FENOC

FirstEnergy Nuclear Operating Company

5501 North State Route 2
Oak Harbor, Ohio 43449

Lew W. Myers
Chief Operating Officer

419-321-7599
Fax 419-321-7582

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United States Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20551-0001

Subject: Reply to NRC Notice of Violations (EA-02-117 and EA-02-257)

Reference:
1. NRC Special Inspections – Substantial Potential for an Overexposure of Occupational Workers (Report No. 50-346/02-16) and Uncontrolled Release of Radioactive Material to the Environment (Report No. 50-346/02-06) Two Preliminary White Findings, dated January 7, 2003 (Log 1-4328)
2. Final Significance Determination for Two White Findings and Notice of Violations, NRC Inspection Report 50-346/02-16, dated February 19, 2003 (Log 1-4348)

Dear Sir or Madam:

FirstEnergy Nuclear Operating Company (FENOC) received the letter dated February 19, 2003 (Log 1-4348), identifying the results of the special inspections conducted by the Nuclear Regulatory Commission (NRC) Special Inspection Teams (SITs). The NRC SITs were dispatched to investigate issues surrounding the personnel contamination incident that occurred during the installation of the steam generator nozzle dams at Davis-Besse Nuclear Power Station (DBNPS) in February 2002.

On January 21, 2003, FENOC notified the NRC staff that the two white findings documented in the letter dated January 7, 2003 (Log 1-4328), appear to be fair and factual characterization of the incident that occurred in February 2002. These findings relate to FENOC's failure to: (1) conduct adequate evaluations of the radiological conditions and potential hazards; and, (2) take suitable and timely measurements of concentrations of radioactive material in air in work areas and adequately monitor the occupational intake of these materials by workers. These two white findings were determined to have low to moderate safety significance.

FENOC acknowledges that evaluations of radiological hazards associated with performing the steam generator nozzle dam work were not adequately performed This was due to the failure to recognize the changing plant conditions (i.e., unaccounted higher radiological hazard condition due to failed fuel during the previous operating cycles and unexpected crud burst during the reactor coolant system cleanup activity). Additionally, appropriate levels of radiological controls were not planned or implemented during and following the work associated with the steam generator nozzle dam installation. This caused unplanned personnel contamination, resulting in

IE01
IE14

internal contamination of workers and release of discrete radioactive particles to the public domain. FENOC recognizes that radiation protection personnel were not sensitive to the impact of the potential internal contamination. Additionally, a timely internal dose evaluation was not performed to determine the level of the contamination of individuals involved.

FENOC recently completed a detailed program compliance review of the radiation protection program. This review was performed by an independent review team that was comprised of industry experts and FENOC individuals who were not directly associated with radiation protection group. The radiation protection program compliance review was conducted to satisfy the NRC Inspection Manual Chapter (IMC) 0350, item 3.h. FENOC has reviewed this report and is currently implementing appropriate recommended corrective actions from this review. The issues identified during the review have been entered into the corrective action program.

Pursuant to the provisions of 10 CFR 2.201, Enclosure 1 provides our response to the notice of violations. Additionally, the attached provides a copy of each of the root cause analyses that were performed by FENOC to address the circumstance associated with the February 2002 incident.

If you have any questions or require further information, please contact
Mr. Patrick J. McCloskey, Manager-Regulatory Affairs, at (419) 321-8450.

Sincerely,

GH:AWB/s

Enclosures
Attachments

cc: J. E. Dyer, NRC/RIII Administrator
J. A. Grobe, Chairman, NRC DB Oversight Panel
W. J. Slawinski, NRC/RIII
J. B. Hopkins, DB-1 NRC/NRR Project Manager
S. P. Sands, DB-1 NRC/NRR Backup Project Manager
C. S. Thomas, DB-1 Senior Resident Inspector
Utility Radiological Safety Board

STATEMENT OF NOTICE OF VIOLATION (EA-02-117)

10 CFR 20.1501(a) requires that each licensee make or cause to be made surveys that may be necessary for the licensee to comply with the regulations in Part 20 and that are reasonable under the circumstances to evaluate the extent of radiation levels, concentrations or quantities of radioactive materials, and the potential radiological hazards that could be present. Pursuant to 10 CFR 20.1003, survey means an evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation.

Contrary to the above, as of February 20, 2002, the licensee did not make surveys to assure compliance with 10 CFR 20.1201(a)(1)(i) and (ii), which limits radiation exposure such that the total effective dose equivalent does not exceed an annual dose limit of 5 rem, and the sum of the deep-dose equivalent and committed dose equivalent to any individual organ or tissue other than the lens of the eye does not exceed an annual dose limit of 50 rem. Specifically, the licensee did not conduct an adequate evaluation of the radiological conditions and potential hazards inside the steam generator (SG) bowls prior to nozzle dam installations. This resulted in the failure to identify the presence of alpha emitting isotopes in the SG bowls in concentrations sufficient to cause a substantial potential for an exposure in excess of applicable regulatory requirements to workers without adequate protection against internal contamination.

This violation is associated with a White SDP finding. (EA-02-117)

REASONS FOR THE VIOLATION

FENOC performed a detailed root cause analysis and determined that several factors contributed to the cause of this incident. The following provides a synopsis of the incident:

On January 22, 2002, radiation work permit (RWP) 2002-5303 (Install and remove nozzle dams and nozzle dam FME covers and equipment setup) was developed in preparation for steam generator nozzle dam work during the February 2002 refueling outage 13 (13RFO). The accompanying as-low-as-reasonable-achievable (ALARA) review for this RWP was performed on January 23, 2002.

When the ALARA briefing was conducted on February 18, the information presented at this briefing was based on historical data as documented in the RWP 2002-5003. The briefing was not well organized and the individuals assigned to this task were not available for this ALARA briefing. Therefore, a decision was made to conduct another ALARA briefing just prior to the evolution. On February 19, upper steam generator manways were removed. Subsequent to this evolution, Radiation Protection (RP) personnel performed a survey of the area but results of the survey were misplaced and were not included in the RWP (surveys were later found in the Auxiliary Building Survey book). The air samples taken from both the west and east steam generators indicated presence of alpha emitters. The east steam generator platform area indicated a derived air concentration (DAC) value of 14 DAC for alpha emitters. A smear sample on the west diaphragm showed a removable contamination level of approximately 46 rad/hr. The dose rate of the east steam generator tube sheet on contact was 10.8 to 12.1 rem/hr. At the time of the evolution, no breathing zone air samples were collected. However, AMS-4 monitors were placed

outside of each steam generator platforms for collecting air samples and radiological air sample pump (RASP) was used to pull an air sample from the plane of the opened manway.

Although the radiological surveys of steam generators were performed prior to start of the job, results of these surveys were not properly evaluated and discussed prior to the start of the nozzle dam installation. Air samples taken from both east and west steam generator manway areas indicated presence of transuranics (TRU). Also, smear samples collected in the general work area showed overall increased contamination levels that were significantly different than that assumed for the RWP and ALARA planning. This change in plant condition was not recognized prior to start of the job.

Other inappropriate performance that contributed to this incident, are as follows:

During the past operating cycles, Davis-Besse Nuclear Station (DBNPS) had experienced varying degree of fuel defects. As a result, the concentration of alpha emitting isotopes has shown a steady increase over time. This increase was identified in the May 2001 self-assessment of the Radiological Air Sampling Program however, these deficiencies were not identified in the corrective action process. Several of the recommendations addressed taking additional measures to account for increased alpha contamination in the plant. Condition Report (CR) 2002-07811 (NRC White Finding Related to 10 CFR 20.1501 Violation) and CR 2003-00588 (Document Recommended Actions From Self Assessment) was subsequently generated to document the failure to capture and implement recommendations of the self-assessment.

During development of the RWP 2002-5303, a latent error was introduced. The historical data of 60 mrad/hour smearable contamination in the steam generator bowl area had inadvertently been altered to 60 rad/hour. This error resulted in a false upper dose limit for the job. This discrepancy was documented in CR 2002-07717 (Error in RWP'S May Be Carried to Next Outages) and the corrective action was subsequently rolled into CR 2002-07811.

In planning for the 13RFO, a benchmarking trip to another facility was conducted to observe how others perform their shutdown chemistry. As a result, a different approach to shutdown chemistry was conducted for 13RFO that involved draining the Reactor Coolant System prior to adding the hydrogen peroxide to oxidize the system. Based on past industry experience, increase in contamination level of the steam generator bowls was not considered to be likely for this evolution. However, due to differences in system design, the outcome of the radiological condition was significantly different than expected. The samples taken from the steam generator indicated there was little or no removal of oxidized material in the steam generators. This resulted in increased dose rates on the steam generator tube sheets and contamination levels greater than previously anticipated. Condition Report 2002-00659 (Shutdown Chemistry Method Utilized for 13 RFO less Effective than Anticipated) was generated to document the result.

During drain down of the RCS system, CRUD burst occurred. This change in the plant condition was not thoroughly considered for potential increase in dose rate prior to commencement of the steam generator nozzle dam job.

Summary of Root Cause Analysis

Subsequent to the contamination incident, FENOC performed detailed investigations to evaluate the incident and to implement appropriate corrective actions to prevent recurrence of this event. The results of the investigation are documented CR 2002-07811 (NRC White Finding of 10 CFR 20.1501 Violation) and CR 2002-07819 (NRC White Finding of 10 CFR 20.1204).

The root cause analysis performed for CR 2002-07811 (NRC White Finding of 10 CFR 20.1501) addresses the issue for this violation (EA-02-117). The analysis determined two root causes and one contributing cause to this incident. The root causes of the incident are characterized in the following problem statements: (1) Less than adequate Work Direction as the preparation for the job did not ensure the workers performing the task would have the necessary information to be successful, and (2) Less than adequate Management Systems in relation to Standards, Policies, or Administrative Controls and a deficiency in the corrective action program.

The problem statements that relate to less than adequate Work Direction are: the preparation for the evolution failed to consider changing plant condition (i.e., RWP 2002-5303 was based on radiological conditions of past refueling outages); the radiological surveys performed prior to the job were not considered during the pre-job briefing; job/schedule time pressure placed on the job crew resulted in inadequate preparation for the job (i.e., inadequate pre-job briefing and ALARA work package); and the selection of workers was less than adequate in that the supervisor providing the oversight and two of the RP technicians assigned the job were unfamiliar with the plant.

The problem statements that relate to less than adequate Management Systems are: standards, policies and controls in the RP organization lacked rigor to ensure those assigned to provide the task oversight and coverage were from the Davis-Besse RP organization; the presence of TRU were documented in the May 2001 self-assessment however, recommendations were not properly implemented which could have provided better radiological controls and work package for the job; and industry and operating experiences were available but were not adequately addressed to ensure incorporation into the RP program.

The contributing cause involved: lack of rigor in preparation of RWP 2002-5303 where a latent error was introduced for anticipated dose rate of the job; less than adequate procedural guidance in radiation control for development of the RWP package for high radiological risk evolutions/jobs; and, use of past knowledge for performance of the steam generator nozzle dam work rather than having a procedural process for performance of the steam generator work (i.e., steam generator entry procedure).

CORRECTIVE ACTIONS TAKEN AND RESULTS ACHIEVED

The following corrective actions were taken:

1. Radiation Protection Night and Standing Order 2002-0015 (Interim ALARA Measures for Alpha Radioactivity) was issued. The standing order identified the known areas where alpha contamination was present and areas that were identified as suspect. The guidance provided appropriate precautions to minimize intake of alpha airborne radioactivity and performing a TEDE evaluation for determination of whether respiratory protection was needed. The

standing order also provided guidance for performing historical checks (i.e., evaluation of historical job surveys for detectable beta/gamma activity), pre-job radiological condition checks (i.e., determination whether special precautions are need for alpha contamination), and in-progress radiological condition checks (i.e., monitoring of beta/gamma to alpha ratio during performance of certain work activity).

2. As part of the extent of condition review, active RWPs were reviewed to determine whether additional typographical errors (e.g., RWP 2002-5303) existed. The review found no other such errors. In addition, the active RWPs were reviewed and where appropriate, the RWPs were rewritten to assure proper radiation protection controls were established.

3. A root cause analysis of this issue was performed and results of the analysis are documented in CR 2002-07811. The corrective actions associated with this incident is documented in the condition report and summarized below (Corrective Actions to Prevent Recurrence).

CORRECTIVE ACTIONS TO PREVENT RECURRENCE

The following corrective actions were implemented to prevent recurrence:

1. Revised RP procedure DB-HP-01901 (Radiation Work Permits) to clearly define when documented, reviewed and approved confirmatory surveys are required prior to proceeding with the work. This action will ensure the field conditions are bounded by the developed RWP (which is required to be discussed at the pre-job brief) and ALARA work package.

2. Revised RP procedures DB-HP-01104 (Radiological Surveillance) and DB-HP-01901 to address the requirements of "Stop Work". This will ensure the appropriate level of evaluation for potential radiological hazards and job controls are in place prior to performance of the job.

3. Developed RP procedure NG-DB-00240 (Radiological Area Access and Work Controls) to establish radiological controls for high radiological risk evolutions/jobs.

4. Developed steam generator entry procedure DB-HP-01115 (Once Through Steam Generator Entry) that establishes specific radiological controls in preparation and performance of work for steam generator work.

5. Developed standard and expectations for radiation protection organization. This is included in the Conduct of Radiation Protection Operations. The standard and expectations clearly defines duties and responsibilities for individuals assigned to provide oversight of high radiological risk jobs. Also, the standards and expectations reinforce the use of "Stop Work" if time pressure to complete the job is perceived (i.e., due to lack of radiological evaluation of job conditions) and if conditions are not adequate for successful performance of the assigned task.

6. A corrective action in CR 2002-07811 was initiated to document the condition where recommendations of May 2001 self-assessment of the radiological air sampling program were not adequately implemented in the RP Program. Subsequently, CR 2003-00588 was initiated

to document the specific recommendations of the self-assessment and to develop corrective actions to implement the recommendations. Also, the self-assessment process was revised to incorporate recommendations from these self-assessments into the corrective action process.

7. Revised RP procedure DB-HP-01901 (Radiation Work Permits) to include a TEDE evaluation process for consideration of impact due to transuranic alpha emitters for dose to individuals.

8. Corrective action has been initiated to develop an action plan and/or a procedure to ensure RP organization is aware of the current source term conditions of the plant (i.e., source term may change due to fuel defect). This process will ensure that the changing plant conditions are evaluated by RP for potential radiological hazards prior to commencement of a job.

9. Corrective action has been initiated to include shutdown chemistry in the radiation protection continual training program. This training will provide better understanding of the basic process of shutdown chemistry to radiation protection personnel.

10. Corrective action has been initiated to request training for RP technicians and appropriate RP staff to reinforce the lessons-learned from this incident. This training will be requested through the Davis-Besse RP Curriculum Review Committee.

11. Condition Report 2002-10275 has been initiated to address the issue with less than adequate use of Operating Experience program for continued RP program improvement.

DATE FULL COMPLIANCE WILL BE ACHIEVED

Based on the above actions, full compliance has been achieved. Corrective actions have been initiated and entered into the corrective action program to capture and track those items through completion.

STATEMENT OF NOTICE OF VIOLATION (EA-02-257)

10 CFR 20.1204(a) states that, for purposes of assessing dose used to determine compliance with occupational dose equivalent limits, the licensee shall, when required under 10 CFR 20.1502, take suitable and timely measurements of concentrations of radioactive material in air in work areas, quantities of radionuclides in the body, quantities of radionuclides excreted from the body or combinations of these measurements.

10 CFR 20.1502(b) requires each licensee to monitor the occupational intake of radioactive material by and assess the committed effective dose equivalent to adults likely to receive, in one year, an intake in excess of 10 percent of the applicable annual limits of intake (ALIs) in Table 1, Columns 1 and 2, of Appendix B to 10 CFR 20.1001 – 20.2402.

Contrary to the above, on February 20, 2002, the licensee failed to take suitable and timely measurements of concentrations of radioactive material in air in work areas. In addition, following internal contaminations on February 20, 2002, the licensee failed to take suitable and timely measurements of the quantities of radionuclides in the body, quantities of radionuclides excreted from the body, or combinations of these measurements for two workers required to be monitored. Specifically, the individuals were likely to receive an intake greater than 10 percent of the applicable annual limits of intake since the licensee knew that increased concentrations of alpha emitting isotopes existed in the plant contamination mix, that high contamination levels existed in the SGs, and that two workers potentially received a relatively large amount of internal contamination.

This violation is associated with a White SDP finding. (EA-02-257)

REASONS FOR THE VIOLATION

On February 20, 2002, Radiation Protection (RP) personnel performed a pre-job brief for the steam generator work group on Radiation Work Permit (RWP) 2002-5303 (Install and Remove Nozzle Dams and Nozzle Dam FME Covers and Equipment Setup). The smear sample of 46 rad/hour smearable and the presence of alpha contamination (14 DAC) was known; however, these conditions were not discussed nor was there an approved survey available for the RP individual during the brief. The RP Manager, RP Supervisor, and As Low As Reasonably Achievable (ALARA) planning personnel were aware of the conditions, however the job was allowed to proceed without any additional precautions added to the RWP. The RWP process at the time was not used for identifying required air samples. This decision was at the discretion of the assigned RP technician or by RP Supervisor direction at the time of the job. There were no breathing zone samples collected during the steam generator entry. This absence of air sample data complicated the dose assessment of the individuals during the following months.

Following the completion of the steam generator nozzle dam installation, the RP technicians and workers exited containment. Upon entering the Personal Contamination Monitors (PCMs) at the containment monitoring point, the instruments alarmed and RP personnel detected facial and nasal contamination on several of the workers. Decontamination efforts, showering and nasal discharge, were used on the contaminated workers (nasal discharge on a swab used during decontamination was later analyzed by gamma spectroscopy with measurable levels of Co-58, Co-60, Ce-141, Ce-144 and other activities and fission products). However, these efforts did not

enable the workers to exit the Radiological Restricted Area without alarming the PCM's. In accordance with station procedures, they were directed to the whole body counter for bioassay.

After performing the investigative Whole Body Count (WBC) on the workers, the RP Supervisor and duty RPM were notified of the positive results. No procedural guidance or further requirements existed for a positive whole body count and the workers were allowed to leave the site.

There were no dose assessments started by the night shift staff and any sense of urgency in performing these calculations was not communicated. Night shift RP personnel attempted to follow the dose assessment procedures but were not certain how to proceed. It was decided to wait until morning to perform the dose calculations.

The dose calculations performed the next day determined a potential dose of approximately 250 mrem. Over the next two weeks additional WBCs were performed and the dose estimates refined. However, none of them considered the likely transuranic intake or dose component. By March 11, dose assignments were made to the workers records. The assignment to the two highest workers were 170 mrem and 101 mRem CEDE. The *in vivo* bioassay (WBC) showed Co-58 and Co-60 and clearance of body burden as observed in contaminated individuals. It was determined that no further bioassays were required.

The results from samples submitted for 10 CFR Part 61 analysis in late June were received from the outside laboratory in early August. These samples measured transuranic radionuclides and additional dose calculations were performed based upon the scaling factors observed in the new data. On August 31, 2002 *in vitro* bioassay samples were collected and samples sent to an independent lab for analysis. In the effort to obtain an appropriate laboratory in a short time, verbal instructions for the samples were communicated to the lab. During these communications, environmental lower limits of detection (LLD) requirements were discussed as being necessary but it was unknown by the parties that this had different meanings to the individual parties.

Two additional *in vitro* bioassay samples (total of 3) were collected and sent to two independent laboratories. With the additional *in vitro* data received from three different laboratories the internal doses for the workers were re-calculated, this time including a transuranic component with refined intake and clearance modeling based on the WBC data. The individual with the maximum dose calculation for the job was assigned 430 mrem Committed Effective Dose Equivalent (CEDE) and 3.4 rem Committed Dose Equivalent (CDE) in December 2002.

Although the event did not result in an overexposure, there was a failure to take timely and suitable measurements of concentrations of radioactive materials in air in work areas, quantities of radionuclides in the body, and quantities of radionuclides excreted from the body for the workers involved in the steam generator nozzle dam installation performed on February 20, 2002. The failure to take suitable and timely measurements resulted in compromised ability to assess dose.

Summary of Root Cause Analysis

The root cause performed for Condition Report 2002-07819 (NRC White Finding of 10 CFR 20.1204) addresses the issue for this violation (EA-02-257). The report identified two root causes and three contributing causes. The root causes of the incident are characterized in the following problem statements: (1) Less than adequate Management System as the perception existed in the organization that transuranic contamination was not a site radiological issue, and (2) Less than adequate Work Direction as there was a lack of direction in the gathering and correlating of data to perform the necessary assessment of the intake.

Those specific issues which relate to the problem statement less than adequate Management Systems are: the RP organization did not have the required sensitivity to potential transuranic contaminations; standards or procedures did not document the responsibility and expectations for the determination of the communications, type, extent, and significance of intakes; and industry and operating experiences were available but were not adequately addressed to ensure incorporation into the RP program.

The specific issue which relates to the problem statement less than adequate Work Direction was the initial assessment showed significant intakes but management did not assign sufficient resources for investigating and performing the necessary follow-ups, including dose assessments. There was a lack of direction in gathering and correlating the data needed to perform the necessary dose assessment. The RP organization did not recognize the potential significance of the intake as assessed from the initial WBC assessment.

The following causes also contributed to this incident:

Guidance on the necessary actions to complete a timely evaluation of dose to an internally contaminated individual was not a documented process. This process for performing an evaluation was left to knowledge by individuals and not in written guidance. Less than adequate procedural guidance included: no procedure guidance for determining external vs. internal contamination or what conditions would require follow-up analysis (*in vivo* and *in vitro* bioassays); no procedure guidance providing requirements for *in vitro* bioassay collection, handling, and analysis of the samples; no procedure guidance for dose assessment when transuranic alpha emitters and/or difficult to detect beta emitters were involved in the contamination; no specific procedure requirement to provide air sampling representative of worker environment for jobs where an airborne radioactive area is likely and particularly where a TEDE/ALARA evaluation is required for determining respiratory requirements; no formal process to periodically assess the source term of the plant to determine the impact of potentially changing conditions on internal dose assessments.

Communications to ensure understanding of the specified request when requiring bioassay analysis from independent laboratories was less than adequate. There was no clear definition of the requirements necessary for the bioassay analysis between the organization and the laboratory and no communication to the laboratory on the required minimal detectable activity (MDA) and length of time since uptake.

Training content and frequency of training in regards to dose assessment, contaminations, transuranic contribution to dose calculations, and performance of initial assessments for

decontamination was not adequate. Those specific causes which contributed to inadequate training include: an organizational dependence on the knowledge of technical staff individuals (because of this the Radiation Protection Operation Supervisor was not familiar with the procedures); the methodology for the decontamination of personnel and distinguishing internal and external contamination was not adequately discussed in training as there was not procedures to detail this type of information; and the significance of the contribution of transuranics on dose calculations and the need for additional *in vitro* samples was not included in training.

CORRECTIVE ACTIONS TAKEN AND RESULTS ACHIEVED

The following corrective actions were taken:

1. Committed effective dose equivalent (CEDE) is now calculated for all WBCs. This action provides a preliminary evaluation of the significance of measured intake.

2. Excreta samples from the two highest exposed individuals were collected and analyzed. Control samples were provided with the second and third excreta samples for quality assurance/control purposes. These samples were split and sent to separate laboratories. The results from the urine and fecal samples were received and an independent dose assessment was performed which assigned a maximum dose of 430 mrem CEDE and 3.4 rem CDE.

3. A root cause analysis of this issue has been performed and is documented in Condition Report 2002-07819. The corrective actions associated with this incident included in the Condition Report are listed below (Corrective Actions to Prevent Recurrence).

CORRECTIVE ACTIONS TO PREVENT RECURRENCE

Below is a list of the corrective actions that have been identified to prevent recurrence.

1. Radiation Protection Dosimetry procedures DB-HP-01342 (Bioassay for Potential Intakes) and DB-HP-01340 (Dose Assessment) have been revised to:

   a.) address and provide guidance on the actions required to perform a dose assessment that include consideration of the potential dose contribution from transuranic and difficult to detect (strontium-90) radionuclides to internal doses.

   b.) provide clear responsibilities of RP personnel involved in the process including the duties and responsibilities for evaluating data, management reviews and approval, individual technical staff members and the line supervisors.

2. Radiation Protection Dosimetry procedure DB-HP-01342 (Bioassay for Potential Intakes) has been revised to:

   a.) provide specific action levels for both intake and dose. The revision includes increasing levels of management notification (i.e., notification of RP Manager and Site Vice President are required for any unplanned intake).

b.) provide clear guidance for follow-up WBC requirements and frequency. This revision included methods required for WBC of internally and externally contaminated individuals and criteria where additional bioassays are required.

c.) describe the methods for obtaining, storing, shipping, and analyzing excreta bioassay sample. This procedure includes details on maintaining a chain of custody and the methodology for determining the required analyses, critical levels, and decision levels.

3. The RP Procedure DB-HP-01701 (Personnel Contamination Evaluation and Decontamination) was revised to provide clear guidance for decontamination, evaluation and management involvement, expectations and standards for management notification, and monitoring of contaminated personnel. Specific changes include, guidance for follow-up WBC's and designate individuals responsible for the timely review of data.

4. Air Sampling procedures have been revised to provide guidance of when general area air sampling and lapel air sampling are required and to ensures that appropriate data for the analysis of personnel intakes is performed and is available to support the assessment of personnel intakes and dose assessment. The Air Sampling procedure revisions include:

   a.) Procedure DB-HP-01901 (Radiation Work Permits) which has been revised to include sampling requirements and instructions on when to collect air samples.

   b.) Procedure DB-HP-01454 (Calibration and the Use of Lapel Air Samplers) now includes instructions on the use of lapel air samplers.

   c.) Procedure DB-HP-01111 (Analysis and Evaluation of Air Samples) now provides instructions on when to evaluate for alpha activity.

5. A standing Purchase Order (PO) for bioassay evaluations as a contingency for internal contaminations has been initiated. The PO contains the Minimum Detectable Activities of the laboratory that have been verified to either meet or are lower than HPS/ANSI N 13.30 - 1996, Appendix C, Table C.4, "Indirect Radiobioassay Minimum Detectable Concentrations (MDC-Urine) and Activities (MDC-Feces)" or guidance in HPS/ANSI N 13.42 - 1997, " Internal Dosimetry for Mixed Fission Activiation Products", Section 12.2, "Performance Criteria for Indirect Analysis" that sensitivity should be at least able to detect intakes less than 0.02 ALI for the radionuclide of interest.

6. A corrective action has been initiated to develop a procedure that will provide for periodic review of the alpha levels for plant contamination and verification that methods established for addressing the internal dose component remain conservative. Plant area smears and a RCS sample shall be analyzed for transuranic radionuclides and other difficult-to-detect radionuclides such as Sr-90 approximately six (6) months prior to a scheduled outage. These results will be considered in the RP outage job planning and evaluations.

7. A corrective action has been initiated to evaluate the need for those individuals which conduct dose calculations and review the frequency of re-qualification. This request will be submitted to the RP curriculum review committee (CRC) .

8. A corrective action has been initiated to request training of RP personnel on the revisions to the procedures detailing the actions required for the decontamination, bioassay (WBC) requirements, and proper management notification in the event of a contaminated individual.

9. Condition Report 2002-10275 has been initiated to address the issue with less than adequate use of Operating Experience program for continued RP program improvement.

DATE FULL COMPLIANCE WILL BE ACHIEVED

Based on the above actions, full compliance has been achieved. Corrective actions have been initiated and entered into the corrective action program to capture and track those items through completion.

COMMITMENT LIST

The following list identifies those actions committed to by the Davis-Besse Nuclear Power Station in this document. Any other actions discussed in the submittal represent intended or planned actions by Davis-Besse. They are described only as information and are not regulatory commitments. Please notify the Manager – Regulatory Affairs (419-321-8450) at Davis-Besse of any questions regarding this document or associated regulatory commitments.

COMMITMENTS	DUE DATE
Revised RP procedure DB-HP-01901 (Radiation Work Permits) to clearly define when documented, reviewed and approved confirmatory surveys are required prior to proceeding with the work. This action will ensure the field conditions are bounded by the developed RWP (which is required to be discussed at the pre-job brief) and ALARA work package.	Complete
Revised RP procedures DB-HP-01104 (Radiological Surveillance) and DB-HP-01901 to address the requirements of "Stop Work". This will ensure the appropriate level of evaluation for potential radiological hazards and job controls are in place prior to performance of the job.	Complete
Developed RP procedure NG-DB-00240 (Radiological Area Access and Work Controls) to establish radiological controls for high radiological risk evolutions/jobs.	Complete
Developed steam generator entry procedure DB-HP-01115 (Once Through Steam Generator Entry) that establishes specific radiological controls in preparation and performance of work for steam generator work.	Complete
Developed standard and expectations for radiation protection organization. This is included in the Conduct of Radiation Protection Operations. The standard and expectations clearly defines duties and responsibilities for individuals assigned to provide oversight of high radiological risk jobs. Also, the standards and expectations reinforce the use of "Stop Work" if time pressure to complete the job is perceived (i.e., due to	Complete

COMMITMENTS	DUE DATE
(Continued) lack of radiological evaluation of job conditions) and if conditions are not adequate for successful performance of the assigned task.	
The self-assessment process was revised to incorporate recommendations from these self-assessments into the corrective action process.	Complete
Radiation Protection Dosimetry procedures DB-HP-01342 (Bioassay for Potential Intakes) and DB-HP-01340 (Dose Assessment) have been revised to address and provide guidance on the actions required to perform a dose assessment that include consideration of the potential dose contribution from transuranic and difficult to detect (strontium-90) radionuclides to internal doses.	Complete
Radiation Protection Dosimetry procedures DB-HP-01342 (Bioassay for Potential Intakes) and DB-HP-01340 (Dose Assessment) have been revised to provide clear responsibilities of RP personnel involved in the process including the duties and responsibilities for evaluating data, management reviews and approval, individual technical staff members and the line supervisors.	Complete
Radiation Protection Dosimetry procedure DB-HP-01342 (Bioassay for Potential Intakes) has been revised to provide specific action levels for both intake and dose. The revision includes increasing levels of management notification (i.e., notification of RP Manager and Site Vice President are required for any unplanned intake).	Complete
Radiation Protection Dosimetry procedure DB-HP-01342 (Bioassay for Potential Intakes) has been revised to provide clear guidance for follow-up WBC requirements and frequency. This revision included methods required for WBC of internally and externally contaminated individuals and criteria where additional bioassays are required.	Complete
Radiation Protection Dosimetry procedure DB-HP-01342 (Bioassay for Potential Intakes) has been revised to describe the methods for obtaining, storing, shipping, and analyzing excreta bioassay sample. This procedure includes details	Complete

COMMITMENTS	DUE DATE
(Continued) on maintaining a chain of custody and the methodology for determining the required analyses, critical levels, and decision levels.	
The RP Procedure DB-HP-01701 (Personnel Contamination Evaluation and Decontamination) was revised to provide clear guidance for decontamination, evaluation and management involvement, expectations and standards for management notification, and monitoring of contaminated personnel. Specific changes include, guidance for follow-up WBC's and designate individuals responsible for the timely review of data.	Complete
Procedure DB-HP-01901 (Radiation Work Permits) which has been revised to include sampling requirements and instructions on when to collect air samples.	Complete
Procedure DB-HP-01454 (Calibration and the Use of Lapel Air Samplers) now includes instructions on the use of lapel air samplers.	Complete
Procedure DB-HP-01111 (Analysis and Evaluation of Air Samples) now provides instructions on when to evaluate for alpha activity.	Complete
A standing Purchase Order (PO) for bioassay evaluations as a contingency for internal contaminations has been initiated. The PO contains the Minimum Detectable Activities of the laboratory that have been verified to either meet or are lower than HPS/ANSI N 13.30 -1996, Appendix C, Table C.4, "Indirect Radiobioassay Minimum Detectable Concentrations (MDC-Urine) and Activities (MDC-Feces)" or guidance in HPS/ANSI N 13.42 - 1997, " Internal Dosimetry for Mixed Fission Activiation Products", Section 12.2, "Performance Criteria for Indirect Analysis" that sensitivity should be at least able to detect intakes less than 0.02 ALI for the radionuclide of interest.	Complete

COMMITMENTS	DUE DATE
Revise radiation protection procedure DB-HP-01901, Radiation Work Permits, to include a TEDE evaluation process for consideration of impact due to transuranic alpha emitters for dose to individuals.	Complete
Develop an action plan and/or a procedure to ensure RP organization is aware of the current source term conditions of the plant (i.e., source term may change due to fuel defect). This process will ensure that the changing plant conditions are evaluated by RP for potential radiological hazards prior to commencement of a job.	May 30, 2003
Include shutdown chemistry in the radiation protection continual training program. This training will provide better understanding of the basic process of shutdown chemistry to radiation protection personnel.	January 1, 2004
Training for RP technicians and appropriate RP staff to reinforce the lessons-learned from this incident.	May 1, 2003
Develop a procedure that will provide for periodic review of the alpha levels for plant contamination and verification that methods established for addressing the internal dose component remain conservative. Plant area smears and a RCS sample shall be analyzed for transuranic radionuclides and other difficult-to-detect radionuclides such as Sr-90 approximately six (6) months prior to a scheduled outage. These results will be considered in the RP outage job planning and evaluations.	August 15, 2003
Evaluate the need for those individuals which conduct dose calculations and review the frequency of re-qualification.	June 20, 2003
Train RP personnel on the revisions to the procedures detailing the actions required for the decontamination, bioassay (WBC) requirements, and proper management notification in the event of a contaminated individual.	May 1, 2003

Docket Number 50-346
License Number NPF-3
Serial Number 2946
Attachment 1

Root Cause Analysis Report CR 2002-07811
NRC White Finding of 10CFR20.1501 Violation

FirstEnergy, DAVIS-BESSE NUCLEAR POWER STATION

Root Cause Analysis Report

NRC WHITE FINDING OF 10CFR20.1501 VIOLATION

CR 2002-07811, Dated 10-10-2002

REPORT DATE: 01-21-2003 Revision 01

Prepared by: Electronic Signature on File
G.W. Gillespie

Reviewed by: Electronic Signature on File
Manager - Chemistry and Radiation Protection

Approved by: Electronic Signature on File
General Manager - DB Plant Operations

Chemistry and Radiation Protection Section

Problem Statement

Description of reason for investigation

On February 20, 2002, several contract workers were both internally and externally contaminated with radioactive material while installing steam generator nozzle dams inside the reactor coolant system (RCS). The actual radiological conditions within the steam generators were significantly different than anticipated and assessed for by "As Low As Reasonably Achievable" (ALARA) planning and assumed in the development of the Radiological Work Permit (RWP). This resulted in a significantly higher than expected internal exposure and substantial potential for an overexposure. As a result, the NRC has issued a "white finding" related to the failure to conduct adequate surveys. Samples collected at the interface of the steam generator manway by radiation protection (RP) personnel showed the increased contamination levels but the job continued with management approval. There were also previous self-assessments and sample data relating to the hazards that were not used or incorporated into the program that could have minimized the exposure and provide adequate controls for the evolution.

Consequences of event/condition investigated

There was a failure on the part of the organization to conduct an adequate evaluation of the radiological hazards that led to the inadequate job controls for the steam generator nozzle dam installation. The failure to adequately plan and have the appropriate personnel in place to perform the job coverage resulted in a radiological intake for the Framatome workers and a substantial potential for an overexposure. The intake to the workers is documented in condition report (CR) 2002-07819, Potential Violation of 10CFR20.1502 (B) (RP Inspection).

Immediate actions taken

1. Development of a Once Through Steam Generator (OTSG) entry procedure to include the lessons learned from the intake incident. (DB-HP-01115, OTSG Entries became effective on July 01, 2002)

Remedial actions taken

1. Standing Order 2002-0015, " Interim ALARA Measures for Alpha Radioactivity", was issued 18 October 2002. This document provided guidance for the preparation of RWPs in those areas of the plant characterized as likely to have transuranic alpha present. This guidance has since been proceduralized by incorporation into DB-HP-01800, ALARA Review, Form DB-0144-2.
2. Self-assessments are now documented in the corrective action program (CAP) by condition reports (CR) to capture the corrective actions necessary to ensure program improvements.

This is in accordance with the FENOC Focused Self-Assessment Guideline, September 2002, Revision 1.

3. All the active RWPs were reviewed by ALARA Planning for accuracy and content. If an RWP was identified to be inadequate in providing the necessary guidance to ensure safe radiological work activities, they were cancelled and rewritten. RP requirements for sampling were incorporated into specific RWPs where the probability of airborne contamination of workers exists.

Remedial actions proposed

1. Review the May 2001 air sampling self-assessment to determine if any of the proposed recommendations need to be immediately incorporated into the RP program. The recommendations of that assessment generally referred to actions necessary near the end of an operating cycle and immediately following containment entry for work activities. CR 2002-08204 was written to document and evaluate the results of this assessment.
2. Roll CR *2002-07717*, Error in RWP'S May Be Carried to Next Outages, into this root cause evalution.
3. A discussion of the steam generator nozzle dam event of February 20, 2003 will be performed in the scheduled continuing training program for 2003. This was completed and is documented in the Second Trimester training records.

Event Narrative

This event narrative developed using previous condition reports and the NRC special inspection reports.

05/2000		CR 2000-1509 is generated to document a suspected fuel defect in the reactor core.
05/2001		Self-Assessment on RP Air Sampling Program documented.
01/22/2002		Radiation Protection (RP) completes the preparation of RWP 2002-5303, "Install and remove nozzle dams and nozzle dam FME covers and equipment setup". The development of this RWP involved utilization of the copy and edit option available on HIS-20, RWP development software. A value of 60 Rad/hour smearable contamination was retained as an expected condition for RWP 2002-5303. This value was an error that occurred at least during the preparation of the RWP's for 11 RFO where 60 mRad/hour was inadvertently entered as 60 Rad/hour. Reviews of the RWP's failed to identify this error since 11 RFO RWP preparation. CR ***2002-07717***
01/23/2002		ALARA review completed for RWP 2002-5303. The ALARA Evaluation form for this RWP stated that respiratory protection "should be used". However, based upon historical data and previous experience with this evolution, the individual preparing the ALARA planning package determined that the total dose for the job was less without the use of respirators.
02/15/2002		Plant begins down power for 13 RFO
02/18/2002	1300	ALARA briefing was completed for RWP 2002-5303. The individual performing the brief was handed the package just prior to the brief and had no time to prepare. In addition, several of the individuals scheduled to perform the evolution were not present. It was determined to do another brief immediately prior to the evolution.
	2141	Commenced drain of the RCS to flange level, Pressurizer (PZR) at 162 inches
02/19/02	0500	Upper steam generator manways are removed. RP personnel perform a survey of the area but the survey is misplaced and is not included in the RWP. The surveys were later discovered in the Auxiliary Building Survey book.
02/20/2002		The duty Radiation Protection Manager (RPM) that planned job takes day off. The RPM had recently returned to the site and was not present for the plant shutdown.
		RP Supervisor following the job takes the day off.

0850 Chalk River Unidentified Deposits (CRUD) burst occurs in the RCS. RP restricted access to the Auxiliary and Containment buildings.

1420 Framatome reports to Outage Management that that both lower steam generator manways have been removed and the shield doors in place. RP survey is in progress.

During the removal of the west steam generator manway, the diaphragm is inadvertently removed with manway hatch. High efficiency particulate absolute (HEPA) unit is not in service when the diaphragm comes off. As a result of the diaphragm coming loose, an alarm of the radioactive air monitor (AMS-4) occurs.

1450 Air sample taken from the west steam generator platform. This sample indicated a derived air concentration (DAC) value of 14 DAC for alpha emitters (Air Sample Record (ASR) Number 2002-0074). Gamma spec printout is provided to the RPM.

A radiological survey is completed for the east steam generator tube sheet and bowl. Dose rates of the tube sheet on contact were 10.8 to 12.1 Rem/hour. Manway dose rates were also determined.

≈1500 Communications were made to RP personnel indicating that the nozzle dam installation needed to be performed immediately due to the low RCS inventory. There was concurrence by RP management to proceed with the evolution immediately.

1500 Air sample taken from the west steam generator manway (ASR Number 2002-0075).

A smear sample on the west diaphragm showed a removable contamination level of approximately 46 Rad/hour. The RP Supervisor and ALARA planning personnel mistakenly thought that this high level of contamination was expected due to the latent error in the RWP development that indicated a contamination level of 60 Rad/hour was expected.

1530 RP personnel brief steam generator work group on RWP 2002-5303 prior to signing in on the RWP. Use of face shields was added during this pre-job brief. It was determined that the workers that entered the bowls of the steam generators did not wear face shields. The contamination levels in the bowls were discussed in this brief and were the basis for use of the face shields.

Steam generator team, four RP technicians and eight Framatome technicians sign in on RWP 2002-5303. This RWP did not require breathing zone air samples to be collected and as such, none were collected. AMS-4 monitors were collecting airborne samples on each platform.

A radiological air sample pump (RASP) was used to pull an air sample from the plane of the opened manway.

1825 Nozzle dam installation started on the east steam generator.

≈1900 Nozzle dam installations for both east and west steam generators were completed.

Door 300 was opened and resulted in the spread of contamination from containment to the Radiological Restricted Area (RRA) entrance/exit. Access to the RRA was restricted. This also caused the personnel contamination monitors (PCM) at the entrance/exit to go into alarm.

Six steam generator workers assigned to RWR 2002-5303 alarm PCM as they attempt to exit the RRA. PCM alarms documented.

Workers decontaminated by using multiple showers, they continued to alarm PCM and portal monitors. Radiation workers provided up to seven showers. No decrease in counts was seen at this time.

≈2000 Whole body counts performed on workers. Investigational body counts (3 minute) performed per procedure DB-HP-01320. RP Supervisor and duty RPM informed of positive body count nuclide results. Individuals with positive counts were allowed to leave site. There were no dose assessments started by the night shift staff and any sense of urgency in performing these calculations was not communicated between the RP Supervisor and the staff. RP Supervisor stated various individuals attempted to read and follow dose calculation procedure but were not certain how to proceed with procedure calculations. It was then decided that the calculations could wait until morning. The individuals were informed they were to be whole body counted when they returned to site for the next work shift.

2/21/2002 0630 WBC data packages turned over to day shift for review.

0700 One RP Supervisor (acting) and one RP technician started dose calculations on body count data. The plan was to each perform three assessments then switch whole body count data packages and perform the dose calculations to independently verify the calculations. The technician was assisted with the process and NUREG-4884 data tables for intake retention fractions (IRF).

≈1400 RPM informed highest activity body count data was approximately 250 mRem. This data and calculation had not been checked thoroughly or independently verified. Duty RPM was informed of initial dose estimates and the regular RPM directed staff to proceed with calculations.

≈1700 The six initial dose calculations were completed. Discrepancies in the time of intakes needed to be verified by the oncoming shift. It was

		recognized this would change the dose calculation results slightly. No calculated dose was greater than 500 mrem, the highest calculated was 220 mRem. RPM informed of latest calculated dose and additional assistance was requested from the oncoming shift. It was recognized dose calculation discrepancies were the result of inconsistent data between calculations. Discrepancies had to do with time between counting and intake and the corresponding IRF used. Additionally procedures DB-HP-01320 and DB-HP-00002 required a post intake whole body count at approximately 24 hours. This count was routinely used for performing dose assessments.
	≈1830	Shift change and data turnover between RP Supervisor (acting) to Duty RPM of data packages and status of dose calculations performed. The dose calculations performed per DB-HP-01340 and those performed using an Excel spreadsheet was communicated to the RPM. The spreadsheet was provided to the RPM. There was a discussion of the data and what further actions were required. This included a peer check of the data and a resolution of the intakes times. Oncoming shift was staffed with a CHP working in ALARA. Individuals with positive counts were counted before starting the shift. Two individuals had left site.
02/22/2002		Friday was a scheduled day off of dayshift RP Supervisor (Acting) knowledgeable of dose calculations.
02/23/2002	0600	No additional work had been performed on refining the dose calculations since 2/20/2002 at1830. Intake time data and was provided from the data logged in the PCM alarm logs.
02/26/2002		Started working on dose calculations for the six individuals with additional whole body count data (~24 hour post intake).
03/12/2002		Initial dose estimates are completed. A high of 308 mRem is calculated.
04/02/2002		Condition Report 2002-01438, Release of Discrete Radioactive Particles from the Davis-Besse Nuclear Station generated.
06/26/2002		Air and area contamination samples obtained from various areas in the plant for waste characterization pursuant to 10CFR Part 61 analysis received by outside laboratory
08/09/2002		Davis-Besse RP section receives data from 10CFR Part 61 analysis samples that indicate the presence of transuranics

Data Analysis

DATA REVIEW

For 12 of the 13 past operating cycles, the Davis-Besse core has experienced varying degrees of fuel failure. As a result of these failures, the concentration of alpha emitting isotopes has shown a steady increase. This increase was identified in several self-assessments and in particular, a 2001 assessment. Despite the trends, the organization failed to adequately address the recommended items. Several of the recommendations that were not implemented included increased surveillance for alpha contamination. In addition, the consideration of alpha emitting isotopes in job surveys and contamination controls was not implemented. Condition report 2002-08204 (Self-Assessment Recommendations not Entered into Corrective Action Process) was generated to document the process weakness of the organization in not utilizing the corrective action program. There was also a lack of adequate resolution and review of industry experiences and operating experiences (OE) within the section. The OE program is being revised at Davis-Besse as part of the restart program. Specific items related to the RP with this assessment program has been documented in CR 2002-10275. Currently, all self-assessments are entered into the FENOC corrective action program.

The shutdown method utilized at Davis-Besse for approximately 6 outages had resulted in a decrease in the dose levels of the steam generator support plates. Although there was historical data documenting the dose and contamination levels in the bowls of the steam generators, there were no specific surveys performed to track or trend the alpha emitting isotope contamination levels. RP personnel used this archival data in January 2002 to prepare RWP 2002-5303, "Install and Remove Nozzle Dams and Nozzle Dam FME Covers and Equipment Setup".

The alpha emitting data from the 10 CRF Part 61 analysis was not used in the RWP development. In addition, a latent error in the RWP development process remained undetected by the RP organization. In the 11th refueling outage (possibly prior to this) RWP development process, the historical data of 60 mRad/hour smearable contamination in the steam generator bowls was inadvertently altered to 60 Rad/hour onto the RWP package. This latent error was carried forward through the use of the "cut and paste" method employed for outage RWP package development. The 60 Rad/hour error was not discovered by the organization despite the reviews by technicians, supervisors, and technical staff. It was not until the NRC special inspection of Radiation Protection in September 2002 that this error was discovered. It was documented on condition report ***2002-07717*** (Error in RWP'S May Be Carried to Next Outages) and is part of the evaluation of this CR. The self-assessments and self-evaluations previously performed did not contain the rigor necessary to identify this lack of adequate job planning and oversight. The evaluations did not include industry peers and as a result, the material in the assessment was limited to comparisons from only within the organization. The process did not include comparing the existing planning and oversight process at Davis-Besse to others in the FENOC fleet.

The TEDE evaluation form for RWP 2002-5303 indicated that respiratory protection "should be used". However, based upon historical data and previous experience with this evolution, the individual preparing the ALARA planning package determined that the total dose for the job was less without the use of respirators. The basis for this assumption was that the conditions in the steam generator bowls would not be different from those experienced in previous outages.
In the effort to decrease the outage time, it was proposed by RP and Outage Management to utilize an alternative method of shutdown chemistry at Davis-Besse for 13 RFO. This revised method involved draining the steam generators prior to adding the hydrogen peroxide to oxidize the system. Contamination levels of the steam generator for the other Framatome plants utilizing this alternative method was not considered extremely high. As a result of discussions with Operations, Outage Management, Chemistry, and Radiation Protection, it was decided to perform the alternative method of shutdown. The final results of the revised method once implemented on February 19-20 were disappointing and are documented in condition report 2002-00695, Shutdown Chemistry Method Utilized for 13 RFO less Effective than Anticipated. One result of the shutdown method was following oxidation, there was no removal mechanism for the accumulated material in the steam generators. This resulted in increased dose rates on the tube sheets (return to Cycle 9 values) and contamination levels greater than previously anticipated. In previous outages, the contamination levels in the steam generator bowls were less than 50 mRad/hour. Following the 13 RFO shutdown, contamination levels were 46 Rad/hour. The NRC Special Inspection team noted that RP personnel were unfamiliar with shutdown chemistry and were unaware of the consequences the alternate shutdown methodology had on steam generator contamination levels.

The Framatome crew performed a mock up of the steam generator bowl activities on February 16-17. During this mock up, the crew practiced the nozzle dam installation. The RP section was invited to participate in the mock up; there was no formal requirement for RP personnel to attend the mock up. As a result, there was minimal RP participation and the mock up was performed without the contamination control setup (bullpens) that the actual evolution would require. In addition, the individuals did not dress in the protective clothing requirements that was specified on the RWP.

On February 18, the ALARA briefing for the RWP 2002-5303 was performed. The information presented at this briefing was based upon the historical data as documented in the RWP. The individual that performed the brief has stated that they did not have time to prepare for the brief and as a result, ended up just reading the RWP to the workers. Not all the individuals assigned to the task were available for this brief and as a result, it was decided to conduct another ALARA brief just prior to the evolution. The steam generators would be open at that time and the group could discuss the conditions in the work area. The scope of work was discussed during the briefing as well as industry events involving entry into steam generators and contaminations.

Delays in the outage as a result of the alternative shutdown chemistry method continued to move the nozzle dam installation away from its scheduled date. As a result of this delay, the RP technicians and the RP Supervisor that participated in the February 18 brief were on a day off when plant conditions supported proceeding with the nozzle dam installation. To compound this loss of resources, the duty RPM that had been involved in the job planning and preparation took a day off on February 20.

At approximately 1700 on February 20, following the initiation of the CRUD burst, the evolution to install the steam generator nozzle dams was initiated. A smear sample of the steam generator manway diaphragm measured 46 Rad/hour smearable. An air sample taken from the plane of the steam generator bowl manway opening was sent to the RP count room for alpha analysis. A derived air concentration (DAC) value of approximately 14 DAC for alpha emitters was calculated for this sample. This information was forwarded to the RP Supervisor who in turn communicated the values to the RPM. They felt with the engineering controls in place (HEPA ventilation) that this level of alpha contamination was not an issue. The RPM had been away from the site for two weeks and had not participated in the February 18 briefing.

On February 20 at 1530 RP personnel performed another brief on RWP 2002-5303 prior to allowing workers to sign onto the RWP. The RP personnel in this brief had not participated in the initial brief held on February 18. In addition, the individual felt there was a great deal of time pressure placed on the RP organization as the evolution was behind schedule and the shift change was scheduled to occur at 1900. During this pre-job brief, there was a discussion of the 46 Rad/hour smearable conditions in the steam generator and it was decided the Framatome workers should wear face shields. The RP technician performing the brief stress how "nasty" it was in the steam generator bowls and reminded the personnel to perform the job efficiently and not to pick up any lose items that may be found in the bottom of the bowls. Due to the urgency to complete the briefing, no documented surveys were available for the brief. Data regarding the work environment was either transmitted orally or by informal paper documents to the individual conducting the brief. No survey that had been officially reviewed and approved was available at the time of the brief.

The supervisor assigned the oversight for this job as well as an individual from ALARA planning was present during the discussions of the steam generator conditions. The individuals assigned to perform the RP coverage for the evolution were not familiar with the plant and had never participated in a nozzle dam installation on an OTSG. This included the supervisor that was assigned the oversight for the evolution.

As a result of the error in the RWP development, the RP supervisor also felt that the 46 Rad/hour was within the parameters considered for the evolution. Actual conditions ranged from 100 to 800 times the historical values.

FACT LIST

- During the 13th operating cycle, at least four fuel failures were detected in the core
- Iodine concentrations continually increased in the system throughout the cycles but did not reach the technical specification limits for the license. Near the end of the 13th operating cycle, an iodine (I-131) concentration of approximately 4.6 E-02 μCi/gm was measured. This is higher than values measured in previous operating cycles.
- There was a self-assessment performed in 2001 that identified weaknesses in the alpha survey surveillance program.

- The Davis-Besse RP program did not consider alpha contamination as an issue for the station although the procedure did state that samples "should" be counted for specific areas in the plant.
- The RWP development process for 2002-5303 did not consider increased steam generator contamination or internal dose from transuranics.
- A human error at least four years previous resulted in false limits for the RWP. As value of 60 mRad/hour smearable was misprinted as 60 Rad/hour smearable.
- As a result of "copy and edit" method of RWP development, this latent human error was carried to the preceding outages. The error was not detected during the review process.
- The TEDE evaluation form for RWP 2002-5303 indicated that respiratory protection "should be used". However, the preparer of the package felt the total dose for the job would be less without the use of respirators. It recommended that respirators not be used.
- The chemistry shutdown method for 13 RFO did not provide a removal mechanism for contamination in the steam generators.
- The individuals that installed the nozzle dams did not wear respirators.
- The RP technician at the job site noted the contamination on the bowls as 46 Rad/hour smearable prior to the evolution.
- The workers, RP Supervisor, RPM, and ALARA planning personnel were aware of the 46 Rad/hour smearable conditions in the steam generators.
- The 46 Rad/hour was within the limits, although incorrect, on the RWP of 50 Rad/hour.
- The RP individual that participated in the brief on February 18, 2002 was not prepared to present RWP 2002-5303. The individual read the RWP to the assembly present for the brief.
- Not all the RP personnel assigned to the task were present for the February 18, 2002 ALARA brief.
- The technicians that participated in the initial ALARA brief and mock up were not at the site when the job was performed.
- With personnel on scheduled days off or calling in for time off, only one crew was assigned to the steam generator evolutions. This included documenting the surveys, complete setting up the job site (bullpen), and RP coverage of the nozzle dam installation.
- This contamination level was communicated to the RP Supervisor, the RPM, and personnel from ALARA planning.
- The RP technicians covering the steam generator nozzle dam installation had not recently performed this task and were unfamiliar with the plant.
- The RP technicians assigned the evolution were unfamiliar with OTSG entry evolutions.

- The RP Supervisor present the day the task was to be performed had little pressurized water reactor steam generator experience and was unfamiliar with the plant.
- The RWP did not require breathing zone air samples. No breathing zone air samples could be located during subsequent investigations.
- Each of the contaminated workers was sent for a whole body count the evening of the incident. In each case, radioactivity was noted with the counts.
- There was a communication problem between the RP technicians in containment due to head set failures.

CONCLUSION

Numerous precursors to this event were noted during the investigation of this incident. The organization was unprepared for conditions in the steam generators outside those previously encountered. Personnel that planned and were prepared for the task were not present the day the task was performed. This resulted in inexperienced personnel using less than adequate procedures to provide RP coverage of the job. During the planning of the job, the RP technician that prepared the RWP relied on the results of previous outages and did not consider the increasing transuranic trends noted in the available data. Additionally, the latent error in the RWP development was not identified during the review process and suggests a lack of rigor in the job planning, review, and oversight. This condition also reflects a lack of programmatic review in the self-assessment and self-evaluation process within the section.

Experience Review

The Corrective Action Tracking System (CATS) database was reviewed for previous Potential Condition Adverse to Quality Reports (PCAQR) and Condition Reports (CR) applicable to this event. CREST was also used to evaluate similar CR's that have been generated since December 2000. The Operating Experience database maintained by INPO was also reviewed for applicable events.

Davis-Besse

CR 2002-00870, Less Than Adequate Job Planning to Move the Reactor Services Crane

Less than adequate planning delayed the movement of the Reactor Services Crane from it's normal position to the top of the west "D:" ring. The Lift Plan did not provide details for the rigging. The industry has experienced numerous cases of slings failing as they sheared across an abrupt edge. Avoiding this pitfall and researching the requirements to meet NUREG 612 commitments delayed the schedule start of the lift.

CR 2002-01108, RWPs for 13 RFO are Exceeding Their Dose Budgets

The RWP dose budget estimates for various RWP's were identified as exceeded beyond the budgets of the RWP and the budgets were not evaluated in a timely manner. The causes attributing to dose budget estimate being exceeded include increased radioactivity in the RCS resulting in increased area dose rates, additional work scope and time committed to a work scope, and less than adequate personnel resources to track and evaluate RWP dose. The cause of this issue is a less than adequate job planning/scoping and the process content was not adequate to prevent this issue (HIS-20 Features Allowed More Controls If Enabled)

Nuclear Industry

IN 97-36 Haddam Neck (November 02, 1996)

In preparation to inspect the fuel transfer mechanism and upender, two workers met with health physics (HP) supervisors and HP technicians to discuss entry into the fuel transfer canal. This task was not on the master schedule and this was the first notice HP had in regards to the task. The work scope was not discussed and HP was unaware that the workers were to pick up any lose material with their hands. A pre-job survey was not performed prior to the workers entering the transfer canal and it was generally assumed to be "clean". This pre-job briefing was less than adequate and the workers were not informed of the actual conditions in the transfer canal. The resulting uptake was calculated to be 913 mRem committed effective dose equivalent (CEDE) and 5873 total organ dose (CED).

Event Number 261-990924-1 Robinson Unit 2 (December 08, 1999)

During a containment inspection of the fire protection system, a RP technician and an Operator's electronic dosimetry went into a dose alarm. There was not an administrative overexposure related to this event. The highest dose by the individuals was 89 mRem and the RWP allowed

for 100 mRem. It was determined the cause of this event was inadequate management oversight related to work planning, inadequate RWP, and insufficient pre-job brief.

Event Number 321-000823-1 Hatch Unit 1 (October 23, 2002)

An initial health physics survey did not identify a dose rate of over 2000 mRem/hr in a job site. The RP technician due to the high noise in the work area did not hear the alarm. The RP technician did not effectively relay this to the following shift. Additional work was performed on the following shift and the same incident occurred. The second shift was unaware of the inability of the first shift to hear the alarm due to noise and the high dose rate received by the first crew. The causes to this event were less than adequate pre-job briefing, shift turnover, and ineffective job surveys, and failure to follow appropriate radiation control/dose monitoring procedures.

Event Number 315-020518-1 D.C. Cook Unit 1 (May 18, 2002)

During the relocation of the remote eddy current testing equipment in the steam generators, two workers became contaminated from airborne radionuclides. This contamination was found during their attempt to exit containment. Loose contamination apparently became airborne during the relocation/installation process for the equipment. The cause of this event was less than adequate oversight by RP personnel assigned to monitor the evolution.

Event Number 282-010131-1 Prairie Island Unit 1 (April 10, 2001)

A hot particle was discovered while performing maintenance on a cold leg safety injection check valve. It dislodged from the shielded area of the valve internal and fell to the adjacent scaffold platform exposing two maintenance workers to an uncontrolled radiation field. The existence of hot particles inside the valve was known for several years. The causes of the event were inadequate radiation protection work planning and work practice.

Conclusions

The operating experience review revealed that this type of event has previously occurred in the industry. In general, a failure to perform adequate surveys and provide appropriate RP oversight has been found to be the cause of several events. In all of the cases noted, there was no overexposure of the worker and established alarm set points did result in worker actions. However, less than adequate planning was a precursor for the occurrence of the alarm. The incorporation of these experiences and resulting corrective actions into the Davis-Besse RP program was less than adequate. This suggests that the review of industry experiences within the section lacked the necessary attention to provide continued improvement. The issue of less than adequate use of OE within the RP section has been documented by CR 2002-10275.

Root Cause Determination

The following are the root causes and contributing causes addressing the issue presented in the Problem Statement. In accordance with FENOC procedures, TapRooT® was used in the evaluation of this data to determine the root causes of this event. Attachment 1, TapRooT® Cause Tree Basic Cause Categories is provided.

ROOT CAUSES

Performance of the TapRooT® Cause Tree Report (Attachment 1) determined several causes associated with this event. These included Procedures, Management System, and Work Direction. It has been determined that Work Direction and Management System are the Root Causes of this event. These correspond to Work Organization/Planning/Scheduling and Management/Supervisory Methods in the FENOC CAP binning and coding.

1. **Less than adequate Work Direction** as the preparation for the job did not ensure the workers performing the task would have all the necessary information to be successful. This is demonstrated by the following deficiencies in the work direction.
   - The preparation for the evolution failed to consider any different type of condition in the steam generator bowl other than what had been previously experienced in past refueling outages.
   - A mock up of the steam generator bowl was performed on February 16-17 with the Framatome workers. RP personnel were invited to attend but it was not a formal requirement for the section. The mock up was not a requirement of the RWP and did not include all the activities associated with the nozzle dam installation.
   - The pre-job briefing that was conducted on February 18 not adequately planned. The RP technician was presented the RWP package just prior to the brief and had no opportunity to review the information. As a result, the individual just read from the RWP. This resulted in limited discussion of the evolution and little if any discussion in regards to industry events and standard practices.
   - There was no walk through by the crew that performed the RP coverage for the job. The individuals were not involved in the mock up or in the planning and preparation for the activity. The RP Supervisor and duty RPM that were to provide the necessary job coverage for the activity either were not onsite the day of the evolution.
   - The RP technician on the job stated that there was considerable job/schedule time pressure placed upon the crew. There was a desire to complete the activity as promptly as possible and prior to the scheduled shift change at 1900. As a result, the conditions were verbally communicated to the individual performing the brief and there was do official documented survey available.
   - The selection of the workers was less than adequate in that the supervisor providing the oversight and two of the RP technicians assigned the job were unfamiliar with the plant. The individuals did not have OTSG steam generator entry experience. None of these individuals were participants in the mock up performed on February 16-17 or

the brief on February 18. The requirements for participation in the mock up would have ensured those involved in the preparation were available for the job.

1. **Less than adequate Management Systems** in relation to Standards, Policies, or Administrative Controls and a deficiency in the CAP. This can be demonstrated in three situations related to this event.
   - There were not standards, policies, or controls in place to ensure those assigned to provide the task oversight and coverage were from Davis-Besse RP. Although plant staff had been involved in the planning and briefing none of these individuals were present for the evolution. This resulted in assigning the task to individuals not familiar with the process and procedures.
   - Although the presence of transuranics had been documented in previous self-assessments and 10CFR Part 61 analysis, this information was not included in the planning process for the evolution. The recommendations noted in the 2001 self-assessment of the air sampling program did not receive formal management review or resolution.
   - Industry and operating experiences were available but were not adequately addressed to ensure incorporation into the RP program. The issue of the less than adequate use of the OE program for continued RP program improvement has been documented in CR 2002-10275.

CONTRIBUTING CAUSES

1. **Less than adequate Procedures** in the development of the RWP package, the ALARA package, and entry into high radiological risk environments.
   - The RWP was incorrect in that it implied conditions as high as 46 Rad/hour smearable was anticipated for this evolution. This latent error had occurred several years previous to this event and there appeared to be a lack of rigor in development and review of the package as it went undetected until September 2002.
   - In previous years, there existed an OTSG entry procedure that was not active at the time of the evolution. This resulted in a loss of past experience and an organized methodology for entry into this type of high radiological risk environment.
   - The procedures were written in a manner that did not ensure tasks would be performed and in some cases, the procedures were not followed as written (CR 2002-09589). The programmatic issues were identified during the program review and have been documented on several condition reports related to specific RP program areas such as contamination control, work control, radioactive materials control, and internal dosimetry.

In order to correlate the TapRooT® root causes and contributing factors, the following codes from the FENOC CAP will be used to track and trend this event.

- G01: Inadequate work plan, as the information was incorrect and limited in scope to previous experiences. There were not contingency plans in place should plant condition deteriorate from the expected norm. There was a lack in rigor in the planning and documentation of the work package by the organization.

- G02: Job scoping and walkdown was incomplete in many aspects. The mock up did not include all the activities associated with the task nor did it include those that would eventually perform the evolution. There was no requirement in the RWP for the mock up or first ALARA brief.
- H03: Emphasis on schedule exceeded emphasis on methods/doing a good job.
- H04: Policy guidance/management expectations were not well defined in that it was not a requirement that the individuals performing this high risk radiological evolution be those involved in the mock up or part of the in-house personnel. Although the supervisor was a FENOC employee, their experience in pressure water reactors and OTSG entries was limited.
- Q06: Response to a known problem was untimely in that there was a self-assessment that documented the issues involving transuranic alpha emitters and the recommendations were not performed.
- B06: As there was a lack of general guidance in the procedures for job planning and verification of the work condition and necessary job controls.
- B05: There was no procedure to define the requirements of a steam generator entry.
- B02: Procedure (RWP in this case) contained technical inaccuracies in that it documented a maximum of 50 Rad/hour smearable was expected. This was actually 100 to 800 times the level experienced in previous outages.
- B02: DB-HP-01111, Analysis and Evaluation of Air Samples requires analysis for long lived alpha emitters for activities such as steam generator entries. However, the procedure made the requirement for the collection of an air sample at the discretion of the RP technician or the RP Supervisor. In this incident, it was chosen not to perform an air sample based upon the expected conditions in the steam generator and the use of a HEPA system on the steam generator. There was also no concern for the potential of alpha contamination based upon previous experience with this evolution. There was no consideration given to the less than effective shutdown chemistry cleanup or the impact of the fuel failures on the system. The individual involved stated they were unaware of the plant had experienced fuel failures.
- I04: As there was a lack of knowledge by RP personnel in the area of shutdown chemistry and the potential conditions that may be present in the RCS should cleanup be less than effective.

Extent of Condition

The RWP's for the site were terminated and reviewed for errors in information as exhibited by RWP 2002-5303. There were no specific errors noted during the rewrite of these documents. There were several RWP's that were considered less than adequate. These were rewritten to enhance and clarify information in the document. The current RWP's are reviewed daily and compared to the dose assignment for the job. Although there have been electronic dosimeter alarms in existing jobs, these have not been the result of less than adequate RWP limits and requirements. The lack of adequate work direction also impacted areas other than work planning. There have been incidents where work direction resulted in errors for high radiation access and incorrect RWP usage. These have been documented in the FENOC CAP.

During the extended shutdown, the RP program was evaluated in comparison to the industry standards, Institute of Nuclear Operation (INPO), and American Nuclear Insurers (ANI) practices. Program deficiencies were noted in the areas of contamination control, job planning, control of radioactive materials, and internal dose assessment. Procedure improvements in these areas have been included in the Davis-Besse restart program and have been documented in the FENOC CAP.

Additional weaknesses were noted in the management expectations and standards in the section. Expectations for the use of procedures were not reinforced or abuses corrected. The procedures were written in a manner that provided many discretionary options to personnel and reduced the consistency of task evolutions in the section. The lack of peer reviews and accountability in the review and oversight of these materials resulted in the sections inadequate identification of the programmatic issues.

Recommended Corrective Action

Corrective Actions

Root Cause 1: **Less than adequate Work Direction** as the preparation, planning, and mock up for the performance of the evolution did not include all the necessary information or individuals necessary to successfully complete the task.

1. Revise RWP/ALARA procedures to clearly define when documented, review and approved confirmatory surveys are required prior to proceeding with the work. This action should require that the field conditions be bounded by the developed RWP and ALARA work package (CR ***2002-07717***). The RWP development should clearly define the "Stop Work" requirements to ensure the appropriate level of evaluation has been performed to verify the radiological hazard encountered and the adequacy of the job controls in place.

   Responsible Group: Chemistry and Radiation Protection
   Action Due Date: March 01, 2003

2. Revise the RWP/ALARA procedures to define high radiological risk evolutions/jobs. For such jobs, there will be RP qualified FENOC supervisory and technician involvement for the job performance.

   Responsible Group: Chemistry and Radiation Protection
   Action Due Date: March 01, 2003

3. Include shutdown chemistry in the RP continuing training program as a knowledge base item. Understanding the basic process is necessary for adequate job coverage of tasks in the primary system following this scheduled evolution.

   Responsible Group: Chemistry and Radiation Protection
   Action Due Date: January 01, 2004

4. Submit to the RP curriculum review committee (CRC) the details of this event to ensure the reinforcement of the "lessons learned" into the knowledge base of the RP technicians and appropriate staff.

   Responsible Group: Chemistry and Radiation Protection
   Action Due Date: May 01, 2003

5. Develop a set of standards and expectations that reinforce a climate of job responsibility and awareness in light of perceived or actual schedule time pressures. This is intended to reinforce the RP personnel's ability and responsibility to "stop work" if conditions are not adequate for the successful performance of the assigned task.

   Responsible Group: Chemistry and Radiation Protection
   Action Due Date: March 01, 2003

Root Cause 2: **Less than adequate Management Systems** in relation to standards, policies, or administrative controls and a lack of use of the CAP process to track self-assessment recommendations. In this incident, the individuals that were involved in the planning, preparation, and mock up for the evolution were on a day off the day the evolution was performed. This resulted in placing an inexperienced crew in charge of the performance of the evolution with little if any preparation.

6. Develop a set of standard and expectations to be included in the Conduct of Radiological Protection Operations that will clearly define the duties and responsibilities for individuals assigned to provide oversight of high radiological risk jobs. This is to include the proper management of resources to ensure there is an adequate number of personnel available to successfully perform the task.

   Responsible Group: Chemistry and Radiation Protection
   Action Due Date: March 01, 2003

7. Document the 2001 RP Air Sampling Program self-assessment in the CAP to ensure adequate management review and approval.

   Responsible Group: Chemistry and Radiation Protection
   Action Due Date: COMPLETE (2003-00588)

8. Develop an action plan and/or a procedure to ensure RP is aware of the source term of the plant and the actions to take in the event of a fuel defect. This is to ensure RP is aware of the source term in the station.

   Responsible Group: Chemistry and Radiation Protection
   Action Due Date: May 30, 2003

Contributing Cause 1: **Less than adequate Procedures** in the development of the RWP package, the ALARA package, and entry into high radiological risk environments.

9. Ensure an adequate review of the RWP and ALARA package is performed to ensure that adequate precautions and protective measures have been considered and implemented.

   Responsible Group: Chemistry and Radiation Protection
   Action Due: Corrective Action #1 of Root Cause 1 on Page 19 of this report. No further action is required.

10. Revise the TEDE evaluation process to consider the impact of transuranic alpha emitters on the dose for the individuals.

    Responsible Group: Chemistry and Radiation Protection
    Action Due Date: COMPLETE - incorporation into DB-HP-01800, ALARA Review, Step 6.2.1.a. referenced Form DB-0144-2 (Attachment 2).

11. Develop a steam generator entry procedure that includes the lessons learned from this incident.

    Responsible Group: Chemistry and Radiation Protection
    Action Due Date: COMPLETE – DB-HP-01115 (OTSG Entry)

12. Develop a procedure(s) that provides the necessary guidance for high-risk radiological work and provide a method to ensure proper planning and oversight.

    Responsible Group: Chemistry and Radiation Protection
    Action Due Date: June 08, 2003

References

Documents reviewed:

Condition Report 2002-00695, Shutdown Chemistry Method Utilized for 13 RFO less Effective than Anticipated
Condition Report 2002-01438, Release of Discrete Radioactive Particles from the Davis-Besse Nuclear Station
Davis-Besse 13RFO Outage Notes on Lotus Notes
Davis-Besse Nuclear Power Station NRC Special Inspection – Substantial Potential for an Overexposure of Occupational Workers, Report No. 50-346/02-16(DRS)
Davis-Besse Nuclear Power Station NRC Special Inspection – Uncontrolled Release of Radioactive Material to the Environment, Report No. 50-346/02-06(DRS)
FENOC Root Cause Analysis Reference Guide, Revision 3

Personnel contacted:

Regis Greenwood
Joe McAdoo
June Scott
Mark Travis

Methodologies employed:

Document Review
Personnel interviews
TapRooT®

Root cause team:

Stewart Bland
Gregory Gillespie
June Scott

Attachments:

Attachment 1: TapRooT® Cause Tree
Attachment 2: DB-0144-2, TEDE Evaluation

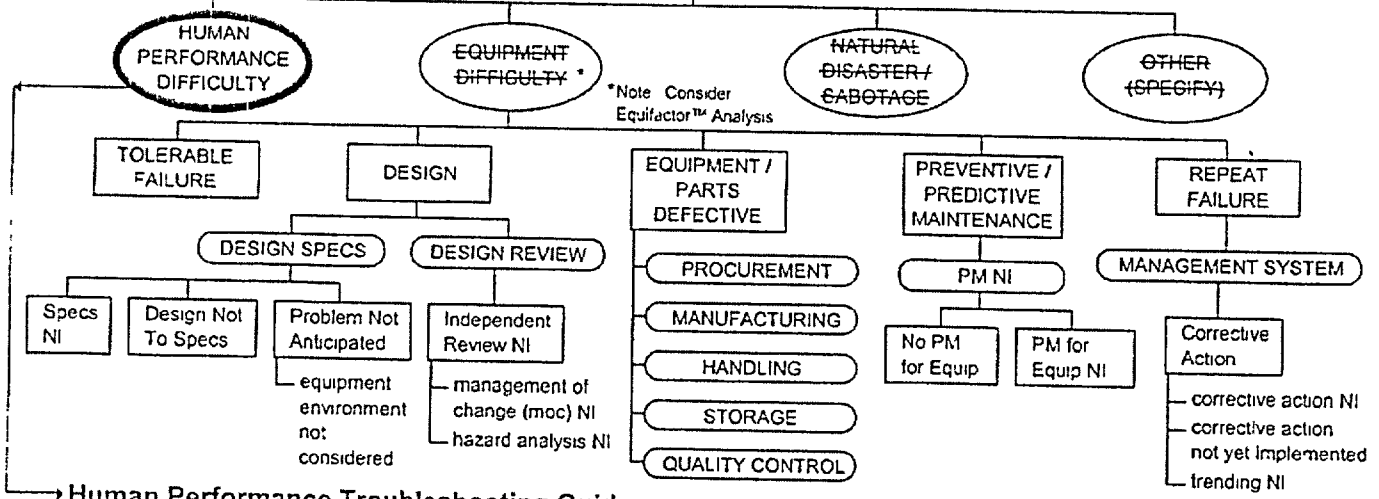
02-07811

TapRooT® Root Cause Tree®

Incident: 02-07811 NRC White Finding of 10CFR20 1501 Violation

Causal Factor: 01 Human Perofrmance Difficulty

START HERE with each causal factor and select or eliminate each category to find root causes



Human Performance Troubleshooting Guide

Directions Answer all questions and then refer to the indicated Basic Cause Categories to investigate the causes of the problem

Individual Performance

- Was a person excessively fatigued, impaired, upset bored distracted, or overwhelmed? — Yes → ~~HUMAN ENGINEERING~~, ~~WORK DIRECTION~~
- Should the person have had and used a written procedure but did not? — Yes → ~~WORK DIRECTION~~, ~~PROCEDURES~~, ~~HUMAN ENGINEERING~~
- Was a mistake made while using a procedure? — Yes → ~~PROCEDURES~~
- Were alarms or displays to recognize or to respond to a condition unavailable or misunderstood? — Yes → ~~HUMAN ENGINEERING~~
- Were displays, alarms, controls, tools, or equipment identified or operated improperly? — Yes → ~~TRAINING~~, ~~PROCEDURES~~, ~~HUMAN ENGINEERING~~
- Did the person need more skill / knowledge to perform the job or to respond to conditions or to understand system response? — Yes → TRAINING, WORK DIRECTION
- Was work performed in an adverse environment (such as hot humid dark cramped or hazardous)? — Yes → ~~HUMAN ENGINEERING~~
- Did work involve repetitive motion, uncomfortable positions vibration, or heavy lifting? — Yes → ~~TRAINING~~, ~~HUMAN ENGINEERING~~, ~~WORK DIRECTION~~

Team Performance

- Did verbal communications or shift change play a role in this problem? — Yes → COMMUNICATIONS
- Did failure to agree about the who/what/when/where of performing the job play a role in this problem? — Yes → ~~TRAINING~~, ~~COMMUNICATIONS~~, ~~WORK DIRECTION~~
- Was communication needed across organizational boundaries or with other facilities required? — Yes → ~~COMMUNICATIONS~~

Management System

- Was a task performed in a hurry or a short-cut used? — Yes → MANAGEMENT SYSTEM, WORK DIRECTION
- Had management been warned of this problem or had it happened before? — Yes → ~~MANAGEMENT SYSTEM~~
- Were policies, admin controls, or procedures, not used missing or in need of improvement? — Yes → MANAGEMENT SYSTEM, WORK DIRECTION, PROCEDURES
- Should an independent quality control check have caught the problem? — Yes → ~~QUALITY CONTROL~~

→ *Proceed to BASIC CAUSE CATEGORIES* →

NI = Needs Improvement May also substitute LTA (Less Than Adequate) or PIO (Potential Improvement Opportunity)

Prepared by TapRooT® software for FirstEnergy Corp

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* indicates a comment

TapRooT® Root Cause Tree®

Incident: 02-07811 NRC White Finding of 10CFR20.1501 Violation

Causal Factor: 01 Human Perofrmance Difficulty

BASIC CAUSE CATEGORIES

PROCEDURES

- **Not Used / Not Followed**
  - ✓ no procedure
  - procedure not available or inconvenient for use
  - procedure difficult to use
  - procedure use not required but should be
- **Wrong**
  - typo
  - sequence wrong
  - ✓ facts wrong
  - ✓ situation not covered
  - wrong revision used
  - second checker needed
- **Followed Incorrectly**
  - format confusing
  - > 1 action / step
  - excess references
  - mult unit references
  - limits NI
  - details NI
  - data/computations wrong or incomplete
  - graphics NI
  - no checkoff
  - checkoff misused
  - misused second check
  - ambiguous instructions
  - equip identification NI

~~TRAINING~~

- **No Training**
  - task not analyzed
  - decided not to train
  - no learning objective
  - missed required training
- **Understanding NI**
  - learning objective NI
  - lesson plan NI
  - instruction NI
  - practice / repetition NI
  - testing NI
  - continuing training NI

~~QUALITY CONTROL~~

- **No Inspection**
  - inspection not required
  - no hold point
  - hold point not performed
- **QC NI**
  - inspection instructions NI
  - inspection techniques NI
  - foreign material exclusion during work NI

~~COMMUNICATIONS~~

- **No Comm or Not Timely**
  - comm. system NI
  - late communication
- **Turnover NI**
  - no standard turnover process
  - turnover process not used
  - turnover process NI
- **Misunderstood Verbal Comm.**
  - standard terminology not used
  - standard terminology NI
  - repeat back not used
  - long message
  - noisy environment

MANAGEMENT SYSTEM

- **Standards, Policies, or Admin Controls (SPAC) NI**
  - ✓ no SPAC
  - not strict enough
  - confusing or incomplete
  - technical error
  - drawings / prints NI
- **~~SPAC Not Used~~**
  - comm. of SPAC NI
  - recently changed
  - enforcement NI
  - no way to implement
  - accountability NI
- **~~Oversight / Employee Relations~~**
  - infrequent audits & evaluations (a & e)
  - a & e lack depth
  - a & e not independent
  - employee communications NI
  - employee feedback NI
- **Corrective Action**
  - ✓ corrective action NI
  - corrective action not yet implemented
  - trending NI

~~HUMAN ENGINEERING~~

- **Human - Machine Interface**
  - labels NI
  - arrangement / placement
  - displays NI
  - controls NI
  - monitoring alertness NI
  - plant / unit differences
  - excessive lifting
  - tools / instruments NI
- **Work Environment**
  - housekeeping NI
  - hot / cold
  - wet / slick
  - lights NI
  - noisy
  - obstruction
  - cramped quarters
  - equipment guard NI
  - high radiation / contamination
- **Complex System**
  - knowledge-based decision required
  - monitoring too many items
- **Non-Fault Tolerant System**
  - errors not detectable
  - errors not recoverable

WORK DIRECTION

- **Preparation**
  - ✓ no preparation
  - ✓ work package/ permit NI
  - ✓ pre-job briefing NI
  - ✓ walk-thru NI
  - ✓ scheduling NI
  - lock out / tag out NI
  - fall protection NI
- **Selection of Worker**
  - ✓ not qualified
  - fatigued
  - upset
  - substance abuse
  - team selection NI
- **Supervision During Work**
  - no supervision
  - crew teamwork NI

NI = Needs Improvement May also substitute LTA (Less Than Adequate) or PIO (Potential Improvement Opportunity)

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* indicates a comment

DB-0144-2

TEDE EVALUATION
(RESPIRATORY USING CONTAMINATION DATA)

RWP/WO No(s). _____ Date _____

Task Description _____

Survey No(s). _____ ASR No(s). _____

A. Evaluate use of respiratory protection based on the following formula:

1. Beta-Gamma Surface Contamination alone

$$\frac{\text{mrad/hr(loose)/100 cm}^2 \times 2}{\text{external dose in mr/hr}} = ____ \quad \frac{\text{mrad/hr/100 cm}^2 \times 2}{_____\ \text{mr/hr}} = _____$$

2. Alpha Surface Contamination alone.

$$\frac{\text{dpm(loose)/100 cm}^2 \times 0.1}{\text{external dose in mr/hr}} = ____ \quad \frac{\text{dpm/100 cm}^2 \times 0.1}{_____\ \text{mr/hr}} = _____$$

B. If both of the above ratios are ≤ 1, AND the sum of the two ratios is ≤ 1 then, no respirator is required.

C. If either of the above ratios are > 1, OR the sum of the two ratios is > 1, then decontamination of area/component (or other suitable engineering controls) is recommended.

If the ratios (or the sum) cannot be reduced to ≤ 1, then respiratory protection is advised.

D. If contamination in area is unknown and not obtainable prior to start of work, then Respiratory Protection is recommended for areas of suspect high contamination until actual levels can be obtained.

E. Use of Engineering Controls (i.e., HEPA ventilation) should be evaluated for all potential airborne causing evolutions. The estimated dose for installation/removal of the engineering controls must be compared to the dose saved by these controls.

F. Conclusion (use calculations when possible): (attach additional sheets as necessary

_____

_____

_____

Performed by: _____ Date: _____

Reviewed by: _____ Date: _____

DB-0144-2

TEDE EVALUATION
(RESPIRATORY BASED ON AIR SAMPLE DATA)

DR = Average or Effective Work Area Dose Rate (mRem/Hr)

T = Time in Work Area

DAC = Expected DAC from measurement, calculation or otherwise estimated.

WE = Worker Efficiency in the chosen respirator (Use 0.85 unless history or other data indicates a more representative value for the job)

PF = Respirator Protection Factor

Estimated Beta-Gamma DAC = Measured Beta –Gamma Concentration (μCi/cc) divided by the DBNPS DAC value (6 E-09 μCi/cc)

Estimated Alpha DAC = Measured Beta –Gamma Concentration (μCi/cc) divided by:

First : the β–γ / α ratio (from Table)

Second: the limiting alpha DAC value (3 E-12 μCi/cc)

Total DAC = the sum of the Estimated Beta-Gamma and Alpha DACs

LOCATION	BETA-GAMMA TO ALPHA RATIO
OTSG and Platforms	850
Inside D-rings	800
CAC Area	1000
General Containment	10,000
Reactor Coolant Pump Area	450

These values are means of the actual range of values **Use Actual Measured Values where Possible**

Calculation of DAC

Measured Beta –Gamma Concentration (μCi/cc) / 6 E-09 μCi/cc = Beta Gamma DAC

(_____) / 6 E-09 = _____ Beta-Gamma DAC

[Measured Beta –Gamma Concentration (μCi/cc) / β–γ / α ratio] / (3 E-12 μCi/cc) =

Alpha DAC

[_____ / _____] / 3 E-12 = _____ Alpha DAC

TEDE EVALUATION
(RESPIRATORY BASED ON AIR SAMPLE DATA) (CONTINUED)

DB-0144-2

Beta-Gamma DAC + Alpha DAC = Total DAC

(_____) + (_____) = (_____)

Determination of Expected Dose With and Without Respirators

Without Respirator

(DR x T) + (DAC x T x 2.5) = Dose w/o Respirator

(_____ x _____)+(_____ x _____ x 2.5) = _____mRem
Without Respirator

With Respirator

[DR x (T / WE)] + [DAC x (T / WE) x (2.5 / PF)] = Dose w/ Respirator

[_____ x (_____ / _____)] +[_____ x (__/__) x (2.5 /__)]=_____mRem
With Respirator

Choose the ALARA Option unless Other Worker Safety Issues Are Over Riding.

Comments: _____

_____

_____

_____

Performed by: _____ Date: _____

Reviewed by: _____ Date _____

Docket Number 50-346
License Number NPF-3
Serial Number 2946
Attachment 2

Root Cause Analysis Report CR 2002-07819
NRC White Finding of 10CFR20.1204(a) Violation

FirstEnergy, DAVIS-BESSE NUCLEAR POWER STATION

Root Cause Analysis Report

NRC WHITE FINDING OF 10CFR20.1204(a) VIOLATION

CR 2002-07819, Dated 10-10-2002

REPORT DATE: 02-11-2003 Revision 02

Prepared by: Electronic Signature on File
G.W. Gillespie

Reviewed by: Electronic Signature on File
Manager - Chemistry and Radiation Protection

Approved by: Electronic Signature on File
General Manager - DB Plant Operations

Chemistry and Radiation Protection Section

Problem Statement

Description of reason for investigation

Deficiencies were identified during and following the February 20, 2002 nozzle dam installation that resulted in a internal exposure to the workers involved. The issues identified were the following:

1. Failure to address recommended program improvements
2. Failure to identify the required surveys necessary for evaluating worker dose and for obtaining timely follow-up of the analysis and evaluation of *in vitro* bioassay samples
3. Failure to adequately control, evaluate and review bioassay sample data.

The Nuclear Regulatory Commission (NRC) Special Inspection of the Radiation Protection (RP) Program identified a white finding related to 10CFR20.1204. This finding dealt with the requirement to obtain suitable and timely measurements of radioactive materials in the air or of quantities in the body or excreta. The RP section's performance is considered less than adequate in these areas.

Consequences of event/condition investigated

Since the event date the following consequences have occurred:

- The NRC has completed an inspection of the event and has issued findings identifying deficiencies in controlling and assessing internal exposure and the timeliness of internal dose assessments.
- Potential non-regulatory consequences are loss of worker confidence regarding internal exposure controls.
- Unmonitored or lack of adequate assessment of workers internal dose

Immediate actions taken

1) Committed effective dose equivalent (CEDE) is now calculated for all whole body counts (WBC). This action provides a preliminary evaluation of the significance of measured intake. This action is completed.
2) Excreta samples from the two highest exposed individuals were collected and analyzed. Control samples were provided with the second and third excreta samples for quality assurance/control purposes.

Remedial actions taken

1) All Dose assessment performed for these individuals have been reviewed and dose records amended as required.

2) For the two higher exposed individuals, the employer (Framatome) was contacted and occupational exposure was restricted pending finalization of the dose assessments.

3) DB-HP-01701 was modified to address the release of personnel unable to pass the personnel contamination monitor (PCM), and address the assessment of internal contamination vs. external contamination (Change 1 to Revision 4).

4) RPAI –056, "Trigger Levels Requiring the Generation of a Condition Report", was issued 16 May 2002. This administrative instruction required generation of a condition report (CR) for Personnel Contamination requiring a dose calculation; where contamination is not reducible by normal decontamination methods; or if the individual must leave the radiologically restricted area (RRA). This instruction also requires the generation of a CR for any intake estimated to be greater than 50 mRem.

5) Standing Order 2002-0008 was issued July 23, 2002. This order requires an incoming and termination WBC for all personnel. This requirement provides an estimate for any intakes attributable to Davis-Besse licensed activities. (Superseded by Standing Order 2003-0002). This requirement will be included in pending procedure revisions.

6) Standing Order 2002-0015, "Interim ALARA Measures for Alpha Radioactivity"' was issued October 18, 2002. This document provides guidance for individuals preparing Radiation Work Permits (RWP) for those areas of the plant that have been characterized as having a high probability for transuranic alpha contamination. This action was proceduralized in DB-HP-01800, TEDE Evaluation, form DB-0144.

7) Davis-Besse "Conduct of Operations for Radiation Protection" was issued August 29, 2002. This documented the operational expectations for all RP organization personnel and clarified these expectations for all RP organization personnel. This included documenting the expectation regarding the generation of condition reports (CRs) for identified issues.

8) Self-assessments are now documented in the Corrective Action Program (CAP). This ensures adequate documenting and tracking of corrective actions and improvement opportunities.

Other Actions Taken

2002-06699 BIO-ASSAY RESULTS FOR INTERNAL DOSE ASSESSMENT OF STEAM GENERATOR WORKERS

Davis Besse received fecal and urine analysis data for steam generator worker to assess internal dose from steam generator work performed on February 20, 2002. Sample results indicated less than detectable for urine and fecal samples for curium-242 (Cm-242), Cm-243/244, plutonium-238 (Pu-238), Pu-239/240 with minimum detectable concentrations ranging from 0.39 - 1.3 pCi. In the fecal sample, Am-241 was detected at 3.8 pCi per sample. A hypothetical calculated dose based solely on americium-241 (Am-241) is estimated at 320 Rem committed dose equivalent

(CDE) bone surface and 19 Rem committed effective dose equivalent (CEDE). The presence of only Am-241 is inconsistent with source term data used to calculate previous and current estimates. Follow-up analysis of the data determined that there was no Am-241 present in the sample. The vendor laboratory documented this issue within their corrective action program (Framatome ANP DE&S Environmental Laboratory Condition Report 02-31 Investigation Report).

To avoid any further communications of non-quality data to the NRC, a protocol was established for the review and transmittal of bioassay data resulting from any analysis. This consisted of identifying a distinct individual (NRC September 2002 Special Inspection Team Leader) from the NRC where the reviewed and approved data was to be communicated.

2002-07809 BIOASSAY SAMPLE ANALYSIS AT FRAMATOME ANP DE&S LABORATORIES

This condition report identifies the following deficiencies in controlling the vendor analyses of the fecal bioassay sample:

a) Davis-Besse had previously obtained data that indicated a suspected isotopic mix, consisting of Am-241 and other transuranic alpha emitters. If this information had been provided to the vendor, the vendor would have suspected an error in their initial analyses. This information was not provided to the vendor laboratory with the purchase order (PO) or analysis request.
b) Davis-Besse was aware at the time of the suspected internal intake in question and could have calculated the necessary analysis minimal detectable activity (MDA). This information was not provided to the vendor laboratory with the PO or analysis request.
    1. Davis-Besse does not have a written procedure / program that delineates the details necessary in a purchase order for offsite analysis to ensure that this issues is not repeated.
    2. Davis-Besse Quality Assurance performed an assessment of the original laboratory and the associated purchase orders. This is documented by Davis-Besse Quality Surveillance 10042-S001.

2002-08289 UNUSUAL PU-241 RESULTS RECEIVED FROM OUTSIDE LABORATORY

Bioassay analysis performed by an outside laboratory on urine samples contained unusually high concentrations of Pu-241. Both the laboratory blank and the human blank supplied to the laboratory were also high in Pu-241 concentration. The vendor was notified of this issue. They determined that their method of analysis resulted in some interferences when the scintillation was performing the measurements. The samples were then analyzed separately and no Pu was measured.

New purchase orders specified the minimal MDA requirements to the additional laboratories. This information was not included in the original purchase order.

Event Narrative

This event narrative developed using previous condition reports, NOMS Log Entries, Davis-Besse 13RFO Notes on Lotus Notes, and the NRC special inspection reports.

05/2002 CR 2000-1509 is generated to document a suspected fuel defect in the reactor core.

05/2001 Self-Assessment on RP Air Sampling Program documented

01/22/02 RP completes the preparation of RWP 2002-5303, "Install and remove nozzle dams and nozzle dam FME covers and equipment setup"

01/23/02 As-Low-As-Reasonably-Achievable (ALARA) review completed for RWP 2002-5303. The ALARA Evaluation form for this RWP stated that respiratory protection "should be used". However, based upon historical data and previous experience with this evolution, the individual preparing the ALARA planning package determined that the total dose for the job was less without the use of respirators.

02/15/02 Plant begins down power for 13th refueling outage (RFO)

02/18/02 1300 ALARA briefing conducted for RWP 2002-5303.

2141 Commenced drain of the reactor coolant system (RCS) to flange level, Pressurizer (PZR) at 162 inches.

02/19/02 0500 Upper steam generator manways are removed. RP personnel perform a survey of the area but the survey is misplaced and is not included in the RWP. The surveys were eventually discovered in the Auxiliary Building Survey book.

02/20/2002 The duty Radiation Protection Manager (RPM) that planned job takes day off. The RPM had recently returned to the site and was not present for the plant shutdown.

RP Supervisor following the job takes the day off.

The Certified Health Physicist (CHP) is out of town on business.

0850 Chalk River Unidentified Deposits (CRUD) burst occurs in the RCS. RP restricts access to the Auxiliary and Containment buildings.

1420 Framatome reports to Outage Management that that both lower steam generator manways have been removed and the shield doors in place. RP survey is in progress.

During the removal of the west steam generator manway, the diaphragm is inadvertently removed with manway hatch. High efficiency particulate absolute (HEPA) unit is not in service when the diaphragm comes off. As a result of the diaphragm coming loose, an alarm of the radioactive air monitor (AMS-4) occurs.

1430 Radiological survey completed for steam generator tube sheet and bowl for the West generator. The West side diaphragm came off with the manway. This was not planned and no air sample was in progress at the time of the event.

1450 Radiological survey completed for east steam generator tube sheet and bowl. Dose rates of the tube sheet on contact were 10.8 to 12.1 Rem/hour. Manway dose rates were measured at 3.2 Rem/hour plane closed window contact and 2.5 Rem/hour plane open window.

Air sample taken from the west steam generator platform. This sample indicated a derived air concentration (DAC) value of 14 DAC for alpha emitters (Air Sample Record (ASR) Number 2002-0074). The data printout was provided to the RPM.

1500 Air sample taken from the west steam generator manway (ASR Number 2002-0075).

A smear of the west diaphragm showed a removable contamination level of approximately 46 Rad/hour. The RP Supervisor and ALARA planning personnel mistakenly thought that this high level of contamination was expected due to the error in the RWP development that indicated a contamination level of 60 Rad/hour was expected. This RWP error is addressed in CR 2002-07811.

02/20/02 1530 RP briefed the steam generator work group on RWP 2002-5303 prior to signing in on the RWP. The use of face shields was added during the pre-job brief but not formally made a requirement of the RWP. The contamination levels in the steam generators was discussed at this brief and was the basis for the use of face shields.

1615 The steam generator team consisting of four radiation protection technicians and eight Framatome workers signed in on RWP 2002-5303. This RWP did not require breathing zone air samples to be collected and as such, none were collected. AMS-4 monitors were collecting airborne samples on each platform. A radiological air sample pump (RASP) was used to collect an air sample from the plane of the opened manway.

1825 Nozzle dam installation was started on the east steam generator.

1900 Nozzle dam installation for both east and west steam generators was reported completed.

Door 300 was opened and resulted in the spread of contamination from containment to the Radiological Restricted Area (RRA) entrance/exit. Access to the RRA was restricted. The spread of contamination also included the PCM's for the containment and RRA exit points.

Six steam generator workers assigned to RWP 2002-5303 alarm PCM as they attempt to exit the RRA. Workers decontaminated by using multiple showers but they continued to alarm the PCM and portal monitors. Radiation workers provided up to seven showers.

Nasal discharge collected for Worker A: follow-up gamma spectroscopy analysis identified cerium-141 (Ce-141) and Ce-144.

2034-2154 Worker A, Worker C, Worker D, Worker E, Worker F and Worker G receive

WBCs due to suspected internal contamination. Investigative body counts (three minutes) performed per procedure DB-HP-01320. RP Supervisor and duty RPM informed of positive body count and radionuclide results. Individuals with positive counts were allowed to leave site. There were no dose assessments started by the night shift staff and any sense of urgency in performing these calculations was not communicated between the RP Supervisor and the staff. RP Supervisor stated various individuals attempted to read and follow dose calculation procedure but were not certain how to proceed with the calculations. It was then decided that the calculations could wait until morning. The individuals were informed they were to report the following day for another WBC.

2/21/02 0630 WBC data packages turned over to day shift for review.

0700 One RP Supervisor (acting) and one RP technician started dose calculations on body count data. The plan was to each perform three assessments then switch whole body count data packages and perform the dose calculations to independently verify the calculations. The technician was assisted with the process and NUREG-4884 data tables for intake retention fractions (IRF).

1215 Worker A, Worker C, Worker D, and Worker E receive termination WBCs.

≈1400 RPM informed highest activity body count data was approximately 250 mRem. This data and calculation had not been checked thoroughly or independently verified. Duty RPM was informed of initial dose estimates and the regular RPM directed staff to proceed with calculations.

≈1700 The six initial dose calculations were completed. Discrepancies in the time of intakes needed to be verified by the oncoming shift. It was recognized this would change the dose calculation results slightly. No calculated dose was greater than 500 mRem, the highest calculated was 220 mRem. RPM informed of latest calculated dose and additional assistance was requested from the oncoming shift. It was recognized dose calculation discrepancies were the result of inconsistent data between calculations. Discrepancies had to do with time between counting and intake and the corresponding IRF used. Additionally procedures DB-HP-01320 and DB-HP-00002 required a post intake WBC at approximately 24 hours. This count was routinely used for performing dose assessments.

≈1830 Shift change and data turnover between RP Supervisor (acting) to Duty RPM of data packages and status of dose calculations performed. The dose calculations performed per DB-HP-01340 and those performed using an Excel spreadsheet was communicated to the RPM. The spreadsheet was provided to the RPM. There was a discussion of the data and what further actions were required. This included a peer check of the data and a resolution of the intakes times. Oncoming shift was staffed with a CHP working in ALARA. Individuals with positive counts were counted before starting the shift. Two individuals had left site.

02/2202 Scheduled day off for the RP Supervisor (acting) knowledgeable of dose calculations.

CR 2002-00709 was written to document the fact that night shift RP personnel were not comfortable in performing dose calculations in accordance with DB-HP-01340 due to a lack of expertise in the area.

02/23/02 0600 No additional work had been performed on refining the dose calculations since 2/20/02 at 1830. A review of follow-up body counts indicated the input of incorrect intake dates when performing the counting. Spectra were re-analyzed with the correct intake dates and times. The dose assessments and body counts were reviewed by the RPM.

02/26/02 RP personnel begin working on dose calculations for the six individuals with additional WBC data (~24 hour post intake).

02/28/02 Worker A, Worker E, Worker F, and Worker G, receive WBC upon returning to the site.

03/02/02 Worker D receives WBC upon return to the site.

03/06/02 Worker A receives WBC upon return to the site.

03/08/02 WBCs for workers A through F reviewed for dose assignment. .

03/14/02 Worker A, Worker C, Worker D, and Worker G, receive WBC. Dose Assessments completed for Workers A through G. Results credited to individuals. Highest individual dose credited and based upon the data was 170 mRem.

The two highest individuals were assigned 170 and 101 mRem CEDE based on the lack of any indication of fission products other than radioiodines. (It was determined later that radioiodines were misidentified by the WBC).

The *in vivo* bioassay (WBC) showed cobalt-58-60 (Co-58/60) and the rapid clearance of intake as noted in previous outages. The WBC showed no indication of fission product either in the printed report or in a manual review. It was determined that no further bioassays were necessary for the individuals.

04/11/02 Condition Report 2002-01438, Potential Release of Hot Particles to Other Sites, reclassified as "Significant Status with Root Cause Investigation". As part of the root cause investigation, all contamination alarms and body counts for the individuals concerned in the off-site particle incidents were reviewed.

04/13/02 Issued Radiation Protection Administrative Instruction (RPAI) 55 to provide specific guidance on handling internally contaminated workers who are unable to pass PCMs.

04/18/02 Review of available data shows discrepancies in reported nuclides between lapel and area air samples and those identified in the Whole Body Counter. Modified the WBC identification library to include ruthenium/rhodium-106 (Ru/Rh-106), Ce-141, Ce-144, and zirconium-95 (Zr-95). The WBC spectra for the six workers were then reanalyzed with the new library.

04/24/02 Radiation Protection decides to re-institute WBC for all incoming (new) and exiting (termination) personnel. Standing Order 2002-0008 was issued July 23, 2002 and has since been superseded by Standing Order 2003-0002.

04/25/02	CR 2002-01688 written to document Incomplete Gamma Spectrum Library Used in Body Counter.
06/24/02	One air sample from once-through-steam-generator (OTSG) upper bowl, two smears from OTSG platform, and one primary coolant CRUD sample sent to Framatome (BWXT) lab for detailed analysis.
07/25-31/02	Additional calculations performed on the dose estimates for the six workers. The highest calculated dose is 142 mRem. Review of all spectra showed no evidence of Ce-141 or 144 and the presumption is made that no transuranics are present.
08/09/02	Laboratory results received from BWXT. Using this data, the scaling factors are recalculated and a dose re-assessment of the six workers commenced.
08/13/02	KAL, Inc contracted to provide independent dose assessment of the workers.
08/23/02	Reassessment of the dose completed for the six workers. The highest dose calculated was 196 mRem. A transuranic dose component was included for Worker A for the non-respiratory portion only.
08/31/02	Fecal and Urine samples obtained from Worker A and sent to the DE&S Laboratory for analysis. Calculations were performed prior to shipment to determine satisfactory minimal detectable activity (MDA) values for the lab to meet. (MDA value equivalent to 1 ALI 200 days post intake –and the MDA value to prove/disprove validity of air sample 200 days post intake were determined by the organization.)
09/09/02	RP sent information to DE&S specifying the name of the individual supplying the samples, fecal and urine samples and the date/time of collection. No other information, instructions, or details were provided.
09/10/02	A PO (7103040 Rev 3) was expedited to the lab to perform Pu, Am, and Cu analyses. The specific terms for the analysis included, "performed under standard E-lab procedures, MDA, count times, and QA program". No reference was made to the previously calculated MDAs. CR ***2002-07809*** identified this communication issue.
09/17/02	Five additional smears sent to BWXT Lab for detailed analysis
09/24/02	In response to a request for expedited results, the laboratory provided preliminary results after a 7,026 second count of 3.8 pCi/sample. CR ***2002-06699*** was written to document this result. The data was forwarded to the NRC without a thorough review by the organization.
09/25/02	The RP organization contacted the laboratory for additional information on analysis. The count was continued to 66,000 seconds yielding a result of 0.87 pCi/sample.
09/25-26/02	Upon receipt of the positive result for Am-241, RP performed a review of the data. The review suggested the results were questionable. The basis of this assumption was that previously known isotopic mixes that yield Am-241 additionally yield positive results for other isotopes. However, no other isotopes were identified by the DE&S analyses. This discrepancy was discussed with DE&S and the lab provided an update based on longer counting time.

09/27/02	Worst case (upper bound) dose assessment was prepared for the six workers. The highest doses calculated, using transuranic scaling factors in both the inhalation and ingestion pathways, was 844 mRem CEDE. This report was marked "Draft". In response to repeated requests from the NRC, this draft copy was sent to Region III.
09/27/02	The doses estimated by this report were used to update dose records and used to determine if this estimate could cause an over-exposure when added to all other dose received in the calendar year.
09/28/02	A second urine/fecal sample is collected from Worker A and Worker D. The samples are split and one portion sent to DE&S and the other portion sent to Eberline.
10/02/02	A separate dose assessment completed by a peer. This report did not use the conservative assumptions used in the September 27, 2002 report. The highest dose assessed was 430 mRem. A copy was provided to the NRC in response to requests for the information.
10/05/02	A third urine/fecal sample collected from Worker A and Worker D. The samples are again split and sent to different laboratories. One portion was sent to GEL Laboratories and the other was sent to an NRC requested laboratory.
10/10/02	Received analysis results for the five additional smears sent to BWXT on September 17, 2002. As a result of a Quality Assurance (QA) Audit of DE&S, CR 2002-07809 was generated. This CR documented the apparent errors in the processing of the urine and fecal samples sent on August 31, 2002 and those processed during the period September 9-24 2002.
10/15/02	Results received from Eberline on the urine samples sent for analysis. Data indicated the presence of Pu-241 in both the laboratory blank and the human blank provided by Davis-Besse. CR ***2002-08289*** was generated to document this discrepancy.
12/05/02	KAL, Inc. issues preliminary report for Worker A. This report lists an upper bound of 150 mRem CEDE and 740 mRem CDE.
12/06/02	Independent dose assessment group issued final dose assessment report for Worker D assigning a maximum dose of 430 mRem CEDE and 3.4 Rem CDE.
12/10/02	Revised final dose for workers entered into records.

Data Analysis

DATA REVIEW

For 12 of the 13 operating cycles for Davis-Besse, the fuel in the core has experienced varying degrees of cladding failure. As a result of these failures, the concentration of transuranic alpha emitting isotopes has steadily increased in the 10CFR Part 61 analysis reports. This increase was identified in several self-assessments and, in particular, a May 2001 assessment. Despite the trends, the organization failed to adequately address the recommended items. The potential of a substantial internal intake with a potential significant transuranic component was not considered to be an issue for the site. As such, no actions were taken despite in-house data and industry experience (Haddam Neck).

The TEDE evaluation form for RWP 2002-5303 indicated that respiratory protection "should be used". However, based upon previous experience with this evolution, the individual preparing the ALARA planning package determined that the total dose for the job was less without the use of respirators. The basis for this assumption was that the conditions in the steam generator bowls would not be different from those experienced in previous outages. In addition, the contribution of transuranics in dose evaluations was not considered in 13 RFO or previous outages.

A revised method used for shutdown chemistry did not provide a removal mechanism for the oxidized radionuclides in the steam generators as had be the case in the previous outages (Basic Cause 2002-00659). As a result, the dose rates and contamination levels in the steam generator bowls was significantly higher than those measured in recent outages. A contamination level of 46 Rad/hour smearable was obtained from the diaphragm of one of the steam generator manways. Samples also indicated the presence of alpha contamination but the organization failed to respond to the significance of this data.

On February 20, 2002 at 1530, RP briefed the steam generator work group on RWP 2002-5302 and discussed the conditions of the steam generators. This briefing provided one of the first opportunities to recognize that the conditions in the steam generators was significantly degraded from previous outages. The smear sample of 46 Rad/hour smearable and the presence of alpha contamination (14 DAC) was known, however there was no reviewed and approved survey available for the RP individual during the brief. The RPM, RP Supervisor, and ALARA planning personnel were aware of the conditions yet the job was allowed to proceed without any additional precautions added to the RWP. The RWP process at the time was not used for identifying required air samples. This decision was at the discretion of the assigned RP technician or by RP Supervisor direction at the time of the job. There were no breathing zone samples collected during the steam generator entry. This absence of air sample data complicated the dose assessment of the individuals during the following months. *Based upon this information, a lack of adequate Work Systems is apparent in that the organization failed to recognize the significance of the contaminations levels in the steam generators, the presence of alpha emitting radionuclide, and the need for enhanced job controls including air samples.*

Following the completion of the steam generator nozzle dam installation, the RP technicians and Framatome workers exited containment at approximately 1900. Upon entering the PCM's at the containment monitoring point, the instruments alarmed. In the case of one worker, RP personnel suspected that the individual had contamination in his nose as several hundred net counts per minute (ncpm) were measured with a frisker when held up to the worker's nostrils. In an attempt to remove the contamination from the nose, a nasal swab was used on several workers. The nasal discharge on the swabs was later analyzed by gamma spectroscopy and Ce-141 and Ce-144 was measured. The contaminated workers were provided with multiple showers (up to seven) and provided new sets of modesty garments. These efforts did not enable the workers to exit the RRA without alarming the PCM's. In accordance with station procedures, they were directed to the whole body counter for bioassay. *Based upon this information, a lack of adequate Work Systems is apparent that the organization failed the recognize the significance of the contamination levels of the workers and the presence of Ce-141 and Ce-144. With these isotopes present, there was a high potential of internal transuranic contamination..*

After performing the investigative WBC (3-minute) on the workers, the RP Supervisor and duty RPM were notified of the positive results. The workers were allowed to leave the site and no further dose assessment was performed during the night shift. Part of this delay in initiating the dose assessment was that night shift personnel were not familiar with the assessment process and did not feel they had the knowledge required to successfully perform the assessment. It was decided to wait and allow the day shift RP personnel perform the assessment. This information and the urgency to perform the dose assessment for the individuals was not communicated during the shift turnover and therefore, no actions were performed on day shift to initiate further investigations and assessments. *This information indicated there was a lack of Procedural guidance in regards to dose assessments and the responses necessary for the evaluation and release of individuals with internal contaminations. It also reflects a lack of adequate Management Systems in that the responsibility and methodology for performing dose assessments relied on the knowledge of RP technical personnel and was not well understood by line personnel. There was a lack of training as dose calculation methodology was not considered to be necessary for most personnel. Training in this arena was not conducted at a frequency where successful performance of the task was not ensured. There was also a failure on the part of the organization to adequately perform an initial assessment of the issue to recognize the significance of the intakes and properly communicate the problem to senior management (either verbally or through the generation of a CR).*

On February 23, three days following the incident, RP staff began refining the dose calculations of the contaminated workers. After assembling and reviewing all the available WBC data, an error in the intake date was discovered. The WBC spectra for the workers was re-evaluated with the correct intake times and dates. The RPM was then notified of the results of this evaluation. The Certified Health Physicist (CHP) returned to the site following a business trip and began performing the dose calculations for the six Framatome workers. This included the additional data of the post-24 hour body counts performed on the workers. By March 11, dose assignments were made to the workers records. The assignment to the two highest workers were 170 mRem and 101 mRem CEDE. The *in vivo* bioassay (WBC) showed Co-58 and Co-60 and clearance of body burden as observed in contaminated individuals in previous outages. It was determined that no further bioassays were required.

In April, discrepancies in the reported nuclides between the general area air samples and those identified in the Whole Body Counter. It had been identified in previous years that the existing sodium iodine whole body counter detector lacked the resolution to adequately identify some radionuclides associated with fuel leaks is the library contained those normally observed in the plant. The vendor also recommended that the "fast scan" library not include these nuclides (associated with fuel leaks) as they may be misidentified by the system. This was particularly true when Co-58 was present as one of the peaks associated with this radioisotope masked the nuclides associated with fuel defects. To provide additional *in vivo* data for the dose calculation, the radionuclide library of the counter was modified to include Ru/Rh-106, Ce-141, Ce-144, and Zr-95 and the spectra of the workers was reanalyzed. This was performed as a conservative measure until a system with improved resolution was received. CR 2002-01688 was generated as a result of the radionuclide library difference. The station will purchase an Accuscan high purity germanium (HpGe) system from Canberra in 2003. Evaluations of the workers doses were performed throughout the June and July timeframe and based on the *in vivo* bioassay, it was assumed that no transuranics were involved in the internal contamination of the workers.

The results from samples collected earlier in the year for 10 CFR Part 61 analysis were received from the outside laboratory in early August. These samples measured transuranic radionuclides and the dose calculations were performed based upon the scaling factors observed in the new data. In additional communications with the NRC, it was decided to collect *in vitro* bioassay samples and have them analyzed by an outside vendor. In the effort to obtain an appropriate laboratory in a short time, verbal communications were performed by the RP organization and the potential vendor. During these communications, environmental LLD requirements were discusses as being necessary but it was unknown by the parties that this had different meanings to the individual parties. The excreta samples were collected on August 31 and sent to the selected laboratory. *This data has identified two inadequacies within the organization. There was a lack of Procedural guidance on the collection of in vitro bioassay samples and therefore several errors were made. This was the first time for such an activity to be performed at Davis-Besse in recent years and it relied on knowledge of the individual or assumed the condition would never be encountered. A communications error with the laboratory also occurred during this time in relation to the necessary LLD's required for the samples. Part of this error was due to the short time provided to identify an appropriate vendor and obtain an approved PO. There were no standards or procedures to provide the necessary guidance in the PO development. The results received from the laboratory did not receive adequate quality control checks prior to be transmitted to the NRC.*

With the additional *in vitro* data received from three different laboratories and the work of several individuals performing the dose calculations, a dose was assigned to the workers. The efforts to perform this analysis was complex as there was less than adequate samples collected and analyzed during the performance of the steam generator evolution and several methodologies could be used in dose assessments. By December, the individual with the maximum dose calculation for the job as assigned 430 mRem CEDE and 3.4 Rem CDE. *The issue of less than adequate data available for evaluation and the repeated dose assessments demonstrate further Procedural inadequacies. There was a general lack of sensitivity to the significance of this intake by the organization despite the indications that transuranics were present in the steam generator bowls and in vitro samples*

FACT LIST

- The Davis-Besse RP program did not consider alpha contamination as a potentially significant internal dose issue.
- The RP organization did not have a written procedure/program that ensures adequate general area and breathing zone air surveys are required.
- Previous RFO steam generator sample (airborne and swipe) data analyzed for 10CRF Part 61 had shown the presence of transuranic radionuclides.
- Deficiencies in the air-sampling program in addressing transuranic were identified in audits/self-assessments prepared in 1999 and 2001. This less than adequate survey is documented in CR 2002-7811.
- Radiation Protection procedures did not delineate the requirements for follow-up bioassay, either *in vivo* or *in vitro.*
- The pre-job briefing for the nozzle dam installation discussed and directed use of face shields. The workers performing the evolution did not use face shields during the evolution.
- Although manway opening air samples showed alpha activity, no lapel samples were taken for personnel entering the steam generators and there was no RWP requirement to perform the analysis.
- The presence of Ce-141 and Ce-144 in the nasal discharge sample was not identified as an indicator of likely transuranic component to the intake.
- A number of whole body counts were performed on each of the three workers until they terminated employment at the site on March 14, 2002. The follow-up counts showed decreasing activity, though all were positive. No reliable indication of Ce-141 or Ce-144 was found.
- The resolution limitations with a sodium iodine whole body counter detector inhibits the positive identification of some radionuclides present as a result of fuel samples if there is an nuclide mixture typical of normal operations. The peak from Co-58 is known to mask these other nuclides and the vendor recommends that they not be included in the typical radionuclide library.
- Dose estimates were updated as additional information was received; a dose of record estimate was entered into the file within 15 days of the intake.
- The intakes were not considered significant by the organization as transuranics were not adequately identified in the initial assessment and the WBC lacked any presence of transuranics. The spectra were later evaluated by the detector's vendor (Canberra) and verification of the absence of Ce-141 or Ce-144 in the spectra was confirmed.
- A bounding worst case dose estimate was entered into the dose of record within seven months of the incident. (The Regulatory Guide 8.9 time frame for assigning dose when class Y radionuclides are involved.) The final revised dose of record was assigned on December 10, 2002.

- No guidance existed on the collection and handling of body excreta bioassay samples.
- Initial fecal and urine samples were collected without a quality control blank.
- MDA's and expected radionuclides were not initially communicated to the vendor performing the initial *in vitro* bioassay analysis.
- The DE&S laboratory preliminary excreta results initially reported positive Am-241. This initial report was incorrect and follow-up confirmatory analyses measured no detectable transuranic radionuclides.
- Information was sent to the NRC without a detailed internal review to ensure the quality of the information.
- A thorough review and evaluation of the exposure event and potential doses was not performed in a timely manner.

CONCLUSION

The analysis of the data and the listed facts reflects an organization that lacked the sensitivity to the controls to prevent and the magnitude of the transuranics on the contribution to dose assessments. Despite precursors indicating their presence in the 10 CRF Part 61 analysis, no additional controls or measures were incorporated into the dosimetry, respiratory, or air sampling programs. The air sample procedures lacked the necessary information to ensure adequate respiratory protection of the workers and necessary information to produce an adequate dose assessment to radiological workers.

The potential for the uptake of transuranics was not anticipated and as a result, procedures and policies were not developed to assist the line supervisors in the event of this type of incident. Although the self-assessments may have identified the issues in previous years, the failure to implement most of the recommendations indicates a lack of rigor in the assessment process and the resolution of the identified issues. The causes of this event are in the management arena in that there was a lack of standards, procedures, policies, or expectations in regards to internal contaminations, particularly those involving transuranic nuclides.

Experience Review

The Corrective Action Tracking System (CATS) database was reviewed for previous Potential Condition Adverse to Quality Reports (PCAQR) and Condition Reports (CR) applicable to this event. CREST was also used to evaluate similar CR's that have been generated since December 2000. The Operating Experience (OE) database maintained by Institute of Nuclear Power Operations (INPO) was also reviewed for applicable events.

Davis-Besse

No failures to adequately implement the requirements of 10CRF20.1502(b) have occurred at this site.

Nuclear Industry

IN 97-36 Haddam Neck (November 02, 1996)

In preparation to inspect the fuel transfer mechanism and upender, two workers met with health physics (HP) supervisors and HP technicians to discuss entry into the fuel transfer canal. This task was not on the master schedule and this was the first notice HP had in regards to the task. The work scope was not discussed and HP was unaware that the workers were to pick up any lose material with their hands. A pre-job survey was not performed prior to the workers entering the transfer canal and it was generally assumed to be "clean". This pre-job briefing was less than adequate and the workers were not informed of the actual conditions in the transfer canal. The resulting uptake was calculated to be 913 mRem committed effective dose equivalent (CEDE) and 5873 total organ dose (CED).

Industry Documents

INPO Data Bases for SOERs, SERs, Nuclear Network Operating Experience, and Plant Events were searched using the Keywords given above. No events with direct similarities were found.

INPO 91-014 was searched for recommendations on types of bioassay for transuranic radionuclides, no specific requirements were found.

Electric Power Research Institute (EPRI) TR-113039, "Guidelines for Industry Response to Personnel Contaminants" does not deal with trans-uranic alpha contamination.

EPRI 1003126, "Program Considerations for Addressing Alpha Emitting Radionuclides at Nuclear Power Plants" outlines a comprehensive alpha survey program, including bioassay frequency, based on detected transuranic indicators.

Conclusions

The operating experience review revealed that this type of event is not a common occurrence in the industry. In general, a failure to maintain adequate procedures and ensure the understanding of internal and external dosimetry by RP personnel contributed to this issue. Less than adequate planning was a precursor for this occurrence and was strictly based upon historical data and experiences. This suggests that the review of industry experiences within the section lacked the necessary attention to provide continued improvement. This is particularly true of the identified event at Haddam Neck where essentially the identical issues were discussed in the industry evaluation report. The issue of less than adequate use of OE within the RP section has been documented by CR 2002-10275.

Root Cause Determination

The following are the root causes and contributing causes addressing the issue presented in the Problem Statement. In accordance with FENOC procedures, TapRooT® was used in the evaluation of this data to determine the root causes of this event. Attachment 1, TapRooT® Cause Tree Basic Cause Categories is provided.

ROOT CAUSES

Performance of the TapRooT® Cause Tree Report (Attachment 1) determined several causes associated with this event. These included Management System, Work Direction, Procedures, and Communications. It has been determined that Management System and Work Direction are the Root Causes of this event. These correspond to Managerial Methods in the FENOC CAP coding and trending.

1. **Less than adequate Management System** as the perception existed in the organization that transuranic contamination was not a site radiological issue. As a result, the procedures and programs were not revised to give specific guidance for work controls or internal dose calculations for this type of contamination. This is demonstrated by three causes related to this event.

   - The RP organization did not have the required sensitivity to potential transuranic contaminations to ensure appropriate response to the condition.
   - In-house experiences and operating events were not effectively used to prevent problems. Self-assessments provided data that transuranic alpha emitting contamination was present in the plant but there was no consideration to these radionuclides in dose assessment. The issue of the less than adequate use of the OE program for continued RP program improvement has been documented in CR 2002-10275.
   - Responsibility and expectations for the determination of the communications, type, extent, and significance of intakes were not documented in standards or procedures. This responsibility relied solely on the judgment of technical staff personnel and did not include line supervision.

2. **Less than adequate Work Direction** as there was a lack of direction in the gathering and correlating of the data to perform the necessary assessment of the intake. The organization failed to recognize the potential significance of the intake as assessed from the initial WBC assessment.

   - Initial assessment showed significant intakes but management did not assign sufficient resources for investigating and performing the necessary follow-ups, including dose assessments.

CONTRIBUTING CAUSES

1. **Less than adequate Procedures** to provide guidance on the necessary actions to complete a timely evaluation of the dose to an internally contaminated individual. The process for performing the evaluation was left to knowledge by individuals and not a documented process.

   - There were no procedure guidance for determining external vs. internal contamination, method for the release of personnel believed to be internally contaminated, or what conditions would require follow-up analysis in the form of both *in vivo* and *in vitro* bioassays.
   - There was no procedure guidance providing the requirements for *in-vitro* bioassay collection, handling, and analysis of the samples. (CR ***2002-06299*** and ***2002-08289***)
   - There was no procedure guidance for dose assessment when transuranic alpha emitters and/or difficult to detect beta emitters were involved in the contamination.
   - Issues in the laboratory analysis were the result of a condition not previously identified. As a result of the DE&S investigation (DE&S Environmental Laboratory Condition Report 02-31 Investigation Report) the laboratory has altered their process to provide a 24 hour hold period for any bioassay sample analyzed by alpha spectroscopy prior to counting if a chemistry clean up process was required. The presence of Am in the sample with no associated radionuclides was documented in CR ***2002-07809.*** No further action is required for this issue as it involves an outside vendor and issues associated with communications below will address this issue.
   - There was no specific procedure requirement to perform air sampling representative of worker environment for jobs where an airborne radioactive area is likely and particularly where a TEDE/ALARA evaluation is required for determining respiratory requirements.
   - There is no formal process to periodically assess the source term of the plant to determine the impact of potentially changing conditions on internal dose assessments.

2. **Less than adequate communications** to ensure understanding of the specified request and final products. The need to locate and provide an approved PO to the selector vendor as rapidly as possible contributed to this communications issue. This is demonstrated by two causes related to this event.

   - Directions between the organization and DE&S laboratory did not clearly define the requirements necessary for the bioassay analysis. The term "environmental lower limits of detection (LLD)" was clearly used but had different meanings between the two organizations.
   - The required MDA's and the length of time since the initial uptake was not communicated to the laboratory until the bioassay analysis process was initiated.

3. **Less than adequate training** content and frequency of training in regards to dose assessment, contaminations, transuranic contribution to dose calculations, and performance of initial assessments for decontamination.

- The organization depended upon the knowledge of a technical staff individual and as a result, were not familiar with the procedure for initial dose calculations.
- The methodology for the decontamination of personnel and distinguishing internal and external contamination was not adequately discussed in training as there was not procedures to detail this type of information.
- The significance of the contribution of transuranics on dose calculations and the need for additional *in vitro* samples was not included in training.

In order to correlate the TapRooT® root causes and contributing factors, the following codes from the FENOC CAP will be used to track and trend this event.

- B05: No procedures existed that provided the responsibility for dose calculations and documenting the method to perform the calculation.
- H04: Policy guidance/management expectations were not well defined to ensure complete and concise communications of problems were elevated to the appropriate level of management.
- H04: Management follow-up and monitoring of the dose calculation data assembly and evaluation did not ensure the problems encountered would be resolved.
- I04: There was a lack of training and frequency of training in regards to dose assessment, contaminations, transuranic contribution to dose calculations, and performance of initial assessments for decontamination.
- B05: There were no procedures for dose calculations of the magnitude encountered with this event, the follow-up bioassays required, or the methodology for the collection, handling, and analysis of *in vitro* samples.
- A02: Communications with the laboratories did not ensure the analysis requirements were fully understood. In addition, pertinent information was not transmitted until the sample analysis was initiated. The development of a standing PO for the organization to utilize in the event bioassay samples are necessary will resolve the communication issue identified in this event.

Extent of Condition

This occurrence is significant in terms of the magnitude of the initial internal contaminations and the potential correlation of its transuranic component. There is no indication of directly similar events in the historical record at Davis-Besse. Corrective actions taken in response to this investigation will preclude such events in the future.

A review was performed for all positive WBC where CEDE was assigned for Cycles 11, 12, and 13. If the assumption is made that the transuranic contributor to CEDE would be the same as in 13 RFO, then assigned beta-gamma doses could be increased by a factor of 2.22 (45% beta-gamma, 55% transuranic). This is a conservative assumption due to differences in the magnitude and number of fuel defects in previous cycles. Additionally, shutdown chemistry was significantly more successful in system cleanup prior to use of the revised method performed for 13 RFO.

Using this multiplier, there are only three individuals whose CEDE would have exceeded 100 mRem. These doses would be 102, 140, and 164 mRem. All others, with the exception of those documented in the CR have CEDE which is less than 100 mRem even with a transuranic component assigned. All of these dose values are below the required monitoring level of 10CFR20.1502.

As part of the restart effort by FirstEnergy, a RP program review was initiated. The need for this evaluation was further substantiated when several RP programs were added to the 0350 list by the NRC. The program was evaluated in comparison to the industry standards, Institute of Nuclear Operation (INPO), and American Nuclear Insurers (ANI) practices. Program deficiencies were noted in the internal dose assessment program and decontamination of personnel procedures. Procedure improvements in these areas have been included in the Davis-Besse restart program and have been documented in the FENOC CAP.

Recommended Corrective Action

Corrective Actions

Root Cause 1: **Less than adequate Management System** as the perception existed in the organization that transuranic contamination was not a site radiological issue. As a result, the procedures and programs were not revised to give specific guidance for work controls or internal dose calculations for this type of contamination.

1. Revise the internal dosimetry procedure to address the potential contribution of transuranic and difficult to detect (strontium-90) radionuclides to internal doses. With the revision of this program clear responsibilities of RP personnel involved in the process will be documented. Specific action levels (intakes and potential doses) shall be included that require an increased level of investigation and management notification. A discussion of this event will be included in the training of personnel of the revised program. This discussion is to reinforce the significance of this event and the impact on TEDE for transuranics.

   Responsible Group: Chemistry and Radiation Protection
   Action Due Date: March 01, 2003

2. Revise the dosimetry procedures to provide clear guidance and expectations on the duties and responsibilities for evaluating data, including management reviews and approvals.

   Responsible Group: Chemistry and Radiation Protection
   Action Due Date: March 01, 2003

Root Cause 2: **Less than adequate Work Direction** as there was a lack of direction in the gathering and correlating of the data to perform the necessary assessment of the intake. The organization failed to recognize the potential significance of the intake as assessed from the initial WBC.

3. Revise the dosimetry procedures to provide clear guidance and expectations on the duties and responsibilities of the individual technical staff members and the line supervisors, including reviews and approvals. Specific action levels (intakes and potential doses) shall be included that require an increased level of investigation and management notification.

Responsible Group: Chemistry and Radiation Protection
Action Due Date: Corrective Action 1 for Root Cause 1 on Page 22 will address this identified Root Cause.

Contributing Cause 1: **Less than adequate Procedures** as the existing documents lacked the necessary guidance on the required response to adequately address the issues associated with an internally contaminated individual. The process for performing the evaluation was left to knowledge by individuals and not a documented process. No program was in place to address this type of situation including the need and collection of follow-up *in vitro* samples.

4. Revise the RP procedure, "Personnel Contamination Evaluation and Decontamination" to provide clear guidance for decontamination, evaluation and management involvement. Specific changes should include, guidance for follow-up WBC's and designate individuals responsible for the timely reviewing of data.

   Responsible Group: Chemistry and Radiation Protection
   Action Due Date: March 01, 2003

5. Revise the dosimetry program procedure to provide clear guidance for follow-up WBC requirements and frequency. This will include the methods required for WBC of internally and externally contaminated individuals and criteria where additional bioassays are required.

   Responsible Group: Chemistry and Radiation Protection
   Action Due Date: March 01, 2003

6. Develop written guidance on the expectations and standards for management notification, management involvement, and monitoring of contaminated personnel.

   Responsible Group: Chemistry and Radiation Protection
   Action Due Date: Corrective Action 4 for Contributing Cause 1 will also address this identified cause.

7. Develop a procedure describing the methods for obtaining, storing, shipping, and analyzing excreta bioassay sample. This procedure shall include details on maintaining a chain of custody and the methodology for determining the required analyses, critical levels, and decision levels.

   Responsible Group: Chemistry and Radiation Protection
   Action Due Date: March 01, 2003

8. Provide guidance in the RP dosimetry procedures on the actions required to perform a dose assessment that include consideration of the dose contribution from transuranic radionuclides and other difficult to detect beta emitter radionuclides (Sr-90).

Responsible Group: Chemistry and Radiation Protection
Action Due Date: March 01, 2003

9. Install and proceduralize the use of a high purity germanium (HPGe) detector WBC to provide upgraded identification and quantification of fission and activation product intakes. The appropriate procedures will contain the necessary correlation factors for transuranic and other "difficult to detect" radionuclides.

   Responsible Group: Chemistry and Radiation Protection
   Action: April 30, 2003

10. Revise the air sampling and evaluation procedure to provide guidance of when general area air sampling and lapel air sampling are required. This will ensure that appropriate data for the analysis of personnel intakes is performed and is available to support the evaluation of the effectiveness of job planning, the respiratory protection program, and assessment of personnel intakes and dose assessment.

    Responsible Group: Chemistry and Radiation Protection
    Action: March 01, 2003

11. Develop a procedure that will provide for periodic review of the alpha levels for plant contamination and verification that methods established for addressing the internal dose component remain conservative (refer to corrective action 8 of Contributing Cause 2). Plant area smears and a RCS sample shall be analyzed for transuranic radionuclides and other difficult-to-detect (Sr-90) approximately six (6) months prior to a scheduled outage. These results shall be considered in the RP outage job planning and evaluations.

    Responsible Group: Chemistry and Radiation Protection
    Action: August 15, 2003

Contributing Cause 2: **Less than adequate Communications** between the organization and the laboratory due to several reasons. These included the need to establish a PO within a limited timeframe and the use of terminology that was not consistent among the two organizations. FENOC does not maintain a standing PO for this type of service but the need is common throughout the fleet.

12. Initiate a standing PO for bioassay evaluations as a contingency for internal contaminations. The PO will include the MDA necessary to provide the expected product.

    Responsible Group: Chemistry and Radiation Protection
    Action Due: April 15, 2003

Contributing Cause 3: **Less than adequate Training** content and frequency of training in regards to dose assessment, contaminations, transuranic contribution to dose calculations, and performance of initial assessments for decontamination.

13. Submit to the RP curriculum review committee (CRC) the details of this event to ensure the reinforcement of the "lessons learned" into the knowledge base of the RP technicians and appropriate staff.

    Responsible Group: Chemistry and Radiation Protection
    Action Due: This action is incorporated into CR 2002-07811 as a corrective action. No further action necessary for this item.

14. Provide training to RP personnel on the revisions to the procedures detailing the actions required for the decontamination, bioassay (WBC) requirements, and proper management notification in the event of a contaminated individual.

    Responsible Group: Chemistry and Radiation Protection
    Action Due: March 12, 2003

15. Submit to the RP curriculum review committee (CRC) a request to evaluate the training population required for dose calculations and frequency of re-qualification. This may include just in time training in preparations for outages.

    Responsible Group: Chemistry and Radiation Protection
    Action Due: June 20, 2003

References

Documents reviewed:

Condition Report 2002-01688, Incomplete Gamma Spectrum Library Used in Body Counter

Condition Report 2002-01714, Weakness Found in DB-HP 01701

Davis-Besse 13RFO Outage Notes on Lotus Notes

Davis-Besse Nuclear Power Station NRC Special Inspection – Substantial Potential for an Overexposure of Occupational Workers, Report No. 50-346/02-16(DRS)

Davis-Besse Nuclear Power Station NRC Special Inspection – Uncontrolled Release of Radioactive Material to the Environment, Report No. 50-346/02-06(DRS)

EPRI TR-113039, "Guidelines for Industry Response to Personnel Contaminants"

EPRI 1003126, "Program Considerations for Addressing Alpha Emitting Radionuclides at Nuclear Power Plants"

FENOC Root Cause Analysis Reference Guide, Revision 3

INPO 91-014, "Guidelines for Radiological Protection at Nuclear Power Stations.

Personnel contacted:

Gil Nordlund, RP Supervisor

Brad Baumgardner, RP Supervisor (Duty RPM - Outage)

Joe McAdoo, RP Technician

June Scott, Senior Nuclear Technologist (Day shift RP Auxiliary Building Supervisor (Acting - Outage))

Kevin Edwards, RP Tester

Regis Greenwood, Staff Nuclear Advisor

Methodologies employed:

Document Reviews

Interviews

Barrier Analysis

TapRooT®

Investigative Team

Stewart Bland

Lawrence Bonker

Gregory Gillespie

Attachments

TapRooT® Cause Tree – Attachment 1

Barrier Analysis – Attachment 2

TapRooT® Root Cause Tree®

Incident: 02-07819 NRC White Finding of 10CFR20 1204 Violation

Causal Factor: 01 Human Performance

START HERE with each causal factor and select or eliminate each category to find root causes.

- HUMAN PERFORMANCE DIFFICULTY
- ~~EQUIPMENT DIFFICULTY~~ *
  - *Note: Consider Equifactor™ Analysis
- ~~NATURAL DISASTER / SABOTAGE~~
- ~~OTHER (SPECIFY)~~

- TOLERABLE FAILURE
- DESIGN
  - DESIGN SPECS
    - Specs NI
    - Design Not To Specs
    - Problem Not Anticipated
      - equipment environment not considered
  - DESIGN REVIEW
    - Independent Review NI
      - management of change (moc) NI
      - hazard analysis NI
- EQUIPMENT / PARTS DEFECTIVE
  - PROCUREMENT
  - MANUFACTURING
  - HANDLING
  - STORAGE
  - QUALITY CONTROL
- PREVENTIVE / PREDICTIVE MAINTENANCE
  - PM NI
    - No PM for Equip
    - PM for Equip NI
- REPEAT FAILURE
  - MANAGEMENT SYSTEM
    - Corrective Action
      - corrective action NI
      - corrective action not yet implemented
      - trending NI

Human Performance Troubleshooting Guide

Directions: Answer all questions and then refer to the indicated Basic Cause Categories to investigate the causes of the problem.

Individual Performance

- Was a person excessively fatigued, impaired, upset, bored, distracted, or overwhelmed? — Yes → ~~HUMAN ENGINEERING~~, ~~WORK DIRECTION~~
- Should the person have had and used a written procedure but did not? — Yes → WORK DIRECTION, PROCEDURES, HUMAN ENGINEERING
- Was a mistake made while using a procedure? — Yes → ~~PROCEDURES~~
- Were alarms or displays to recognize or to respond to a condition unavailable or misunderstood? — Yes → ~~HUMAN ENGINEERING~~
- Were displays, alarms, controls, tools, or equipment identified or operated improperly? — Yes → ~~TRAINING~~, ~~PROCEDURES~~, ~~HUMAN ENGINEERING~~
- Did the person need more skill / knowledge to perform the job or to respond to conditions or to understand system response? — Yes → ~~TRAINING~~, ~~WORK DIRECTION~~
- Was work performed in an adverse environment (such as hot, humid, dark, cramped, or hazardous)? — Yes → ~~HUMAN ENGINEERING~~
- Did work involve repetitive motion, uncomfortable positions, vibration, or heavy lifting? — Yes → ~~TRAINING~~, ~~HUMAN ENGINEERING~~, ~~WORK DIRECTION~~

Team Performance

- Did verbal communications or shift change play a role in this problem? — Yes → ~~COMMUNICATIONS~~
- Did failure to agree about the who/what/when/where of performing the job play a role in this problem? — Yes → TRAINING, COMMUNICATIONS, WORK DIRECTION
- Was communication needed across organizational boundaries or with other facilities required? — Yes → ~~COMMUNICATIONS~~

Management System

- Was a task performed in a hurry or a short-cut used? — Yes → ~~MANAGEMENT SYSTEM~~, ~~WORK DIRECTION~~
- Had management been warned of this problem or had it happened before? — Yes → MANAGEMENT SYSTEM
- Were policies, admin controls, or procedures, not used, missing, or in need of improvement? — Yes → MANAGEMENT SYSTEM, WORK DIRECTION, PROCEDURES
- Should an independent quality control check have caught the problem? — Yes → ~~QUALITY CONTROL~~

→ *Proceed to BASIC CAUSE CATEGORIES* →

NI = Needs Improvement May also substitute LTA (Less Than Adequate) or PIO (Potential Improvement Opportunity)

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* Indicates a comment

TapRooT® Root Cause Tree®

Incident: 02-07819 NRC White Finding of 10CFR20.1204 Violation

Causal Factor: 01 Human Performance

BASIC CAUSE CATEGORIES

PROCEDURES

- **Not Used / Not Followed**
  - ✓ no procedure
  - procedure not available or inconvenient for use
  - procedure difficult to use
  - procedure use not required but should be
- **Wrong**
  - typo
  - sequence wrong
  - facts wrong
  - * ✓ situation not covered
  - wrong revision used
  - second checker needed
- ~~**Followed Incorrectly**~~
  - format confusing
  - > 1 action / step
  - excess references
  - mult unit references
  - limits NI
  - details NI
  - data/computations wrong or incomplete
  - graphics NI
  - no checkoff
  - checkoff misused
  - misused second check
  - ambiguous instructions
  - equip identification NI

TRAINING

- **No Training**
  - task not analyzed
  - * ✓ decided not to train
  - no learning objective
  - missed required training
- **Understanding NI**
  - learning objective NI
  - lesson plan NI
  - instruction NI
  - * ✓ practice / repetition NI
  - testing NI
  - continuing training NI

~~QUALITY CONTROL~~

- **No Inspection**
  - inspection not required
  - no hold point
  - hold point not performed
- **QC NI**
  - inspection instructions NI
  - inspection techniques NI
  - foreign material exclusion during work NI

COMMUNICATIONS

- **No Comm. or Not Timely**
  - comm. system NI
  - * ✓ late communication
- ~~**Turnover NI**~~
  - no standard turnover process
  - turnover process not used
  - turnover process NI
- **Misunderstood Verbal Comm.**
  - standard terminology not used
  - * ✓ standard terminology NI
  - repeat back not used
  - long message
  - noisy environment

MANAGEMENT SYSTEM

- **Standards, Policies, or Admin Controls (SPAC) NI**
  - ✓ no SPAC
  - ✓ not strict enough
  - confusing or incomplete
  - technical error
  - drawings / prints NI
- ~~**SPAC Not Used**~~
  - comm. of SPAC NI
  - recently changed
  - enforcement NI
  - no way to implement
  - accountability NI
- ~~**Oversight / Employee Relations**~~
  - infrequent audits & evaluations (a & e)
  - a & e lack depth
  - a & e not independent
  - employee communications NI
  - employee feedback NI
- ~~**Corrective Action**~~
  - corrective action NI
  - corrective action not yet implemented
  - trending NI

HUMAN ENGINEERING

- ~~**Human - Machine Interface**~~
  - labels NI
  - arrangement / placement
  - displays NI
  - controls NI
  - monitoring alertness NI
  - plant / unit differences
  - excessive lifting
  - tools / instruments NI
- ~~**Work Environment**~~
  - housekeeping NI
  - hot / cold
  - wet / slick
  - lights NI
  - noisy
  - obstruction
  - cramped quarters
  - equipment guard NI
  - high radiation / contamination
- **Complex System**
  - * ✓ knowledge-based decision required
  - * ✓ monitoring too many items
- ~~**Non-Fault Tolerant System**~~
  - errors not detectable
  - errors not recoverable

WORK DIRECTION

- ~~**Preparation**~~
  - no preparation
  - work package/ permit NI
  - pre-job briefing NI
  - walk-thru NI
  - scheduling NI
  - lock out / tag out NI
  - fall protection NI
- ~~**Selection of Worker**~~
  - not qualified
  - fatigued
  - upset
  - substance abuse
  - team selection NI
- **Supervision During Work**
  - ✓ no supervision
  - * ✓ crew teamwork NI

NI = Needs Improvement May also substitute LTA (Less Than Adequate) or PIO (Potential Improvement Opportunity)

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* indicates a comment

TapRooT® Root Cause Tree® Comment Report

Incident: 02-07819
NRC White Finding of 10CFR20.1204 Violation

Causal Factor: 01
Human Performance

Root Cause: Human Performance Difficulty (1H)
Procedures (3P)
Not Used / Not Followed (4NU)
No procedure (5NP)

No comment has been entered for this Root Cause

Root Cause: Human Performance Difficulty (1H)
Procedures (3P)
Wrong (4WI)
Situation not covered (5IS)

DE&S Condition Report 02-31, Recommendation #2 (Davis-Besse CR 2002-06699)

This also true of distinguishing between internal dose and high external contamination

Root Cause: Human Performance Difficulty (1H)
Training (3T)
No Training (4NT)
Decided not to train (5DT)

The organization relied upon the expertise of a technical staff individual and it was decided not to provide detailed training for dose calculations.

Root Cause: Human Performance Difficulty (1H)
Training (3T)
Understanding NI (4UL)
Practice/repetition NI (5RL)

The organization depended upon the knowledge of a technical staff individual and training was not routinely performed on the methodology for dose calculation.

Root Cause: Human Performance Difficulty (1H)
Communications (3C)
No Communication or Not Timely (4NC)
Late communication (5LC)

There was a need to find a laboratory to perform the bioassay and establish a purchase order with the laboratory within 3 days. Exact information was not initially discussed.

Root Cause: Human Performance Difficulty (1H)
Communications (3C)
Misunderstood Verbal Communication (4MV)
Standard terminology NI (5SI)

Plant discussion with laboratory assumed same terminology in regards to "environmental levels". This was not the case.

TapRooT® Root Cause Tree® Comment Report

Root Cause: Human Performance Difficulty (1H)
Management System (3M)
Standards, Policies, or Admin. Controls NI (4SL)
No SPAC (5NO)

No comment has been entered for this Root Cause

Root Cause: Human Performance Difficulty (1H)
Management System (3M)
Standards, Policies, or Admin. Controls NI (4SL)
Not strict enough (5NS)

No comment has been entered for this Root Cause

Root Cause: Human Performance Difficulty (1H)
Human Engineering (3H)
Complex System (4CS)
Knowledge-based decision required (5KB)

Practice was to obtain input from staff personnel during these types of issues. It was based upon the knowledge of the individual

Root Cause: Human Performance Difficulty (1H)
Human Engineering (3H)
Complex System (4CS)
Monitoring too many items (5MI)

Need to perform other duties did distract from placing focus on issue

Root Cause: Human Performance Difficulty (1H)
Work Direction (3I)
Supervision During Work (4SD)
No supervision (5SN)

No comment has been entered for this Root Cause

Root Cause: Human Performance Difficulty (1H)
Work Direction (3I)
Supervision During Work (4SD)
Crew teamwork NI (5TW)

Many individuals had possession of information but no direction was provided to obtain it

Attachment 2: Barrier Analysis

Barriers that Should Have Precluded Event	Barrier Assessment (Why the Barrier Failed)
Managers, Radiation Protection	• Weaknesses in RP Procedures, specifically : DB-HP-00002, DB-HP-01111,DB-HP-01201,DB-HP-01320,DB-HP-01340,DB-HP-01454, DB-HP-01701, DB-HP-01800 • Multiple Assignments of WBC System, equipment, and review duties. • Multiple and frequently changing priorities placed on dose assessment team.
Outage Duty RP Managers	• Unfamiliar with Dose Assessment procedure • Unfamiliar with WBC equipment setup and operation capabilities other than routine operation. Did not know what additional information was available from the WBC software. • Did not understand potential for significant contribution to dose of "hard to detect " nuclides
RP Supervisors	• Unfamiliar with the dose assessment procedure and methodology. • Unfamiliar with WBC equipment setup and operation capabilities other than routine operation • Would not ask any technician to perform calculations • Less Than Adequate understanding of the need for sampling for "hard to detect" nuclides.

	• Did not identify differences between gamma analyses at the WBC and those done by gamma spec.
Health Physics Staff	• Weaknesses in RP Procedures, specifically : DB-HP-00002, DB-HP-01111,DB-HP-01201,DB-HP-01320,DB-HP-01340,DB-HP-01454, DB-HP-01701, DB-HP-01800 • Did not treat the incident with sufficient urgency. • Assumed that since there were no trans-uranic indicators, there were no trans-uranics, and therefore did not recommend excreta bioassay.
RP Technicians	Did not identify differences between gamma analyses at the WBC and those done by gamma spec.