



**UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
REGION II  
SAM NUNN ATLANTA FEDERAL CENTER  
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ATLANTA, GEORGIA 30303-8931**

May 13, 2004

EA-04-096  
NMED No. 040169

Westinghouse Electric Company  
ATTN: Mr. M. Fecteau, Manager  
Columbia Plant  
Commercial Nuclear Fuel Division  
Drawer R  
Columbia, SC 29250

SUBJECT: NRC INSPECTION REPORT NO. 70-1151/2004-001

Dear Mr. Fecteau:

This refers to the inspection conducted on April 12-16, 2004, at the Columbia Nuclear Fuel Plant. The purpose of this inspection was to determine whether activities authorized by the licensee were conducted safely and in accordance with NRC requirements. At the conclusion of this inspection, the findings were discussed with those members of your staff identified in the enclosed report.

Areas examined during the inspection are identified in the report. Within these areas, the inspection consisted of selective examinations of procedures and representative records, interviews with personnel, and observations of activities in progress.

Based on the results of this inspection, the NRC has determined that nine apparent violations of NRC requirements occurred. The apparent violations and the circumstances surrounding the violations are described in the subject inspection report. The apparent violations involved the failure to control the uranium concentration in the incinerator system within the subcritical limit by allowing concentration of uranium in ash to exceed the minimum infinite critical concentration; failure to implement a specifically identified control by failing to regularly perform radiological surveys of the incinerator cross-over pipe; failure to incorporate sufficient margins of safety to require at least two unlikely, independent and concurrent changes in process conditions in the incinerator system before a criticality accident was possible; failure to establish controls to maintain concentration to ensure that incinerator ash was less than the minimum infinite critical concentration for uranium in the incinerator off-gas system, failure to establish controls to maintain concentration to ensure that incinerator ash was less than the minimum infinite critical concentration for uranium in the incinerator ash handling system; failure to communicate to appropriate operations personnel the bounding assumption of uranium concentration being limited to the minimum infinite critical concentration for uranium in the incinerator system; failure of licensee personnel to perform an adequate independent technical review and confirmation of incinerator criticality safety evaluation conclusions during initial preparation or subsequent revisions; failure to identify that less than previously documented double contingency protection remained and notify the NRC during a Nuclear Criticality Safety

(NCS) review of a 1998 event involving excess mass accumulation in the incinerator cross-over pipe; and failure to identify that less than previously documented double contingency protection remained and notify the NRC during an NCS review of a 2003 event involving excess mass accumulation in the incinerator knock-out pot. No Notice of Violation is presently being issued for the inspection findings and no response regarding the apparent violations is required at this time.

These apparent violations remain under NRC review and the number and characterization of the apparent violations may change as a result of this NRC review. You will be advised by separate correspondence of the results of our deliberations on this matter.

In accordance with 10 CFR 2.390 of NRC's "Rules of Practice," a copy of this letter and its enclosures will be available electronically for public inspection in NRC's Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC web site at <http://www.nrc.gov/reading-rm/adams.html> (the Public Electronic Reading Room).

Should you have any questions concerning this letter, please contact us.

Sincerely,

**/RA BY DOUGLAS M. COLLINS FOR/**

Jay L. Henson, Chief  
Fuel Facility Inspection Branch 2  
Division of Fuel Facility Inspection

Docket No. 70-1151  
License No. SNM-1107

Enclosure: NRC Inspection Report

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COPY?	YES NO	YES NO	YES NO	YES NO	YES NO

U.S. NUCLEAR REGULATORY COMMISSION

REGION II

Docket No.: 70-1151

License No.: SNM-1107

Report No.: 70-1151/2004-001

Licensee: Westinghouse Electric Corporation

Facility: Commercial Nuclear Fuel Plant

Location: Columbia, South Carolina

Dates: April 12-16, 2004

Inspectors: Wayne L. Britz, Fuel Facility Inspector, Region II  
Richard Gibson, Health Physicist, Region II  
Omar Lopez, Fuel Facility Inspector, Region II  
Dennis Morey, Senior Criticality Safety Inspector, NRC-HQ  
Debbie Seymour, Senior Fuel Facility Inspector, Region II

Accompanying Personal: Jay L. Henson, Chief  
Fuel Facility Inspection Branch 2  
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Approved By: Jay L. Henson, Chief  
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Division of Fuel Facility Inspection

Enclosure

## EXECUTIVE SUMMARY

### Commercial Nuclear Fuel Division NRC Inspection Report 70-1151/2004-001

This routine announced inspection was conducted in the areas of radiation protection, chemical operations, maintenance and surveillance, and criticality safety. In addition, the inspectors reviewed the facts and circumstances related to a criticality safety event reported by the licensee on March 5, 2004, involving incinerator operations. The inspection identified the following aspects of the licensee programs as outlined below:

#### **Radiation Protection**

- The inspector concluded that the licensee's self-assessments of the radiation protection program were implemented in accordance with the license and regulatory requirements (Paragraph 2.a).
- The external exposure monitoring program was implemented in a manner to maintain doses as low as reasonably achievable (ALARA). Exposures were less than the occupational limits in 10 CFR 20.1201 (Paragraph 2.b).
- Internal exposures were significantly less than the limits in 10 CFR Part 20.1201. However, some employees internal exposures have exceeded the licensee's administrative action limits. (Paragraph 2.c).
- Radiological safety postings and Radiation Chemical Work Permits (RCWP) were properly utilized to communicate potential hazards and protective equipment requirements to workers (Paragraph 2.d).
- The radiation and contamination survey program were appropriately implemented to protect workers, and identify potential work areas posing an internal or external radiation hazard to workers (Paragraph 2.e).
- Based on records review and interviews, the inspector concluded that the licensee's ALARA program was being properly implemented (Paragraph 2.f).

#### **Chemical Operations**

- Process Safety Information was maintained current for the existing plant configuration and was readily accessible to employees. The licensee's program inventory of hazardous chemicals was adequate to control the chemical hazards (Paragraph 3.a).
- Safety analyses appropriately identified process hazard information. Safety significant controls reviewed were adequately implemented and maintained (Paragraph 3.b).
- Chemical operations were conducted with appropriate operating procedures and operators were qualified to perform their work (Paragraph 3.c).

- The maintenance program was adequately implemented to ensure that important safety significant controls were calibrated, and functional tests performed to ensure operability and reliability. The audit program was adequately implemented to ensure that recommendations from audit findings were addressed in a timely manner (Paragraph 3.d).
- The licensee's change request system provided appropriate safety review and management approval (Paragraph 3.e).

### **Maintenance and Surveillance**

- The conduct of maintenance on the steam chest was adequately performed by knowledgeable and qualified individuals to ensure its availability and reliability. The licensee was effectively scheduling and tracking safety significant preventative maintenance work items (PMs) (Paragraph 4.a).
- The procedures for surveillance, calibration and maintenance were properly approved by licensee management, and included instructions for performing maintenance activities and for conducting post-maintenance functional testing of the equipment (Paragraph 4.b).
- Surveillance testing of the uranyl nitrate (UN) bulk storage tank agitator, UN storage tank rupture disk, UN storage tank operator inspection, incinerator fire doors, incinerator wall inspection, incinerator natural gas valves and incinerator safety interlocks were being performed in accordance with the established procedures and schedules to ensure the availability and reliability of the safety controls (Paragraph 4.c).

### **Headquarters Criticality Safety Program**

- An upset condition involving fissile material occurred when the licensee incinerator exceeded the bounding assumption for concentration several times from December 1996 to March 2004. The March 2004 event was accurately reported to the NRC within 24 hours as required by NRC Bulletin 91-01. Prompt and appropriate action was taken by the licensee to shutdown operation of the incinerator pending investigation and resolution of the problem (Paragraph 5.a).
- An apparent violation was identified due to licensee operation of the incinerator outside the safety basis. An apparent violation was identified due to licensee failure to perform a radiological survey of the incinerator cross-over pipe credited in the criticality safety evaluation (CSE) as a defense against fissile material accumulation in the off-gas system (Paragraph 5.b).
- Criticality is credible in the upper combustion chamber of the licensee incinerator. Four apparent violations were identified based on licensee failure to recognize a credible accident sequence leading to criticality in the incinerator off-gas and ash handling systems resulting in the failure to implement adequate controls to maintain double contingency protection in the incinerator off-gas and ash handling systems. The as-found condition in the incinerator was subcritical.

An apparent violation was identified due to licensee failure to perform adequate independent review of the incinerator CSE. Two apparent violations were identified due to licensee failure to report previous incinerator mass accumulation events. A weak licensee audit program contributed to the failure to identify a credible scenario leading to criticality (Paragraph 5.c).

- The licensee root cause analysis did not recognize the extent of the incinerator upset or investigate all contributing factors (Paragraph 5.d).
- An accident scenario leading to criticality was not analyzed or controlled resulting in a mass accumulation upset in the licensee incinerator. The as-found condition of the upset was subcritical. The accumulation of uranium in the incinerator was uncontrolled and increased with the time of incinerator operation. There were no controls to limit the amount of material in the incinerator to below a minimum critical mass (Paragraph 5.e).

### **Followup**

- The corrective actions to IFI 2003-02-01, IFI 2003-03-01, IFI 2003-04-01, EN 38656, EN 40246 and EN 40255 were reviewed, the corrective actions completed and adequately addressed by the licensee. The inspectors determined that the corrective actions were complete and comprehensive and these items were closed (Paragraph 6).

## REPORT DETAILS

### 1. Summary of Plant Status

This report covered the period of April 12-16, 2004. Powder, pellet, and fuel assembly production proceeded at normal rates.

### 2. Radiation Protection (Inspection Procedure (IP) 83822)

#### a. Radiation Protection Program Implementation (R1.01)

##### (1) Inspection Scope

The inspector conducted interviews and reviewed licensee documentation to ascertain the status of self-assessments of radiation program implementation.

##### (2) Observations and Findings

The licensee conducted self-assessments of the radiation protection program monthly. The self-assessments were performed by the health physics staff to determine if various program elements were being implemented in accordance with the license and NRC regulations. Licensees' identified issues were documented in a red-book and tracked via a plant-wide system known as the Corrective Action Process (CAPs). The inspector determined that the self-assessments were effective in verifying program implementation and included both compliance and performance activity. The inspector also focused his inspection efforts on circumstances surrounding an event with the licensee's incinerator. Results are documented in the criticality safety section of this report.

##### (3) Conclusions

The inspector concluded that the licensee's self-assessments of the radiation protection program were implemented in accordance with the license and regulatory requirements.

#### b. External Exposure Control (R1.04)

##### (1) Inspection Scope

The inspector reviewed radiation protection procedures, and discussed with licensee representatives personnel exposure data to determine if exposures were in compliance with 10 CFR Part 20.1201 limits, and if controls were in place to maintain occupational doses As Low As Reasonably Achievable (ALARA).

##### (2) Observations and Findings

Based on interviews, procedural reviews, and observations of plant personnel inside radiation control areas, the licensee's monitoring program was consistent with requirements in 10 CFR Part 20. Table 1 below displays the maximum assigned exposure data for calendar years (CY) 2003, and CY 2002 which was reviewed during the last inspection. CY 2003 annual exposures were similar to the exposures for

CY 2002 but slightly higher in the deep dose and the committed effective dose exposures. The licensee continued to take actions through its ALARA committee to try to maintain internal and external exposures below their action limits.

Table 1. Annual Exposures

Year	Deep Dose Equivalent (DDE)	Shallow Dose Extremity (SDE)	Total Effective Dose Equivalent (TEDE)	Collective TEDE (person-rem)	Committed Effective Dose Equivalent (CEDE)
2002	1.03 rem	18.78 rem	1.57 rem	279 person-rem	0.771 rem
2003	1.23 rem	12.58 rem	1.53 rem	245 person-rem	0.949 rem

(3) Conclusions

The external exposure monitoring program was implemented in a manner to maintain doses ALARA. Exposures were less than the occupational limits in 10 CFR 20.1201.

c. Internal Exposure Control (R1.05)

(1) Scope

The inspector reviewed licensee procedures for assessing internal exposure to determine if controls were in place to monitor occupational doses, and verify that the administrative limits were established to control occupational dose ALARA. Exposure data was examined to determine if exposures resulting from various plant operations were exceeding limits in 10 CFR Part 20.

(2) Observations and Findings

The licensee continued to use the annual limit on intake (ALI) and derived air concentration (DAC) values based on dose coefficients adopted by the International Commission on Radiological Protection (ICRP) as published in ICRP Publication 68. The procedures contained action limits which were set below federal limits to ensure personnel exposures did not exceed occupational limits in 10 CFR 20.1201. Table 1 above shows a slight increase in the committed effective dose equivalent (CEDE) for CY 2003 compared to CY 2002. The licensee continued to improve its engineering features and administrative controls to reduce contamination and airborne activities. The inspector determined that the administrative controls and procedures were in place to both monitor and assign dose resulting from routine operations or an unplanned release of radioactive material. Employees, who were approaching and/or exceeded the licensee's action limits for internal exposures were placed on a work restriction in accordance with Procedure No. ROP-05-028, Issuing and Documenting Employee Work Restrictions.

(3) Conclusions

Internal exposures were significantly less than the limits in 10 CFR Part 20.1201. However, some employee's internal exposures have exceeded the licensee's administrative action limits.

d. Postings, Labeling and Control (R1.07)

(1) Inspection Scope

The inspector reviewed the licensee's program for posting as required by 10 CFR 19.11 to determine if documents were posted in sufficient places to permit individuals engaged in licensed activity to observe them. Several work locations were examined to determine if radioactive containers were properly labeled and to assess the adequacy of 20.1902. Radiation Chemical Work Permits (RCWPs) were reviewed to determine the adequacy of the requirements posted for worker protection and the degree to which those requirements were being implemented.

(2) Observations and Findings

Bulletin boards located in designated areas were posted such that workers may observe documents or obtain details as to where documents may be examined.

All observed work areas involving radioactive material or potentially contaminated material were properly posted and containers labeled. The inspector determined through review of records and observations that all radiologically controlled areas were properly posted and identified. The inspector observed work on the conversion line in which the operator removed a plug from the feeder screw assembly. In addition, the inspector observed the replacement of a tool bit on the pellet line. The areas were posted as airborne areas and the workers were required to wear a respirator for the job. The work was conducted under Procedure No. ROP-05-055, Surveillance Non-Routine Operations. Randomly selected active and closed RCWPs were reviewed for adequacy in providing the appropriate level of protection to workers. No problems were noted.

(3) Conclusions

Radiological safety postings and RCWPs were properly utilized to communicate potential hazards and protective equipment requirements to workers.

e. Surveys (R1.08)

(1) Inspection Scope

The radiation survey of ventilation equipment and the contamination control survey program were reviewed to determine if surveys were effective in the identification of radiation and contamination, and performed in accordance with procedures.

(2) Observations and Findings

The results disclosed that the routine and non-routine surveys were adequate in the identification of potential radiation and contaminated areas. During plant tours, the inspector observed the health physicist (HP) perform impactor (air samplers) sampling and contamination surveys during maintenance work on the feeder screw assembly for the conversion line and the tool bit assembly for the pelleting line. In addition, the inspector walked the ventilation equipment line with an HP to identify areas for radiation surveys. The inspector reviewed Procedure Nos. ROP-05-055 and ROP-05-062 for adequacy in providing the appropriate level of coverage for each job. No problems were noted.

(3) Conclusions

The radiation and contamination survey program were appropriately implemented to protect workers, and identify potential work areas posing an internal or external radiation hazard to workers.

f. Implementation of ALARA Program (R1.10)

(1) Inspection Scope

The licensee's ALARA program was reviewed to determine if the program and ALARA goals were being developed and implemented in accordance with the license. In addition, the program for re-enforcing the ALARA concept among employees was assessed.

(2) Observations and Findings

On a quarterly basis, the licensee conducted mini-ALARA meetings detailing ALARA goals and exposure summaries to identify undesirable trends. In those cases where exposures were elevated, consideration was given to ways for reducing exposures. Annual ALARA reports were provided by the licensee for review with management.

Health physicists, managers and operators were interviewed regarding ALARA and demonstrated an adequate knowledge and/or understanding of ALARA concepts. The inspector interviewed the HP engineer assigned responsibility for the ALARA evaluations and assessments associated with external and internal exposures. From the interviews and review of records, the inspector determined that the licensee evaluation of the ALARA program was appropriate.

(3) Conclusions

Based on records review and interviews, the inspector concluded that the licensee's ALARA program was properly implemented.

### 3. Chemical Operations (IP 88056-63)

#### a. Process Safety Information (IP 88056)

##### (1) Inspection Scope

The inspector interviewed licensee management and staff regarding Process Safety Information (PSI) to ensure that it is maintained current and that employees have access to the information they need. The inspector also examined the licensee's inventory of hazardous chemicals.

##### (2) Observations and Findings

Environmental Health & Safety (EH&S) staff stated that the PSI is maintained through the configuration management process. The inspector reviewed the plant configuration control procedure and determined that the process provides for the up-date of PSI when additions or plant modifications occur.

The inspector also interviewed operations staff regarding PSI. Tank farm and Conversion operators were knowledgeable of the chemical hazards related to their job, as well the location and use of Material Safety Data Sheets (MSDSs) for chemicals used in their process area. The inspector noted that the MSDSs located in Uranium Recycling and Recovery Services (URRS) and Conversion control rooms were easily accessible.

The inspector noted that the licensee utilized a computerized program for real-time process and tank level information, which allowed it to determine the current inventory of the bulk chemicals stored on site. The inspector determined that the hazardous chemical inventories were below the quantities listed in the Site Emergency Plan, which lists the maximum capacities allowed to be stored on site. The inspector also determined that the licensee had information on the quantities, forms, and storage locations of the most hazardous chemicals on site.

##### (3) Conclusions

Process Safety Information was maintained current for the existing plant configuration and was readily accessible to employees. The licensee's program inventory of hazardous chemicals was adequate to control the chemical hazards.

#### b. Hazard Identification and Assessment (IP 88057)

##### (1) Inspection Scope

The inspector reviewed the Integrated Safety Analysis (ISA) for the tank farm and the conversion area to ensure that they contained process hazard information and safety related controls for the existing plant configuration.

(2) Observations and Findings

The inspector toured the tank farm, conversion and erbia processes. During the plant tours the inspector noted that postings and procedures were available to the operators. Plant personnel working in chemical areas wore the proper personal protective equipment. Safety showers and eye wash stations were in satisfactory condition. The inspector did not observe any issues where the housekeeping could affect the radiological safety or emergency egress of the facility.

The inspector walked down safety significant controls for the tank farm and the conversion area with operations personnel. The inspector confirmed that active and passive engineered controls, and administrative controls that were referenced in the ISA were maintained and implemented adequately. Operators were knowledgeable of the function and location of safety significant controls in their work area. No safety issues were identified.

The inspector reviewed and discussed with a cognizant engineer the recommendations for the "Process Hazard Analysis Revalidation for the Anhydrous and Aqueous Ammonia Systems". The inspector noted that recommendations were of minor safety significance and the licensee was in the process of addressing them. No safety issues were identified.

(3) Conclusions

Safety analyses appropriately identified process hazard information. Safety significant controls reviewed appeared to be adequately implemented and maintained.

c. Standard Operating Procedures (IP 88058)  
Chemical Safety Training (IP 88061)

(1) Inspection Scope

The inspector observed operations throughout the facility and reviewed selected operating procedures to verify that appropriate procedures were being used. The inspector reviewed training documentation to verify that operators were qualified to perform their work.

(2) Observations and Findings

The inspector observed conversion, URRS, and tank farm operators to verify that they were in compliance with operating procedures. The inspector noted that operators were knowledgeable of the operating procedures, as well as chemical hazards in their process areas. Also, operators stated that they were involved in the development of new procedures. The inspector noted that reviewed procedures adequately identified safety significant controls, and addressed process parameters and steps to mitigate unusual events. The inspector also noted that the procedures available to the operators

were all contained in the computer terminals present throughout the process areas. This system ensured that operators had access to only the most current revision of the procedure. In addition, the procedures were approved by the appropriate safety manager. No issues were noted.

The inspector reviewed training checklists for several operators currently working in the conversion, URRS, and tank farm areas to verify that they were qualified to perform their work. The inspector noted that the training checklists included safety and health hazards, safety significant controls, hazard communication, and housekeeping. The inspector determined that operators were appropriately qualified for their positions.

(3) Conclusions

Chemical operations were conducted with appropriate operating procedures and operators were qualified to perform their work.

d. Detection and Monitoring (IP 88060)  
Maintenance and Inspection (IP 88062)  
Audits and Inspection (IP 88066)

(1) Inspection Scope

The inspector examined calibration, preventive maintenance, and functional test records from a selection of safety significant controls. The inspector examined the records from a sample of safety-significant Environmental Health & Safety (EH&S) audits performed during the previous year.

(2) Observations and Findings

The inspector interviewed licensee personnel regarding the status of preventive maintenance activities for mechanical integrity including, but not limited to, piping leak tests, piping and valve inspections, dike inspections, tank exterior visual inspections, and relief valve replacement. The inspector observed that preventive maintenance was performed at the required frequency.

The inspector verified calibration of selected instruments and functional test records for safety-significant controls including but not limited to, high pressure interlocks, ammonia detection system, and high temperature interlock. The inspector also observed functional testing of a high and high-high level alarm on an autoclave and no issues were identified. The inspector determined that calibrations and functional test for safety controls were current and that the procedures used to perform the tests contained adequate detail.

The inspector reviewed the EH&S 2003 audit and the Safety Significant Work Order Program audit. The audit reports described any observation about the program and provided corrective actions to address them. The inspector considered the audit findings and corrective actions to be adequate. The inspector confirmed that the corrective actions were tracked using the licensee's corrective actions program.

(3) Conclusions

The maintenance program was adequately implemented to ensure that important safety significant controls were calibrated, and that functional tests to ensure operability and reliability were performed. The audit program was adequately implemented to ensure that recommendations from audit findings were addressed in a timely manner.

e. Maintenance of Change (IP 88063)

(1) Inspection Scope

The inspector reviewed the licensee's change control system for recent facility modifications to verify that safety significant modifications were reviewed, approved, and documented in accordance with their procedures.

(2) Observations and Findings

The inspectors discussed and reviewed with the licensee engineering change requests related to the installation of a ammonium diuranate and acid mixer station, and the installation of new level transmitters in different tanks through the tank farm. The inspector reviewed standard operating instructions (SOI) related to the changes and confirmed that operators were trained on the SOIs. The inspector confirmed that modifications to safety systems were adequately controlled, and sufficient reviews were performed before and after installation. The change request records adequately detailed the extent of the modifications.

(3) Conclusions

The licensee's change request system provided appropriate safety review and management approval.

**4. Maintenance/Surveillance (Inspection Procedure (IP) 88025)**

a. Conduct of Maintenance (F1.01).

(1) Inspection Scope

The conduct of maintenance on safety significant equipment and qualification of maintenance personnel were reviewed to verify that maintenance was adequately performed by knowledgeable individuals according to approved procedures, to ensure the proper operation of the equipment upon completion of the maintenance work.

(2) Observations and Findings

The inspectors observed reactive and preventive maintenance on the V401B UF<sub>6</sub> cylinder steam chest. The inspectors interviewed the staff (operations, maintenance and engineering) performing the work. The inspectors noted that the staff was knowledgeable of the equipment and of the procedures. The inspectors' review

included verifications that appropriate confined space permits were used. The inspectors verified that functional testing was performed prior to returning the components to operational status. The inspectors interviewed the individuals performing and overseeing the work, and noted that the individuals had detailed knowledge of the equipment, the work orders, and the safety controls impacted by the maintenance. The inspectors also reviewed the licensee's system for scheduling safety significant preventive maintenance work items (PM). Inspectors determined that the licensee had an effective method for scheduling and tracking safety significant PMs.

(3) Conclusions

The conduct of maintenance on the steam chest was adequately performed by knowledgeable and qualified individuals to ensure its availability and reliability. The licensee was effectively scheduling and tracking safety significant PMs.

b. Work Control Procedures (F1.02) and Work Control Authorizations (F1.03)

(1) Inspection Scope

Work control procedures for maintenance activities were reviewed to verify that they were properly approved by licensee management, and included instructions for performing maintenance activities and for conducting post-maintenance functional testing of the equipment.

(2) Observations and Findings

The inspectors reviewed procedures for plant configuration control, maintenance work order handling, safety significant controls (as it pertains to maintenance), verification of safety significant controls, locating safety significant control listings, uranyl nitrate concentration monitor calibration, verification of interlock ADUVAP-903, safe geometry dissolver system solids feeder speed and dissolvers uranyl nitrate concentration monitors RT-736A & RT-746A calibration. Work orders were reviewed for the incinerator interlocks and incinerator cleanout. The inspectors observed that the procedures and work orders included adequate descriptions of the work to be performed.

(3) Conclusions

The procedures for surveillance, calibration and maintenance were properly approved by licensee management, and included instructions for performing maintenance activities and for conducting post-maintenance functional testing of the equipment.

c. Surveillance Testing (F1.06)

(1) Inspection Scope

Surveillance testing of engineered safety controls were reviewed to verify tests were being performed at the frequency established to ensure availability and reliability of the controls.

(2) Observations and Findings

The inspectors reviewed the preventative maintenance descriptions, precautions and preparations, inspection instructions and records of surveillance tests performed on the fire alarm system, uranyl nitrate (UN) bulk storage tank agitator, UN storage tank rupture disk, UN storage tank operator inspection, incinerator fire doors, incinerator wall inspection, incinerator natural gas valves and incinerator safety interlocks. The inspectors found that the surveillance tests were being performed at the designated intervals.

(3) Conclusions

Surveillance testing of the uranyl nitrate (UN) bulk storage tank agitator, UN storage tank rupture disk, UN storage tank operator inspection, incinerator fire doors, incinerator wall inspection, incinerator natural gas valves and incinerator safety interlocks were being performed in accordance with the established procedures and schedules to ensure the availability and reliability of the safety controls.

**5. Headquarters Criticality Safety Program (IP) 88015**

(a) Incinerator Safety Basis Event Description

(1) Inspection Scope

The inspectors reviewed facts and circumstances related to a criticality safety event reported by the licensee on March 5, 2004 involving incinerator operations outside the approved safety basis. The review included walking down the incinerator equipment and procedures, interviewing engineers, operators, and root cause investigators and reviewing technical analyses, data logs, and other documentation.

(2) Observations and Findings

Introduction

On March 5, 2004, the licensee reported an event to the NRC concerning operation of the incinerator off-gas system outside the approved safety basis. The problem was discovered during a technical review of a proposed procedure change. A licensee Nuclear Criticality Safety (NCS) engineer reviewed data from samples of ash deposits in the incinerator off-gas system and determined that the ash deposited at various locations in the system exceeded the 21.6 wt% uranium concentration assumed to be bounding for incinerator ash. Incinerator operations were immediately halted pending investigation and the NRC was notified. Subsequently, the licensee performed a complete clean-out of the incinerator and analyzed the removed material for uranium content. This analysis determined that the mass of ash removed exceeded expectations for deposition in the system and that uranium content of the ash exceeded

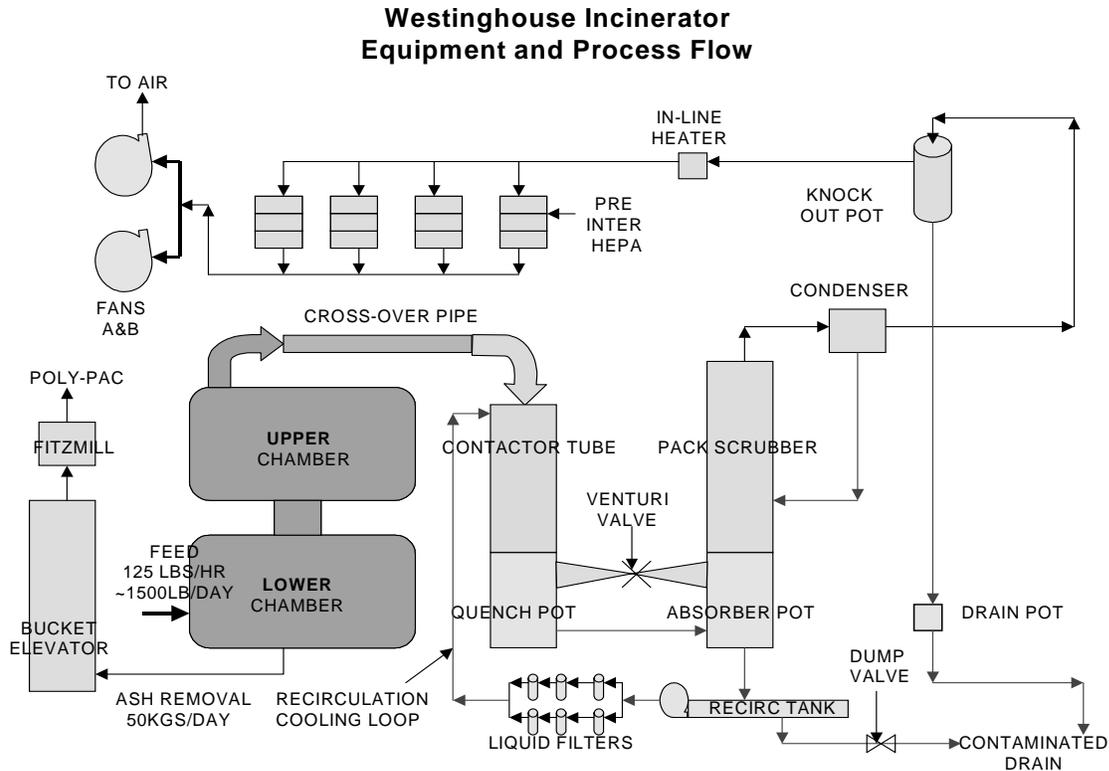
the bounding assumption for concentration. At this time, the licensee realized that the ash handling system safety basis, discussed in a different Criticality Safety Evaluation (CSE) and also using 21.6 wt% uranium as a bounding assumption, had been exceeded and filed a supplementary NRC notification.

### System Description

The licensee uses a standard industrial incinerator to reduce uranium-contaminated process waste volume and facilitate uranium recovery from the waste. The licensee incinerator consists of an upper and lower combustion chamber, a cross-over pipe (flue) to a quench system consisting of quench and scrubber columns, a recirculation system for quench water, and a system to transport the processed off-gas to the high-efficiency particulate air (HEPA) filter. Figure #1 below shows the equipment and process flow for the incinerator. The incinerator consists of the upper and lower combustion chambers, the ash handling system consists of the bucket elevator and Fitzmill grinder, the off-gas system consists of the cross-over pipe and all downstream equipment, and the incinerator system is all equipment combined.

The licensee places burnable waste in drums which are assayed to establish mass content. Waste is removed from the drums and introduced into the incinerator lower combustion chamber under mass control. Subsequent to a burn campaign and cool-down period, ash is pushed from the lower combustion chamber by a hydraulic ram. A bucket elevator then transports the ash to a Fitzmill grinder. After grinding, the ash is loaded into poly packs for uranium recovery.

The incinerator lower combustion chamber operates at approximately 1000 degrees F and the upper combustion chamber operates at approximately 1300 degrees F. Off-gas cools several hundred degrees in the cross-over pipe and approaches the quench column at approximately 1000 degrees F where it is reduced to approximately 150 degrees F in the upper quench column contactor tube. Off-gas is directed through a condenser and knock-out pot to the final HEPA filter. Quench water is circulated through a filter and cooling loop and returned to the quench column contactor tube spray nozzles. Quench water is pH adjusted in the recirculation tank. City water at normal pressure is connected to the quench column to provide emergency cooling capacity to protect off-gas system components.



**Figure 1**

### Sequence of Events

The licensee acquired the present trash incinerator in 1985. The CSE establishing its present safety basis was prepared and approved in September 1996. Analysis focused on accumulation of sufficient mass in the system to support criticality. Based on mass limits on the input waste stream, licensee NCS engineers determined that most mass resulting from incineration would accumulate in the lower combustion chamber and that ash in the incinerator would never exceed a concentration of 0.216 gm-U/gm. Because 21.6 wt% uranium is always subcritical in infinite media at an expected optimal moderator ratio, the licensee established mass controls only for the lower combustion chamber. Licensee NCS engineers believed that only limited amounts of fly-ash would carry over to the upper combustion chamber and off-gas system and that mass controls in the lower combustion chamber would limit concentration throughout the off-gas system. This led the licensee's NCS engineers to conclude that criticality in the off-gas system was not credible. Based on the same rationale, the licensee's NCS engineers

also determined that criticality in the incinerator ash handling system was not credible. The inspectors determined that conclusions regarding concentration of uranium in the ash were based on sampling of ash removed from the lower combustion chamber.

Subsequent to approval and implementation of the incinerator CSE in September 1996, the licensee updated the criticality safety basis by first developing an enhanced CSE in March 1999, and then an integrated safety analysis (ISA) in March of 2002. During the preparation of this documentation, CSEs were reviewed, revised, approved and implemented. The CSE upgrade process consisted of review and revision by a responsible NCS engineer and independent review of results by a second NCS engineer. Process engineers familiar with the incinerator system were consulted during preparation of the original CSE but did not concur in the final product or revisions. Licensee NCS engineers concluded that no changes in incinerator operations had occurred since the original CSE so no revision of the analysis was undertaken. As a result, the original CSE conclusions that criticality was not credible in the off-gas and ash handling systems were passed on from revision to revision.

From September 1996 until March 5, 2004, the licensee increased control of burn residence time to improve compliance with environmental regulations and reduced burning of inert materials to reduce solids in the ash which were difficult to clean out of the incinerator. Longer residence time reduces carbon content of the resulting ash thus increasing uranium concentration and allows more time for fly-ash to carry over from the lower combustion chamber. Reduction of inert materials into the incinerator also increases the uranium concentration in the ash. These steady and uncontrolled process changes resulted in gradually increasing uranium concentration throughout the system as shown in Figure #2:

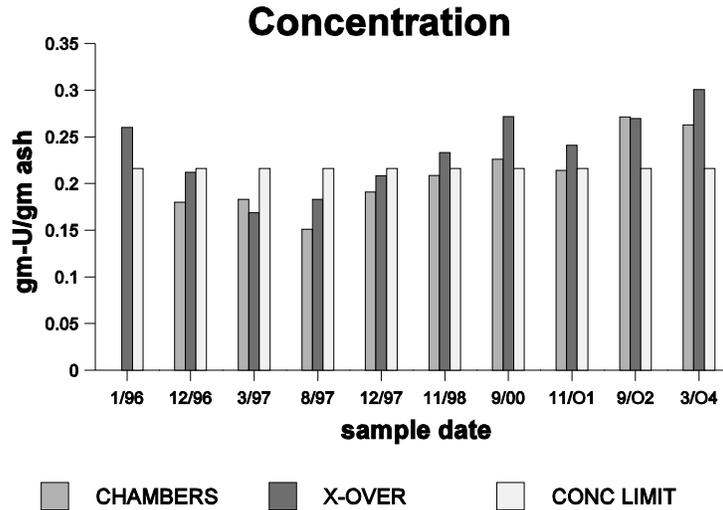
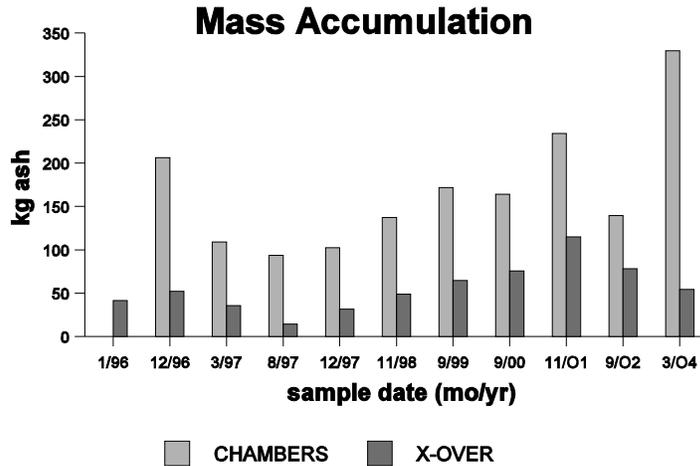


Figure 2

The process changes also resulted in a gradual increase in the amount of ash deposited particularly in the upper combustion chamber and cross-over pipe as shown in Figure #3:



**Figure 3**

In March 2004 during a routine review of proposed changes to the incinerator procedure, licensee NCS staff determined that the concentration of uranium in the incinerator fly-ash exceeded the 21.6 wt% uranium bounding assumption of the CSE. Specifically, the maximum concentration of uranium in incinerator ash was determined to be 28.9 wt% in December 1996, 23.3 wt% in November 1998, 27.2 wt% in September 2000, 24.1 wt% in November 2001, and 27.2 wt% in September 2002. Incinerator operations were halted pending resolution, and the entire incinerator system was cleaned out and the ash sampled for uranium content. Cleanout and sampling revealed that significantly more fly-ash than expected was being deposited throughout the incinerator off-gas system and concentration routinely exceeded assumptions at several locations.

(c) Conclusions

An upset condition involving fissile material occurred when the licensee incinerator exceeded the bounding assumption for concentration several times from December 1996 to March 2004. The March 2004 event was accurately reported to the NRC within 24 hours as required by NRC Bulletin 91-01. Prompt and appropriate action was taken by the licensee to shutdown operation of the incinerator pending investigation and resolution of the problem.

b. Plant Operations

(1) Inspection Scope

The inspectors walked down the incinerator system and reviewed incinerator operations to determine how the equipment was operated relative to the approved safety basis. The following documents were reviewed:

- Procedure RA-102, Revision 13, "Environmental Health and Safety Compliance Audits," dated August 8, 2002
- Procedure COP-830210, Revision 28, "Incinerator Operation," dated November 10, 2003
- Procedure COP-830211, Revision 0, "Incinerator Clean-Out," dated March 10, 2004

(2) Observations and Findings

The inspectors noted that CSE controls on the lower combustion chamber effectively maintained the mass limits for that portion of the incinerator but did not effectively maintain the concentration limit as assumed so that mass was not controlled outside the lower combustion chamber and concentration was not controlled anywhere. As shown in Figure #2, the licensee had data in 1996 indicating that the concentration of uranium in ash exceeded 21.6 wt%. The inspectors determined that the licensee had operated the incinerator since at least December of 1996 in excess of the assumed subcritical limit on uranium concentration. Operation of the incinerator without controls on concentration led to an upset condition of excess fissile material accumulation in an unsafe geometry, the upper combustion chamber.

Section 6.1.3 of the License Application states, in part, that nuclear criticality safety will be achieved by controlling one or more parameters of a system within subcritical limits. Section 6.2.3(a) of the License Application states, in part, that with respect to credible abnormal conditions that could lead to single contingency protection, there will be sufficient margin of safety to ensure that, based on these parameters, the 95/95  $k_{\text{eff}}$  is  $\leq 0.98$ , including all applicable biases and calculated parameters. CSE for the incinerator contained in ISA Section 5.3.4.9 states, in part, that controlling the uranium concentration of the incinerator feed also serves the purpose of ensuring that the resulting ash is less than the minimum infinite critical concentration for mass. Failure to control the uranium concentration in the incinerator system within the subcritical limit of  $k_{\text{eff}} \leq 0.98$  by allowing concentration of uranium in ash to exceed 21.6 wt%, the minimum infinite critical concentration for mass is **Apparent Violation 70-1151-2004-001-01**.

The inspectors noted that cartridge filters from the quench water recirculation system may be burned without assigning a mass value when they are changed out during a burn cycle because any mass in them is already assigned to the burn. The incinerator operating procedure, COP-830210, Revision 28, discussed this practice in section II.3

but used an incorrect reference in step II.1.3 where the criticality safety mass limits were listed. This error appeared to have been introduced in the most recent revision and did not contribute to the event. The incorrect reference was a weakness in the procedure to be corrected prior to the incinerator restart.

The inspectors noted that the CSE for the incinerator took credit for radiological surveys of the cross-over pipe as protection against the accumulation of ash in the incinerator off-gas system. The inspectors reviewed radiological controls for the incinerator and determined that surveys of the cross-over pipe were not being performed. The licensee was not able to provide evidence that the surveys had ever been performed. The inspectors interviewed radiological control technicians and none could remember ever performing the surveys. Although some licensee staff questioned the usefulness of this type of survey, it is possible that such a survey would have produced independent data resulting in earlier discovery of the analytical error.

Section 6.1.1 of the License Application states, in part, that criticality safety analyses and evaluations are utilized to identify the specific limits and controls necessary for the safe and effective operation of a process. Criticality Safety Analysis contained in Integrated Safety Analysis, Revision 1, "Incinerator," dated March 31, 1999, Section 5.3.4.5.3 states, in part, that as a safety precaution, the cross-over pipe is surveyed regularly by the health physics function. Failure to implement a specifically identified control by failing to regularly perform radiological surveys of the incinerator cross-over pipe is **Apparent Violation 70-1151-2004-001-02**.

The inspectors noted that city water at normal pressure was connected to the quench system to provide backup cooling in the event temperature in the off-gas system exceeded 200 degrees F. Several spill events have caused flooding in the incinerator area which the licensee corrected by eliminating the floor drain and directing quench system overflow through hard piping out of the incinerator room. Protection of the off-gas system against damage by heat and potential fire is accomplished by interlocks to shut off the incinerator and initiate city water flood when quench system temperature reaches 200 degrees F. The only controls (uncredited) preventing moderator from reaching the incinerator system are level alarms in the quench system which notify operators of rising water levels but do not physically intervene. The inspectors determined that sufficient moderator was available to the incinerator to support criticality during credible upsets.

(3) Conclusions

An apparent violation was identified due to licensee operation of the incinerator outside the safety basis. An apparent violation was identified due to licensee failure to perform a radiological survey of the incinerator cross-over pipe credited in the CSE as a defense against material accumulation in the off-gas system.

(c) NCS Functions(1) Inspection Scope

The inspectors reviewed the criticality safety analysis for the incinerator, the incinerator off-gas system, and the incinerator ash handling system to determine the adequacy of the existing safety basis and to understand the circumstances leading to the event. The inspectors reviewed the licensee procedures for independent review to determine the adequacy of review of the incinerator CSE during preparation and revision. The inspectors reviewed licensee audit procedures to determine how internal auditing contributed to the event. The inspectors reviewed two mass accumulation events which occurred after the CSE for the incinerator was approved and before the upset was discovered. The following documents were reviewed:

- ISA Section 5.3.4, Revision 1, "Incinerator," dated March 31, 1999
- ISA Section 5.3.5, Revision 1, "Ash Handling System," dated March 31, 1999
- Procedure RA-310, Revision 8, "Nuclear Criticality Safety Independent Technical Reviews," dated June 26, 2003
- Procedure RA-107, Revision 14, "Corrective Action Process for Regulatory Events," dated May 29, 2003
- Procedure RA-311, Revision 2, "NCS Programs and Annual Process Reviews," dated May 4, 2000

(2) Observations and Findings**Mass Controls on the Incinerator**

The licensee performed a CSE of the incinerator in September of 1996 and concluded that criticality in the off-gas and ash handling systems was not credible. Criticality was deemed credible only in the incinerator lower combustion chamber and appropriate mass controls were developed and implemented for this portion of the incinerator. Mass controls on the lower combustion chamber consisted of a 125-pound limit on waste charges with up to 100 grams  $U^{235}$  allowed per charge. Total waste charge rate is limited to 500 pounds per hour with a limit of 1386 grams  $U^{235}$  allowed before raking of the lower combustion chamber is required.

**Moderator Intrusion into the Incinerator**

The licensee reviewed the availability of water and carbon from input waste material as a source of moderation but did not consider the quench system or city water connected to it. Availability of moderator was assumed for the lower combustion chamber and controls were placed on mass accumulation which were felt to be sufficient for the system. Licensee analysis did not consider the availability of water from other sources, and no controls were placed on the quench system. The inspectors determined that interlocks were in place to cause automatic activation of city water to flood the quench column in the event that system temperature should exceed 200 degrees F. The interlock includes shutting off the incinerator and opening up a dump valve from the recirculation tank. No credit was taken for the interlocks which were installed to protect

the off-gas system from fire. The inspectors concluded that the failure of the dump valve was a credible scenario leading to moderator intrusion into the incinerator.

### **Double Contingency Analysis**

The detailed argument for the non-credibility of criticality outside of the lower combustion chamber is found in Section 5.3.5.9. of the ISA in the CSE for the ash handling system and is based on the accumulation of sufficient mass. Licensee NCS engineers determined that it was unlikely for significant mass to pass the upper combustion chamber and that the average uranium concentration in the ash was not known to exceed 0.10 to 0.15 gm-U/gm. Based on this conclusion, NCS engineers performed infinite media calculations to show that  $k_{\infty}$  for ash, equals 1.0 for saturated uranium dioxide ( $UO_2$ ) powder at a concentration of 21.8 wt% uranium. This corresponds to 21.6 wt% uranium for  $k_{\infty}$  equal to 0.98, therefore, 21.6% became a bounding assumption for the system. Based on acceptance of this assumption, the licensee eliminated the need to further investigate or review estimated deposition in the upper combustion chamber or availability of moderator during operation or shutdown periods. Licensee sampling data from 1996 (shown in Figure #2) demonstrated that the bounding assumption regarding concentration was not correct.

The inspectors analyzed the upper combustion chamber using a  $UO_2$  and water mixture to bound wet fly-ash at a concentration of 30 wt% uranium and one inch of water to bound the refractory material. The calculation, using dense water, shows that the upper combustion chamber reaches  $k_{\text{eff}}$  of 0.98 near 500 kilograms of material. The inspectors varied the ash and refractory material descriptions and densities in the calculation to gain confidence in the result. Based on the clear trend of concentration and mass values shown in figures #2 and #3, the inspectors concluded that criticality was credible in the incinerator upper combustion chamber. Because the actual mass accumulation in the upper combustion chamber was 271 kilograms and no other upset had occurred, the inspectors concluded that substantial margin against criticality remained in the as-found condition.

Section 6.1.1 of the License Application states, in part, that the double contingency principle will be the basis for design and operation of processes using special nuclear material. Double contingency protection means that all process designs will incorporate sufficient margins of safety to require at least two unlikely, independent and concurrent changes in process conditions before a criticality accident is possible. The failure to incorporate sufficient margins of safety to require at least two unlikely, independent and concurrent changes in process conditions in the incinerator system before a criticality accident was possible is **Apparent Violation 70-1151-2004-001-03**.

Licensee analysis concluded that concentration in the incinerator would be limited by controls on mass in the lower combustion chamber. Lack of controls on concentration in the off-gas system resulted in concentration exceeding the established subcritical limit. Section 6.1.3.e.1 states, in part, that limiting concentration may be used for nuclear criticality safety control of systems within the facility, and when utilized, that controls will be established to ensure that the concentration level is maintained within the analyzed system defined limits. CSE for the incinerator contained in ISA Section 5.3.4.9 states, in

part, that controlling the uranium concentration of the incinerator feed also serves the purpose of ensuring that the resulting ash is less than the minimum infinite critical concentration for uranium. License Application Section 6.1.3.e.1 states, in part, that controls will be established to ensure that the concentration level is maintained within the analyzed system defined limits. Failure to establish controls to maintain concentration to ensure that incinerator ash was less than the minimum infinite critical concentration for uranium in the incinerator off-gas system is **Apparent Violation 70-1151-2004-001-04**.

Licensee analysis concluded that concentration in the incinerator would be limited by controls on mass in the lower combustion chamber. Lack of controls on concentration in the ash handling system resulted in concentration exceeding the established subcritical limit. Section 6.1.3.e.1 states, in part, that controls will be established to ensure that the concentration level is maintained within the analyzed system defined limits. CSE for the incinerator contained in ISA Section 5.3.4.9 states, in part, that controlling the uranium concentration of the incinerator feed also serves the purpose of ensuring that the resulting ash is less than the minimum infinite critical concentration for uranium. License Application Section 6.1.3.e.1 states, in part, that controls will be established to ensure that the concentration level is maintained within the analyzed system defined limits. Failure to establish controls to maintain concentration to ensure that incinerator ash was less than the minimum infinite critical concentration for uranium in the incinerator ash handling system is **Apparent Violation 70-1151-2004-001-05**.

As allowed by Section 6.1.3.j of the License Application, the licensee took credit for a physical property of the incinerator operation, specifically that the ash would never exceed a uranium concentration of 21.6 wt% and had dismissed criticality in the off-gas system as not credible. Section 6.1.3.j.1 states, in part, that the bounding assumptions will be defined through the criticality safety analyses, criticality safety evaluations, or integrated safety analysis process and operational limits will be identified within each specific analysis; and, will be communicated, through training and procedures to appropriate operations personnel. CSE for the incinerator contained in ISA Section 5.3.4.9 states, in part, that controlling the uranium concentration of the incinerator feed also serves the purpose of ensuring that the resulting ash is less than the minimum infinite critical concentration for uranium. Failure to communicate to engineering staff in the Uranium Recovery and Recycle Systems organization the bounding assumption of uranium concentration being limited to the minimum infinite critical concentration for uranium for the incinerator system is **Apparent Violation 70-1151-2004-001-06**.

The inspectors concluded that the initial analytical error occurred during initial preparation of the incinerator CSE due to the failure of URRS process engineers to provide information regarding the actual concentration of uranium in incinerator ash and history of ash deposition to NCS engineers. The initial error went uncorrected due to the failure to have process engineers review the final NCS analysis. The inspectors determined that process engineers did not provide all data concerning uranium concentration and deposition that was available to them when requested during CSE preparation. A process engineer commented that the NCS analysis was not available to him even after completion because the analysis was locked in a room with limited access. The inspectors determined that poor communication between licensee

engineering staff regarding the expected uranium concentration in and deposition of incinerator ash contributed to the failure of NCS engineers to identify a credible accident scenario leading to criticality.

The licensee was required to perform independent review of criticality analysis as specified in Section 6.2.4 of the license application and this requirement is implemented by licensee procedure RA-310. The inspectors determined that independent reviewers of the CSE failed to verify the conclusion that criticality was not credible in the incinerator outside of the lower combustion chamber. License Application Section 3.4.1 states, in part, that operations to assure safe compliant activities involving nuclear material will be conducted in accordance with approved procedures. Licensee Procedure RA 310 Section 6.3.1B requires, in part, that conclusions be confirmed for CSEs, including supplements and revisions. Failure of licensee personnel to perform an adequate independent technical review and confirmation of incinerator CSE conclusions during initial preparation or subsequent revisions is **Apparent Violation 70-1151-2004-001-07**.

### **Previous Incinerator Events**

Licensee staff indicated that large mass accumulations occurred in the incinerator since it was installed in 1985. The first documented event occurred in November 1998 when the incinerator was shutdown due to operational difficulties. The licensee discovered that about 100 kg of fly-ash was blocking the cross-over pipe. Two samples gave uranium concentration results of 23.3 wt% and 20.2 wt%. Both the mass accumulation and the concentration violated assumptions of the CSE and so the event should have been reported. The second event occurred in June of 2003 due to problems with the off-gas air filters. The licensee discovered that the knock-out pot had an accumulation of 150 kg of damp ash at 2 wt% uranium. This much ash accumulating that far into the off-gas system also violated an assumption of the CSE and should have been reported. Both events were reviewed by licensee NCS staff resulting in a conclusion that double contingency was maintained. License Application Section 3.4.1 states, in part, that operations to assure safe compliant activities involving nuclear material will be conducted in accordance with approved procedures. Licensee Procedure RA 107 Section 8.5 requires, in part, that 24-hour notification to the NRC be made for any nuclear criticality safety event, in an analyzed system, for which less than previously documented double contingency protection remains. Failure to identify that less than previously documented double contingency protection remained and notify the NRC during an NCS review of a 1998 event involving excess mass accumulation in the incinerator cross-over pipe is **Apparent Violation 70-1151-2004-001-08**. Failure to identify that less than previously documented double contingency protection remained and notify the NRC during an NCS review of a 2003 event involving mass accumulation incinerator knock-out pot is **Apparent Violation 70-1151-2004-001-09**.

The licensee performed NCS Program Reviews in accordance with procedure RA-311 Revision 2, "NCS Programs and Annual Process Reviews," on a schedule that resulted in a complete program review every three years. The inspectors reviewed results of recent NCS-related reviews conducted in accordance with this procedure and determined that the reviews did not systematically evaluate the adequacy of NCS controls relative to their analytical bases. Licensee efforts in this regard are narrowly focused on compliance with NCS limits. Validation of the analytical basis for NCS controls is not routinely undertaken unless significant changes to the system have occurred. The inspectors noted that a systematic review of analytical assumptions may have detected the error in the incinerator CSE much earlier. The inspectors determined that the failure to routinely and systematically review the NCS analytical bases was a weakness in the licensee audit program.

(3) Conclusions

Criticality is credible in the upper combustion chamber of the licensee incinerator. Four apparent violations were identified based on licensee failure to recognize a credible accident sequence leading to criticality in the incinerator off-gas and ash handling systems resulting in the failure to implement adequate controls to maintain double contingency protection in the incinerator off-gas and ash handling systems. The as-found condition in the incinerator was subcritical.

An apparent violation was identified due to licensee failure to perform adequate independent review of the incinerator CSE. Two apparent violations were identified due to licensee failure to report previous incinerator mass accumulation events. A weak licensee audit program contributed to the failure to identify a credible scenario leading to criticality.

(d) Licensee Root Cause Analysis

(1) Inspection Scope

The inspectors reviewed the licensee root cause analysis and interviewed root cause team members to determine the adequacy of the licensee root cause analysis of the incinerator event.

(2) Observations and Findings

The licensee assembled a root cause investigation team in accordance with its procedure and conducted a root cause investigation which had just been completed at the time of the inspection. The licensee root cause team thoroughly investigated the original error in the CSE but did not investigate several opportunities to identify the problem during revisions and did not investigate the independent NCS review of the CSE. As a result, licensee root cause analysis did not recognize or investigate the extent of the upset or take note that the upset occurred gradually beginning some time after approval of the CSE.

The licensee root cause analysis report correctly concluded that the initial error in the CSE was isolated but was narrowly focused on NCS program issues relative to analysis.

(3) Conclusions

The licensee root cause analysis did not recognize the extent of the incinerator upset or investigate all contributing factors.

e. Safety/Risk Significance

(1) Inspection Scope

The inspectors evaluated the safety significance of the event including potential for criticality in unevaluated portions of the incinerator and any uncredited controls which would have prevented an inadvertent criticality event.

(2) Observations and Findings

The fissile material removed from the incinerator after the event took approximately 18 months to accumulate. The incinerator combustion chambers, the cross-over pipe, portions of the ash handling system are not favorable geometry. Available data indicated that, as the licensee asserts in the original CSE, off-gas system components downstream of the cross-over pipe did not see uranium concentration in the fly-ash above 10 wt%. Because ash does not accumulate in the ash handling system, the risk significance of violating the concentration assumption there is considered low. The lower combustion chamber is mass limited and ash is raked out daily while burning. Mass limits on the lower combustion chamber were not violated as a result of the event. The remainder of the incinerator is only cleaned out when specifically requested and may go 18 months or longer between clean-outs.

Criticality in the upper combustion chamber is credible. Sufficient mass readily accumulates in the upper and lower combustion chambers and cross-over pipe and moderator is readily available in the quench system. No controls were in place on mass, concentration or moderator in the incinerator with the exception of total mass in the lower chamber. The event demonstrated that concentration and mass of uranium in incinerator ash were not limited as expected.

Risk Significance of As-Found Condition

Subsequent to the event, the licensee removed approximately 58.4 kg of ash at 0.263 gm-U/gm from the lower combustion chamber, 271.3 kg of ash at 0.255 gm-U/gm from the upper combustion chamber and approximately 54.4 kg of ash at 0.301 gm-U/gm from the cross-over pipe. Licensee calculations based on an optimally moderated sphere indicate that  $k_{\text{eff}}$  was 0.92 for the upper combustion chamber and 0.78 for the cross-over pipe. The diameter of the cross-over pipe versus the spherical analytical geometry leads to the conclusion that criticality is not credible in the cross-over pipe. Since the minimum critical mass for the as-found condition in the upper combustion chamber is near 550 kg, safety margin remained in that area.

### Potential Risk Significance

The licensee did not remove material from the upper combustion chamber during every shutdown so that accumulation of mass was likely. Accumulation of sufficient mass in the upper combustion chamber at a concentration that would support criticality is considered credible. Both mass and concentration are seen to increase in Figures #2 and #3 indicating progression of the upset.

Sufficient moderator in the quench system is always available to the incinerator to create a critical system. Uncredited licensee operational controls on the quench system were alarms which would not physically prevent water from reaching the incinerator during a water level upset. City water intruding from a flooded quench column would rapidly cool the equipment but would not be expected to cause enough damage to prevent entrance to the incinerator.

Criticality is credible in the upper combustion chamber. Although the as-found condition was subcritical, no controls were in place on mass or moderator outside the incinerator lower combustion chamber. The continued accumulation of ash in the upper combustion chamber could have resulted in a critical mass of uranium in an unfavorable geometry.

### (3) Conclusions

An accident scenario leading to criticality was not analyzed or controlled resulting in a mass accumulation upset in the licensee incinerator. The as-found condition of the upset was subcritical. The accumulation of uranium in the incinerator was uncontrolled and increased with the time of incinerator operation. There were no controls to limit the amount of material in the incinerator to below a minimum critical mass.

## **6. Followup (IP 92701)**

### a. Inspection Scope

The licensee's actions to address previously identified issues were reviewed to determine completion to closure.

### b. Observations and Findings

IFI 2003-02-01 Verify corrective actions taken in response to the lack of health physics support to the fire brigade and AEOC. The inspectors reviewed the licensee's records of the training and drills conducted to improve the health physics support to the fire brigade and AEOC. The licensee's corrective actions were completed on December 8, 2003. Based on these corrective actions, IFI 2003-02-01 was closed.

IFI 2003-03-01 Review formalization of procedure requirements for team managers. The inspectors reviewed the licensee's corrective actions which included procedure revision and rewording. The corrective actions were completed on August 6, 2003. Based on these corrective actions, IFI 2003-03-01 was closed.

IFI 2003-04-01 Identify the location and provide training on where to evacuate in the event of a criticality or sounding of a criticality alarm during severe weather. The inspectors reviewed the licensee's corrective actions which included replacing assembly point signs and conducting annual training. The corrective actions were completed on February 28, 2004. Based on these corrective actions, IFI 2003-04-01 was closed.

EN 38656, January 27, 2003, 91-01 Event, Failure of operators to follow procedure and process material left in vertical pipe connecting hood and granulator into polypaks before the removal of the granulator screen. The inspectors reviewed the licensee's corrective actions which included procedure revision and personnel training. The personnel training records were reviewed. Based on these corrective actions, EN 38656 was closed.

EN 40246, October 14, 2003, 91-01 Event, Dry combustible trash was placed into a single 55-gallon drum without proper mass control. An operator removed a single drum from a scale and then filled the drum with dry combustible trash. The inspectors reviewed the licensee's corrective actions. The employee concerned was disqualified, disciplined and was later requalified. Based on these corrective actions, EN 40246 was closed.

EN 40255, October 16, 2003, 91-01 Event, Abnormal shutdown of the Windows-based system caused two copies of the PLC interface program to be running, breaking communications between the PLC and the moisture database after the scan of a pack with acceptable moisture occurred. 122 packs were subsequently dumped without consulting the moisture database. The inspectors reviewed the licensee's corrective actions which included the plant configuration change control form, a change authorization to correct the problem and interlock verification. Based on these corrective actions, EN 40255 was closed.

c. Conclusions

The corrective actions to IFI 2003-02-01, IFI 2003-03-01, IFI 2003-04-01, EN 38656, EN 40246 and EN 40255 were reviewed, the corrective actions completed and adequately addressed by the licensee. These items were closed.

7. **Exit Meeting**

The inspection scope and results were summarized on April 16, 2004, with those persons indicated in the Attachment. Although proprietary documents and processes were occasionally reviewed during this inspection, the proprietary information is not included in this report. Dissenting comments were not received from the licensee.

## ATTACHMENT

### 1. LIST OF PERSONS CONTACTED

#### Licensee

C. Aguilar, Manager, Uranium Recycle and Recovery System  
S. Ari, Measurement Control Coordinator, Environment, Health and Safety  
M. Connelly, Nuclear Criticality Safety Engineer  
M. Fecteau, Plant Manger  
R. Fischer, Senior Engineer, Regulatory Engineering and Operations  
R. Gale, Manager, Chemical Operations  
D. Graham, Technician, Environment, Health and Safety  
J. Heath, Manager, Integrated Safety Engineering  
S. McDonald, Manager, Environment, Health and Safety  
G. Page, Manager, Maintenance  
N. Parr, Licensing, Environment, Health and Safety  
J. Rue, Manager, Mechanical Manufacturing  
T. Shannon, Operations Manager, Environment, Health and Safety  
C. Snyder, Nuclear Criticality Safety Engineer  
E. Steck, Principal Manufacturing Engineer

Other licensee employees contacted included engineers, technicians, production staff, security, and office personnel.

### 2. INSPECTION PROCEDURES USED

IP 83822      Radiation Protection  
IP 88056-63    Chemical Operations  
IP 88025      Maintenance/Surveillance  
IP 88015      Headquarters Criticality Safety Program

### 3. LIST OF ITEMS OPENED AND CLOSED

<u>Item Number</u>	<u>Status</u>	<u>Description</u>
AV 70-1151-2004-001-01	Opened	Failure to control the uranium concentration in the incinerator system within the subcritical limit of $k_{\text{eff}} \leq 0.98$ by allowing concentration of uranium in ash to exceed 21.6 wt%, the minimum infinite critical concentration for mass
AV 70-1151-2004-001-02	Opened	Failure to implement a specifically identified control by failing to regularly perform radiological surveys of the incinerator cross-over pipe

AV 70-1151-2004-001-03	Opened	The failure to incorporate sufficient margins of safety to require at least two unlikely, independent and concurrent changes in process conditions in the incinerator system before a criticality accident was possible
AV 70-1151-2004-001-04	Opened	Failure to establish controls to maintain concentration to ensure that incinerator ash was less than the minimum infinite critical concentration for uranium in the incinerator off-gas system
AV 70-1151-2004-001-05	Opened	Failure to establish controls to maintain concentration to ensure that incinerator ash was less than the minimum infinite critical concentration for uranium in the incinerator ash handling system
AV 70-1151-2004-001-06	Opened	Failure to communicate to engineering staff in the Uranium Recovery and Recycle Systems organization the bounding assumption of uranium concentration being limited to the minimum infinite critical concentration for uranium for the incinerator system
AV 70-1151-2004-001-07	Opened	Failure of licensee personnel to perform an adequate independent technical review and confirmation of incinerator CSE conclusions during initial preparation or subsequent revisions
AV 70-1151-2004-001-08	Opened	Failure to identify that less than previously documented double contingency protection remained and notify the NRC during an NCS review of a 1998 event involving excess mass accumulation in the incinerator cross-over pipe
AV 70-1151-2004-001-09	Opened	Failure to identify that less than previously documented double contingency protection remained and notify the NRC during an NCS review of a 2003 event involving mass accumulation incinerator knock-out pot
IFI 70-1151-2003-02-01	Closed	Verify corrective actions taken in response to the lack of health physics support to the fire brigade and AEOC

IFI 70-1151-2003-03-01	Closed	Review formalization of procedure requirements for team managers
IFI 70-1151-2003-04-01	Closed	Identify the location and provide training on where to evacuate in the event of a criticality or sounding of a criticality alarm during severe weather
EN 38656	Closed	91-01 Event, Failure of operators to follow procedure and process material left in vertical pipe connecting hood and granulator into polypaks
EN 40246	Closed	91-01 Event, Dry combustible trash was placed into a single 55-gallon drum without proper mass control. An operator removed a single drum from a scale and then filled the drum with dry combustible trash
EN 40255	Closed	91-01 Event, Abnormal shutdown of the Windows-based system caused two copies of the PLC interface program to be running, breaking communications between the PLC and the moisture database after the scan of a pack with acceptable moisture occurred. 122 packs were subsequently dumped without consulting the moisture database

#### 4. LIST OF ACRONYMS USED

ALARA	As Low As Reasonably Achievable
ALI	Annual Limit of Intake
CAP	Corrective Action Process
CEDE	Committed Effective Dose Equivalent
CFR	Code of Federal Regulation
COP	Chemical Operating Procedure
CSE	Criticality Safety Evaluation
CY	Calendar Year
DAC	Derived Air Concentration
ES&H	Environmental Safety and Health
GET	General Employee Training
HEPA	High Efficiency Particulate Air
HP	Health Physicist
ICRP	International Commission on Radiological Protection
IFBA	Integrated Fuel Burnable Absorber
IP	Inspection Procedure
ISA	Integrated Safety Analysis

$K_{\text{eff}}$	K-effective, a mathematical measure toward a criticality situation
MSDS	Material Safety Data Sheet
NCS	Nuclear Criticality Safety
NFG	Unfavorable Geometry
NMED	Nuclear Materials Event Database
No.	Number
NOV	Notice of Violation
NRC	Nuclear Regulatory Commission
PIC	Procedure Improvement and Compliance
PARS	Publicly Available Records
PM	Preventative Maintenance
PSI	Process Safety Information
RCWP	Radiation Chemical Work Permits
SNM	Special Nuclear Material
SOI	Standard Operating Instruction
U	Uranium
$U^{235}$	Uranium Isotope 235
$UF_6$	Uranium Hexafluoride
UN	Uranyl Nitrate
$UO_2$	Uranium Dioxide
URI	Unresolved Item
URRS	Uranium Recycling and Recovery Services
VIO	Violation
WT%	Weight per cent