply added to the length of the appropriate dipole. Therefore, the maximum contraction length is calculated 0.5(15.815 m + 15.815 m) + 0.5 m = 16.315 m.

The ambient tunnel temperature is assumed to be 293 K.

The individual component materials and operating temperatures will be given along with their thermal coefficients of expansion in the following paragraphs.

Beam Tube Contraction

Temperature Range : 4 - 293 K

Material : Nitronic 40

Coefficient of Expansion : 295E-5

295E-5 x 16.315 m = 0.04815 (1.89")

Cold Mass Contraction

Temperature Range : 4 - 293 K

Material : 304 Stainless Steel

Coefficient of Expansion : 296E-5

296E-5 x 16.315 m = 0.04829 m (1.90")

Single Phase Return Contraction

Temperature Range : 4 - 293 K

Material : 316L Stainless Steel

Coefficient of Expansion : 297E-5

297E-5 x 16.315 m = 0.04846 m (1.91")

4K Gas Return Contraction

Temperature Range : 4 - 293 K

Material : 316L Stainless Steel

Coefficient of Expansion : 297E-5

297E-5 x 16.315 m = 0.04846 m (1.91")

20K Shield Contraction

Temperature Range : 20 - 293 K

Material : 6063 Aluminum

Coefficient of Expansion : 415E-5

415E-5 x 16.315 m = 0.0677 m (2.67")

80K Shield Contraction

Temperature Range : 80 - 293 K

Material : 6063 Aluminum

Coefficient of Expansion : 391E-5

391E-5 x 16.315 m = 0.06739 m (2.51")

OFHC Copper Bus Bar Contraction

Temperature Range : 4 - 293 K

Material : OFHC Copper

Coefficient of Expansion : 325E-5

325E-5 x 16.315 m = 0.05302 m (2.09")

G-10 Fiberglass Pultrusion Contraction

Temperature Range : 4 - 293 K

Material : G-10 Fiberglass

Coefficient of Expansion : 706E-5 (Normal Direction)

Coefficient of Expansion : 241E-5 (Warp Direction)

706E-5 x 16.315 m = 0.11518 m (4.53") Normal Direction

241E-5 x 16.315 m = 0.03932 m (1.55") Warp Direction

Vacuum Vessel Contraction

Temperature Range : 283 - 303 K (Assumed)

Material : Steel

Coefficient of Expansion : 2.4E-4

2.4E-4x 16.315 m = 0.00392 m (0.15")

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THERMAL CONTRACTION STUDY UPDATE
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THERMAL CONTRTACTION STUDY UPDATE
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The Thermal Contraction Study dated February 27, 1990 assumed an ambient tunnel (assembly location) temperature of 293 K. A pre-operating temperature range of 253 - 310 K has been reported in the Prime Item Development Specification. The following is an updated version of the study assuming a high temperature of 310 K.

Beam Tube Contraction

Temperature Range : 4 - 310 K

Material : Nitronic 40

Coefficient of Expansion : 324E-5

324E-5 x 16.315 m = 0.05284 (2.08")

Cold Mass Contraction

Temperature Range : 4 - 310 K

Material : 304 Stainless Steel

Coefficient of Expansion : 324E-5

324E-5 x 16.315 m = 0.05284 m (2.08")

Single Phase Return Contraction

Temperature Range : 4 - 310 K

Material : 316L Stainless Steel

Coefficient of Expansion : 324E-5

324E-5 x 16.315 m = 0.05284 m (2.08")

4K Gas Return Contraction

Temperature Range : 4 - 310 K

Material : 316L Stainless Steel

Coefficient of Expansion : 324E-5

324E-5 x 16.315 m =0.05284 m (2.08")

20K Shield Contraction

Temperature Range : 20 - 310 K

Material : 6063 Aluminum

Coefficient of Expansion : 454E-5

454E-5 x 16.315 m = 0.07409 m (2.92")

80K Shield Contraction

Temperature Range : 80 - 310 K

Material : 6063 Aluminum

Coefficient of Expansion : 430E-5

430E-5 x 16.315 m = 0.07017 m (2.76")

OFHC Copper Bus Bar Contraction

Temperature Range : 4 - 310 K

Material : OFHC Copper

Coefficient of Expansion : 355E-5

355E-5 x 16.315 m = 0.05793 m (2.28")

Vacuum Vessel Contraction

Temperature Range : 283 - 310 K

Material : Steel

Coefficient of Expansion : 3.24E-4

3.24E-4 x 16.315 m = 0.00529 m (.21")