TECHNICAL DIVISION
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From: A. A. TUDOR, 773-41A
A. A. Tudor

PKL REACTOR TANK BOTTOM PRESSURES IN ACCIDENT SCENARIOS

INTRODUCTION

Nuclear Engineering Division requested estimates of the maximum PKL reactor tank pressures associated with postulated reactor accidents (reference 1). Tank bottom pressures calculated in establishing confinement protection limits (CPL) in Mark 16B-31 and Mark 22 reactor charges are given in this document. These pressures supersede previous estimates given to NED (reference 3). An estimated tank bottom pressure of 13 psig in a Loss of Pumping Accident, given in reference 2, is still valid. This estimate was obtained from reference 4.

SUMMARY

CPL and the associated maximum tank bottom pressures for Mark 16B-31 and Mark 22 charges are given in the following Table.

Confinement Protection Limits and Reactor Tank Bottom Pressures

Charge: PKL Generic Mark 16B-31

SSS Ink Delay,sec	0.7	T_{eff}, °C				Target power MW		Max Rx tank bottom pres, psig
		Assy						
Plenum Inlet, °C		Mk16B	Mk31A	Mk 31B	Rx	Mk31A	Mk 31B	
31.9		120.6	120.3	120.4	103.4	7.06	5.86	26.7
41.9		120.2	119.7	119.7	103.5	7.06	5.88	26.7
52.3		120.3	120.5	120.4	103.4	7.06	5.91	26.3
SSS Ink Delay,sec	1.2							
Plenum Inlet, °C								
31.9		119.2	119.2	119.2	103.4	7.06	(1)	26.1
41.9		119.7	119.6	119.6	103.4	7.06	(1)	26.0
52.3		120.0	120.3	119.8	103.4	7.06	(1)	26.0

Charge: K Mark 22

SSS Ink Delay,sec	0.7			1.2		
	T_{eff}, °C		Max Rx tank bottom pres, psig	T_{eff}, °C		Max Rx tank bottom pres, psig
Plenum Inlet, °C	Mk 22	Rx		Mk 22	Rx	
32.7	115.3	103.3	24.1	114.2	103.3	24.5
42.7	117.2	103.3	24.2	115.8	103.3	24.2
53.0	119.0	103.3	24.3	117.8	103.3	24.2

(1) LOTA calculations are incomplete.

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DISCUSSION

Confinement protection limits (CPL) are established for SRP reactor charges to limit the steam pressure force to a value less than would be required to lift the plenum in the following postulated reactor accidents:

Single rod withdrawal (SRW) at operating power.

Gang rod withdrawal (GRW) at operating power.

Loss of target (LOTA) at operating power for Mk16B-31 charges..

Pump shaft break (PSB).

Rotovalve closure (RVC) in systems 2 & 5.

Loss of AC power to the D_2O pump motors (LOAC) with the DC pump motors operating.

Loss of H_2O flow in both (A & B) headers.

CPL are calculated with AA3 which calculates tank pressures generated during the transients. Pressure at the reactor tank bottom is calculated by AA3 as;

PBOTT = (SPRES + BGASP + static pressure + atms pressure), $_{psia}$.

where PBOTT = reactor tank bottom pressure.

SPRES = steam pressure.

BGASP = blanket gas pressure.

static pressure = 19.3 × 0.455 = static head (ft) converted to psia.

atms pressure = 14.7 $_{psia}$.

The gage pressures given in this document are maximum values of PBOTT in the CPL calculations minus 14.7. Tank pressures for the Mk16B-31 transients were obtained from current AA3 calculations to revise the generic Mk16B-31 CPL to include "heavy Mk16B" charges irradiated to 5.5% ^{240}Pu subcycles and to include effects of double pressure plate bottom fitting inserts. The Mark 22 pressures were obtained from recent AA3 calculations of CPL for the 432 assembly K-13 Mk22 charge irradiated to 58% ^{235}U burnup. CPL are defined for an ink delay of 0.7 sec. Calculations are also made for an ink delay of 1.2 sec to assess the sensitivity of CPL to the ink delay. Results of the AA3 calculations are given in Tables 1 and 2. Previous estimates of reactor tank maximum pressures given in reference 3 were psia, but because of a transcription error, they were labeled psig.

REFERENCES

1. W. E. Jule to F. Beranek. *L Reactor Tank Bottom Pressure*, letter, February 18, 1987.

2. J. A. Smith and J. P. Church to C. E. Ahlfeld. memorandum, October 9, 1985.

3. D. A. Sharp to W. E. Jule. *Maximum Tank Pressures During Postulated Accidents - PKL Reactors*, letter, December 16, 1986.

4. J. A. Smith. *Reactor Pressure Relief Calculations*, DPST-81-718, September 15, 1981..

Table 1

AA3 Calculation Results for Generic Mark 16B-31 CPL IN PKL

Acc	RWT °C	Reactor Power, MW	P. I. °C	Teff, °C Mk16B	Mk31A	Mk31B	Rx	Ink Delay, sec	Max Force,* 10^6 lbs	Max Btm Pres,** psig
SRW	5	3107	31.78	122.42	122.24	122.30	103.74	0.7	0.532	21.2
	20	2675	41.85	121.92	121.81	121.90	103.75	0.7	0.506	20.6
	35	2220	52.30	121.99	121.97	122.01	103.59	0.7	0.511	20.8
	5	3107	31.78	122.42	122.24	122.30	103.74	1.2	0.574	22.3
	20	2675	41.85	121.92	121.81	121.90	103.75	1.2	0.517	21.0
	35	2220	52.30	121.99	121.97	122.01	103.59	1.2	0.531	21.3
GRW	5	3107	31.90	122.01	122.02	122.05	103.51	0.7	0.714	25.6
	20	2675	41.95	120.81	120.69	120.28	103.58	0.7	0.711	25.6
	35	2220	52.39	120.60	120.80	120.94	103.45	0.7	0.715	25.7
	5	3107	31.90	121.50	121.50	121.47	103.53	1.2	0.714	25.6
	20	2675	41.95	120.05	119.69	119.71	103.60	1.2	0.702	25.6
	35	2220	52.39	120.15	120.32	119.80	103.47	1.2	0.712	25.8
LOTA	5	3107	31.90	120.62	120.73	120.47	103.55	0.7	0.710	25.9
	20	2675	41.95	120.81	120.69	120.28	103.58	0.7	0.697	25.5
	35	2220	52.39	120.67	120.91	121.00	103.46	0.7	0.709	25.5
	5	(1)								
	20	(1)								
	35	(1)								
PSB	5	3107	31.90	120.94	121.20	121.21	103.54	0.7	0.710	26.7
	20	2675	41.95	122.17	122.07	121.95	103.55	0.7	0.709	26.7
	35	2220	52.39	122.85	122.85	123.00	103.40	0.7	0.714	26.3
	5	3107	31.90	120.09	120.39	119.98	103.56	1.2	0.713	26.1
	20	2675	41.95	120.77	120.73	120.69	103.58	1.2	0.712	26.0
	35	2220	52.39	121.65	121.39	121.62	103.44	1.2	0.712	26.0
RV Closure Sys 2&5	5	3107	31.90	120.62	120.26	120.47	103.55	0.7	0.710	25.5
	20	2675	41.95	120.19	119.69	119.71	103.58	0.7	0.657	24.4
	35	2220	52.39	120.30	120.50	120.64	103.45	0.7	0.642	24.0
	5	3107	31.90	119.21	119.26	119.22	103.58	1.2	0.700	25.7
	20	2675	41.95	119.72	119.56	119.66	103.60	1.2	0.707	25.7
	35	2220	52.39	120.30	120.50	120.64	103.45	1.2	0.708	25.6

*Limiting force on reactor top shield = 0.715×10^6 lb.

** Maximum pressure generated at reactor tank bottom, psig.

(1) Calculations for LOTA with 1.2 sec ink delay are incomplete.

Table 1 (Cont'd)

AA3 Calculation Results for Generic Mark 16B-31 CPL IN PKL

Acc	RWT °C	Reactor Power, MW	P. I. °C	Teff, °C Mk16B	Mk31A	Mk31B	Rx	Ink Delay, sec	Max Force,* 10^6 lbs	Max Btm Pres,** psig
LOAC	5	3107	31.97	121.81	121.82	121.84	103.37	0.7	0.641	23.9
	20	2675	42.02	120.63	120.51	120.11	103.46	0.7	0.498	21.2
	35	2220	52.44	120.15	1120.35	120.49	103.35	0.7	0.481	20.8
	5	3107	31.97	121.81	121.82	121.84	103.37	1.2	0.714	25.6
	20	2675	42.02	120.63	120.51	120.11	103.46	1.2	0.543	22.4
	35	2220	52.44	120.15	120.35	120.48	103.35	1.2	0.549	22.0
Loss of H_2O Flow	5	3107	31.90	122.01	122.02	122.05	103.51	0.7	0.321	15.9
	20	2675	41.95	120.81	120.69	120.28	103.58	0.7	0.238	14.5
	35	2220	52.39	120.30	120.50	120.64	103.45	0.7	0.247	14.7
	5	3107	31.90	122.01	122.02	122.05	103.51	1.2	0.328	16.4
	20	2675	41.95	120.81	120.69	120.28	103.58	1.2	0.242	14.6
	35	2220	52.39	120.30	120.50	120.64	103.45	1.2	0.235	14.3

*Limiting force on reactor top shield = 0.715×10^6 lb.

** Maximum pressure generated at reactor tank bottom, psig.

(1) Calculations for LOTA with 1.2 sec ink delay are incomplete.

Table 2

AA3 Calculation Results for K-13 Mark 22 CPL

Acc	RWT °C	Reactor Power,MW	P. I. °C	Teff, °C Mk22	Teff, °C Rx	Ink Delay sec	Max Force* 10^6 lbs	Max Btm Pres** psig
SRW	5	3093	32.75	119.11	103.34	0.7	0.357	17.0
	20	2660	42.69	119.18	103.35	0.7	0.357	17.0
	35	2207	53.02	119.11	103.29	0.7	0.354	17.0
	5	3093	32.75	119.11	103.34	1.2	0.387	17.8
	20	2660	42.69	119.18	103.35	1.2	0.369	17.4
	35	2207	53.02	119.11	103.29	1.2	0.368	17.3
GRW	5	3093	32.75	119.11	103.34	0.7	0.515	20.9
	20	2660	42.69	119.18	103.35	0.7	0.518	21.0
	35	2207	53.02	119.11	103.29	0.7	0.536	21.4
	5	3093	32.75	119.11	103.34	1.2	0.544	21.7
	20	2660	42.69	119.18	103.35	1.2	0.538	21.8
	35	2207	53.02	119.11	103.29	1.2	0.562	22.1
PSB	5	3092	32.74	115.31	103.33	0.7	0.616	24.0
	20	2660	42.69	117.26	103.33	0.7	0.617	24.2
	35	2210	53.04	118.99	103.33	0.7	0.618	24.3
	5	3092	32.74	114.23	103.35	1.2	0.618	24.3
	20	2660	42.69	115.86	103.35	1.2	0.618	24.2
	35	2210	53.04	117.82	103.36	1.2	0.616	24.2
RV Closure Sys 2&5	5	3097	32.78	119.36	103.36	0.7	0.617	24.1
	20	2663	42.71	120.50	103.32	0.7	0.617	24.1
	35	2212	53.05	120.04	103.34	0.7	0.533	22.1
	5	3095	32.76	117.01	103.35	1.2	0.617	24.5
	20	2662	42.71	118.37	103.34	1.2	0.616	24.2
	35	2212	53.05	119.51	103.35	1.2	0.606	23.9
LOAC	5	3093	32.75	120.08	103.35	0.7	0.452	19.5
	20	2659	42.68	120.05	103.33	0.7	0.429	18.9
	35	2209	53.03	120.07	103.35	0.7	0.402	18.2
	5	3093	32.75	120.08	103.35	1.2	0.486	21.0
	20	2659	42.68	120.05	103.33	1.2	0.454	20.2
	35	2209	53.03	120.07	103.35	1.2	0.421	19.2

*Limiting force on reactor top shield = 0.618×10^6 lb.

** Maximum pressure generated at reactor tank bottom, psig.

Table 2 (Cont'd)

AA3 Calculation Results for K-13 Mark 22 CPL

Acc	RWT °C	Reactor Power, MW	P. I. °C	Teff, °C Mk22	Teff, °C Rx	Ink Delay sec	Max Force* 10^6 lbs	Max Btm Pres** psig
Loss of	5	3093	32.75	120.07	103.35	0.7	0.247	14.7
H_2O	20	2659	42.68	120.04	103.33	0.7	0.250	14.5
Flow	35	2209	53.03	120.07	103.35	0.7	0.238	14.4
	5	3093	32.75	120.07	103.35	1.2	0.248	14.9
	20	2659	42.68	120.04	103.33	1.2	0.253	14.9
	35	2209	53.03	120.07	103.35	1.2	0.243	14.6

*Limiting force on reactor top shield = 0.618 × 10^6 lb.

** Maximum pressure generated at reactor tank bottom, psig.