Stress Analysis Of SVT Beryllium Carrier Assemblies With Different Orientations Around The Beam Pipe

1. Introduction

There are totally 36 beryllium carrier assemblies in the SVT assembly. These carriers are mounted around the beam pipe and form three concentric super-layers (inner, middle and outer layers) with different orientations. (See Fig. 1) The stresses in the carrier assembly would vary depending on where it is mounted. The purpose of this report is to evaluate the maximum stresses, deformations and reaction forces in the carrier assembly due to this factor.

The following analysis focused on the weight effect. However, the hydraulic forces applied on the hydraulic connectors were also considered. The whole assembly was supported at the four standoff locations on the detector carrier. These standoffs will be mounted on the end rings in the actual integration.

2. Model description

The carrier assembly included a detector carrier assembly and two electronics carrier assemblies, which have the following components:

(1) Detector carrier assembly:

Be Detector carrier (1)	22.06" x 2.480" x .070"
Rohacell (2)	17.362" x .110" x .015"
G10 Interface board (2)	2.480" x 1.750" x .060"
Silicon detector (7)	2.480" x 2.480" x .012"

(2) G10 Angle bracket (2) — 22.06" x .110" x .110" (22.5°, 30° and 45° angle)

(3) Electronics carrier assembly

Be Electronics carrier (2)	22.06" x .787" x .070"
Water channel (2)	21.81" x .612" x .030"
Hybrid (14):	2.480" x .677" x .060"
- Beryllia	2.480" x .677" x .040"
- Silicon	2.480" x .677" x .020"
Kapton cable (2)	2.480" x .677" x .020"

The whole structure was held at four "standoffs" locations on the detector carrier. The loading to the structure was basically its own weight plus the weight of water, cables, hybrids, silicon wafers and hydraulic forces applied at the connectors. The finite-element model with the designated coordinate system is shown in Fig. 2. To simulate the different orientations of the carrier assemblies, the direction of the gravity force was rotated with respect to each carrier assembly in the computer analyses.

3. Assumptions

Assumed that

1. Material properties were shown in Table 1.
2. The water density was .036 lbs/in3.
3. The weight of cables at each end of the electronics carrier was .055 lbs.
4. The interior pressure of the electronics carrier at the inlet was -2 psig and was -4 psig at the outlet.
5. The standoffs were assumed fixed constraints.
6. The distance between the standoffs on each end was 0.48î.
7. The carriers were flat initially.
8. The stiffness of kapton, beryllia, and interface board were ignored in the present analysis for the conservative results.

4. Derivation of Parameters

The hydraulic forces, applied on the electronics carrier were derived as follows:

$$F = (P + \rho Q(Q/A)/g)A$$

where F = the flow force, ρ = water density, Q = rated flow rate, A = fitting opening area, and g = gravity constant. Since Q = .55 in^3/sec (see Section X), A = π $(.17)^2/4$ = .0227 in^2, ρ = .036 lbm/in^3, and g = 386 in/s^2,

At the inlet: $F1 = (-2 + .036 \times .55^2/.0227/386) \times .0227 = -.045$ lbf
At the outlet: $F2 = (-4 + .036 \times .55^2/.0227/386) \times .0227 = -.091$ lbf

5. Analysis Results

Finite element analyses, using ANSYS, were performed to analyze the structure. The maximum stresses in the carrier assemblies and the maximum deformations of the detectors on the inner, middle and outer layers are shown in Fig. 3, Fig. 4 and Fig. 5 respectively. The maximum reaction forces at the standoff location are shown in Table 2, which occurred in the outer layer at 180° position.

6. Conclusions

From the above results, we found that

1. The maximum stress (156 psi) was very low compared with the yielding stress of the material (~ 40 ksi) and the maximum deformation of the detectors (0.4 mils) was small compared to the SVT Alignment Requirements. (~ 2 mils).

2. When the carrier assembly was at the 180° position, the stresses and the reaction forces on the carrier assembly were the largest compared with those of other positions, since that the loads applied on the carrier are the largest at this position.

Table 1 : Mechanical properties of materials

Material	Elastic modulus	density
Beryllium	42 x 106 psi	.067 lbs/in^3
Aluminum	10 x 106 psi	.098 lbs/in^3
Silicon	15.5 x 106 psi	.085 lbs/in^3
S. Steel	28 x 106 psi	.290 lbs/in^3
G/E Comp.	20 x 106 psi	.061 lbs/in^3
Rohacell (Gr.31)	5120 psi	.001 ibs/in^3
G10	2.2 x 106 psi	.067 lbs/in^3
Lexan	3.9 x 105 psi	.044 lbs/in^3
Kapton	---	.051 lbs/in^3
Beryllia	---	.103 lbs/in^3

Table 2: The maximum reaction forces at the standoff

Fx (lbf)	Fy (lbf)	Fz (lbf)	Mx (in-lbf)	My (in-lbf)	Mz (in-lbf)
-.215	-.532	-.251	.015	-.146	0

Fig. 1: SVT assembly with three super-layers of carrier assemblies

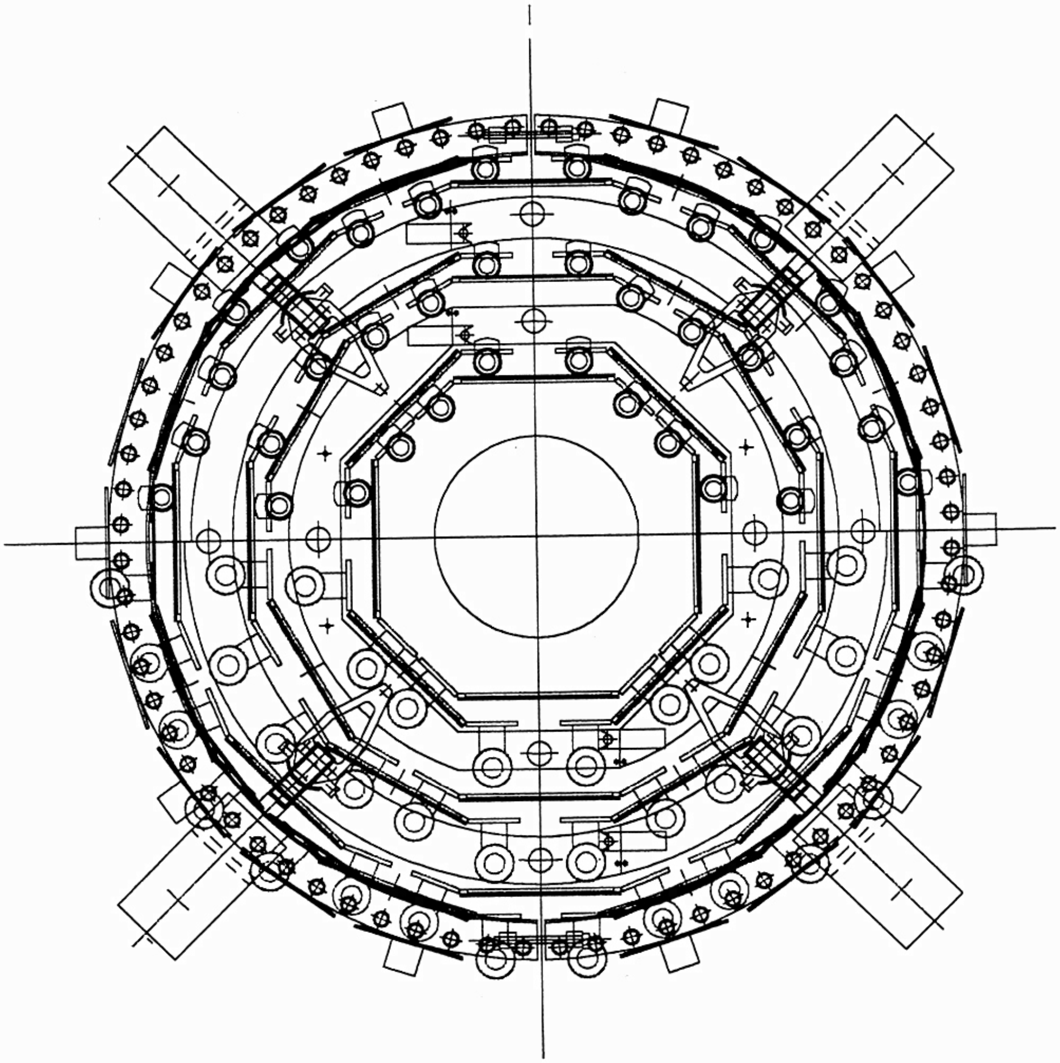


Fig.2: The model of the carrier assembly with the designated coordinate system

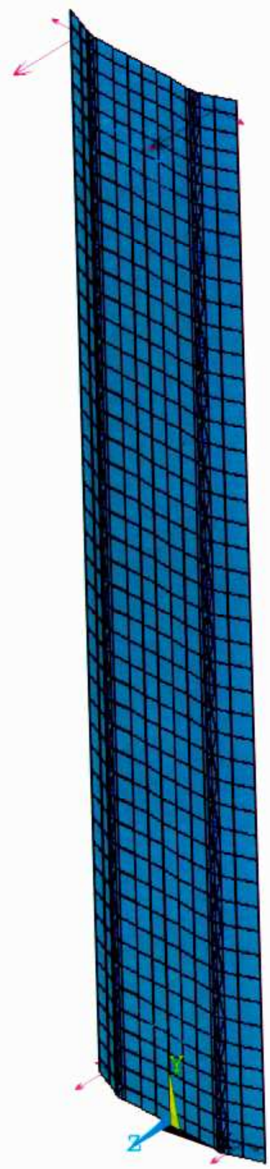
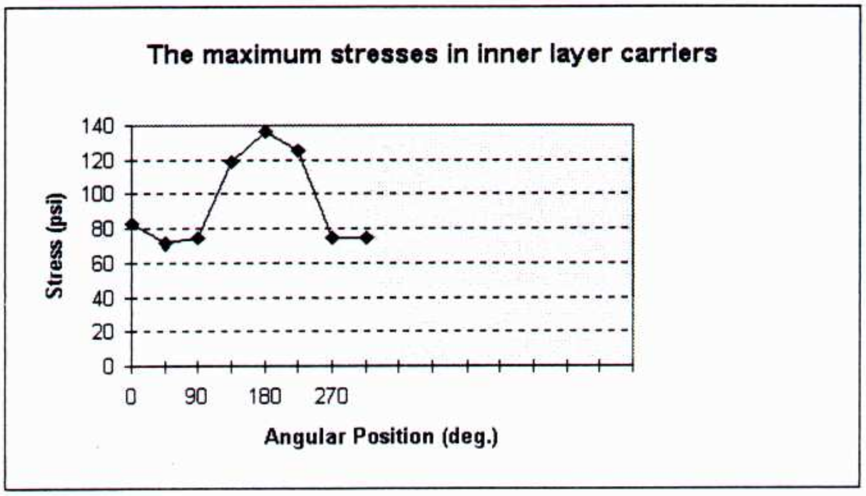


Fig. 3: The stress analysis results of the carrier assemblies in the inner layers



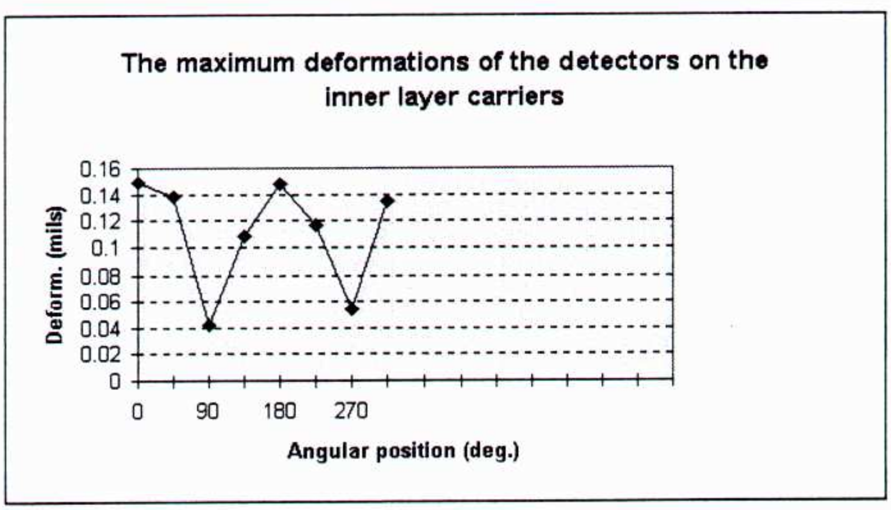
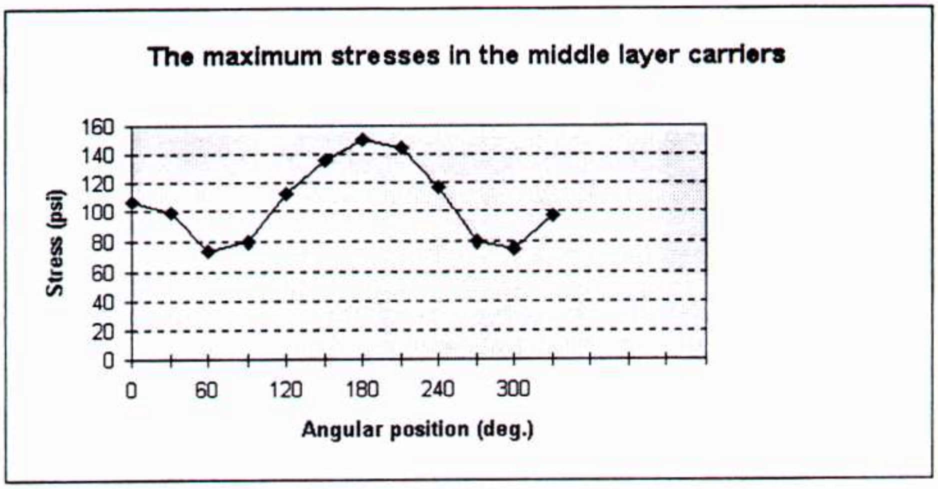


Fig. 4: The stress analysis results of the carrier assemblies in the middle layers



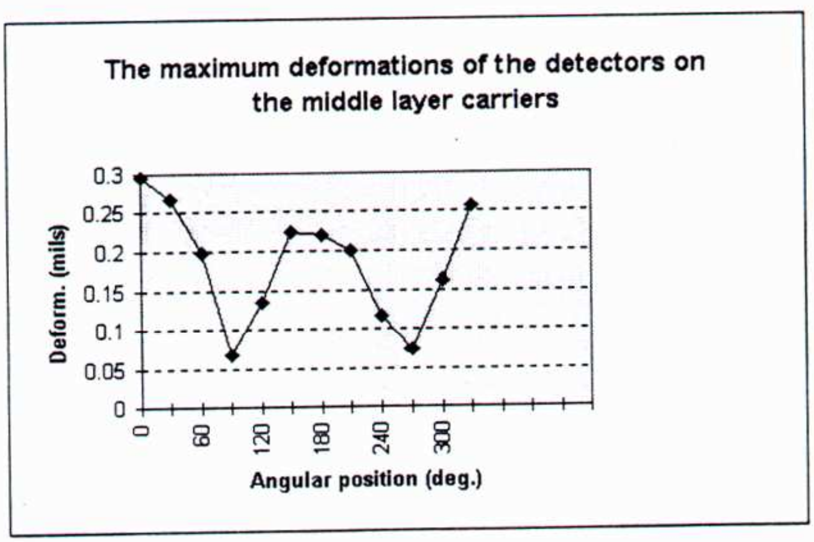


Fig. 5: The stress analysis results of the carrier assemblies in the outer layers