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

October 25, 1993

TO: ALL HOLDERS OF OPERATING LICENSES OR CONSTRUCTION PERMITS FOR NUCLEAR POWER REACTORS

SUBJECT: RESEARCH RESULTS ON GENERIC SAFETY ISSUE 106, "PIPING AND THE USE OF HIGHLY COMBUSTIBLE GASES IN VITAL AREAS" (GENERIC LETTER 93-06)

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this generic letter to inform addressees about technical findings resulting from the NRC resolution of Generic Safety Issue 106 (GSI-106), "Piping and the Use of Highly Combustible Gases in Vital Areas." It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this generic letter are not NRC requirements; therefore, no specific action or written response is required.

DISCUSSION

The basic regulatory requirement dealing with the storage, distribution, and use of combustible gases at nuclear power plants is General Design Criterion (GDC) 3, "Fire Protection," Appendix A, Part 50, Title 10 of the Code of Federal Regulations (10 CFR Part 50). This criterion states, in part, that "structures, systems, and components important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions." Additional discussion of the regulation of this subject is provided in NUREG-1364, "Regulatory Analysis for the Resolution of Generic Safety Issue 106: Piping and the Use of Highly Combustible Gases in Vital Areas," Section 1.2 (Enclosure 1).*

Reviews of plant literature, site visits, and discussions with licensees have indicated large differences in individual plant characteristics that could affect risk from failures of hydrogen system lines or components. These differences include the hydrogen storage and distribution system design features and relative locations of hydrogen components and safety-related equipment. On the basis of generic evaluations, the NRC staff has concluded that several possible methods to reduce risk, involving equipment modifications and administrative controls, could provide cost-effective safety benefits at some plants. However, the NRC staff also concludes, based on a small sample of plants, that the safety benefit of recommended actions for

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*Copies of this document are enclosed for addressees. For other readers, a copy of this document is available for inspection and copying in the NRC Public Document Room, 2120 L Street NW, Washington, DC 20037.

some or all licensees or applicants is marginal. The reviews indicated that a number of plants have system design characteristics, operating procedures, and other mitigating features that would be responsive to some or all of the concerns of this generic issue. While the staff analysis indicates that the industry-wide risk is small, it cannot preclude the possibility of larger risk at some plants. The NRC is aware that information relevant to 10 CFR Part 21, has been made available to licensees and applicants with General Electric boiling-water reactor (BWR) plant designs, emphasizing the need for individual licensees and applicants to determine the safety hazard of a postulated generator coolant hydrogen explosion in their plants (Enclosure 2). In addition, in March 1993, a turbine fire, which may have been caused by turbine blade failure, vibration, and hydrogen seal leakage, occurred in a nuclear power plant in India.

In view of the observed large differences in plant-specific characteristics affecting the risk associated with the use of hydrogen, and the marginal generic safety benefit that can be achieved in a cost-effective manner, the NRC intends to resolve this generic issue by making these results available in this generic letter. This information may help licensees in their plant evaluations recommended by Generic Letter 88-20, Supplement 4, "Individual Plant Examination of External Events for Severe Accident Vulnerabilities," June 28, 1991.

As part of the NRC evaluation of GSI-106, the risk from potential hydrogen system failures was analyzed by the Idaho National Engineering Laboratory (INEL). The technical findings are reported in NUREG/CR-5759, "Risk Analysis of Highly Combustible Gas Storage, Supply, and Distribution Systems in Pressurized Water Reactor Plants," July 1991; EGG-SSRE-10198, "Risk Analysis of Highly Combustible Gas Storage, Supply, and Distribution Systems in Pressurized Water Reactor Plants--Supplementary Cost/Benefit Analysis," March 1992; and EGG-NTA-9082, "Scoping Risk Analysis of Highly Combustible Gas Storage, Supply, and Distribution Systems in Boiling Water Reactor Plants," November 1991. In addition, the NRC staff evaluated the safety benefits and costs of implementing various alternatives to reduce generic risk in NUREG-1364. This regulatory analysis includes discussion of several precursor events involving the storage, distribution, and use of hydrogen (the combustible gas of principal concern) at nuclear power plants.**

The scope of GSI-106 included evaluation of the risk from (1) the storage and distribution of hydrogen for the volume control tank (VCT) in PWRs and the main electric generator in BWRs and PWRs; (2) other sources of hydrogen such as battery rooms, the waste gas system in PWRs and the offgas system in BWRs; and (3) small, portable bottles of combustible gases used in maintenance, testing, and calibration. The risk from large storage facilities outside the reactor, auxiliary, and turbine buildings is being addressed separately and is not within the scope of GSI-106.

**Copies of these reports are available for inspection and copying in the NRC Public Document Room, 2120 L Street NW, Washington DC 20037.

Screening studies described in NUREG/CR-5759 and EGG-NTA-9082 indicated small risk for the battery rooms, waste gas and offgas systems, and portable bottles. The assessment for the generic risk associated with the hydrogen distribution system to the electric generator at BWRs involved a vital area analysis for an actual plant configuration (a BWR-4 with a Mark I containment), supplemented by information obtained from visits to five other plants. The scoping analysis based on this sample of BWRs (two BWR-3s, two BWR-4s, and two BWR-5s) indicates a small generic risk, but cannot preclude the possibility of a larger plant specific risk because of the possible presence of safety-related equipment in the turbine building. In addition, this scoping analysis did not consider the effect of hydrogen explosions on barrier walls and on penetrations such as doors between the turbine building and the adjoining reactor, control, or auxiliary buildings for these six BWR plants.

The findings of a more detailed generic risk analysis for the distribution systems for the VCT and electric generator at PWRs are reported in NUREG/CR-5759. The hydrogen distribution systems to the VCT and generator are not located near the reactor and primary coolant system piping. Hence, hydrogen fires or explosions would not lead to such events as pipe break loss of coolant accidents (LOCAs), anticipated transients without scram, and steam generator tube ruptures. INEL divided the remaining transient-induced core damage events into transients with failure of decay heat removal systems (T/DHR) and transient-induced loss of coolant accidents (T/LOCA). The initiating event is either a random or seismically induced leak or break in the hydrogen system that releases hydrogen. This released hydrogen creates the potential for a fire or explosion that could cause loss of equipment and lead to either a T/DHR or a T/LOCA. The T/DHR events involve scenarios with loss of all forms of core cooling and coolant release at high pressure from the pressurizer safety and relief valves. The T/LOCA events involve failure of reactor coolant makeup or recirculation systems following a loss of reactor coolant pump seal cooling or stuck-open safety or relief valves. In its generic analysis of GSI-106, INEL addressed risks associated with the T/DHR and T/LOCA events and considered such plant functional characteristics as feed-and-bleed cooling capability and relative locations of hydrogen distribution systems and pertinent equipment (e.g., auxiliary feedwater, normal and emergency ac power, essential service water, and component cooling water).

For the auxiliary building, which may contain most of the safety-related systems at the plant, the following alternatives were found to be cost effective: (1) use of restricting orifices or excess flow valves to limit the maximum flow rate from the storage facility to the postulated break and (2) use of a smaller storage facility normally connected to the VCT to limit the maximum hydrogen release in a single event. An alternative involving use of a normally isolated supply with intermittent manual makeup was somewhat less cost-effective. These approaches include preoperational testing and subsequent retesting of excess flow valves and measures to prevent buildup of unacceptable amounts of trapped hydrogen and inadvertent operation with the safety features bypassed.

For the turbine building, which may also contain safety-related equipment, two cost-effective alternatives were found for protection against breaks in the hydrogen supply line up to the hydrogen control station below the generator, including any branch lines from this line to other buildings. These involve limits on the maximum flow rate or operation with a normally isolated supply. Isolation of the large quantities of hydrogen (up to about 700 standard cubic meters [25,000 standard cubic feet]) contained in the generator probably is not possible for most breaks downstream of the hydrogen control station. The only alternative considered applicable to breaks at or near the generator involved structural modifications to prevent fire or blast damage to affected safety-related equipment; this alternative was not found to be cost-effective.

Additional general measures for risk reduction, such as the use of color coding, warning signs and training to handle events in the auxiliary and turbine buildings were considered. Of these, training to stop hydrogen flow (e.g., isolation of the storage facility or venting and purging of the generator) and training to prevent associated large oil fires in the turbine building were deemed most important.

BACKFIT DISCUSSION

In this generic letter, the NRC is only communicating information on results of government-sponsored research to resolve a generic safety issue and is not recommending that licensees or applicants take particular courses of action or requesting that licensees communicate information back to the NRC on this matter. Consequently, this generic letter does not represent a backfit.

If you have any questions about this information, please call one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

Sincerely,

for James G. Partlow
Associate Director for Projects
Office of Nuclear Reactor Regulation

Enclosures:
1. NUREG-1364, "Regulatory Analysis for the Resolution of Generic Issue 106: Piping and the Use of Highly Combustible Gases in Vital Areas" (for addressees)
2. Letter from J. P. Riley, General Electric Company, to S. E. Scace, Millstone Nuclear Power Station, on "Postulated Hydrogen Explosion in a Non-United States Reactor Turbine Building Mezzanine," December 23, 1992
3. List of Recently Issued NRC Generic Letters

Technical Contacts: Gerald Mazetis, RES
(301) 492-3906

Vern Hodge, NRR
(301) 504-1861

ENCLOSURE 2

GE Nuclear Energy

General Electric Company
PO Box 910 Prestige Drive Meriden CT 06450

G-EH-92-052
December 23, 1992

RECEIVED
DEC 30 1992
PROJECT SERVICES DEPARTMENT
H.P. RISLEY

Mr. S.E. Scace
Vice President - Millstone Station
Millstone Nuclear Power Station
Northeast Utility Service Co.
P.O. Box 128
Waterford, CT. 06385

Subject: Postulated Hydrogen Explosion in a Non - United States Reactor Turbine Building Mezzanine

Dear Mr. Scace:

A BWR/3 utility located outside of the U. S., recently informed GE that a postulated hydrogen gas line break in the plant's Turbine Building mezzanine could result in a hydrogen detonation. U. S. BWR utilities may have similar turbine building configuration/equipment arrangements which could result in a similar condition. However, th: portion of the plant is in the utility's Architect Engineer's scope ‹ supply and therefore cannot be evaluated by GE within the context of the U.S. Code of Federal Regulations 10 CFR Part 21. GE is, therefore, obligated, under the requirements of 10 CFR Part 21, to pass this information on to the potentially affected BWR utilities sc that they can review the following information for applicability to their unique plant design.

At the subject plant, the pipe lines which carry hydrogen gas to cool the generator are routed from the hydrogen bottles outside the turbir building to the hydrogen controls in the turbine building mezzanine area and up to the generator. It was postulated that if a break occurred in one of these lines, up to 16,000 cubic feet (459 cubic meters) of hydrogen gas would rapidly blow down into the mezzanine (a semi-enclosed area). This room has a volume about 56,000 cubic feet (1,600 cubic meters) of oxygen so that even with uniform mixing, the average hydrogen concentration could easily exceed 25% by volume, which is well above the lower limit of a detonatable mixture (13% by volume).

A scoping calculation indicated that hydrogen gas could enter the roc from a major pipe break at an initial rate of about 10,000 cubic feet per minute (cfm), and release all 16,000 cubic feet in about three minutes. If all of the hydrogen were retained in the room, a detonatable concentration would exist. However, the mezzanine at thi plant is well ventilated with a ducted flow of 2,000 cfm of air and a total flow of about 30,000 cfm coming from other sources. Thus, a more realistic calculation yielded an average hydrogen concentration in the room of about 10%, which is equivalent to about 30 pounds of hydrogen. This 10% concentration can be ignited and result in an explosion.

At the subject plant, the room below the generator contains the hydrogen piping and generator output busses, their cooling and air conditioning systems, and the generator auxiliary equipment. This includes the piping containing hydrogen and oil mixtures. An opening in the structure supporting the generator indirectly exposes some of the plant's 1E and non-1E electrical busses to the effects of an explosion or a fire. Based on the above estimated average hydrogen gas concentration of 10% by volume in a part of the mezzanine, a conservatively estimated blast pressure of 40 psi would have to be contained at the opening to prevent blast waves from exiting this area and damaging the vital busses. To avoid the possibility of consequential damage, a recommendation will be made to the utility to provide a blast shield or ignitors to mitigate or prevent a potential blast.

GE recommends that all BWR utilities perform an evaluation to determine if a postulated generator coolant hydrogen explosion represents a substantial safety hazard at their facility.

Northeast Utilities should evaluate this information as it relates to existing or future plant equipment, conditions, procedures or plans. GE cannot determine if this information affects U. S. BWR utilities. GE is, therefore, notifying all U. S. BWR owners of this information. The owners of GE BWRs located outside the U. S. also will receive this information.

Sincerely,

J.P. Riley
Nuclear Services Manager
GE Nuclear Energy

cc: P.A. Blasioli
L.D. Davison
E.A. DeBarba
R.T. Harris
H.F. Haynes
H.P. Risley
W.D. Romberg
R.W. Tobin. GE Site

Notice

This 10 CFR Part 21 information pertains only to GE BWRs. GE Nuclear Energy (GE-NE) has not considered or evaluated the applicability, if any, of this information to any plant or facility other than GE BWRs.

LIST OF RECENTLY ISSUED GENERIC LETTERS

Generic Letter	Subject	Date of Issuance	Issued To
93-05	LINE-ITEM TECHNICAL SPECIFICATIONS IMPROVEMENTS TO REDUCE SURVEILLANCE REQUIREMENTS FOR TESTING DURING POWER OPERATION	09/27/93	ALL HOLDERS OF OLs OR CPs FOR NPRs
89-10, SUPP. 5	INACCURACY OF MOTOR-OPERATED VALVE DIAGNOSTIC EQUIPMENT	06/28/93	ALL LICENSEES OF OPERATING NUCLEAR POWER PLANTS AND HOLDERS OF CONSTRUCTION PERMITS FOR NUCLEAR POWER PLANTS
93-04	ROD CONTROL SYSTEM FAILURE AND WITHDRAWAL OF ROD CONTROL CLUSTER ASSEMBLIES, 10 CFR 50.54(f)	06/21/93	ALL HOLDERS OF OLs OR CPs FOR (W)-DESIGNED NPRs EXCEPT HADDAM NECK ALL HOLDERS OF OLs OR CPs FOR (CE)-DESIGNED AND (B&W)-DESIGN NPRs AND HADDAM NECK
93-03	VERIFICATION OF PLANT RECORDS	10/20/93	ALL HOLDERS OF OLs OR CPs FOR NPRs
93-02	NRC PUBLIC WORKSHOP ON COMMERCIAL GRADE PROCUREMENT AND DEDICATION	03/23/93	ALL HOLDERS OF OLs OR CPs FOR NPRs AND ALL RECIPIENTS OF NUREG-0040, "LICENSEE CONTRACTOR AND VENDOR INSPECTION STATUS REPORT" (WHITE BOOK)
93-01	EMERGENCY RESPONSE DATA SYSTEM TEST PROGRAM	03/03/93	ALL HOLDERS OF OLs OR CPs FOR NPRs, EXCEPT FOR BIG ROCK POINT AND FACILITIES PERMANENTLY OR INDEFINITELY SHUT DOWN
92-09	LIMITED PARTICIPATION BY NRC IN THE IAEA INTERNATIONAL NUCLEAR EVENT SCALE	12/31/92	ALL HOLDERS OF OLs OR CPs FOR NPRs

OL = OPERATING LICENSE
CP = CONSTRUCTION PERMIT