UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA ST., N.W.
ATLANTA, GEORGIA 30323

APR 0 7 1988

Report No.: 50-416/88-05

Licensee: System Energy Resources, Inc.
Jackson, MS 39205

Docket No.: 50-416 License No.: NPF-29

Facility Name: Grand Gulf

Inspection Conducted: March 7-11, 1988

Inspectors: R. R. Marston 4/5/88
R. R. Marston Date Signed

Accompanying Personnel: C. A. Hughey

Approved by: John B Kahle 4/5/88
J. B. Kahle, Section Chief Date Signed
Division of Radiation Safety and Safeguards

SUMMARY

Scope: This special, announced inspection was conducted in the areas of offgas system hydrogen control and offsite dose assessments during charcoal bed bypasses.

Results: No violations or deviations were identified.

REPORT DETAILS

1. Persons Contacted

   Licensee Employees

   R. Brinkman, Radiological Engineer
   *J. Cross, Site Director
   *C. Ellsaesser, Operations Coordinator
   *R. Hutchinson, General Manager
   J. Lassetter, HP/Chemistry Specialist
   *A. McCurdy, Manager, Plant Operations
   *J. Parrish, Chem/Rad Superintendent
   G. Smith, Plant Chemist
   *J. Summers, Compliance Coordinator

   Other licensee employees contacted included engineers, technicians, cperators, and office personnel.

   Other Organizations

   L. Nesbitt, General Electric Company

   Nuclear Ragulatory Commission

   *R. Butcher, Senior Resident Inspector
   *J. Mathis, Resident Inspector

   *Attended exit interview

2. Exit Interview

   The inspection scope and findings were summarized on March 11, 1988, with those persons indicated in Paragraph 1. The inspector described the areas inspected and discussed in detail the inspection findings listed below. No dissenting comments were received from the licensee. The licensee did not identify as proprietary any of the material provided to or reviewed by the inspector during this inspection.

3. Licensee Action on Previous Enforcement Matters

   This subject was not addressed in the inspection.

4. Introduction

   On February 27, 1988, while changing from the "B" to the "A" steam jet air ejector (SJAE), operations personnel noticed a sudden loss of offgas flow and spiking of the hydrogen (H_2) inline analyzers located in the offgas system. This was caused by a sudden burn of excess H_2 within the offgas system. Although this burn apparently caused only minor equipment damage, there was a potential for major equipment damage and personnel injury, exposure, and contamination.

The following paragraphs include a description of the event, the causes and corrective actions related to the burn and the dose assessment relating to the increase in gaseous radioactivity discharged from the plant.

5. General System Description

a. Design Objectives

The offgas system at Grand Gulf was designed to meet the following regulatory objectives:

- The ALARA objectives of 10 CFR 50, Appendix I
- The dose restrictions of 10 CFR 20, Appendix B
- General Design Criteria No. 60 (Control of Releases of Radioactive Materials to the Environment) and No. 64 (Monitoring of Radioactive Releases) of 10 CFR 50, Appendix A

The primary design objectives of the system were:

- To recombine hydrogen and oxygen gases produced in the reactor by the radiolytic decomposition of water and therefore reduce explosion hazards.
- To provide sufficient hold-up time for radioactive activation products and fission products to decay prior to release.
- To minimize the release of the particulate daughter products of noble gases.
- To provide for the controlled release of radioactive gases to the environment during normal and off-normal operating conditions.

b. System Description

The inspector reviewed system descriptions from the FSAR and current plant drawings, held discussions with licensee representatives, and performed a walkdown of the system with a cognizant licensee representative.

(1) There were two redundant offgas processing system trains, each one capable of processing the entire offgas flow from the plant (A and B trains). Each train was composed of systems to process noncondensable gases and to control the release of radioactive

effluents to the environment. The condenser air removal system and the offgas system perform these functions. Neither train contains rotating parts.

(2) Condenser Air Removal System

The condenser air removal system consists of a first stage steam jet air ejector (SJAE), an intercondenser and a second stage SJAE. Main steam flows to the air ejectors to:

- Pump noncondensable gases from the main condenser
- Provide the motive force for the offgas system
- Dilute the offgas stream to less than 4% hydrogen concentration, and
- Remove noncondensables from the offgas flow.

An intercondenser is located between the first and second stage SJAEs. The intercondenser is cooled by plant service water (PSW) and functions to remove moisture from the offgas flow.

The significant gaseous wastes removed from the main turbine condenser by the SJAEs consist of the following:

- Radiolytic hydrogen and oxygen
- Condenser air inleakage
- Nitrogen-13, Nitrogen-16, and Oxygen-19
- Krypton, Xenon, and Iodine isotopes

These gases are produced in the core region and travel to the main condenser along with the main steam.

(3) Offgas System

The offgas system begins at the outlet of the second stage SJAE and ends at a connection to the radwaste ventilation system. The following is a brief sequential discussion of the major system components and their operating functions.

(a) The offgas reheater (heat exchanger) superheats the gases and steam from the second stage SJAE to about 300°F before entering the recombiner. This increases the recombiner catalyst efficiency by eliminating moisture. Main steam is used as a heat source.

(b) The catalytic recombiner recombines the hydrogen and oxygen produced by radiolytic decomposition by passing the process flow over trays of a platinum alloy catalyst. The water vapor temperature at the exit of the recombiner is normally in excess of 600°F. Gas flow rate prior to the recombiner is in excess of 100 standard cubic feet per minute (SCFM) and is 20 SCFM as it exits the recombiner. This latter flow rate remains constant through the rest of the offgas system.

(c) The superheated water vapor and inleakage air mixture from the recombiner flows through the offgas condenser where the bulk of the water vapor is cooled (160°F), condensed and removed. This condenser (heat exchanger) is cooled by Turbine Plant Cooling Water (TPCW) flow through the tube side.

(d) The process flow enters a water separator where entrained water droplets are removed as the flow passes through a stainless steel wire mesh de-entraining element.

(e) Two redundant inline hydrogen analyzers continuously monitor the H_2 concentrations in the offgas process flow prior to entering the hold-up line. If a preset value on the monitors is exceeded, a main control room annunciator is actuated. An inline pretreatment radiation monitor also monitors the radioactivity of the process flow prior to entering the hold-up line. A more detailed discussion of these monitors is included in Paragraph 5.c.

(f) A hold-up line, consisting of a straight run of piping 500 feet long and 6 inches I.D. provides a delay of approximately seven and one-half minutes to allow for the decay of short-lived radionuclides.

(g) The cooler condenser (heat exchanger) cools the process flow by means of a glycol refrigeration system to as low as possible without freezing (35 °F). This removes moisture from the process flow.

(h) Another moisture separator removes any moisture droplets in the process flow that are not removed in the cooler condenser.

(i) A high efficiency particulate air prefilter element (aluminum separator and glass fiber filter elements) removes particulate daughter products of fission product gases from the process flow.

(j) Any additional moisture is removed by passing the process flow through one of four desiccant dryer beds. The dryer beds are regenerated on a regular basis using an electric heater/dryer chiller system. The dewpoint of the process flow after the desiccant dryers is normally about -80°F.

(k) Two redundant dewpoint analyzers continuously monitor the process flow relative humidity. Excess moisture in the process flow reduces the adsorption efficiency of noble gases on the charcoal beds.

(l) The gas coolers further cool the process flow prior to entering the charcoal adsorber beds by means of a glycol refrigeration system. This cooling helps increase charcoal adsorption efficiency.

(m) Eight charcoal adsorber vessels, each containing about three tons of charcoal, adsorb radioactive fission product gases (xenon and krypton) thereby allowing significant delay and allowing for their decay. Any particulate daughter products, along with radioactive isotopes of iodine, are retained in the charcoal beds. The gas coolers and adsorber beds are enclosed in a refrigerated vault kept at 0°F.

A bypass line is constructed around the gas coolers and adsorber beds and is used during startup.

(n) Two redundant post-treatment radiation monitors continuously monitor radiation levels within the process stream. These monitors provide for automatic termination of offgas releases in case of high radiation levels in the process stream. A more detailed discussion of these monitors is included in Paragraph 5.c.

(o) The process flow is then filtered through high efficiency particulate air (HEPA) after-filters to remove any remaining particulate daughter products and carbon dust.

(p) The final effluent from the offgas system is incorporated into the radwaste ventilation system which is monitored for radioactivity prior to release to the environment. A more detailed discussion of the radiation monitors is included in Paragraph 5.c.

(q) Several water-filled loop seals are located along each train to prevent gas escape from the process flow through various system drains.

c. Radiological Monitoring Systems

The following systems were evaluated:

(1) Offgas Pretreatment Radiation Monitoring System

This system monitors radioactivity in the condenser offgas at the inlet to the hold-up piping after it has passed through the offgas condenser and moisture separator. A continuous sample is extracted from the offgas pipe via a sample line. It is then passed through a sample chamber and sample panel before being returned to the suction side of the steam jet air ejector (SJAE). The sample panel can be purged with room air to check detector response to background radiation. The sample panel measures and indicates sample line flow. A Geiger-Muller (GM) tube is positioned adjacent to the vertical sample chamber and monitoring is provided locally and to the control room. The monitor range is $1\text{-}10^6$ mR/hr on a six decade log scale. The principal gases detected are Kr-85, Kr-87, Kr-88, Xe-133m, and Xe-135. Three trip circuits provide alarm functions only. Readings are displayed on a radiation monitor and actuate the following control room annunciators: Offgas high-high, offgas high, and offgas downscale. High or low sample line flow measured at the sample panel actuates a control room offgas sample high-low flow annunciator. The radiation level output of the monitor can be directly correlated to the concentration of the noble gases by using the semiautomatic vial sample panel to obtain a grab sample. The sample is analyzed in the plant counting room with the multichannel analyzer (MCA) and the results correlated with the monitor reading.

(2) Carbon Bed Vault Monitor

The carbon vault is monitored for gross gamma radiation levels with a single channel GM tube monitor. The monitor reads out over a range of $1\text{-}10^6$ mR/hr over a six decade logarithmic scale. The principal nuclides detected are Xe-135, Xe-135m, Kr-87, and Kr-88. The channel includes a sensor and converter, an indicator and trip unit, and a locally mounted auxiliary unit. The indicator and trip unit is located in the control room. The channel provides for both local and remote readout of gamma radiation over a range of $1\text{-}10^6$ mR/hr. The indicator and trip unit has one adjustable upscale trip for alarm and one downscale trip. The trip circuits may be verified by means of test signals or through use of portable gamma sources. A licensee representative stated that the detector was located near the room ventilation exhaust duct.

(3) Offgas Post-treatment Radiation Monitor

This system monitors radioactivity in the offgas piping downstream of the offgas charcoal adsorbers and upstream of the offgas system discharge valve. A continuous sample is passed through the offgas post-treatment sample panel for monitoring and sampling and returned to the offgas system piping. The sample panel has a pair of filters (one for particulate collection and one for halogen collection) in parallel (with respect to the flow) with two identical gross radiation detection assemblies (for determination of noble gases). Each gross radiation detection assembly consists of a shielded chamber, a set of GM tubes and a check source. Two radiation monitors in the control room display the measured gross radiation level over a range of $10\text{-}10^6$ over five decades on a logarithmic scale. The principal nuclides detected are Kr-85 and Xe-133.

The sample panel shielded chambers can be purged with room air to check detector response to background radiation. The sample panel measures and indicates sample line flow. A check source for each detection assembly operated from the control room can be used to check operability of the gross radiation chamber.

Each radiation monitor has three trip circuits: two-upscale (high-high-high, and high) and one downscale (low). Each trip is visually displayed on the radiation monitor. These three trips actuate corresponding control room annunciators: offgas post-treatment high-high-high radiation offgas post-treatment high radiation, and offgas post-treatment downscale. A trip circuit on the recorder actuates an offgas post-treatment high-high radiation annunciator. High or low sample flow actuates a control room annunciator.

A trip auxiliary unit in the control room takes the high-high-high and downscale trip setpoint and initiates closure of the offgas system discharge and drain valves if its logic is satisfied. A vial sampler panel similar to the pretreatment sampler panel is provided for grab sample collection to allow isotopic analysis and gross monitor calibration.

(d) Offgas and Radwaste Building Ventilation Radioactivity Monitoring System

The system monitors for gaseous radioactivity in the offgas and Radwaste Building discharge, including radwaste storage tank vents for gross radiation level, and collects halogen and particulate samples. The gross radiation detection assembly consists of a shielded chamber, a beta sensitive GM tube, and a check source. A radiation monitor in the control room analyzes and visually displays the measured gross radiation level over a range of $10\text{-}10^6$ cpm. The sample panel shielded chamber can be purged with room air to check detector response to background radiation. The sample panel measures and indicates sample line flow. A check source operated from the control room can be used to check operability of the gross radiation channel.

The radiation monitor has three trip circuits; two upscale (high-high and high) and one downscale (low).

6. Event Description

On Friday, February 26, 1988, at approximately 1630 hours, preparations were begun by operations personnel for changeover from "B" SJAE to "A" SJAE. A 20 SCFM air purge was placed through the "A" SJAE until the changeover from the "B" SJAE at about 1700 hours the next evening, Saturday, February 27, 1988. At the time of the changeover on Saturday, the following conditions existed:

- Plant was at 100% power
- Preheater "B" outlet temperature was 305°F
  Preheater "A" outlet temperature was 295°F
- Recombiner "A" outlet temperature was 395°F
  Recombiner "B" outlet temperature was 600°F
- Preheater "B" steam pressure was 110 psig
  Preheater "A" steam pressure was 100 psig
- Offgas flow rate was 40 SCFM (including purge flow)
- Post-treatment radiation monitor was indicating 60-65 cpm
- "A" H_2 analyzer was in auto in "zero purge" mode
  "B" H_2 analyzer was in manual and "sample" mode reading 0.2-0.5 H_2 concentration.

After placing the second stage of the "A" SJAE in service, the steam supply pressure was being raised to the normal operating pressure of 130 psig, when operations personnel received a second stage low steam flow alarm. Steam supply pressure was reduced to 80 psig while instrument (I&C) technicians were called to vent the pressure transmitters. This venting cleared the alarms and steam supply pressure was brought back up to 130 psig.

The final step in changeover from the "B" to the "A" SJAE was begun by "bumping" open the suction valve (F003A) from the low pressure condenser to the first stage "A" SJAE, as per procedure. As offgas flow to "A" recombiner increased, "B" recombiner temperature started to decrease as expected. However, there was no corresponding increase in "A" recombiner temperature. (The $2H_2+O_2$ to $2H_2O$ recombination is an exothermic reaction). The "A" recombiner pressure differential was normal; therefore, operations personnel continued to "bump" open F003A in an attempt to increase offgas flow and therefore raise "A" recombiner outlet temperature.

At about 1745 hours, operations personnel noticed spiking of both in-line hydrogen analyzers (analyzers indicate 0-5% H_2) and a loss of offgas flow. Water induction into the recombiner was suspected at that time. Operations personnel opened the "B" drain valves and then the "A" recombiner drain valves as per procedure. Subsequently, offgas flow indication returned. The hydrogen monitors were reset within ten minutes after flow return. The "A" recombiner outlet temperature quickly increased to 600°F (normal operating temperature) from an indicated 400°F. It was later discovered that the recorder could not indicate below 400°F because of recorder mechanical problems.

The first charcoal adsorber beds in each of the two parallel trains were determined to be hot immediately after the burn. Charcoal adsorber bed D012B was at 140°F and and D012A was at 110°F. (Offgas flows in parallel through two trains of four charcoal beds and one gas cooler each).

Inline dewpoint indicators also pegged out high. It was later determined that high system temperature during the burn had destroyed the electrodes associated with the instruments.

Because of the hydrogen burn, plant power was reduced to 75%. Health physics personnel were requested to survey offgas system areas. No significant increases in airborne radiation levels were detected, indicating that no offgas system loop seals had been blown. This was also an indication that no major pressure transients occurred during the burn because any system pressure exceeding approximately six (6) psig would have blown loop seals. Normal system operating pressure was one (1) psig.

By 1845 hours, the charcoal treatment system was bypassed. Plant power had been reduced to 55% to help ensure that offgas process flow radiation levels stayed below radiation monitor trip-points.

By 1945 hours, nitrogen purging of the charcoal adsorber beds had begun. Temperatures peaked at 443°F in bed D012A and 700°F in bed D012B at about 2300 hours. By March 1, 1988, the bed temperatures had decreased to the 20-30°F range with the nitrogen purge continuing.

On March 2, 1988, at about 0900, three beds of the "A" charcoal train were placed back in service. Nitrogen purging of D012A and all of "B" train beds continued.

Radiological Significance of Event

The inspector evaluated the radiological aspects of the event through discussion with licensee representatives, review of records, and examination of radiation sampling, monitoring, and analysis equipment used in conjunction with the offgas system. The inspector also reviewed calculations of monitor setpoints and dose assessment for releases during the event.

While the offgas flow was bypassed the Radwaste Building Ventilation Exhaust Radiation Monitor reading peaked at 2.0 E+3 counts per minute (cpm) at 0645 CST on February 29, compared to a pre-event reading of 1.0 E-2 cpm.

The maximum effluent rate (61.9 microcuries per second) occurred at 0327 CST on February 29. The effluent monitor gross reading peaked at a later time due to increasing background radiation. The instantaneous dose rate at the plant boundary corresponding to the maximum source term was 2.10 mrem per year, well within allowable limits.

The inspector reviewed Technical Specification and procedural requirements for the:

- Offgas Pretreatment Monitor;
- Carbon Bed Vault Radiation Monitor;
- Offgas Post Treatment Monitor;
- Offgas and Radwaste Building Ventilation Exhaust Radiation Monitor;
- Hydrogen Analyzers; and
- Charcoal and HEPA filter testing (Offgas After Filters and Radwaste Building Ventilation Exhaust filters).

Operating and surveillance requirements for the offgas pretreatment monitor, the offgas post-treatment monitor, the offgas and radwaste monitor, and the hydrogen analyzers were found in Technical Specification Tables 3.3.7.12-1, and 4.3.7.12-1. Technical Specification Table 4.4.5-1 provided additional surveillance requirements for the offgas pretreatment monitor. Technical Specification Tables 3.3.7.1-1 and 4.3.7.1-1 provided operating and surveillance requirements for the carbon bed vault radiation monitor, and Technical Specification Tables 3.3.7.5-1 and 4.3.7.5-1 provided additional operating and surveillance requirements for the Offgas and Radwaste Building ventilation exhaust radiation monitor. Technical Specification Sections 3.11.2 and 4.11.2 also provided operating and surveillance requirements for the monitors and the hydrogen analyzers.

The inspector selectively reviewed procedures implementing the Technical Specification requirements and reviewed licensee documentation showing that surveillances (calibrations, functional tests, filter testing, and dose calculations) had been performed within the required frequencies.

The radiation monitors appeared to have been functioning properly at the time of the event. The hydrogen analyzer recorders went offscale (greater than 5 percent) at the time of the event, so grab samples were taken and analyzed. Procedure 06-CH-IN62-0051, "Offgas Hydrogen Concentration," Revision 23, was used for this operation. The first sample was taken at 7:47 pm on February 27. Since licensee personnel were concerned about the operability of the gas chromatograph, a "pop" test was conducted on the sample. The test indicated that the concentration of hydrogen in the sample was less than 4 percent by volume. Two more samples were taken over the next five hours and were analyzed on the gas chromatograph, which had been determined to be operational and and had been functionally checked. The results indicated concentrations by volume of 0.03 percent hydrogen and 0.04 percent hydrogen. The hydrogen analyzers were reading back on scale by this time.

Causes/Conclusions/Corrective Actions

After the event, the licensee assembled a task force consisting of the Manager-Plant Operations, key onshift personnel involved with the event, various plant department representatives and a vendor (GE) expert in the design and operation of the offgas system to determine the root causes, conclusions and corrective actions.

a. Equipment Damage

As a result of the ignition, the licensee noted the following equipment damage:

(1) The inservice prefilter had been damaged with partial melting of the aluminum separator material. The filter was subsequently removed and the other filter was placed in service.

(2) The inline dewpoint indicator electrodes had been destroyed. (These electrodes were considered to be possible ignition sources.)

(3) About 25 pounds total of charcoal (calculated value) was burned in the charcoal beds. Each bed contains approximately 3 tons of charcoal. The licensee considered this an insignificant loss and did not plan to replace or add charcoal.

b. Causes and Corrective Actions

(1) Intercondenser Fouling

During the week prior to the ignition, plant performance monitoring personnel had noted a degradation of plant efficiency. Low pressure (LP) condenser pressure had equalized with intermediate pressure (IP) condenser pressure resulting in a 5-6 megawatt loss in plant electrical output. This degradation was the result of fouling problems within the intercondenser of the inservice "B" SJAE. Flow through both intercondensers is cooled by Plant Service Water (PSW). Biological fouling within the Intercondenser (tube-side) lowered its ability to condense first stage SJAE effluent and therefore maintain sufficient pressure differential across the air ejector. This degradation was the main reason for initiating the swap to the "A" SJAE.

Biocides and dispersants added to the PSW in the past had been ineffective in preventing intercondenser fouling. Periodic mechanical or hydraulic cleaning had been required to keep these heat exchangers clean. The licensee had very recently changed to a different biocide/dispersant treatment regime in order to reduce fouling. Biological fouling (macro and micro) had been an ongoing problem in general at Grand Gulf Nuclear Station.

(2) Recombiner Wetting

Wetting and subsequent cooling of the "A" recombiner catalyst resulted in the buildup of H_2 in the offgas system prior to ignition. This wetting occurred as a result of the procedural sequence for opening a drain valve in a low area between the preheater and recombiner. Condensation collects in this area due to piping configuration and needs to be drained.

Wetting of the recombiner catalyst was not detected during the event because the recombiner temperature recorder (located in the main control room) had pegged low at about 400°F due to a mechanical failure of the recorder. Temperature history of the recombiner below 400°F cannot, therefore, be reproduced.

The licensee had subsequently revised System Operating Instructions 01-1-01-N62-1, Offgas System, to: (a) revise the sequence for opening the offgas header to the recombiner drain valves to ensure that any condensation and moisture had been drained prior to initiating offgas flow and (b) establish procedural holdpoints for verification of proper recombiner temperature profile.

(3) Ignition Source

At the time of the inspection the licensee had not positively identified the ignition source. Because of the stoichiometric concentrations of hydrogen, oxygen and humidity in the process flow at the time of ignition only a small amount of energy would have been required to ignite the mixture. The licensee suspected that the ignition occurred in the area of the desiccant dryers. The licensee and the inspector agreed that by insuring proper recombiner operation, ignition sources become a secondary consideration.

(4) Preheater Steam Supply Pressure

Several design problems existed in the main steam supply to the preheaters. Sufficient steam pressure could not be supplied to both A and B preheaters to allow simultaneous operation of both of the condenser air removal/offgas trains or to make a rapid changeover between trains. Insufficient steam supply to the preheaters reduced their ability to preheat process flow to the proper recombiner inlet temperature. A rapid switch from one train to another could slug the recombiner with water.

To alleviate this problem, a Design Change Request (No. 87/113, dated 9/25/87) had been previously authorized to redesign the piping runs between the main steam equalizing header and the preheaters to allow sufficient steam supply pressure with both preheaters inservice.

The licensee had also experienced cycling problems with solenoid valves in the steam supply lines to the preheaters. During plant startup in January 1988, with the plant at 3% power, a valve in the steam supply line to the inservice preheater inadvertently closed, shutting off steam supply to the preheater. Subsequent wetting of the recombiner resulted in H_2 concentration of 14% in the offgas system. There was no ignition at that time.

Design Change Request No. 87/113 also included provisions for replacing each solenoid valve with two manual valves. The licensee indicated that modifications described in the DCR would be completed during the next refueling outage. The inspectors urged the licensee to ensure that these modifications be completed as scheduled.

8. Radiological Considerations

The licensee performed an analysis of the radiological output from the plant which could result from operating with only three charcoal beds operating in the offgas treatment system instead of the normal eight. The analysis showed that the plant could be expected to operate within Technical Specification limits for effluents.

9. Summary and Conclusions

The hydrogen burn took place in a system which was designed to contain such burns and detonations. The burn was fully contained.

The licensee was still in the process of evaluating the event at the time of the inspection. The integrity of the offgas system boundary did not appear to have been violated. The licensee had identified contributing causes of the incident, though the ignition source had not been identified.

The licensee had evaluated the event and had identified corrective actions, some definite and some tentative, depending on what further analysis might reveal. No radiological effluent restrictions were exceeded during the event.

No violations or deviations were identified.