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Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Perry Nuclear Power Plant
Docket Nos. 50-440; 50-441
Off-Gas System Unusual Events

Dear Mr. Denton:

This letter provides a brief summary of the Cleveland Electric Illuminating Company's response and activities related to the off-gas system charcoal adsorber combustion events that occurred at Perry, Unit 1 on June 20, 1986 and July 6, 1986. We have been working very closely with NRC Region III in our resolution of these events. Although much of the information presented below is not yet finalized, it provides an overview of the events, the investigative activities we have undertaken and our plans for returning the off-gas system to operation.

Background

The Perry off-gas processing system, consists primarily of three sections: hydrogen recombination, gas delay and charcoal adsorption. The charcoal adsorption section is comprised of eight charcoal adsorber vessels (each 25 ft. high by 4 ft. in diameter) arranged in two trains of four vessels each, numbered 1N64D012A & B, 13A & B, 14A & B and 15A & B. Each adsorber vessel contains approximately three tons of activated coconut shell charcoal. The adsorbers are located in the off-gas system charcoal vaults in the off-gas building. The first adsorber in each train is located in a separate vault. The remaining three adsorber vessels in each train are located in another vault along with two process gas coolers. The off-gas vault refrigeration system cools the four vaults in which the charcoal adsorbers are located. It is designed to maintain the temperature in the vaults at approximately $0^{\circ}F$ for maximum efficiency of the charcoal adsorption process. The system is further described and a simplified system diagram is provided in Attachment 1 (Figure N64-1).

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Testing of the off-gas vault refrigeration system began in late May, 1985. During this testing, portable heaters were installed in the charcoal vessel vaults. The vaults were heated and then stabilized at a temperature of 150°F and held at that temperature for 4-1/2 hours. The heat-up process took approximately 33-1/2 hours. The off-gas vault refrigeration system was started in the pull-down mode and the acceptance criteria of 0°F was successfully achieved in less than 20 hours. Charcoal temperature indications were not required to be monitored during the heat-up and cool-down process, although charcoal was installed in the vessels.

Preoperational testing of the off-gas process system was completed in October, 1985, with test exceptions remaining open. One of the exceptions identified during testing concerned the ability of the off-gas vault refrigeration system to maintain vault and charcoal adsorber vessel temperatures at 0°F ±2°F. Prior to retesting the off-gas process system to close these test exceptions, it was decided to gather additional information to verify the cool down capability of the off-gas vault refrigeration system. A deferral of this preoperational testing activity was requested in our letter dated February 27, 1986 and concurred with by NRC in their granting of our low power operating license on March 18, 1986 (NPF-45, Attachment 1, Item A).

Events

Retest of the off-gas vault refrigeration system began on June 18, 1986, in accordance with approved procedures. Radiant-type space heaters were placed in the charcoal adsorber bed vaults to raise the vault and equipment temperatures to above 150°F, a specified initial condition for the test. Vessel charcoal temperatures were monitored using permanently installed instrumentation consisting of internal thermocouples (3 per vessel) with readout in the control room on a 24-point pen recorder with a range of -50°F to +250°F. Vault air temperature was also monitored using permanently installed instrumentation and a single-point readout in the control room with a range of -50°F to +200°F. Dry instrument air flow was established through both the A and B trains of adsorber beds to simulate operational flow conditions, also an initial condition for the test.

While establishing these initial conditions but prior to commencement of the actual temperature pull-down test, combustion occurred in the third of four charcoal adsorber vessels in each train (i.e. vessels 14A & 14B), as evidenced by excessive temperature indication on the 14A center and 14B center and bottom thermocouples. The space heaters were deenergized and the vault refrigeration system was started in the pull-down mode to cool the vault and vessels. Instrument air flow through the beds was secured and a nitrogen purge was established to extinguish any combustion activity in the beds.

An Unusual Event was declared on June 20, 1986, when it was determined that combustion was occurring. The Unusual Event was terminated on June 23, 1986, after all beds had exhibited rapid rates of temperature decrease and all temperatures had dropped to below 250°F.

Following termination of the Unusual Event, CEI developed a Recovery Plan (Attachment 1) that addresses all the activities described in NRC Regions III's Confirmatory Action Letter dated June 23, 1986. NRC Region III reviewed and concurred with this Recovery Plan and recovery activities commenced. The recovery consisted of chemical and physical analysis of the charcoal in the beds and metallurgical testing of the vessel material. Preliminary results indicated that the charcoal and vessels were adequate to perform their intended functions and plans were made to reestablish testing conditions. The charcoal beds were maintained under a nitrogen blanket throughout the recovery process and up until July 6, 1986. All monitoring indicated that combustion ceased on June 23, 1986 and that the charcoal remained extinguished from that point on. Therefore, retesting was deemed appropriate.

On July 3, 1986, NRC Region III's concurrence was obtained to retest the off-gas vault refrigeration system. It was agreed that the test would be started from ambient temperature conditions rather than from the elevated temperature of 150°F as originally planned. The nitrogen purge was secured and dry, instrument air flow through both the A and B trains of adsorber beds was commenced on July 6, 1986.

Approximately one (1) hour after initiating instrument air flow through the beds, it became apparent from vessel thermocouple readings that combustion was again occurring in the 14A & 14B vessels. An Unusual Event was again declared on July 6, 1986. Instrument air flow through the charcoal beds was immediately secured, the vault refrigeration system started and a nitrogen purge initiated through the beds to extinguish the combustion activity and to cool the vaults and beds. This second Unusual Event was terminated on July 8, 1986, after it was determined that we had experienced an acceptable rate of decrease in temperature and negligible concentrations of combustion products were present in the nitrogen purge stream. Our Recovery Plan from the first event was revised to encompass this second event and has been concurred with by NRC Region III (Attachment 1).

Chemical and Physical Analysis of Charcoal

Following the first event charcoal samples were taken from the vessels (14 A and B) that were known to have experienced combustion. Samples were also taken from the first vessel in each train (12 A and B) since these were the least likely to have undergone combustion or to contain combustion products and, thus, could be analyzed to determine if hydrocarbons, glycol, or other contaminants may have been present in the beds prior to the test. Samples of unused charcoal were also evaluated for comparison.

The following chemical and physical properties were evaluated: Xe and Kr delay, volatile content, moisture, apparent density, hardness, particle size, total ash, and ignition temperature. No significant deviations were noted among any of the samples for any of the properties analyzed. No evidence of glycol or above-normal volatile content was observed. No excessive amount of ash was found to be present in any of the samples including the 14A & B vessel samples. All samples were judged to be suitable for use in delaying noble gases and, thus, suitable for the intended purpose and for continued use.

The charcoal met the ASTM minimum ignition temperature specification of 482°F at an air flow rate of 100 feet per minute face velocity both before and after the event. The ignition temperatures for the charcoal in vessels 14A & B were determined to be as low as 307°F and 428°F respectively, however, at a system air flow rate of four (4) lineal feet per minute. Preliminary conclusions are that the first combustion event resulted from simply exceeding these thresholds while heating with the space heaters. Neither excessive moisture nor volatile content appear to have been contributors.

We believe the second event to have been caused by the residual effects of the first event, in particular, residual hot spots remaining within the adsorber vessel beds. Once instrument air was readmitted to these beds, combustion again occurred. Additionally, we are evaluating the potential for a phenomenon known as "clean carbon oxidation" which could have contributed to the second event. This effect assumes the carbon (charcoal) was chemically reduced during the earlier event and subsequent nitrogen purge and remained in this chemical state until oxygen was readmitted, whereupon the carbon underwent rapid oxidation with attendant heat generation, contributing to reignition.

Metallurgical Analysis

Several techniques were employed to determine whether there were any combustion or temperature effects on the metallurgy of the adsorber bed vessels and piping following the first event. Visual inspections were made of all equipment, piping and components located within the charcoal vaults in which the event took place. A detailed walkdown of the vaults on June 21, 1986, revealed no indication of thermal growth in piping and conduit lines such as scratched paint or galvanizing at support locations. In addition, no abnormalities were found in adsorber vessel supports, adsorber connectors, rubber jacketing, flex conduit, vault sheet metal liners, or concrete floor slabs. The one abnormality noted was a discoloration/oxidation of the coating on two adsorbers vessels, 14A & B. The discolorations are circumferential near the upper portions of the adsorber beds and are estimated to be three (3) to five (5) feet in height on adsorber bed 14A and five (5) to seven (7) feet in height on adsorber bed 14B. These discolorations indicate exposure to higher temperatures than elsewhere on the adsorber beds as no other discolorations were noted.

Selected sites within the areas of discoloration were examined metallurgically using a replication process which allowed the comparision of metal grain sizes between the heat affected and unaffected areas of the vessels. Preliminary results show that the grain sizes of the affected and unaffected areas are identical indicating no change in metallurgical characteristics related to grain size.

A local hardness tester was utilized in the same locations within the affected and unaffected areas described above to determine if vessel hardness had been altered. Again, preliminary results indicate that metal hardness was not altered as a result of this event.

Laboratory specimens of material which closely matches the Perry charcoal adsorber vessel material were subjected to conditions that would promote temper embrittlement if the material were susceptible to this phenomenon. They were then tested and compared to control samples to determine the level of toughness reduction. These tests show that appreciable toughness reduction did not occur.

Metallurgical analysis results to date indicate that the charcoal adsorber vessels were not subjected to temperatures high enough to significantly change any of their physical or metallurgical properties.

Future Plans

Visual examinations of the external surfaces of the adsorber bed vessels 14 A & B are being conducted. These visual examinations are intended to identify any additional adsorber bed vessel coating discolorations. Photographs of the external surfaces of the adsorber bed vessels 14A & B will also be taken to photographically document the condition of the vessel external surfaces following the July 6, 1986, event and to compare them to the photographs taken following the first event.

Visual examinations of the internal surfaces of adsorber vessel beds 14A & B and 15A & B will also be conducted. These visual examinations are intended to identify any localized granular carbon particle fusion to the internal vessel wall which would require repair.

Adsorber bed vessel contact temperatures and thermocouple temperatures taken during the July 6, 1986, event are being reviewed by CEI and General Electric metallurgists to determine if any further metallurgical examinations are necessary based upon this recent event. The data indicates that temperatures reached during the July 6, 1986, event were much lower than during the first event.

The structural and physical properties of the vessels will also be evaluated to ensure the vessels are acceptable for operation.

Since adsorber beds 14A & B (and possibly 15A & B - based an subsequent evaluation of the data we now believe the original event involved the 15A & B vessels as well) experienced combustion upon reintroduction of instrument air even after having been inerted with nitrogen and cooled for thirteen days, we have decided to completely replace the charcoal in all eight of the adsorber beds. The charcoal will be vacuumed from the top of all eight vessels using a water-soak hose process in which water is injected into the suction hose and combined with the charcoal as it is vacuumed from the vessels. The charcoal will be discharged to a tank (truck-mounted) containing water. To further minimize any fire hazard associated with residual hot spots within the vessels we will spray the 13, 14 and 15 vessels internally with water as we remove the charcoal. The 12A & B vessels will not be wetted internally, since they are the least likely to contain hot spots.

Upon removal of all the charcoal, the vessels will be thoroughly dried and new charcoal added. The off-gas vault refrigeration system testing will then be completed.

All of these steps will be performed with NRC Region III's concurrence. Entry into Operational Condition 2 will not occur until NRC, Region III is satisfied that the combustion events have been thoroughly analyzed and that the adequacy of the off-gas system has been demonstrated.

We will provide you with the results of our further evaluations by July 21, 1986. If you have any questions or comments, please do not hesitate to call.

Very truly yours,

Murray R. Edelman

Murray R. Edelman
Senior Vice President
Nuclear Group

MRE:njc

Attachments

cc: Jay Silberg, Esq.
John Stefano (2)
J. Grobe
J. Keppler