EC TUBE FITS

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A handwritten signature in cursive script, reading "Kurt J. Kempf", is written over a horizontal line. The signature is fluid and stylized, with the first and last names being more prominent.

INTRODUCTION

In the design of the EC, the beam tube, through which the beam line travels, can be found in the IH tube which is centrally located in the IH module. However, also between the beam tube and the IH tube lie both the vacuum and inner tubes of the vacuum and inner vessels. It is the vacuum between these vessels which provides insulation between the ambient beam tube and liquid argon in the cryostat. See Fig. 1. While the vacuum tube is supported along its length with the inner tube as best as possible, the inner tube will only be supported at the ends. The beam tube will also be end-supported, but it will be allowed to rest directly on the inner surface of the vacuum tube. It is required that the beam tube be able to slide in and out of the vacuum tube with relative ease in order that the EC's can be moved away from the CC when necessary (repair work, etc.). Although the frequency of such a move is not known, it is hoped to be low, and it would therefore be desirable, for cost reasons, to be able to use stock tubing for the vacuum and beam tubes instead of using specially machined tubing.

Fig. 1

TUBE QUALITIES

Once positioned inside of the IH tube, the inner tube will remain there, so ease of movement is not a primary factor, and a small clearance is acceptable. The clearance between the inner tube and the vacuum tube is large enough to provide room for thermal contraction movements and insulation. Stock tubing, which may be neither perfectly straight nor round, can be used for the inner and vacuum tubes because the clearance is large. However, the beam tube must be able to move within the vacuum tube with relative ease, and here, the calculated clearance is small, in comparison, at 0.075" (on the diameter). Considering the weight of the

trial beam tube used, along with a coefficient of friction of 0.1 to 0.3, the calculated force needed to move the beam tube through the vacuum tube is between 0.53 and 1.6 lbs. However, this is only true for ideal tubes -- those which are both straight and round. The actual clearance can be greatly reduced by any imperfections in the tubing, but any deflection of the vacuum tube due to its own weight and that of the inner tube when both are supported at the ends is a maximum of $3.12e-6$ " and has virtually no effect on the clearance of the tubes. See Appendix.

TUBE TESTING

Two sample stock tubes, one with an O.D. of 2" and a thickness of 0.028" and the other with an O.D. of 2 1/8" and a thickness of 0.025", were used to get an idea of what magnitude of force was necessary to slide one tube through the other with the provided 0.075" clearance. The larger tube was clamped down and the smaller one pulled through it for a distance of about 30", the force required to do so measured with a spring scale. This force varied widely, not only during the course of the 30" pull, but also when the inner tube was positioned at different angles within the outer tube (0° , 90° , 180° , 270°). Values for the measured force varied from 9 to 29 lbs, much higher than those calculated for ideal tubes. See Table 1.

		FORCE (lbs)			
ANGLE		region 1	region 2	region 3	region 4
	0	15	19	13	11
	90	25	29	23	15
	180	23	25	15	13
	270	19	21	11	9

Table 1

Since such high values demonstrate that the stock tubes are not ideal in either straightness, roundness, or both, the question of whether or not they are good enough for their intended purpose arises. There were scratches on the outer surface of the inner tube showing places where the clearance between the tubes was very small, and a great force was required to move the tubes through these areas. These scratches could cause the tubes to gall and perhaps eventually lock-up over a period of time.

CONCLUSION

One alternative to provide for ease of movement is to leave the tubes as they are, with the given dimensions, and lubricate them, providing more ease of movement. Another alternative would be to increase the clearance between the tubes. Doing so would allow more freedom of movement between the vacuum and beam tubes, and although the tubes may not be either perfectly straight or round, they would still be able to move with relative ease, and thus, stock tubes could be used and costs kept down.

APPENDIX

$$\Sigma F_x = 0 = F - f, F = f$$

$$\Sigma F_y = 0 = N - w, N = w$$

$$w = 5.33 \text{ lbs}$$

$$\mu = 0.1 \text{ or } 0.3$$

$$f = \mu N$$

$$F = \mu w$$

$$F = (0.1) * (5.33 \text{ lbs}) = 0.53 \text{ lbs}$$

or

$$F = (0.3) * (5.33 \text{ lbs}) = 1.6 \text{ lbs}$$

simply supported beam

length: 68.466"

weight of outer and vacuum tubes: 6.264 lbs

distributed load= $F/l=(6.264 \text{ lbs})/(68.466")=0.0915 \text{ lbs/in}$

Maximum deflection: $3.12e-6 \text{ in}$