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TECHNICAL NOTE

MICE Spectrometer Solenoid: Radiation Heat Loads

1. Introduction

A systematic review of the dominant heat sources is made to determine if the baseline thermal load estimates provided by the vendor in the "Final Engineering Design" (FED) are appropriate. Furthermore, an effort is made to determine the range of uncertainty in the different heat load estimates, so as to provide guidance for the excess cooling power that should be provided.

2. Radiation from vacuum vessel to shield

Table I. Key dimensions of the vacuum vessel and shield.

	Inner section		**Outer section**			
	ID	**OD**	**ID**	**OD**	**Length**	**Material**
Vacuum vessel:	404	407.175	1388.125	1404	2923	304SS
LN shield:	458.0255	462.788	1138.2248	1143	2618.99	6061-T6

The heat load on the shield was estimated to be 10.75W, corresponding to an effective heat flux of 0.72W/m^2, and a thermal conductivity of 8.2e^{-5} W/mK. This value is in fair agreement with experimental data taken by Shu et al. [1] (see Fig. 1), as well as experimental data on thermal conductivity compiled by Ekin [2].

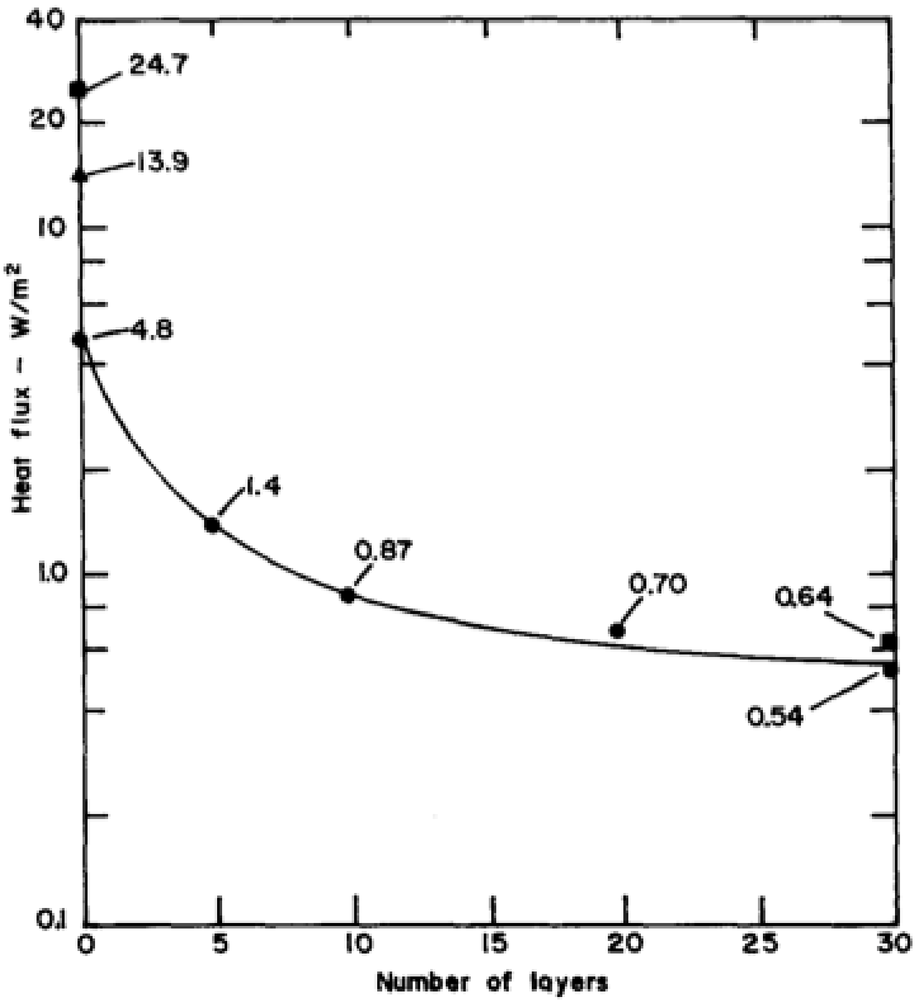

Figure 3 Heat flux as a function of the number of MLI layers and surface preparation at a vacuum of 2 × 10^{-5} Torr. Data on polished and painted copper taken from Reference 1. ■, MLI on copper painted black; ▲, polished copper; ●, MLI on taped copper

Figure 1. Data from Shu et al [1].

3. Radiation from vacuum vessel to shield

The radiation load from the shield to the ~4.2K cold mass was estimated to be 0.0314 W in the CDR; the assumptions were 15 layers of superinsulation and a heat flux of 0.003 W/m^2, or an effective thermal conductivity of 1.08W/mK. A series of experiments on thermal insulation systems at CERN [3] yielded effective heat flux values of ~0.05-0.07 W/m^2, more than an order of magnitude larger than anticipated in the CDR. Using the surface areas from the CDR, the resulting 4.2K heat load emanating from radiation/conductivity through the superinsulation would be ~0.5W. The surface area used in the CDR was 10.14 m^2; a review of the combined surface areas suggests this value should be ~16.5 m^2, which would increase the effective 4.2K "radiation" load to ~0.85W.

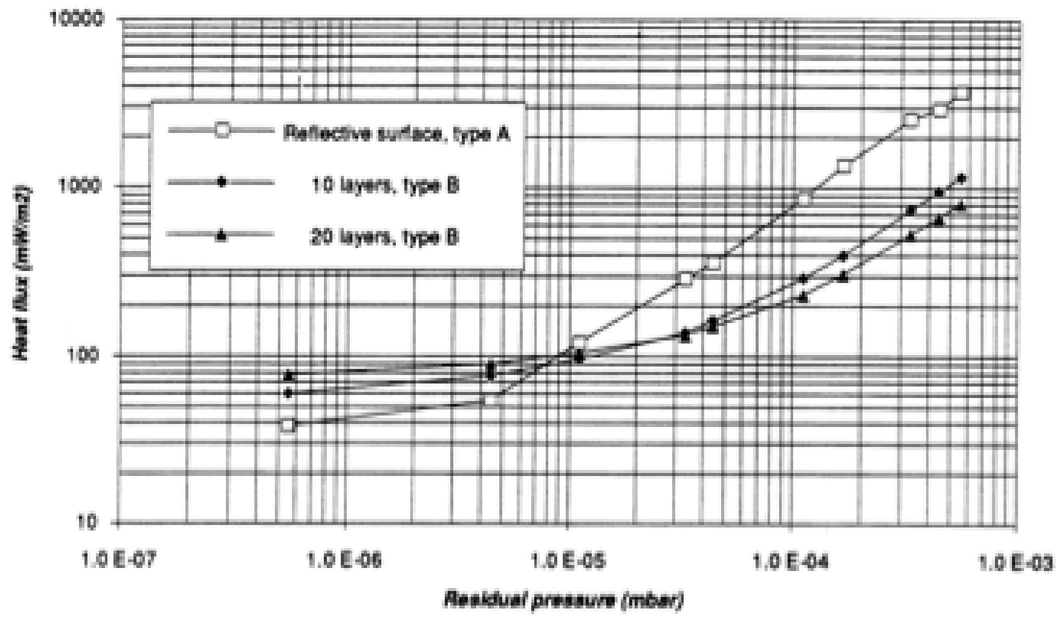

Figure 2 Performance of type B multilayer insulation, compared with reflective surface A

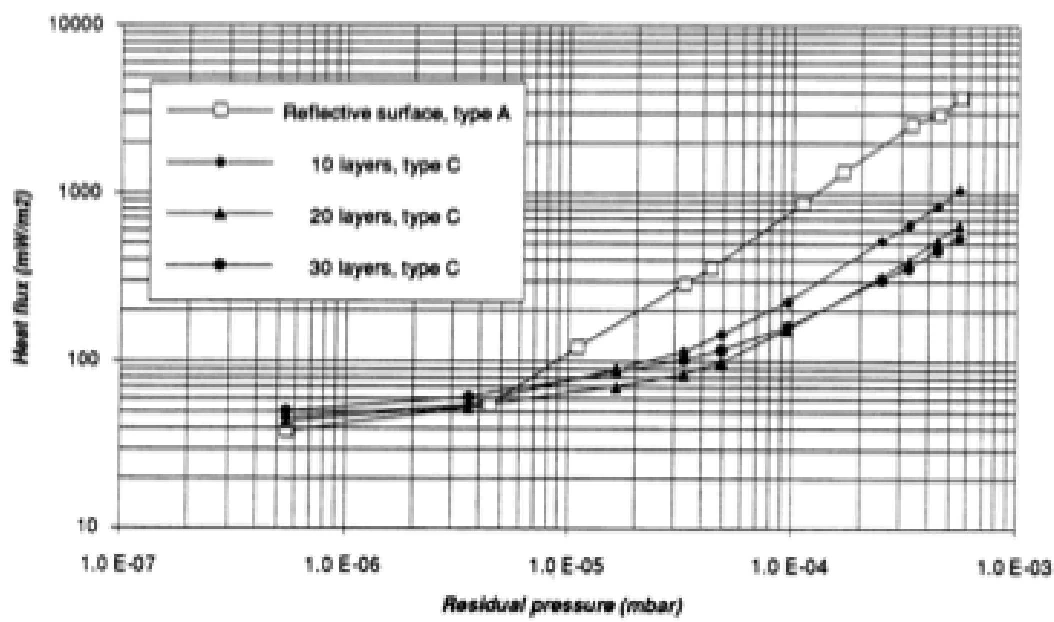

Figure 3 Performance of type C multilayer insulation, compared with reflective surface A

Figure 2. Measurement from Lebrun et al on thermal insulation system performance from 80 to 4.2K. [3]

4. References

[1] Q. S. Shu, R. W. Fest, and H. L. Hart, "Heat Flux from 277 to 77 K through a few layers of multilayer insulation".

[2] J. Ekin, "Experimental Techniques for Low Temperature Measurements"

[3] Phillippe Lebrun, Luigi Muzzone, Vinicio Sergo, and Bruno Vallierme, "Investigation and Qualification of Thermal Insulation Systems Between 80K and 4.2K"