



Department of Energy  
Washington, D.C. 20545

Docket No. 50-537  
HQ:S:83:237

MAR 23 1983

Dr. J. Nelson Grace, Director  
CRBR Program Office  
Office of Nuclear Reactor Regulation  
U.S. Nuclear Regulatory Commission  
Washington, D.C. 20555

Dear Dr. Grace:

CELL LINER DESIGN VALIDATION PROGRAM - CIRCULAR PENETRATION ANALYSIS

Reference: Letter HQ:S:83:231, J. R. Longenecker to J. N. Grace,  
"Cell Liner Design Validation Program," dated March 4, 1983

This letter transmits new information related to the Clinch River Breeder  
Reactor Plant Cell Liner Design Validation Program promised in the  
reference. Specifically attached is the analysis of the wall liner at  
circular penetrations.

Any questions regarding the information provided or further submittals  
can be addressed to Mr. P. Washer (FTS 626-6179) or Mr. V. Fayne  
(FTS 626-6394) of the Project Office Oak Ridge staff.

Sincerely,

John R. Longenecker  
Acting Director, Office of  
Breeder Demonstration Projects  
Office of Nuclear Energy

Enclosure

cc: Service List  
Standard Distribution  
Licensing Distribution

Dool

8303250013 830323  
PDR ADOCK 05000537  
A PDR

## ATTACHMENT I

### CELL LINER

#### WALL LINER AT CIRCULAR PENETRATIONS

Analyses of a wall liner near a circular penetration were considered based on the mathematical model of Figure A-1.

The following ANSYS elements were used in the model: STIF 48 for the plate, STIF 20 and STIF 8 for the studs and STIF 52 for the interface between the plate and the concrete.

Two cases were considered:

- a) Initiating a diagonal checkerboard buckling pattern. This was considered by imposing forces in the center of the liner panels as shown in Figure A-2.
- b) With the liner plate initially flat and allowing the plate to buckle without imposing any buckling pattern.

The analyses upto 240°F indicate that the results for the two cases are in very close agreement. Therefore, further analyses up to the design temperature was limited to case a) only. The maximum design temperature for the wall liner at a circular penetration is 670°F.

Table A-1 shows the maximum strains and Figure A-3 shows the calculated buckling pattern in terms of the displacement contours. The maximum equivalent von Mises strains are:

Plate - .011 (in/in) (Membrane); .026 (in/in) (Membrane plus Bending)

Stud - .051 (in/in) (Membrane); 0.143 (in/in) (Membrane plus Bending)

The strain allowables in accordance with the liner design criteria are .105 (in/in) for the membrane strain and 0.141 (in/in) for the membrane plus bending strain.

Liner strains are well below allowables by a factor of 5.5.

Stud strains are at the maximum allowable for combined membrane plus bending, however this is acceptable because the large strains experienced by stud do not adversely influence the liner integrity.

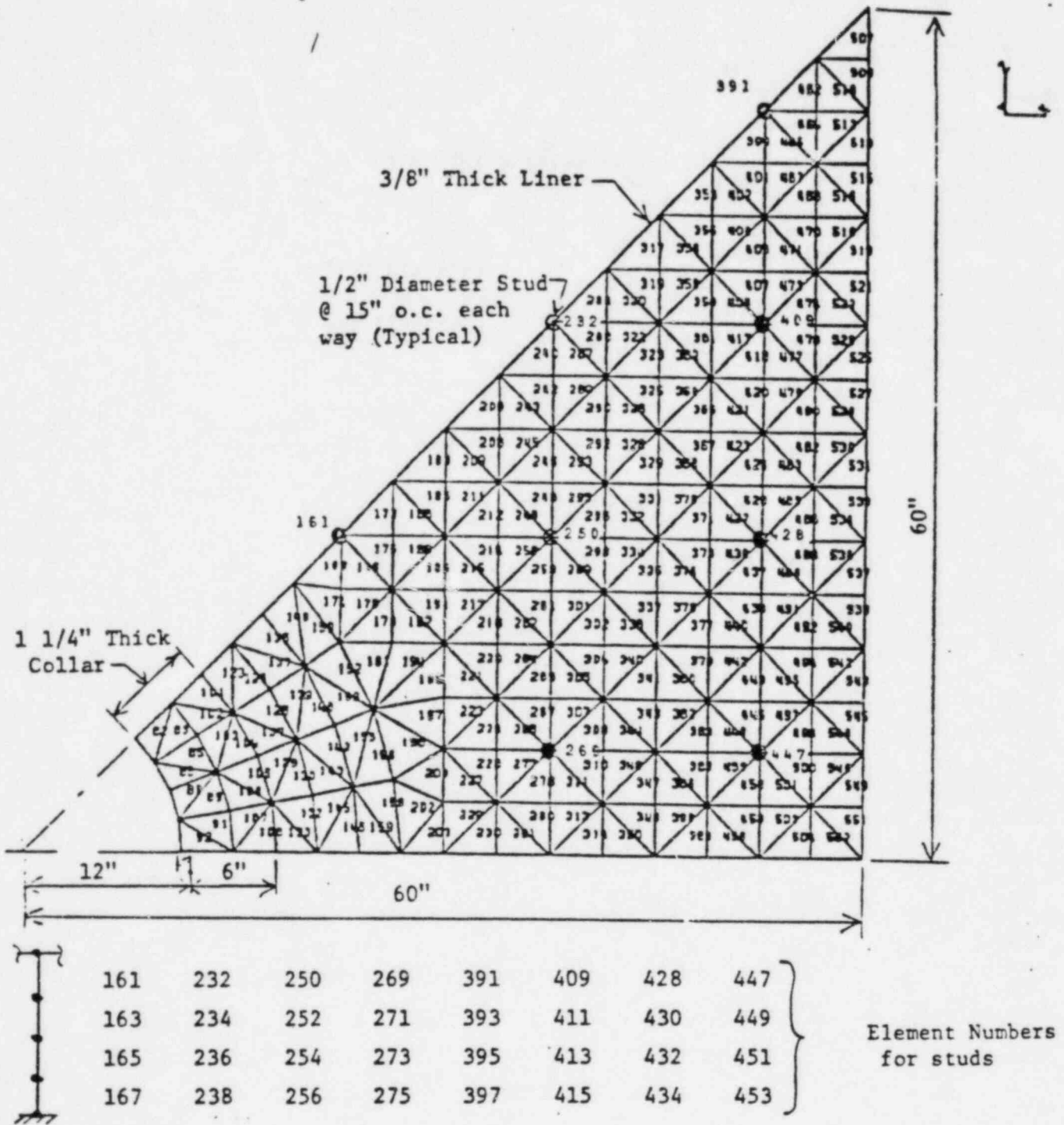


FIGURE A-1 WALL LINER AT CIRCULAR PENETRATION MATHEMATICAL MODEL

- 1/2" DIAMETER STUD
- ⊙ UNIT FORCE (1 lb) AWAY FROM THE WALL
- ⊗ UNIT FORCE TOWARDS THE WALL

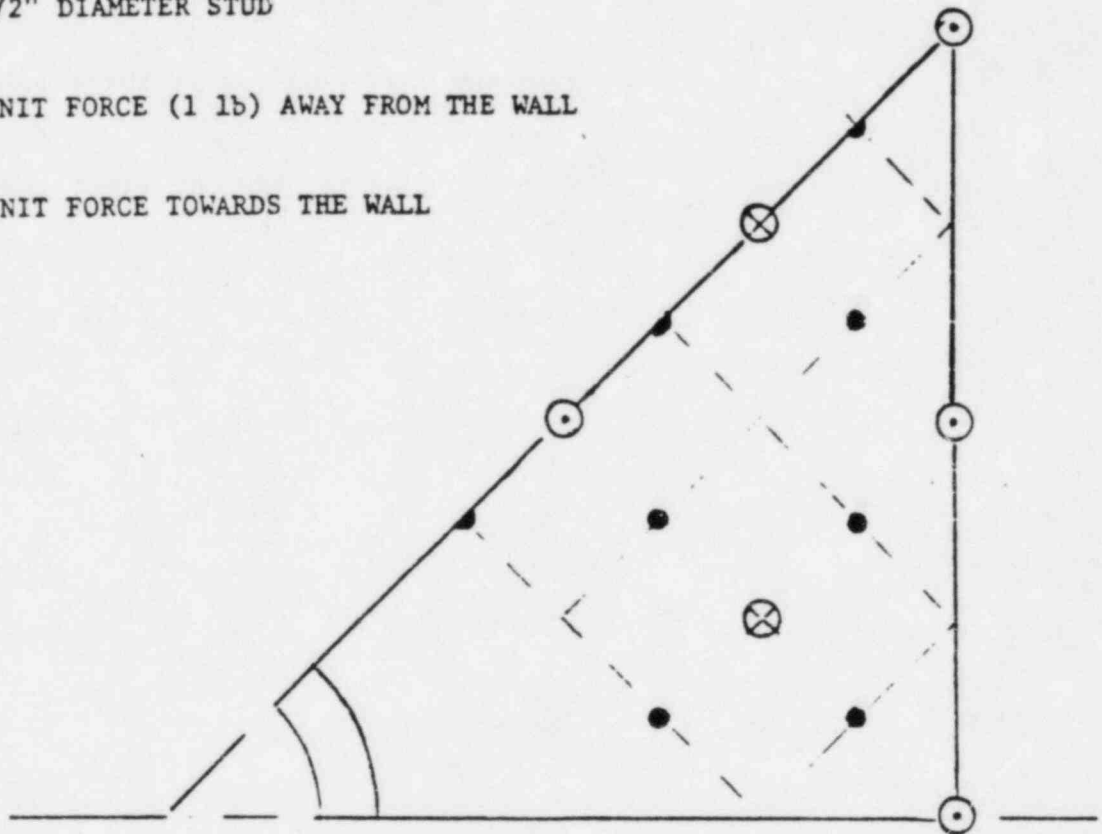
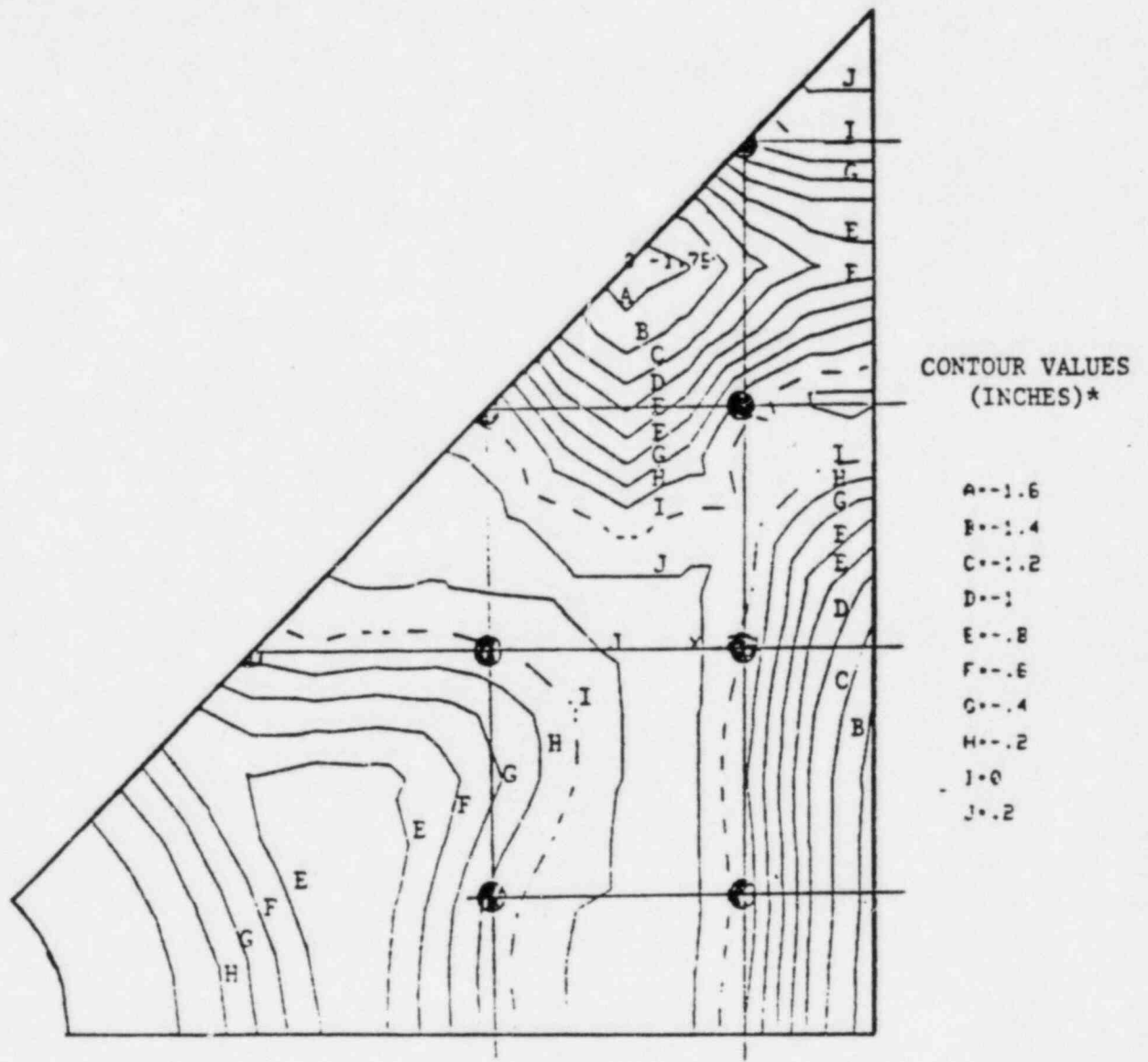


FIGURE A-2 WALL LINER AT CIRCULAR PENETRATION  
APPLIED INITIAL FORCES



\* Negative value indicates displacement away from concrete.

FIGURE A-3 WALL LINER AT CIRCULAR PENETRATIONS  
DISPLACEMENT CONTOURS

TABLE A-1 WALL LINER AT CIRCULAR PENETRATIONS;  
EQUIVALENT STRAINS (IN/IN)

<u>ELEMENT</u>	<u>MEMBRANE</u>	<u>MEMBRANE + BENDING</u>	
123	0.003884	0.013095	LINER
124	0.002956	0.012740	LINER
126	0.002813	0.012403	LINER
127	0.001063	0.009686	LINER
129	0.001064	0.009563	LINER
130	0.000877	0.009670	LINER
132	0.000695	0.009709	LINER
133	0.000609	0.008584	LINER
136	0.002647	0.003248	LINER
137	0.000827	0.001987	LINER
139	0.001134	0.002175	LINER
140	0.001667	0.002517	LINER
142	0.001363	0.002347	LINER
143	0.000851	0.001823	LINER
145	0.000672	0.002064	LINER
146	0.001346	0.002689	LINER
149	0.007734	0.020487	LINER
150	0.004982	0.013505	LINER
152	0.004243	0.013444	LINER
153	0.001669	0.003174	LINER
155	0.001387	0.003046	LINER
156	0.001411	0.003209	LINER
158	0.001646	0.003234	LINER
159	0.001325	0.002768	LINER
161	0.026526	0.061145	STUD-TOP
161	0.023992	0.026975	STUD-BOTTOM
163	0.024625	0.027915	STUD-TOP

TABLE A-1 WALL LINER AT CIRCULAR PENETRATIONS;  
EQUIVALENT STRAINS (IN/IN)

<u>ELEMENT</u>	<u>M</u>	<u>M + B</u>	
163	0.023798	0.023899	STUD-BOTTOM
165	0.024002	0.024269	STUD-TOP
165	0.023799	0.024236	STUD-BOTTOM
167	0.023775	0.024217	STUD-TOP
167	0.024161	0.026358	STUD-BOTTOM
169	0.003591	0.009243	LINER
171	0.003926	0.007179	LINER
173	0.001980	0.009838	LINER
175	0.001409	0.006651	LINER
176	0.002374	0.006250	LINER
178	0.002431	0.006060	LINER
179	0.001970	0.006508	LINER
181	0.002198	0.007191	LINER
183	0.001830	0.004952	LINER
185	0.001737	0.007229	LINER
186	0.000913	0.005770	LINER
188	0.001280	0.002153	LINER
189	0.001227	0.001712	LINER
191	0.001036	0.004539	LINER
192	0.000941	0.006193	LINER
194	0.001074	0.007564	LINER
195	0.001060	0.010082	LINER
197	0.001257	0.006906	LINER
198	0.001838	0.009196	LINER
200	0.002023	0.011426	LINER
202	0.002760	0.012227	LINER
203	0.003203	0.014540	LINER
204	0.003671	0.004213	LINER
208	0.002883	0.004972	LINER
209	0.002617	0.004541	LINER
211	0.002121	0.006242	LINER
212	0.002197	0.005477	LINER
214	0.001238	0.002915	LINER
215	0.000847	0.002274	LINER
217	0.000962	0.005503	LINER
218	0.001894	0.008634	LINER
220	0.000973	0.006146	LINER
221	0.000944	0.006802	LINER
223	0.001249	0.003115	LINER
224	0.001396	0.002965	LINER

TABLE A-1 WALL LINER AT CIRCULAR PENETRATIONS;  
EQUIVALENT STRAINS (IN/IN)

<u>ELEMENT</u>	<u>M</u>	<u>M + B</u>	
226	0.001102	0.002389	LINER
227	0.001259	0.002948	LINER
229	0.001321	0.002745	LINER
230	0.000847	0.002638	LINER
232	0.047910	0.130693	STUD-TOP
232	0.034918	0.044234	STUD-BOTTOM
234	0.037478	0.047358	STUD-TOP
234	0.036057	0.036427	STUD-BOTTOM
236	0.036266	0.036743	STUD-TOP
236	0.036326	0.037609	STUD-BOTTOM
238	0.036058	0.037168	STUD-TOP
238	0.037642	0.051584	STUD-BOTTOM
240	0.003029	0.010751	LINER
242	0.003906	0.007529	LINER
243	0.004043	0.004461	LINER
245	0.003438	0.006660	LINER
246	0.002979	0.005278	LINER
248	0.003264	0.006136	LINER
249	0.003032	0.005506	LINER
250	0.000736	0.030007	STUD-TOP
250	0.000220	0.004924	STUD-BOTTOM
252	0.000463	0.006258	STUD-TOP
252	0.000204	0.001213	STUD-BOTTOM
254	0.000265	0.001351	STUD-TOP
254	0.000323	0.001691	STUD-BOTTOM
256	0.000194	0.001438	STUD-TOP
256	0.000511	0.006496	STUD-BOTTOM
258	0.002102	0.004612	LINER
259	0.001997	0.005555	LINER
261	0.003016	0.009994	LINER
262	0.002223	0.008445	LINER
264	0.001159	0.004947	LINER
265	0.001136	0.002300	LINER
267	0.001390	0.003336	LINER
268	0.001578	0.003769	LINER
269	0.013331	0.045345	STUD-TOP
269	0.006569	0.011469	STUD-BOTTOM
271	0.008141	0.013646	STUD-TOP
271	0.006223	0.006396	STUD-BOTTOM
273	0.006671	0.007004	STUD-TOP



TABLE A-1 WALL LINER AT CIRCULAR PENETRATIONS;  
EQUIVALENT STRAINS (IN/IN)

<u>ELEMENT</u>	<u>M</u>	<u>M + B</u>	
273	0.006408	0.007681	STUD-BOTTOM
275	0.006014	0.007278	STUD-TOP
275	0.008320	0.013182	STUD-BOTTOM
277	0.001137	0.003359	LINER
278	0.000886	0.003532	LINER
280	0.000527	0.001373	LINER
281	0.000718	0.001264	LINER
284	0.001660	0.003795	LINER
286	0.002782	0.004551	LINER
287	0.003132	0.011727	LINER
289	0.003148	0.009780	LINER
290	0.005026	0.010528	LINER
292	0.006549	0.015396	LINER
293	0.004261	0.007765	LINER
295	0.004536	0.008450	LINER
296	0.004194	0.007435	LINER
298	0.003622	0.006235	LINER
299	0.002514	0.005916	LINER
301	0.003002	0.009268	LINER
302	0.002966	0.006139	LINER
304	0.002081	0.003641	LINER
305	0.000937	0.002031	LINER
307	0.001168	0.003976	LINER
308	0.001768	0.006309	LINER
310	0.000929	0.004777	LINER
311	0.000856	0.006142	LINER
313	0.000630	0.004242	LINER
314	0.000819	0.004059	LINER
317	0.000817	0.009356	LINER
319	0.001082	0.007480	LINER
320	0.002925	0.012068	LINER
322	0.003693	0.011925	LINER
323	0.004019	0.012950	LINER
325	0.004852	0.012819	LINER
326	0.005326	0.009392	LINER
328	0.006796	0.010677	LINER
329	0.006580	0.014057	LINER
331	0.004346	0.005817	LINER
332	0.004403	0.008565	LINER
334	0.003860	0.005970	LINER

TABLE A-1 WALL LINER AT CIRCULAR PENETRATIONS;  
EQUIVALENT STRAINS (IN/IN)

<u>ELEMENT</u>	<u>M</u>	<u>M + B</u>	
335	0.003329	0.004836	LINER
337	0.002813	0.004307	LINER
338	0.003215	0.004853	LINER
340	0.002124	0.004173	LINER
341	0.002644	0.004543	LINER
343	0.002168	0.004651	LINER
344	0.001815	0.004364	LINER
346	0.000906	0.002257	LINER
347	0.000929	0.001984	LINER
349	0.000837	0.002027	LINER
350	0.000639	0.001978	LINER
353	0.002323	0.014190	LINER
355	0.001316	0.013719	LINER
356	0.001001	0.011323	LINER
358	0.003190	0.009864	LINER
359	0.003770	0.014364	LINER
361	0.004978	0.014668	LINER
362	0.006026	0.018642	LINER
364	0.007447	0.018708	LINER
365	0.007608	0.014292	LINER
367	0.007333	0.012416	LINER
368	0.006451	0.014077	LINER
370	0.004147	0.005668	LINER
371	0.003899	0.007231	LINER
373	0.003273	0.005765	LINER
374	0.003968	0.008264	LINER
376	0.003531	0.008170	LINER
377	0.002825	0.007715	LINER
379	0.002229	0.006950	LINER
380	0.002656	0.004923	LINER
382	0.002187	0.004978	LINER
383	0.001533	0.002496	LINER
385	0.001242	0.002001	LINER
386	0.000944	0.001978	LINER
388	0.000836	0.001969	LINER
389	0.000874	0.001919	LINER
391	0.042028	0.113334	STUD-TOP
391	0.028348	0.036948	STUD-BOTTOM
393	0.031063	0.040330	STUD-TOP
393	0.029744	0.030131	STUD-BOTTOM

TABLE A-1 WALL LINER AT CIRCULAR PENETRATIONS;  
EQUIVALENT STRAINS (IN/IN)

<u>ELEMENT</u>	<u>M</u>	<u>M + B</u>	
395	0.029989	0.030557	STUD-TOP
395	0.029845	0.030480	STUD-BOTTOM
397	0.029734	0.030307	STUD-TOP
397	0.030768	0.038604	STUD-BOTTOM
399	0.010029	0.016489	LINER
401	0.006471	0.014251	LINER
402	0.006227	0.012071	LINER
404	0.003975	0.011182	LINER
405	0.005039	0.018589	LINER
407	0.005391	0.009916	LINER
408	0.004770	0.008466	LINER
409	0.035214	0.127611	STUD-TOP
409	0.014614	0.028516	STUD-BOTTOM
411	0.018091	0.034141	STUD-TOP
411	0.013607	0.014741	STUD-BOTTOM
413	0.014426	0.016032	STUD-TOP
413	0.014439	0.016793	STUD-BOTTOM
415	0.013559	0.015404	STUD-TOP
415	0.018381	0.034651	STUD-BOTTOM
417	0.004738	0.007489	LINER
418	0.005189	0.019727	LINER
420	0.004661	0.015313	LINER
421	0.008454	0.018861	LINER
423	0.008681	0.020582	LINER
424	0.006763	0.013707	LINER
426	0.005822	0.015090	LINER
427	0.005153	0.015270	LINER
428	0.022236	0.096372	STUD-TOP
428	0.011619	0.022350	STUD-BOTTOM
430	0.013819	0.025990	STUD-TOP
430	0.010543	0.011539	STUD-BOTTOM
432	0.010989	0.012263	STUD-TOP
432	0.011334	0.013671	STUD-BOTTOM
434	0.010619	0.012463	STUD-TOP
434	0.014649	0.029461	STUD-BOTTOM
436	0.004714	0.014229	LINER
437	0.003832	0.013113	LINER
439	0.003983	0.012312	LINER
440	0.003567	0.012815	LINER
442	0.003063	0.012227	LINER

TABLE A-1 WALL LINER AT CIRCULAR PENETRATIONS;  
EQUIVALENT STRAINS (IN/IN)

<u>ELEMENT</u>	<u>M</u>	<u>M + B</u>	
443	0.001333	0.011117	LINER
445	0.001207	0.012674	LINER
446	0.001755	0.012235	LINER
447	0.051451	0.142780	STUD-TOP
447	0.029136	0.041227	STUD-BOTTOM
449	0.033249	0.046732	STUD-TOP
449	0.031219	0.031760	STUD-BOTTOM
451	0.031614	0.032358	STUD-TOP
451	0.031542	0.033034	STUD-BOTTOM
453	0.031208	0.032555	STUD-TOP
453	0.033137	0.049206	STUD-BOTTOM
455	0.001343	0.011811	LINER
456	0.000880	0.012783	LINER
458	0.001006	0.011357	LINER
459	0.001716	0.012429	LINER
462	0.002034	0.013455	LINER
464	0.005235	0.015168	LINER
465	0.005583	0.013932	LINER
467	0.005482	0.014118	LINER
468	0.009181	0.022738	LINER
470	0.008306	0.018313	LINER
471	0.006254	0.017588	LINER
473	0.005526	0.010925	LINER
474	0.005573	0.018473	LINER
476	0.002259	0.020726	LINER
477	0.005955	0.020742	LINER
479	0.009309	0.013782	LINER
480	0.010906	0.013082	LINER
482	0.009204	0.011594	LINER
483	0.003714	0.006690	LINER
485	0.002438	0.007391	LINER
486	0.002134	0.003733	LINER
488	0.002119	0.003648	LINER
489	0.001235	0.002474	LINER
491	0.001502	0.003136	LINER
492	0.001016	0.001984	LINER
494	0.001379	0.002101	LINER
495	0.001045	0.001935	LINER
497	0.001004	0.002624	LINER
498	0.000758	0.002561	LINER

TABLE A-1 WALL LINER AT CIRCULAR PENETRATIONS;  
EQUIVALENT STRAINS (IN/IN)

<u>ELEMENT</u>	<u>M</u>	<u>M + B</u>	
500	0.000355	0.002204	LINER
501	0.000418	0.001936	LINER
503	0.000663	0.001918	LINER
504	0.000415	0.000823	LINER
507	0.000489	0.000900	LINER
509	0.002422	0.008539	LINER
510	0.001392	0.007680	LINER
512	0.002840	0.009120	LINER
513	0.004899	0.011181	LINER
515	0.010145	0.026256	LINER
516	0.010911	0.022456	LINER
518	0.010304	0.018841	LINER
519	0.007571	0.014991	LINER
521	0.006783	0.021701	LINER
522	0.003792	0.014148	LINER
524	0.003678	0.015399	LINER
525	0.006006	0.012056	LINER
527	0.005803	0.009442	LINER
528	0.008307	0.017090	LINER
530	0.007313	0.017361	LINER
531	0.008167	0.020679	LINER
533	0.007378	0.018805	LINER
534	0.004201	0.017610	LINER
536	0.004153	0.016931	LINER
537	0.003569	0.015754	LINER
539	0.003572	0.015623	LINER
540	0.002096	0.014940	LINER
542	0.001956	0.014726	LINER
543	0.002494	0.015783	LINER
545	0.002630	0.015721	LINER
546	0.002681	0.016284	LINER
548	0.002727	0.016470	LINER
549	0.001666	0.015074	LINER
551	0.001604	0.015072	LINER
552	0.001107	0.014416	LINER

0 0

Allowable Strains

0.105 (in/in) Membrane

0.141 (in/in) Membrane Plus Bending