UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
COMBUSTIBLE GAS CONTROL IN CONTAINMENT
HADDAM NECK PLANT
DOCKET NO. 50-213

1.0 INTRODUCTION

The requirements of 10 CFR 50.44(c)(3)(ii) state that each light-water nuclear power reactor that relies upon a purge/repressurization system as the primary means for controlling combustible gases following a LOCA shall be provided with either an internal recombiner or the capability to install an external recombiner following the start of an accident.

By letter dated March 4, 1983, the Connecticut Yankee Atomic Power Company (the licensee) submitted a report on combustible gas control for the Haddam Neck plant to document its position against the above regulation. Based on its analysis, the licensee indicated that a total of 475 pounds of hydrogen must be released to the containment in order to obtain a flammable gas mixture (i.e., 4% by volume concentration of hydrogen inside containment) and this flammable limit would not be reached until approximately 13 months from the onset of a design-basis LOCA if the containment was not purged before then. Subsequently, the licensee revised the analysis and changed the time to reach the flammability limit from 13 months to 8.5 months. The licensee also stated that the hydrogen concentration could be diluted by pressurizing the containment with air. Increasing the containment pressure to one fourth of design pressure could maintain the hydrogen concentration below the flammable limit for a time interval of ten years. Thus, the licensee's position on combustible gas control is that the plant relies upon the specific design features of the containment as the primary (passive) means of control of hydrogen generation without requiring use of the purge system. The licensee stated that use of the purge/repressurization system, or the installation of an external hydrogen recombiner could be implemented within the above time frame before the containment atmosphere reaches the lower flammability limit. Based on the analysis and the long time frame to take action to supplement the existing purge/repressurization means of hydrogen control, the licensee concluded that the plant need not be provided with a hydrogen recombiner capability. By letter dated May 19, 1989, the licensee further emphasized that the plant would not require hydrogen recombiner capability. The licensee's analysis and position on combustible gas control for the plant are discussed in the following evaluation.

2.0 EVALUATION

The staff reviewed the licensee's initial analysis of combustible gas control at the Haddam Neck plant. The licensee assumed 5% of the mass of metal in the cladding cylinder surrounding the fuel, excluding the cladding surrounding the plenum

volume reacted with the reactor coolant to produce hydrogen post-LOCA. This 5% of the fuel rod cladding that is oxidized results in 56.5 lbs of hydrogen being generated. Since the plant utilizes stainless steel clad fuel, the expected amount of hydrogen generated by metal-water reaction will be less than in those plants utilizing zircaloy clad fuel. The staff found the licensee's analysis for short-term hydrogen generation to be conservative. However, the licensee also stated that under a strict interpretation of 10 CFR 50.44, the regulation does not apply to the Haddam Neck plant because it was specifically written for plants with zircaloy fuel cladding. The staff finds this interpretation of the regulation incorrect, since the Amendment to 10 CFR 50.44, published in the Federal Register (Volume 46, No. 231, December 2, 1981) explicitly addressed this point indicating applicability of 10 CFR 50.44 to all light water reactors with either zircaloy or stainless steel cladding.

The licensee also calculated the radiolytic decomposition of the post-accident emergency cooling solutions by assuming a hydrogen generation rate from radiolysis of 0.44 mole/100eV absorbed. The licensee used this value as an upper bound for the radiolytic yield of hydrogen in lieu of the value 0.5 mole/100eV given in Regulatory Guide (RG) 1.7, Revision 2. The radiolysis of water in the containment sump and the portion of hydrogen generated from zinc and aluminum protective coatings inside containment were neglected in licensee's original analysis. The staff found that the licensees analysis for long-term hydrogen generation deviated from the guidelines of RG 1.7 and informed the licensee of this concern. By letter dated November 17, 1986, the licensee provided additional information and revised its original analysis to include the hydrogen generated from corrosion of zinc and aluminum protective coatings inside containment. The revised analysis indicated that the hydrogen flammability limit would be reached in 8.5 months versus the 13 months originally calculated.

In order to evaluate the adequacy of the licensee's calculated hydrogen generation values, the staff performed a confirmatory analysis in accordance with RG 1.7 using the NRC approved COGAP computer code. The analysis indicated that the time required to reach flammability for a zircaloy core would be 180 days (or 6 months) versus the licensee's calculated 8.5 months. The difference in the time estimation to reach flammability is primarily due to differences in the licensee's calculation assumptions which deviate from RG 1.7 and Standard Review Plan Section 6.2.5 guidelines. The staff performed additional calculations to reduce the hydrogen concentration to 2.5 v/o by assuming the injection of air at 10 psi to the containment (equivalent to the licensee assumed one fourth of design pressure). The air injection was arbitrarily assumed to begin when the containment hydrogen concentration reached a value slightly less than 4 v/o and was assumed to be added for three days. The result showed that the hydrogen concentration would reach 4 v/o again after 840 days (or 28 months) from the beginning of a LOCA. Consequently, if the containment could be purged/repressurized on a intermittent basis, the hydrogen accumulation inside the containment could be maintained well below the flammable limit. The staff also found through the COGAP output that the hydrogen concentration would reach 3 v/o in 3 months following a design basis accident.

Because the licensee's primary means of combustible gas control is passive (i.e., reliance on containment design), and the large containment volume results in a low hydrogen accumulation rate, the staff finds that sufficient time exists following a LOCA to establish additional hydrogen control capability as may be necessary. In the May 19, 1989 letter, the licensee stated that a containment penetration was available which could be used to install an external hydrogen recombiner following a LOCA. Therefore, the staff finds that the licensee need take no further action in order to ensure adequate post accident hydrogen control.

3.0 CONCLUSION

Based on the above, the staff concludes that the large containment at Haddam Neck results in a slow hydrogen accumulation rate and ensures that sufficient time is available to implement additional hydrogen control features as may be necessary following an accident. Therefore, no further hydrogen control capability need be provided, and the plant meets the requirements of 10 CFR 50.44.

Dated: October 18, 1989

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