SSC-N-136

BELLOWS LENGTH

BY

M. TIGNER

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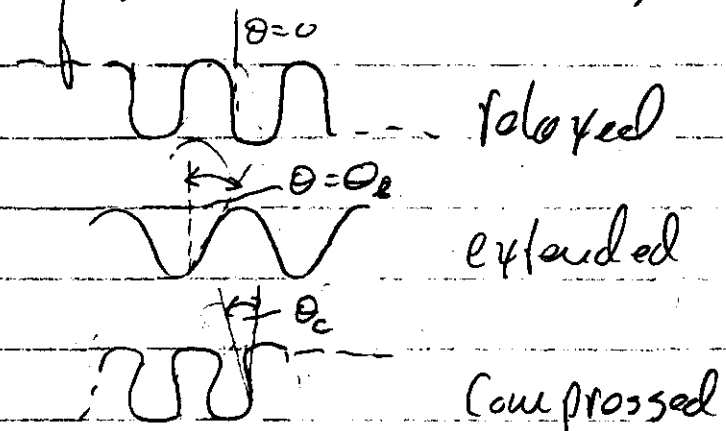
To: Alex
From: Mary 2/19/86
Re: Bellows length

Abstract

After going over it again from scratch I conclude that the length of simple bellows, of the style described in SSC-SR-1017, required will be approximately the 1200 meter posited in that report.

Computation of Stroke to Length Ratio

Examining bellows catalogs (eg: Metal bellows Cat. No. 1500-83) it appears that the extension limit for a given bellows is determined by a maximum angle through which the long side wall of the convolution moves during flexure



$\theta_c \simeq 1.5\,\theta_e$

Thus if we are given θ_c for a bellows, the

full allowed stroke corresponds to $1.66\,\theta_c = \theta_{tot}$.

In the PEP bellows shield we have an example of a narrow span bellows for which specifications are available (PEP Dwg. DD-202-208-02-R

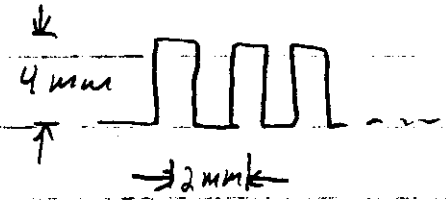
Total compression for 2.75" length and 30 convolutions is specified to be 0.56" for 50 cycle life. Thus

$$\theta_c \simeq \frac{0.56}{30}\left[\begin{matrix}\text{Comp. per}\\ \text{convolution}\end{matrix}\right] \times \frac{1}{2}\left[\begin{matrix}\text{2 sides per}\\ \text{convolution}\end{matrix}\right] \times \frac{1}{0.2}\left[\text{span}\right]$$

$$= 0.047 \text{ radian}$$

$$\therefore\ \theta_{tot} \simeq 0.077.$$

The "Simple Bellows" described in JSC-SR-1017 have the dimensions



Thus the ratio of allowed stroke to length is

$$\frac{2 \times 4\text{mm} \times .077}{2} = \underline{\underline{0.31}}$$

Computation of Thermal Contraction

From the attached curve of α vs T we see that over the range of interest $\alpha \simeq 13 \times 10^{-6}$ for "typical" stainless steels - the beam tube material. (per K)

As the cold length of the SSC ~ 76 km, the total motion on cool down is

$$\Delta L \sim 76 \times 10^3 \times 13 \times 10^{-6} \times 300^\circ K \simeq 296 \text{ meter}$$

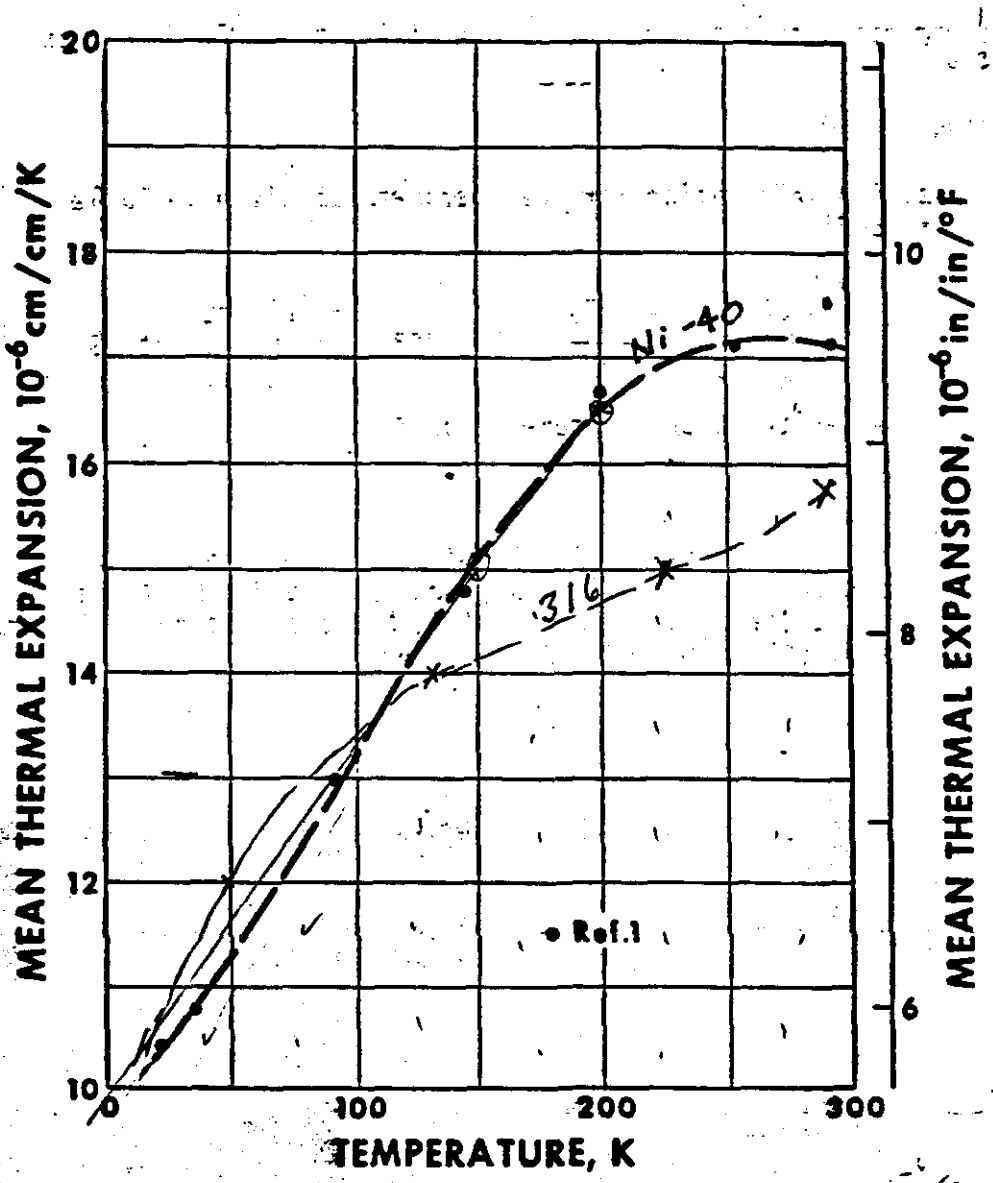
Putting this together with the allowed stroke to length ratio for the bellows that must take up the contraction we have

$$L_{Bellows} \simeq \frac{296}{.31} \simeq 956 \text{ Meter}$$

STRUCTURAL MATERIALS FOR SUPERCONDUCTING MAGNETS

MATERIAL	PROPERTY
21Cr-6Ni-9Mn STAINLESS STEEL (ANNEALED)	MEAN THERMAL EXPANSION, INTERIM

$\int_{T_i}^{T} \alpha(T)\,dT$



for 316

Figure 1. The data shown were used to compute the interim curve of mean thermal expansion for 21Cr-6Ni-9Mn stainless steel.