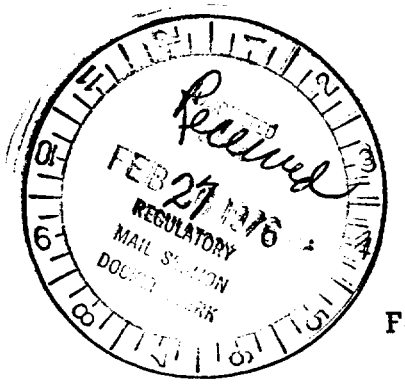
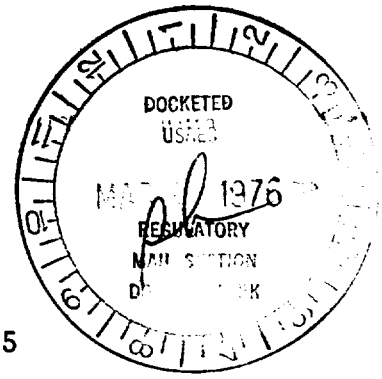


NL Nuclear

February 27, 1976

Mr. Charles E. MacDonald, Chief
Transportation Branch
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555



Subject: NL Industries, Inc.
Docket 71-9023
NLI 10/24 Rail Cask Application

Reference: (1) NRC letter dated November 5, 1975
(2) NRC letter dated November 21, 1975

Gentlemen:

In response to the referenced letters, NL Industries has revised and/or expanded the appropriate sections of the NLI 10/24 Rail Cask Safety Analysis Report and herewith submits the consolidated Safety Analysis Report for your review and approval.

Enclosed herewith please find ten (10) copies of the consolidated Safety Analysis Report. Revised pages are those listed on Attachment 1 to this letter.

NLI is not requesting any proprietary data withholding regarding the attached data and drawings; therefore, you are hereby authorized to release all of the enclosed data and drawings as deemed necessary by your staff.

Sincerely,

C. E. Williams
Program Manager

/lc

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Nuclear Division/NL Industries, Inc.
Foot of West Street, Wilmington, Del. 19801 Tel. (302) 656-1661

List of Revised Pages
to NLI 10/24 Rail Cask
Safety Analysis Report

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SECTION XI

Appendix F

Introduction

This appendix augments the structural section of this Application. There are two areas in which this appendix amplifies and clarifies the structural analysis of the cask. The first area of concern is the influence of the newer lead stress-strain data on the parts of the evaluation of the cask that were completed using the earlier data. And second, this appendix presents an additional normal cycle evaluation of the cask using the Section VIII, Appendix D, temperature distributions. This evaluation provides the data required in Section XV in the discussion of the thermal acceptance criteria.

F.1 Influence of the Change in High Temperature Lead Stress-Strain Properties

Reference 81 presents high temperature stress-strain curves for the lead alloy used as shielding in the cask. The lead data of Ref. 81 correlates well with the lower temperature lead stress-strain data of Tietz, Ref. 20, at the one temperature common to both studies, 325° F. These two sets of curves, which are presented in Fig. 4.9.6-13 and in Section 1.2.3, provide a complete set of lead stress-strain properties. However, prior to obtaining the high temperature data of Ref. 81, the stress-strain curves above 325° F were determined from the Tietz data by extrapolation to the 620° F melting point. The stress-strain curves that result from this extrapolation are shown in Appendix B, Section B.5. The extrapolated curves and the experimental Ref. 81 curves are seen to differ significantly at the higher temperatures, i.e., above a temperature of approximately 380° F. Therefore, it was necessary to examine the

analyses that were completed using the older lead stress-strain curves to determine if using the revised curves significantly alters the computed stress results.

The fourteen base case solutions (less cases 1 and 11) discussed in Section 3.8.4 were all completed using the older lead stress-strain curves. Additionally, the lead pressure study of Appendix B incorporated the older lead data. The lead pressure and buckling calculations of Section XI, 4.6.2.1 and 4.9.6, were all completed with the revised set of lead stress-strain curves.

To assess the influence of the newer lead curves on the base case solutions, only the cases with temperatures above the deviation point between the two sets of lead data require some re-examination. Below this point, the lead properties used in the analyses were correct. Thus, only the 70 kw, 130° F ambient normal and post-fire, and the 70 kw, -40° F ambient post-fire cases are in question. Of these cases, the 70 kw, 130° F ambient normal case is the most critical since it is an extreme condition of the normal cycle, and further, the evaluation for the normal cycle stress range using this condition currently meets the stress allowable by a relatively small margin. Therefore, the ANSYS solution for this case was re-computed using the revised lead representation.

It was found from this later ANSYS solution that the resulting stresses in the cask shells were not significantly altered by the imposed change in the lead stress-strain properties. For example, the maximum change in stress level at the critical inner shell, mid-cask location (the location of highest temperature and largest stress range) was found to be only about 500 psi. Small stress changes were computed in the other cask locations, but none of the changes was significant enough to alter the conclusion of the stress range calculation or any of the other normal case evaluation steps which found the cask shells to be struc-

turally adequate. The stress component results for the inner shell, mid-cask locations, Locations 11 and 12 of Fig. 3.8.4-15, for the old lead properties solution and the revised solution are presented below.

	LOCATION 11		LOCATION 12	
Stress Component (psi)	Old	Revised	Old	Revised
σ_r	-16	-16	-708	-710
σ_z	-20830	-20698	-18680	-19207
σ_h	-23556	-23508	-20748	-20698
σ_{rz}	0.0	0.0	0.0	0.0

From the comparison of the two ANSYS solutions, it is reasonable to conclude that the thermal-elastic properties of the lead are of major significance in producing the shell stresses, while the detailed shapes of the lead stress-strain curves are not. The thermal-elastic properties of the lead were not altered in any of the ANSYS solutions.

To assess a possible change in the stress-free temperature computed in Appendix B, the calculation in Appendix B that included the highest assumed temperature, 500° F, was repeated using the revised lead stress-strain properties.

The results of this calculation were essentially identical to the previous solution, and no change in the computed stress-free temperature was found. The important factors leading to the very close agreement between the two solutions were believed to be: 1) the importance of the thermal-elastic properties in producing shell stresses as discussed above, and 2) the presence of creep in the Appendix B calculations. Even though the lead stress-strain curves of the re-

vised solution were different, the indicated equivalent stresses at each point in the two solutions were identical, thus indicating that the creep of the lead acted to degrade the stress-strain properties effectively to the same levels.

The post-fire evaluation, which included base cases incorporating the old lead data, indicated that there was a substantial margin between the computed and allowable stresses. (A very conservative estimate of the smallest margin, the margin in the accident range calculation, is approximately 30%.) Further, since the results of the two calculations for the normal cycle and stress-free temperature discussed above did not differ significantly from the previous results, the post-fire cases that used the old lead properties were not repeated. The assumption was that if these cases were repeated, the resulting stresses and evaluation would lead to the same conclusions as the existing evaluation of Section 4.9.6.

F.2 Stress Evaluation Using Normal Condition Temperatures of Section VIII, Appendix D

To provide a bounding case for the thermal acceptance test criteria presented in Section XV, a stress evaluation using the Section VIII, Appendix D, temperature distribution for the 70 kw, 130° F ambient normal case was performed.

In this evaluation, the 70 kw, -40° F ambient and -40 kw, -40° F ambient normal temperature distributions were taken from Section, Appendix E. This is not consistent with the 70 kw, 130° F ambient solution; however, this 70 kw, 130° F ambient case along with the -40° F isothermal generally make up the extremes of the normal cycle for the different cask locations, notably the critical inner shell, mid-plane location. The other normal temperature distributions represent intermediate loading cases. Further, the 70 kw, 130° F ambient case

is always the highest temperature case of the cycle and therefore sets the allowable stress for each evaluation. Thus, the inconsistency of the thermal solutions does not cause any limitation on the evaluation presented in this appendix.

The methods used for this evaluation were the same as presented in Sections 3.8.4 and 5, including the adding of the additional stresses due to the non-axisymmetric heating at the inner shell, mid-cask location. The base case stresses and the evaluation results are given in Tables F.2-1 and 2. Tables F.2-1 and 2 correspond to Table 3.8.4-2 and Table 3.8.5-3, respectively. The other tables of Section 3.8, i.e., the primary stress listing, primary stress evaluation, and the stress range load cases, were not altered.

All stress allowables are satisfied in this revised evaluation.

TABLE F.2-1 REV. 1-2/76

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
1	1	0	0	0	0
1	2	-0	38589	13740	-0
1	3	-0	30352	11074	-0
1	4	-16	9817	-6924	0
1	5	0	21696	8599	0
1	6	-16	17703	-26774	0
1	7	-0	-3621	-1032	-0
1	8	-0	-1086	-47	-0
1	9	-0	-555	-531	-0
1	10	-100	1964	968	-0
1	11	-0	204	-0	-0
1	12	-16	39188	5827	0
1	13	-16	35788	1688	0
1	14	-16	34561	-19753	0
2	1	0	0	0	0
2	2	1510	-20457	-8491	-791
2	3	1276	-17360	-7076	-538
2	4	688	-29436	-20423	-220
2	5	1408	-10115	-4022	-456
2	6	680	-80532	-61123	41
2	7	-174	-2582	-722	58
2	8	-82	-626	98	52
2	9	-109	-69	-343	53
2	10	102	-299	153	-58
2	11	-0	204	-0	-0
2	12	1456	-34616	-21078	-606
2	13	1200	-42980	-26541	-382
2	14	-200	-75403	-58354	291
3	1	0	0	0	0
3	2	2505	-19246	-9884	759
3	3	1903	-14883	-7620	579
3	4	476	1155	-2240	329
3	5	1504	-14795	-12401	474
3	6	-466	16383	-10535	-72
3	7	-520	695	-32	-136
3	8	67	-233	103	26
3	9	50	-138	-340	14
3	10	-90	-114	211	-38
3	11	-0	278	-0	-0
3	12	1158	-10397	-9797	730

TABLE F.2-1 (CONT.) REV. 1-2/76

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
3	13	-189	-4345	-7474	20
3	14	-1161	18652	-13302	-213
4	1	0	0	0	0
4	2	-0	13690	1722	-0
4	3	-0	10893	1448	-0
4	4	-235	-1616	3341	0
4	5	0	8535	1138	0
4	6	0	-25280	-15429	0
4	7	0	-11812	-3669	-0
4	8	-0	-932	-102	-0
4	9	-100	72	-263	-0
4	10	-0	418	380	-0
4	11	-0	278	-0	-0
4	12	-14	4542	84	0
4	13	-33	319	902	0
4	14	0	-38661	-23438	0
5	1	0	0	0	0
5	2	-0	-1150	-443	-0
5	3	-0	-919	-377	-0
5	4	-235	25021	12811	0
5	5	0	-884	3012	0
5	6	0	20846	20101	0
5	7	-0	-5297	-716	-0
5	8	-0	-3339	-509	-0
5	9	-100	8831	2572	-0
5	10	-0	-25	61	-0
5	11	-0	274	-0	-0
5	12	-14	10775	-2449	0
5	13	-33	14221	5449	0
5	14	0	35048	18925	0
6	1	0	0	0	0
6	2	-0	-925	-375	-0
6	3	-0	-677	-265	-0
6	4	0	-12080	1681	0
6	5	0	3684	4382	0
6	6	0	21075	20170	0
6	7	-0	850	1129	-0
6	8	-0	298	583	-0
6	9	-0	-6682	-2082	-0
6	10	-0	160	116	-0

TABLE F.2-1 (CONT.) REV. 1-2/76

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
6	11	-0	274	-0	-0
6	12	0	-5549	-1914	0
6	13	0	-5117	-352	0
6	14	0	12092	12038	0
7	1	0	0	0	0
7	2	-0	-875	39789	-0
7	3	-0	-791	29377	-0
7	4	-16	-11158	-11275	0
7	5	0	-358	25802	0
7	6	-16	-28860	-32165	0
7	7	-0	-3722	-964	-0
7	8	-0	-860	-19	-0
7	9	-0	136	-897	-0
7	10	-100	458	957	-0
7	11	-0	273	-0	-0
7	12	-16	-6743	22532	0
7	13	-16	-12241	12143	0
7	14	-16	-26901	-10856	0
8	1	0	0	0	0
8	2	1398	2736	39237	52
8	3	1085	1104	28730	67
8	4	-383	-10535	-9902	-105
8	5	905	1521	25028	950
8	6	-1065	-30301	-30890	31
8	7	-20	-3789	-938	-90
8	8	-2	-884	-27	-8
8	9	-33	2	-909	11
8	10	-64	525	938	-12
8	11	-0	273	-0	-0
8	12	742	-3335	22988	-320
8	13	419	-6467	14093	-335
8	14	-431	-20391	-8025	-228
9	1	0	0	0	0
9	2	1303	-4994	-22178	119
9	3	967	-3916	-16574	102
9	4	-421	-3508	-2070	-136
9	5	896	-7031	-16790	56
9	6	-872	-12172	10037	-10
9	7	10	-4766	-130	-86
9	8	-3	-1016	48	41

TABLE F.2-1 (CONT.) REV. 1-2/76

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
9	9	-50	-7	-820	-5
9	10	-42	253	599	-4
9	11	-0	373	-0	-0
9	12	644	-4296	-14561	-276
9	13	171	-4890	-13035	-344
9	14	-367	-15718	-533	-183
10	1	0	0	0	0
10	2	0	-7592	-21440	0
10	3	0	-5390	-15882	0
10	4	-235	6752	6890	0
10	5	0	-3569	-11674	0
10	6	0	6171	20583	0
10	7	0	-4450	-34	0
10	8	0	-1006	48	0
10	9	-100	-91	-798	0
10	10	0	303	573	0
10	11	-0	372	-0	-0
10	12	-14	484	-8641	0
10	13	-33	6573	872	0
10	14	0	842	11006	0
11	1	0	0	0	0
11	2	0	9045	40061	0
11	3	0	6864	29480	0
11	4	-16	-22572	-25589	0
11	5	0	6676	27363	0
11	6	-16	-29632	-42799	0
11	7	0	-2318	-137	0
11	8	0	-2712	-30	0
11	9	0	-75	-1176	0
11	10	-100	396	1098	0
11	11	-0	377	-0	-0
11	12	-16	-4680	17403	0
11	13	-16	-16381	247	0
11	14	-16	-34147	-26639	0
12	1	0	0	0	0
12	2	1209	9042	38783	-3
12	3	894	6860	28540	-2
12	4	-697	-20500	-22788	6
12	5	800	6214	26033	-5
12	6	-1093	-27529	-39393	1

TABLE F.2-1 (CONT.) REV. 1-2/76

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
12	7	-3	-2315	-133	32
12	8	-1	-2712	-30	-11
12	9	-38	-75	-1140	0
12	10	-60	399	1059	0
12	11	-0	377	-0	-0
12	12	506	-3338	18159	0
12	13	-10	-14105	2449	0
12	14	-819	-31834	-23587	0
13	1	0	0	0	0
13	2	1459	-8223	-23865	-3
13	3	1092	-6240	-17111	-1
13	4	-714	-97	2497	-9
13	5	1006	-8840	-17236	-4
13	6	-1134	-7334	14707	4
13	7	3	-2630	-70	-29
13	8	-6	-2685	99	39
13	9	-51	11	-834	0
13	10	-44	281	651	0
13	11	-0	512	-0	-0
13	12	460	-4243	-11136	0
13	13	-110	-2849	-4426	0
13	14	-856	-9741	7796	0
14	1	0	0	0	0
14	2	0	-8247	-21371	0
14	3	0	-6264	-15995	0
14	4	-235	9878	11719	0
14	5	0	-4408	-11834	0
14	6	0	2118	22673	0
14	7	0	-2624	-64	0
14	8	0	-2685	93	0
14	9	-100	11	-786	0
14	10	0	283	609	0
14	11	-0	512	-0	-0
14	12	-14	-4243	-11136	0
14	13	-33	-2849	-4426	0
14	14	0	486	16752	0
15	1	0	0	0	0
15	2	0	-1356	0	0
15	3	0	-1042	0	0
15	4	-235	8379	12685	0

TABLE F.2-1 (CONT.) REV. 1-2/76

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
15	5	0	1784	0	0
15	6	0	26887	-19	0
15	7	0	-2223	4	0
15	8	0	-2641	-4	0
15	9	-100	1464	5417	0
15	10	0	87	0	0
15	11	-0	506	-0	-0
15	12	-14	3368	748	0
15	13	-33	5861	1509	0
15	14	0	32512	-33	0
16	1	0	0	0	0
16	2	0	-1365	0	0
16	3	0	-1042	0	0
16	4	0	8498	12721	0
16	5	0	1784	0	0
16	6	0	26995	13	0
16	7	0	-2223	3	0
16	8	0	-2641	-3	0
16	9	0	1464	5417	0
16	10	0	87	0	0
16	11	-0	506	-0	-0
16	12	0	3430	767	0
16	13	0	5975	1521	0
16	14	0	32695	22	0
17	1	0	0	0	0
17	2	0	-1219	16977	0
17	3	0	-3401	12926	0
17	4	-16	-4907	-6819	0
17	5	0	5956	15797	0
17	6	-16	-17600	-21849	0
17	7	0	-478	-1278	0
17	8	0	-884	242	0
17	9	0	642	-777	0
17	10	-100	2566	1867	0
17	11	-0	174	-0	-0
17	12	-16	7013	16423	0
17	13	-16	7985	10575	0
17	14	-16	3127	-4322	0
18	1	0	0	0	0
18	2	1682	14413	21759	711

TABLE F.2 (CONT.) REV. 1-2/76

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
18	3	1621	12774	17922	532
18	4	-585	-11310	-8011	177
18	5	1661	-7061	9033	28
18	6	-830	-40657	-26435	11
18	7	-493	-7138	-3726	-135
18	8	42	-5336	-1193	-7
18	9	-167	-792	-1254	-98
18	10	-157	85	1016	-28
18	11	-0	174	-0	-0
18	12	1604	-32362	1103	-323
18	13	950	-36269	-5975	-296
18	14	-966	-44064	-19572	-350
19	1	0	0	0	0
19	2	0	8960	16132	0
19	3	0	5186	12479	0
19	4	-16	-14527	-6762	0
19	5	0	-4241	10580	0
19	6	-16	-35515	-15895	0
19	7	0	-1099	-1281	0
19	8	0	-3699	-327	0
19	9	0	244	-739	0
19	10	-100	1915	1923	0
19	11	-0	174	-0	-0
19	12	-16	-16914	8842	0
19	13	-16	-15243	5466	0
19	14	-16	-22134	-3520	0
20	1	0	0	0	0
20	2	0	10097	16473	0
20	3	0	8547	13488	0
20	4	0	8986	292	0
20	5	0	12650	15647	0
20	6	0	17063	-122	0
20	7	0	-7039	-3063	0
20	8	0	3351	1788	0
20	9	0	-742	-1035	0
20	10	0	373	1460	0
20	11	-0	174	-0	-0
20	12	0	22316	20611	0
20	13	0	16663	15038	0
20	14	0	19027	8829	0

TABLE F.2-1 (CONT.) REV. 1-2/76

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
21	1	0	0	0	0
21	2	1861	0	15407	0
21	3	-1494	0	12410	0
21	4	14551	0	96	0
21	5	-19599	0	4874	0
21	6	38415	0	3591	0
21	7	-498	0	-1569	0
21	8	1243	0	761	0
21	9	105	0	-888	0
21	10	-151	0	1095	0
21	11	-0	0	-0	-0
21	12	-13959	0	7879	0
21	13	-9482	0	4452	0
21	14	5446	0	-2847	0
22	1	0	0	0	0
22	2	1716	0	12849	0
22	3	-1395	0	10461	0
22	4	-14419	0	-9849	0
22	5	16681	0	17536	0
22	6	-37361	0	-22505	0
22	7	736	0	-1018	0
22	8	-1403	0	-318	0
22	9	104	0	-784	0
22	10	-159	0	1246	0
22	11	-0	0	-0	-0
22	12	9880	0	16647	0
22	13	6377	0	10596	0
22	14	-5070	0	-6189	0
23	1	0	0	0	0
23	2	1977	2609	-10743	-959
23	3	1549	2446	-8148	-532
23	4	-467	-5660	-8162	130
23	5	1105	-4274	-12135	-424
23	6	-748	-18752	-12941	48
23	7	457	2307	99	-124
23	8	-323	-7502	-1817	137
23	9	-89	151	-831	29
23	10	-178	-463	314	69
23	11	-0	237	-0	-0
23	12	944	-4309	-12024	118

TABLE F.2-1 (CONT.) REV. 1-2/76

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
23	13	0	-8438	-11510	344
23	14	-1354	-28600	-20067	219
24	1	0	0	0	0
24	2	0	-7242	-13055	0
24	3	0	-5721	-10116	0
24	4	-235	9080	3286	0
24	5	0	-4780	-8545	0
24	6	0	10783	3155	0
24	7	0	-1832	-1204	0
24	8	0	-3988	-583	0
24	9	-100	-257	-893	0
24	10	0	625	636	0
24	11	-0	237	-0	-0
24	12	-14	-2172	-6956	0
24	13	-33	3894	-726	0
24	14	0	7020	-1947	0
25	1	0	0	0	0
25	2	0	-13635	-8237	0
25	3	0	-10556	-2418	0
25	4	0	17434	-8605	0
25	5	0	-4631	-5280	0
25	6	0	62964	-19394	0
25	7	0	-2690	-561	0
25	8	0	5797	26	0
25	9	0	43	-356	0
25	10	0	900	130	0
25	11	-0	200	-0	-0
25	12	0	3762	-4011	0
25	13	0	15600	-3073	0
25	14	0	75983	-14153	0
26	1	0	0	0	0
26	2	0	23117	3398	0
26	3	0	8236	2964	0
26	4	-235	-13597	-9104	0
26	5	0	-3500	-1236	0
26	6	0	-69868	-45419	0
26	7	0	3576	1147	0
26	8	0	-17483	-6159	0
26	9	-100	-197	-491	0
26	10	0	-822	-342	0

TABLE F.2-1 (CONT.) REV. 1-2/76

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
26	11	-0	200	-0	-0
26	12	-14	-9923	-3114	0
26	13	-33	-20066	-6764	0
26	14	0	-96828	-53277	0
27	1	0	0	0	0
27	2	0	-2953	48	0
27	3	0	-2206	24	0
27	4	-235	41830	8100	0
27	5	0	535	3958	0
27	6	0	49485	16661	0
27	7	0	-2856	-530	0
27	8	0	-4203	-1156	0
27	9	-100	9246	2562	0
27	10	0	291	-11	0
27	11	-0	197	-0	-0
27	12	-14	12558	3533	0
27	13	-33	20685	5353	0
27	14	0	59703	-10156	0
28	1	0	0	0	0
28	2	0	883	1198	0
28	3	0	615	870	0
28	4	0	-28830	-13098	0
28	5	0	2444	4531	0
28	6	0	-6899	-254	0
28	7	0	433	456	0
28	8	0	-934	-176	0
28	9	0	-7124	-2349	0
28	10	0	-158	-146	0
28	11	-0	197	-0	-0
28	12	0	-7206	-2396	0
28	13	0	-11399	-4273	0
28	14	0	-8003	1692	0
29	1	0	0	0	0
29	2	0	4588	1274	0
29	3	0	3215	892	0
29	4	-16	460	-2696	0
29	5	0	1527	1445	0
29	6	-16	-1150	-393	0
29	7	0	-6176	-1801	0
29	8	0	3528	1059	0

TABLE F.2 (CONT.) REV. 1-2/76

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
29	9	0	-45	-9	0
29	10	-100	6953	2173	0
29	11	-0	106	-0	-0
29	12	-16	3249	1563	0
29	13	-16	2075	1078	0
29	14	-16	1163	670	0
30	1	0	0	0	0
30	2	0	11675	3400	0
30	3	0	8369	2439	0
30	4	0	-5229	-4403	0
30	5	0	5339	2589	0
30	6	0	-15233	-4617	0
30	7	0	-1978	-541	0
30	8	0	-3660	-1098	0
30	9	0	-326	-93	0
30	10	-0	-4519	-1263	-0
30	11	-0	106	-0	-0
30	12	0	909	861	0
30	13	0	-1608	-27	0
30	14	0	-4510	-1032	0
31	1	0	0	0	0
31	2	0	10409	3020	0
31	3	0	7582	2202	0
31	4	0	-22142	-4685	0
31	5	0	11024	2209	0
31	6	0	-39304	-8805	0
31	7	0	180	106	0
31	8	0	-5066	-1519	0
31	9	0	-46	-9	0
31	10	0	-1218	-278	0
31	11	-0	0	-0	-0
31	12	0	-10840	4028	0
31	13	0	-18018	-3778	0
31	14	0	-26309	-5339	0
32	1	0	0	0	0
32	2	0	13374	3910	0
32	3	0	9335	2729	0
32	4	0	15532	-4685	0
32	5	0	-1886	-1562	0
32	6	0	15863	7745	0

TABLE F.2-1 (CONT.) REV. 1-2/76

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
32	7	0	-10838	-3199	0
32	8	0	3512	1054	0
32	9	0	-500	-145	0
32	10	0	3460	1125	0
32	11	-0	0	-0	-0
32	12	0	16010	6000	0
32	13	0	18112	7061	0
32	14	0	21296	8943	0
33	1	0	0	0	0
33	2	0	5187	1213	0
33	3	0	3300	803	0
33	4	0	22486	10006	0
33	5	0	-6049	-2944	0
33	6	0	30512	12707	0
33	7	0	-6060	-1871	0
33	8	0	3387	1803	0
33	9	0	-320	1	0
33	10	0	2830	932	0
33	11	-0	0	-0	-0
33	12	0	10861	-2523	0
33	13	0	17614	5745	0
33	14	0	26429	-31605	0
34	1	0	0	0	0
34	2	0	18478	5200	0
34	3	0	13534	3873	0
34	4	0	-29386	-5555	0
34	5	0	15606	3552	0
34	6	0	-54181	-12701	0
34	7	0	-4664	-1453	0
34	8	0	-4730	-632	0
34	9	0	-214	33	0
34	10	0	-529	-76	0
34	11	-0	0	-0	-0
34	12	0	-5957	-1396	0
34	13	0	-17798	-4879	0
34	14	0	-31605	-5541	0

TABLE F.2-2 REV. 1-2/76

NORMAL CYCLE PRIMARY PLUS SECONDARY RANGE EVALUATION

STRESS RANGE DATA LOAD CASE 2 USED AS REFERENCE

LOC	MAX TEMP	MIN TEMP	STRESS RANGE	ALLOWABLE STRESS	MIN TEMP	STRESS RANGE	ALLOWABLE STRESS
1	320	-40	39342	68725	70	0	68725
2	317	-40	25893	68755	70	0	68755
3	295	-40	25581	68969	70	0	68969
4	272	-40	21931	69193	70	0	69193
5	261	-40	29193	69301	70	0	69301
6	261	-40	18092	69301	70	0	69301
7	346	-40	51051	68472	70	0	68472
8	342	-40	47365	68511	70	0	68511
9	313	-40	25362	68794	70	0	68794
10	302	-40	28575	68901	70	0	68901
11	412	-40	65639	67738	70	0	67738
12	406	-40	59671	67842	70	0	67842
13	364	-40	28555	68296	70	0	68296
14	339	-40	33344	68540	70	0	68540
15	325	-40	15469	68667	70	0	68667
16	326	-40	15362	68667	70	0	68667
17	342	-40	23779	68511	70	0	68511
18	337	-40	53607	68560	70	0	68560
19	335	-40	29309	68579	70	0	68579
20	335	-40	17208	68579	70	0	68579
21	335	-40	28097	68579	70	0	68579
22	335	-40	22762	68579	70	0	68579
23	308	-40	15730	68842	70	0	68842
24	282	-40	18858	69096	70	0	69096
25	292	-40	34292	68998	70	0	68998
26	264	-40	48440	69271	70	0	69271
27	259	-40	46842	69320	70	0	69320
28	259	-40	33295	69320	70	0	69320
29	324	-40	5635	68686	70	0	68686
30	324	-40	19147	68686	70	0	68686
31	306	-40	33564	68862	70	0	68862
32	306	-40	14909	68862	70	0	68862
33	279	-40	17976	69125	70	0	69125
34	279	-40	48810	69125	70	0	69125

TABLE F.2-U (CONT.) U REV. 1-2/76

NORMAL CYCLE PRIMARY PLUS SECONDARY RANGE EVALUATION

STRESS RANGE DATA LOAD CASE 8 USED AS REFERENCE

LOC	MAX TEMP	MIN TEMP	STRESS RANGE	ALLOWABLE STRESS	MIN TEMP	STRESS RANGE	ALLOWABLE STRESS
1	320	-40	31105	68725	70	31105	58830
2	317	-40	29214	68755	70	29214	58859
3	295	-40	20607	68969	70	20607	59074
4	272	-40	19408	69193	70	19408	59298
5	261	-40	28962	69301	70	28962	59405
6	261	-40	18230	69301	70	18230	59405
7	345	-40	40639	68472	70	40639	58576
8	342	-40	37172	68511	70	37172	58615
9	313	-40	20826	68794	70	20826	58898
10	302	-40	23017	68901	70	23017	59005
11	412	-40	55058	67738	70	55058 ←	57843
12	405	-40	49743	67842	70	49743	57946
13	364	-40	22811	68296	70	22811	58401
14	339	-40	27968	68540	70	27968	58645
15	326	-40	15155	68667	70	15155	58771
16	326	-40	15039	68667	70	15039	58771
17	342	-40	20108	68511	70	20108	58615
18	337	-40	52018	68560	70	52018	58664
19	335	-40	25535	68579	70	25535	58684
20	335	-40	16086	68579	70	16086	58684
21	335	-40	28455	68579	70	28455	58684
22	335	-40	20374	68579	70	20374	58684
23	308	-40	14361	68842	70	14361	58947
24	282	-40	17337	69096	70	17337	59200
25	292	-40	37032	68998	70	37032	59103
26	264	-40	33559	69271	70	33559	59376
27	259	-40	46095	69320	70	46095	59425
28	259	-40	33027	69320	70	33027	59425
29	324	-40	4263	68686	70	4263	58791
30	324	-40	15841	68686	70	15841	58791
31	306	-40	30737	68862	70	30737	58966
32	306	-40	14103	68862	70	14103	58966
33	279	-40	19863	69125	70	19863	59230
34	279	-40	43866	69125	70	43866	59230

TABLE F.2 - (CONT.) REV. 1-2/76

NORMAL CYCLE PRIMARY PLUS SECONDARY RANGE EVALUATION

STRESS RANGE DATA LOAD CASE 16 USED AS REFERENCE

LOC	MAX TEMP	MIN TEMP	STRESS RANGE	ALLOWABLE STRESS	MIN TEMP	STRESS RANGE	ALLOWABLE STRESS
1	320	-40	31803	68725	70	31803	58830
2	317	-40	29537	68755	70	29537	58859
3	295	-40	27337	68969	70	22364	59074
4	272	-40	20174	69193	70	17651	59298
5	261	-40	30923	69301	70	30694	59405
6	261	-40	16498	69301	70	16498	59405
7	345	-40	51051	68472	70	40639	58576
8	342	-40	47365	68511	70	37172	58615
9	313	-40	23055	68794	70	18484	58898
10	302	-40	28575	68901	70	23017	59005
11	412	-40	65633 ←	67738	70	55058 ←	57843
12	406	-40	59671	67842	70	49743	57946
13	364	-40	28555	68296	70	21464	58401
14	339	-40	33344	68540	70	27968	58645
15	326	-40	18667	68667	70	18353	58771
16	326	-40	18560	68667	70	18237	58771
17	342	-40	23779	68511	70	23242	58615
18	337	-40	32843	68560	70	32843	58664
19	335	-40	25822	68579	70	22048	58684
20	335	-40	20319	68579	70	20319	58684
21	335	-40	38976	68579	70	38976	58684
22	335	-40	31241	68579	70	31240	58684
23	308	-40	14250	68842	70	11408	58947
24	282	-40	20355	69096	70	18834	59200
25	292	-40	38296	68998	70	38296	59103
26	264	-40	40505	69271	70	25624	59376
27	259	-40	48087	69320	70	47340	59425
28	259	-40	32050	69320	70	31782	59425
29	324	-40	4965	68686	70	4283	58791
30	324	-40	18477	68686	70	15171	58791
31	306	-40	33673	68862	70	33673	58966
32	306	-40	20787	68862	70	20787	58966
33	279	-40	28874	69125	70	28874	59230
34	279	-40	48810	69125	70	45465	59230

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NL Industries has revised and/or expanded sections of the NLI 10/24 Rail Cask Safety Analysis Report and submits h the Safety Analysis

ENCLOSURES: Report.....

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