GPU Nuclear

GPU Nuclear Corporation
Post Office Box 480
Route 441 South
Middletown, Pennsylvania 17057-0191
717 944-7621
TELEX 84-2386
Writer's Direct Dial Number:

August 2, 1984
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Office of Nuclear Reactor Regulation
Attn: John F. Stolz, Chief
Operating Reactors Branch No. 4
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Stolz:

Three Mile Island Nuclear Station, Unit I, (TMI-1)
Operating License No. DPR-50
Docket No. 50-289
Supplement to Technical Specification Change Request No. 135, Rev.1

The attached analysis provides supplemental justification for Technical Specification Change Request No. 135 Rev. 1 (GPUN letter 5211-84-2175, July 11, 1984) as discussed with C. Nichols and D. DiIanni of your staff. This analysis is consistent with and provides further details of the safety evaluation provided with TSCR 135 Rev. 1, and demonstrates the explosion resistance of the TMI-1 Waste Gas Holdup System under worst case conditions.

Sincerely,

H. D. Hukill,
Director, TMI-1

Enclosure

cc: J. Van Vliet
D. DiIanni
T. Gerusky
J. H. Kopp
J. E. Minnich

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The explosion resistance of the TMI-1 WGHS is based upon the magnitude of the pressure pulse resulting from ignition of worst case H_2/air mixtures regardless of whether detonation or deflagration occurs. The pressure pulse is defined in terms of the multiplication factor F where:

$$F = \frac{Pmax}{P}$$

where P is the pressure of the system in psia before ignition of a H_2/air mixture and Pmax is the maximum pressure resulting from the ignition event.

The experimental data (see Table 1, Table 2 and Table 3) show that

$$F = \frac{Pmax}{P} = 5$$

is a conservative value for the worst case waste gas system H_2/air mixtures. Furthermore these data are consistent with the theoretically derived (NUREG/CR-2726, section 2.3.2, figure 2-10; EPRI/NP-2955, section 5, page 5-9 and 5-10, figure 5-21) combustion Pmax/P factors where the lower, relative to theory, experimental values are due to heat loss which is not taken into account in the theoretical treatment. The experimental data and theoritical comparison in Figure 2-19 of NUREG/CR 2726, Figure 1.2-1 of EPRI/NP-3476 and Figure 5-21 of EPRI/NP-2955 substantiate this approach. Considering the extent of conservatism and consistency of the experimental data with theory, the use of 5.0 for the worst case of H_2 % level mixtures feasible is deemed appropriate for the waste gas system tank analysis.

Two worst case scenarios, for introducing H_2 into the waste gas system, are addressed as follows:

1) H_2 degassing of water transferred to tanks venting to the waste gas system
2) H_2 venting of the makeup tank to the waste gas decay tank

The following analysis was used to determine the highest H_2 content in air mixture possible for these scenarios:

I. H_2 via degassing

The quantity (V_d) of H_2 resulting from transferring 11050 ft^3 (i.e. the equivalent of one reactor coolant bleed tank water volume) of reactor coolant water at 70°F containing 40 scc/kg of dissolved H_2 is:

V_d = 40 scc/kg X 0.001 kg/g X .998 g/cc X 11050 ft^3

= 441 scf

Now the minimum gas volume of the waste gas system upstream of the compressors is 3806 ft^3 therefore the resultant H_2 concentration would be

$$\frac{441\ scf}{3806\ ft^3} \times 100 = 11.6\%$$

II. H_2 via Makeup Tank Venting

The quantity (V_u) of H_2 resulting from venting the makeup tank to the decay tank is comprised of H_2 from changing the makeup tank gas space (205 ft^3) pressure from 35 to 18 psig (V_2):

$$P_1 V_1 = P_2 V_2$$

$$(35-18)\ 205 = 14.7\ V_2$$

$$V_2 = 237 \text{ scf}$$

and H_2 degassing (V_d) of the water in the makeup tank (395 ft^3) due to the 35 to 18 psig pressure change (i.e. dissolved H_2 content will go from 38.5 scc/kg at 35 psig to 20.0 scc/kg at 18 psig):

$$V_d = (38.5 - 20.0) \text{ scc/kg X } 0.001 \text{ kg/g X } .998 \text{ g/cc X } 395 \text{ ft}^3$$

$$= 7 \text{ scf}$$

so

$$V_u = V_2 + V_d = 237 + 7 = 244 \text{ scf}$$

The highest H_2 concentration would result for transfer of this 244 scf of H_2 to a decay tank containing air at 0 psig (1125 ft^3 of air):

$$\frac{244}{1125 + 244} = \frac{244}{1369} \text{ X } 100 = 17.8\%$$

Although 17.8% is the highest H_2 concentration achievable, this would not present the worst case combustion effects. The pressure pulse is the product of the multiplication factor and the initial operating pressure. The highest operating pressure achievable in a decay tank with a combustible H_2 mixture (5%) containing 244 scf of H_2 is:

$$14.7(1369 \text{ X } \frac{17.8}{5.0}) = P\ (1125)$$

$$P = 63.7 \text{ psia (basis of ** in Table 3)}$$

The hoop stress equation used for the present tank analysis is

$$\sigma = \frac{P\ F\ D}{2t}$$

where σ is the stress in psia
P is the tank pressure prior to ignition in psia
F is the pressure pulse factor equal to Pmax/P
D is the component diameter in inches
t is the tank wall thickness in inches

In order to demonstrate the combustion pressure pulse capabilities of the tanks and pipes, rearrange this equation to analyze for F_u (pressure pulse factor which will result in a stress equal to the materials ultimate stress value)

$$F_u = \frac{\sigma_u \, 2 \, t}{P \, D}$$

which can then be compared to the F=5.0 value. Table 4 shows the equation parameters and resultant analysis. Clearly the tanks and pipes will survive combustion pressure pulses of H_2/air mixture having the above stated worst case H_2 contents.

As stated in the safety evaluation for TSCR 135 Rev. 1, the largest feasible volumes of hydrogen were assumed to be introduced into the waste gas system for both types of transfer. Three key conservative assumptions were made: 100% air, instead of the operationally realistic nitrogen, is taken as the dilutent gas; no credit is taken for pressure relief via safety devices which is not realistic for the type conditions found for the worst cases in the analysis and no credit is given for corrective action which would normally occur as a result of the H_2/O_2 alarm set points. This analysis demonstrates that the existing system design and the proposed specification (TSCR 135 Rev 1) assure an equivalent level of protection against the release of radiation from the TMI-1 WGHS as the existing technical specifications.

TABLE 1

From Table D-1 (page D-6) EPRI Report: Hydrogen Combustion and Control Studies in Intermediate Scale, EPRI NP-2953, Final Report, June 1983

H_2 % Vol	P_i (psia)	Pmax (psia)	Pmax/P_i
5	18.4	26.5	1.4
7.5	19.0	53.2	2.8
10.7	21.2	68.7	3.2
10.7	20.2	69.0	3.4
7.5	19.1	59.3	3.1
7.5	19.4	58.7	3.0
7.5	20.7	52.3	2.5
10.7	20.9	69.0	3.3

$$\frac{\text{test vessel length}}{\text{test vessel diameter}} = \frac{17'}{7'} = 2.4$$

TABLE 2

From Table 2 (page 30) of L. W. Carlson, R. M. Knight and J. O. Henrie, Flame and Detonation Initiation and Propagation in Various Hydrogen - Air Mixtures, with and without Water Spray, Atomics International Report AI-73-29, May 11, 1973

H_2 % Vol	P_i (psia)	Pmax (psia)	Pmax/P_i
12	14.7	28.9	2.0
12	22.0	54	2.5
12	29.4	64	2.2
16	14.7	48.8	3.3
16	22.0	70	3.2
16	29.4	85	2.9
11	13.8	18.2	1.3

$$\frac{\text{test vessel length}}{\text{test vessel diameter}} = \frac{40'}{1.3'} = 30$$

TABLE 3

From Table 5-1 (page 5-18) and 5-2 (page 5-20) EPRI Report: Intermediate-Scale Combustion-Studies of Hydrogen-Air-Steam Mixtures, EPRI NP-2955, Final Report, June 1984

H_2 % Vol	P_i (psia)	Pmax (psia)	Pmax/P_i
5	14.2	16.1	1.13
5.5	14.2	17.7	1.25
5	14.2	15.7	1.11
5	14.2	15.4	1.09
5	14.2	15.2	1.07
6	14.2	18.1	1.28
5.5	14.2	29.4	2.07
7	14.2	32.3	2.28
7	14.2	37.6	2.65
6.2	14.2	21.0	1.48
6	14.2	26.8	1.89
6	14.2	23.6	1.66
8	14.2	35.4	2.49
8	14.2	32.5	2.29
8	14.2	19.7	1.39
8	14.2	41.3	2.91
7	14.2	30.2	2.13
7	14.2	20.7	1.46
7	14.2	34.8	2.45
10	14.2	45.4	3.20
14	14.2	56.3	3.96
11	14.2	46.8	3.30
8	14.2	40.3	2.84
8.5	14.2	37.0	2.61
7	14.2	35.2	2.48
5.7	14.2	25.1	1.77
8.4	14.2	39.6	2.79
10	14.2	51.9	3.65
5	14.2	15.7	1.11
6	14.2	39.6	2.79
8.5	14.2	37.0	2.61
8.5	14.2	47.9	3.37
7.5	14.2	17.1	1.20
5.5	14.2	17.0	1.20
15.0	14.2	58.1	4.09
20.0	14.2	70.8	4.99
10.0	14.2	45.4	3.20
11.0	14.2	45.5	3.20

TABLE 3 Cont'd

10.0	14.2	37.3	2.63
10.0	14.2	35.7	2.51
10.0	14.2	30.5	2.15
16.0	14.2	56.7	3.99
21.0	14.2	60.8	4.28
15.6	14.2	51.2	3.61
20.0	14.2	70.2	4.94
22.2	14.2	57.7	4.06
10.0	14.2	44.7	3.15

TABLE 4

WASTE GAS SYSTEM MAJOR COMPONENT ANALYSIS

	d(in)	L (in)	t (in)	σ_u (psia)	P (psia)	Fu
Misc. Waste Storage Tanks	165.75	286.5	0.375	75,000	16.5*	20.6
RC Bleed Tanks	240.8	540.63	0.40	75,000	16.5*	15.1
Delay Tank	96	136	0.375	55,000	16.5*	26.0
Decay Tank	120	212.75	0.813	55,000	63.7** 94.7***	11.7 7.87
Schedule 40 carbon steel pipe	1.61(1 1/2") 3.068(3")	- -	.145 .216	70,000 70,000	16.5* 16.5*	764 597
Schedule 40 SS steel pipe	1.61(1 1/2")	-	.145	75,000	94.7***	143

* - compressor operation initiated at this pressure, is the basis for this prior to ignition pressure

** - highest combustible mixture pressure resulting from makeup tank venting

*** - operational limit for tank pressurization