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TO:
Jan Boissevain
PHENIX, P-25

Dear Jan,

As you requested, I investigated what effect adding a layer of adhesive between the silicon and the foam would have. The following memo details the results.

The effect is dramatic. With addition of a bond layer in between the silicon and foam, stresses in the foam are reduced to an acceptable level. Stresses in the silicon are reduced only slightly, but the silicon has a considerably higher allowable stress.

If the assumption is made that the change in relative humidity, Δ%RH, is 30%, compared with the previously used value of 50%, the stress in the silicon can be kept to an acceptable value. I could possibly acknowledge that controlling the humidity to within a 30% band would be possible if considerable care is taken, and considering that the parylene coating would dampen any sudden but short-term humidity excursions occurring from unexpected shut-downs, removal of access openings, etc.

The *Araldite* material is probably preferable to the RTV material even though the RTV results in a somewhat smaller stress. This is because the *Araldite* has a considerably higher allowable stress, while the RTV material's tensile stress limit is exceeded.

Reducing the adhesive thickness from 0.005 in to 0.0025 in results in only a very modest increase in stress. This implies that the adhesive thickness could probably be even thinner. I would have to spend more time and make a more detailed model to find out just how thin we could go.

It would still be very useful if a material with less hydroscopic expansion could be found. If this material could be substituted for the ROHACELL, the original concept and dimensions for the C-module could be used with less concern. Barry Berenberg is our composites expert. Perhaps if we could have a conference with him, he might be able to check his literature for such a material

If I can be of further help please let me know.

Thank you.

Sincerely,

Chris Potter
ESA-DE

CC:

W. Gregory	H821
B. Jacak	H846
J. Kapustinsky	H846
R. Martin	H821

SUMMARY OF FEA RUNS TO DETERMINE EFFECT OF ADHESIVE INTERFACE

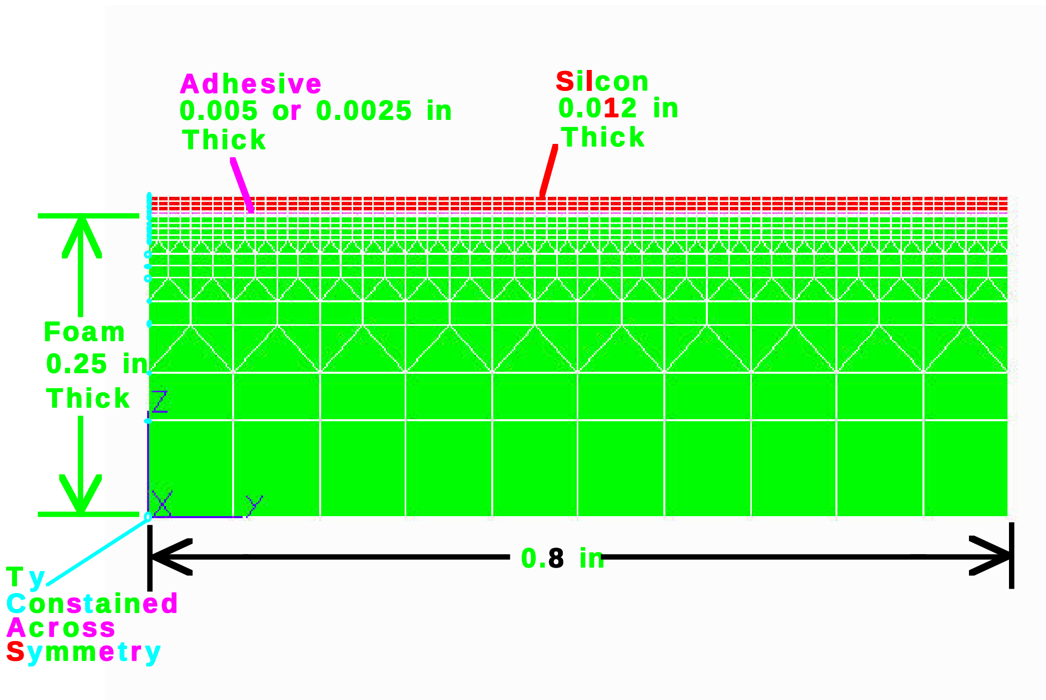
run	**DESCRIPTION**	Δ % RH	Max Stress, psi	Silicon Stress, psi Sa = 5000	Foam Stress, psi Sa = 325
MVDG	Model in previous memo 6mm thick X 74 mm long Rigid bond.	50%	6,941	6,689	
AD1	Control Case Rigid Bond	50%	6746	6,477	
AD2	Araldite (Sa = 4800 psi) 0.005 in thick	50%	6,763	6,319	129
AD3	RTV (Sa = 510 psi) 0.005 in thick	50%	4,797	4,797	98
AD4	Araldite 0.005 in thick Reduced Δ%RH	30%	4,058	3,792	77
AD5	Araldite 0.0025 in thick Reduced Thickness	30%	4,056	3,839	79

FEA MODEL:

Several finite-element stress runs were made. English units were used as most of the properties were available in these units, and to simplify conversions. A dimension of 0.25 inch (6.35 mm) approximated the 6.0 mm thick foam section. The foam was modeled as a symmetric half-section, the half section being 0.8 inches (20.32 mm) long, for an entire length of 1.6 inches. This length appeared to be sufficient so that stresses in the center of the foam beam were one-dimensional, that is, varied only with the depth of the beam.

A 0.012 inch (0.3048 mm or approximately 300 μ) thick silicon panel was placed on top of the foam. The adhesive thickness was 0.005 inches (0.127 mm), except in the rigid bond case, and case AD5, using 0.0025 in.

Typically the maximum stress occurs towards the outer end of the adhesive-silicon interface. This stress was typically not more than 7% higher than the stress at the center of the beam. For the RTV case, the maximum stress was at the center. The stress at the center is used for comparison purposes as it is believed to be largely one-dimensional, that is, not influenced by length-wise effects.

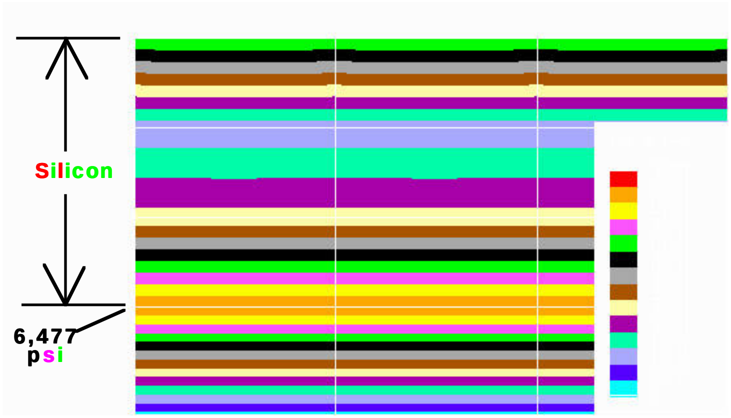


PROPERTIES USED:

MATERIAL	E (psi)	ρ (lbs / in^3)	Tensile Strength (psi)	Hydroscopic α (ΔL / L) / (Δ%RH)
ROHACELL	15,435	0.00271	235	1.789×10^{-4}
SILICON	10,897,000	0.0842	~5000	-0-
ARALDITE	65,174	0.0379	4800	-0-
RTV 11	65.7	0.043	510	-0-

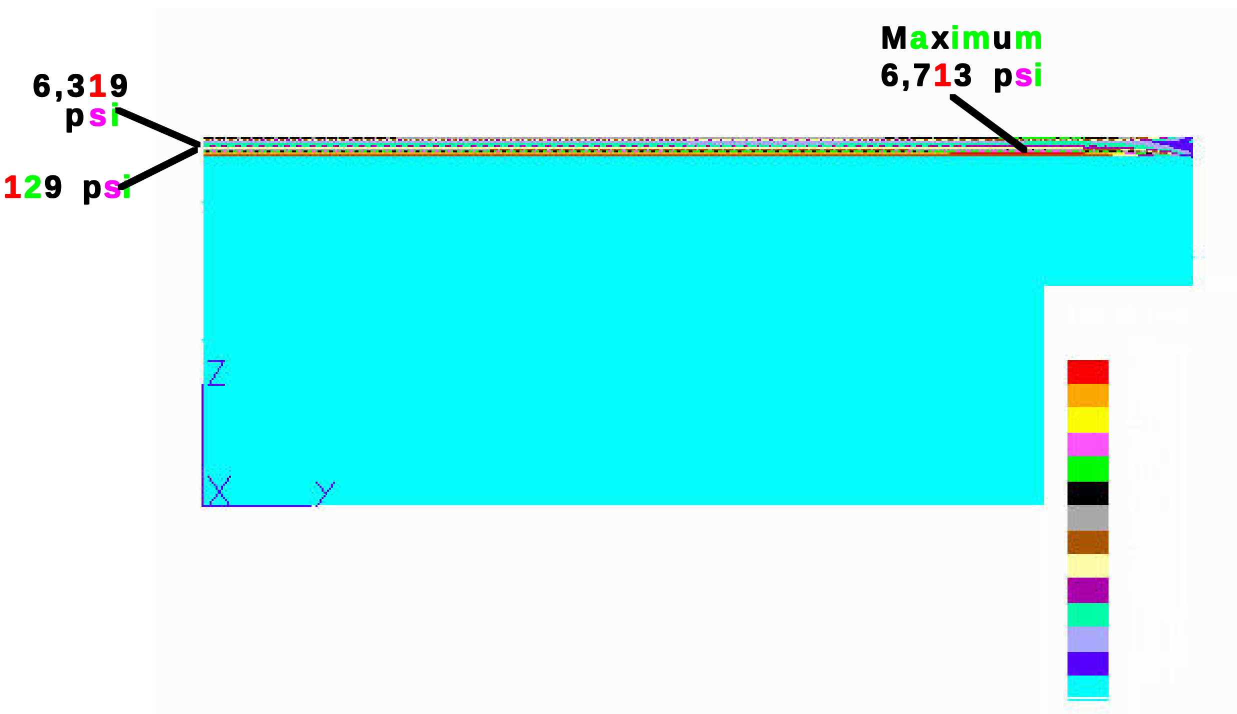
1. Run AD1. Control Case

A control run was made with a rigid bond between the silicone and foam. Stress at the interface center is 6,477 psi, 96.8% (-3.2%) of the 6,689 psi value obtained in the model in the previous memo that I sent to you. The model used here uses a finer mesh. The relatively small difference in values indicates that the mesh being used is sufficiently fine so that making it still smaller will not result in significant gains in accuracy, and that the current model is valid.



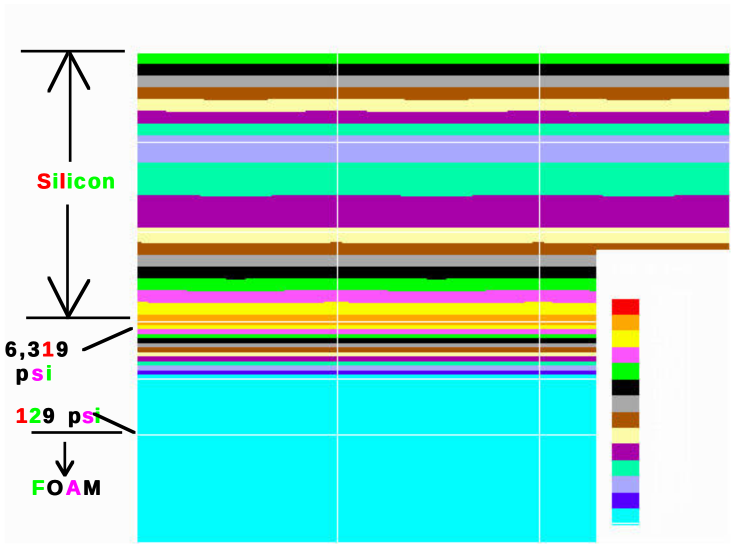
2. Run AD2. Araldite Adhesive

The following shows the complete view of run AD2. The maximum stress occurs towards the outer end of the beam and is 6,763 psi. The stresses at the center of the beam are used for comparison rather than this maximum stress. This is because the stresses at the center are regarded as being more one-dimensional, varying only with beam depth.



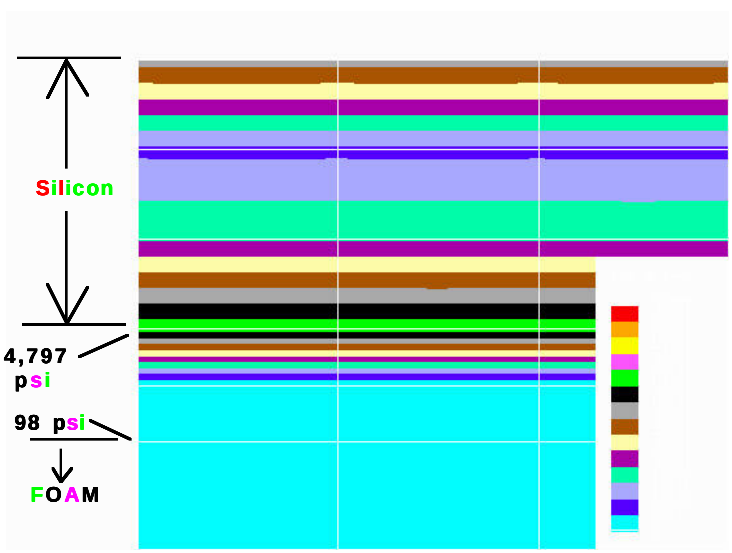
Run AD2. ARALDITE ADHESIVE

This run used the *Araldite* material as an adhesive with a spacing of 0.005 in and a Δ%RH of 50%. The foam stress went dramatically down, from 6,477 psi to 129 psi. The stress in the silicon dropped only slightly, from 6,477 psi to 6,319 psi. Because the tensile stress of the Araldite is 4,800 psi, and that of the the silicone about 5,000 psi; a solution is being approached, but has not been obtained.



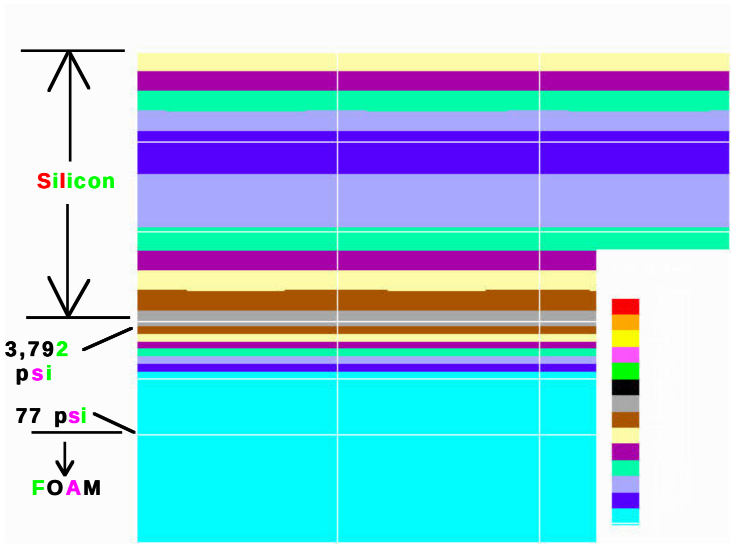
Run AD3. RTV Adhesive

This run substituted RTV adhesive for the *Araldite* material. The stresses drop considerably from the *Araldite*, with the silicon stress going from 6,319 psi to 4,797 psi; and the foam stress going from 129 to 98 psi, both a reduction to 76% of the previous values. (This is still considerable less than in direct proportion to the ratio of the materials' modulus of elasticity.) However, the yield stress of RTV is only 510 psi, making it dubious for use at the silicon-adhesive interface.



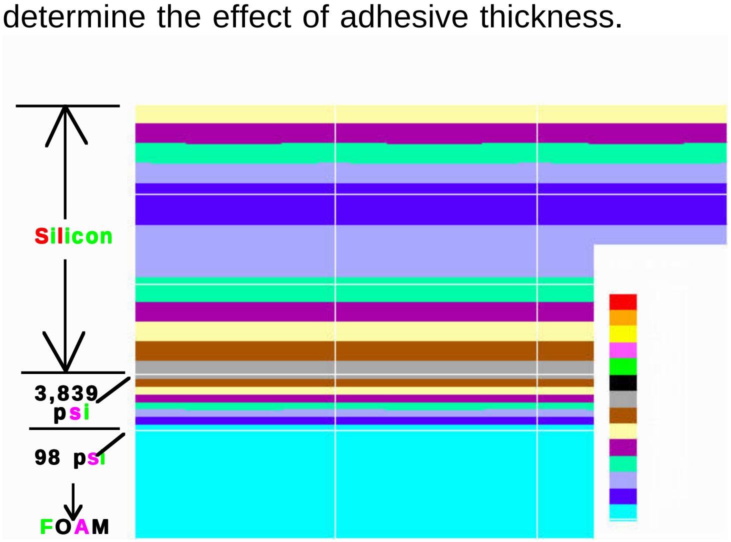
Run AD4. Araldite. Δ%RH reduced to 30%

It was regarded that with careful control of conditions surrounding the actual assembly, a reduction of the value in Δ%RH to 30% for use in the calculation might be permissible. The silicon stress goes from 6,319 psi to 3,792 psi, and the foam stress goes from 129 psi to 77 psi. These are both linear, 60% (30%ΔRH / 50%ΔRH) reductions.

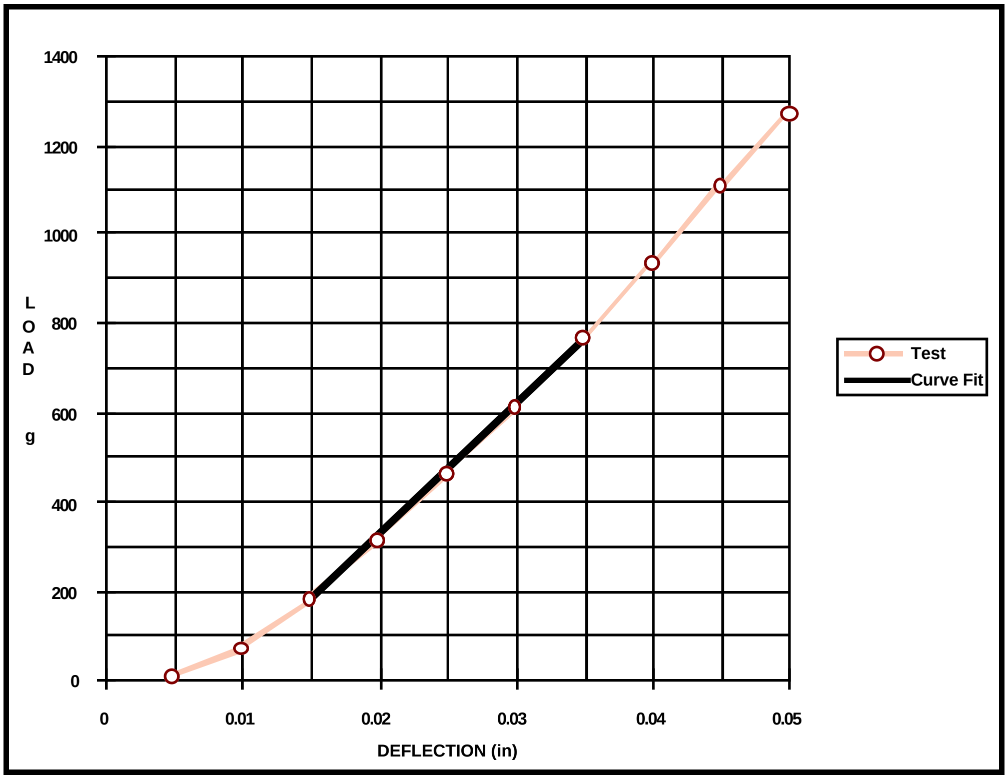


Run AD5. Araldite. 30% ΔRH. Adhesive Thickness Reduced to 0.0025 in

In this run the thickness of adhesive is halved to 0.0025 inches. The stress in the foam and in the silicon increase only very slightly. The stress in the silicon rises from 3,792 psi to 3,839 psi. The stress in the foam rises from 77 psi to 79 psi. This implies that at a thickness of 0.0025 in, the adhesive layer is still having an effect of reducing the stress, and that it is probably possible to further reduce the adhesive layer thickness. Further work is required with a finer mesh model to definitively determine the effect of adhesive thickness.



MODULUS OF ELASTICITY OF RTV 11:



TEST RESULTS OF LOAD / DEFLECTION FOR RTV

"white" RTV 11 Specimen

Deflection (in)	Load (g)
0.005	4.5
0.010	67
0.015	180
0.020	313
0.025	460
0.030	612
0.035	765
0.040	930
0.045	1103
0.050	1267

Using 0.015 and 0.035 data points:

ΔL =	0.035" - 0.015" =		0.020 inches
ΔP =	765 g -180 g =	585 g =	1.29 lb.
Diameter of specimen =	~1.0 inch $\Rightarrow$	A =	0.785 in^2
L = Length =			~ 0.8 inches

$$E = \frac{P/A}{\Delta L / L} = \frac{P \cdot L}{A \cdot \Delta L} = \frac{(1.29\ lb)(0.8\ in)}{(0.785\ in^2)(0.02\ in)} = \boxed{65.7\ psi}$$