ENCLOSURE 2

U.S. NUCLEAR REGULATORY COMMISSION

REGION I

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Licensee:	Connecticut Yankee Atomic Power Company Hartford, CT 06141-0270
Facility:	Haddam Neck Station
Location:	Haddam, Connecticut
Dates:	November 2, 1996 - November 27, 1996
Inspectors:	Ronald L. Nimitz, CHP, Senior Radiation Specialist William J. Raymond, Senior Resident Inspector
Approved by:	John R. White, Chief, Radiation Safety Branch Division of Reactor Safety

Purpose of Inspection: This inspection was a special reactive safety inspection to review an airborne radioactivity event that occurred in the fuel transfer canal and reactor cavity at the Haddam Neck Plant on November 2, 1996. The inspection included aspects of licensee operations, maintenance, and plant support, and the licensee's recovery from a significant radiological event.

Results: Twelve findings were identified that compose several apparent violations including failure to correct conditions adverse to quality per 10 CFR 50, Appendix B, Criterion XVI; failure to instruct workers per 10 CFR 19.12; failure to follow radiation protection procedures as required by Technical Specification 6.11; and failure to implement High Radiation Area controls as required by Technical Specification 6.12. Overall, these results revealed significant weakness in management oversight of on-going activities, poor plant staff sensitivity to the control of shutdown risk, and a breakdown in the applied radiological controls program at the Haddam Neck Power Station.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT'D)

Report Details

Purpose and Scope of Inspection

This inspection was an announced special reactive safety inspection to review the circumstances, licensee evaluations, and licensee corrective actions associated with a November 2, 1996, unplanned personnel exposure event in the fuel transfer canal and reactor cavity at the Haddam Neck Plant. The event was caused by workers unknowingly generating elevated concentrations of airborne radioactive material during their inspection of the fuel transfer canal and fuel transfer equipment, and their performance of housekeeping activities within the fuel transfer canal. As a result of the event, a substantial potential for an occupational exposure of personnel in excess of NRC limits occurred.

During the inspection, the inspector also reviewed and evaluated the licensee's response to the event and plant management's and staff's sensitivity to the control of shutdown risk.

Background (General)

On November 2, 1996, the plant was in Mode 6 (i.e., refueling) and in day 78 of a refueling and maintenance outage (the reactor had been subcritical for 102 days following a shutdown on July 22, 1996). The RCS was depressurized with the pressurizer vented to the vent header. RCS integrity and modified containment integrity were in effect and being tracked. As part of the core offload sequence, the RCS had been drained on October 28, 1996, to a level of 10 inches below the vessel flange with activities in progress to disconnect reactor attachments in preparation for lifting the head.

The plant was in a configuration of high shutdown risk, relative to other shutdown conditions, with reduced vessel inventory with a projected time of 78 minutes to heat up the reactor coolant to 200° F. Both RHR loops were operable with the B RHR pump operating and both heat exchangers in service. RCS temperature was about 100° F.

In preparation for flooding of the reactor cavity following head removal, the fuel transfer canal was to be inspected for debris. The fuel transfer cart, cart tracks, and upender were also to be inspected and identified debris removed to ensure cleanliness prior to flooding.

According to the licensee's Radiation Protection Manager (RPM), this was the first time in the past 15 years that personnel had been authorized to enter the transfer canal to perform the visual inspection in this manner with limited protective clothing and equipment (e.g., respirators). Previously, due to radiological controls concerns, divers were used to perform the inspection with the cavity full of water or personnel had used respiratory protective equipment to enter the canal with the floor of the cavity covered with several inches of waster to minimize exposure. However, because a diver had missed seeing and removing a wrench from the transfer mechanism during the previous outage, the licensee elected to decontaminate the transfer canal, to the extent necessary to allow personnel to enter the transfer canal and perform visual inspections.

The decontamination of the fuel transfer canal was performed in early August 1996, and personnel entered the transfer canal and walked on the fuel transfer cart rails at that time (without respiratory protection equipment) after the decontamination. The licensee's airborne radioactivity surveys during those entries, according to the licensee, did not indicate any significant airborne radioactivity. As a result, the licensee believed personnel could safely enter the fuel transfer canal with standard protective clothing and walk on the transfer cart rails without use the respiratory protective equipment.

On November 2, 1996, two individuals (Individual A and Individual B) entered the reactor cavity at about 8:30 a.m. to complete the inspection. Following their work activities, the workers exited the reactor cavity at about 9:00 a.m. and health physics (HP) personnel identified that: 1) the workers apparently generated elevated airborne radioactivity concentrations in the transfer canal, 2) the workers were contaminated about the face, and 3) the workers had collected and carried debris that measured about 20 R/hr to 60 R/hr on contact with the bag (about 600 mR/hr at 12 inches). The licensee's HP personnel notified HP supervision and a review of the conditions and the event's cause were initiated. Unknown to HP personnel at the time, the airborne radioactivity within the fuel transfer canal migrated to the reactor cavity causing high airborne radioactivity concentrations within the reactor cavity. Due to insufficient evaluation of the radiological conditions, other workers were permitted to enter the reactor cavity for work without any respiratory protective equipment or compensatory controls.

Event Summary (Specifics)

In preparation for flooding of the reactor cavity for fuel movement, two workers (Individual A and Individual B) initiated action to inspect the fuel transfer cart, rails, mechanism, and fuel transfer cavity. The two workers met with radiological controls personnel, including the acting Assistant Radiation Protection Supervisor (AARPS), at about 7:30 a.m. on November 2, 1996, to discuss the scope of the planned work. The work, inspection of the fuel transfer canal and mechanism, was not on the master outage schedule and this was the first time HP personnel were aware that the work was to be performed.

> Inspector Note: The workers were to perform checks outlined in Sections 9.1.10 and 9.2.10 of the refueling procedure. The procedure provided various instructions regarding the inspections. However, the procedure provided no details regarding the defined work scope for the debris inspection and removal. In particular, the description as to what constituted debris to be removed was not provided in the procedure or commonly understood between the workers and HP personnel.

The HP personnel believed that the work scope was that the workers were to enter the reactor cavity to inspect instrumentation tubes (spring clips on instrumentation bullet noses) on the reactor head and then move to the fuel transfer canal to inspect the fuel transfer canal, cart, rails and mechanism. The workers were permitted to pick up debris from the fuel transfer canal which originated from the charging floor. However, the workers apparently believed they were authorized to pick up any type of debris they encountered. The workers signed in at 7:56 a.m. (as directed by the AARPS) on radiation work permit (RWP) No. 411 (Revision 4), Job Task 13, Containment - Reactor-Inspect/Repair/Install/Remove Pit Seal and Sand Box Covers.

Inspector Note: This RWP (No. 411) was not valid for work within the fuel transfer canal in that the work location was specified as the refueling cavity. RWP No. 417 was specifically established for the transfer canal cleaning and inspection. This RWP provided additional controls (Step 5 of Job Task 5) to survey materials prior to removal from the cavity. In addition, RWP No. 417 Job Step 2, provided comprehensive directions to radiation protection personnel providing job coverage of workers entering the transfer canal. This coverage included the need for representative air samples, comprehensive briefings of workers and understanding of work, and updating of surveys if surveys were not current. This RWP was not used by the HP personnel providing job coverage for workers entering the canal so that workers would not need to exit the cavity and re-sign in on the canal RWP before entering the canal. Rather a general containment HP coverage RWP was used (RWP No. 408, Revision 3).

The two workers received a radiological controls briefing at the Containment Radiation Protection control point (by HP technician A) at about 8:00 a.m. The briefings provided by the technician were not comprehensive. Relative to fuel transfer canal work, the technician (HP technician A) believed that the workers were to spend the majority of their time walking along the fuel transfer canal tracks but could periodically leave the tracks to pick up debris (e.g., tie wraps) that had fallen from the charging floor. This understanding was not shared by the workers.

Inspector Note: The NRC inspector noted that no radiation surveys were performed within the fuel transfer canal to support this specific work. Rather, the technician relied on radiation surveys made subsequent to the decontamination of the transfer canal in August 1996. The inspector noted that radiation surveys of the fuel transfer canal floor and walls were not used to brief the workers, and the workers were not informed of high levels of removable surface contamination, including alpha emitters or informed of a 25 R/hr hot spot on the floor of the canal over which one worker later passed. As of November 22, 1996, the licensee was not able to provide any documentation of any surveys of removable alpha contamination within the transfer canal except near the bellows area.

The workers, wearing standard protective clothing (coveralls) including two pair of rubber boots, entered the reactor cavity via a construction type stairwell located in the south west area of the reactor cavity at about 8:30 a.m. The workers did not have a survey meter and an HP technician did not accompany them. The workers were provided integrating alarming dosimeters with alarms set at an integrated dose of 200 mR and a dose rate alarm of 400 mR/hr. The workers were not provided extremity monitors.

Inspector Note: The workers indicated that apparently at no time in the reactor cavity did the electronic monitors alarm (either dose rate, integrated dose, stay time). The electronic dosimeter of Individual A did alarm when exiting the reactor cavity due to integrated dose (i.e., greater than 200 mR). The inspector noted that a print out of the minute-by-minute readout of Individual A's time in the reactor

cavity and fuel transfer cavity (via the electronic dosimeter) indicated he was in a maximum radiation field of 2.074 R/hr and his dose rate had exceeded the 400 mR/hr alarm setpoint at least six times. If working properly, the monitor should have alarmed at least six times prior to the final integrated exposure alarm.

The workers spent about 15 minutes in the reactor cavity and performed inspections on the reactor head then moved to the fuel transfer canal area, climbed over the five-foot coffer dam and climbed down onto the fuel transfer mechanism and rails located in the southwest area of the fuel transfer canal. No air sample was collected in the reactor cavity while the workers were present. An air sample (positioned at the northeast corner of the canal) was however started at about the same time the workers entered the reactor cavity (air sample No. 110201).

Inspector Note: The NRC inspector was not able to identify an air sample for the reactor cavity collected prior to the workers' entry into the reactor cavity. Further, the air sample collected in the transfer canal was not representative of the workers' breathing zone in the canal in that sampler head was suspended from the northeast side of the canal in an area with substantially less contamination then the general areas within the canal traversed by the workers. In addition, the sample would not be representative of the airborne radioactivity to which the workers were subjected as they placed highly radioactive dry debris in the plastic bag.

During the inspection in the canal one worker (Individual A) stepped to the canal floor from the cart rails and performed an inspection of the southeast side of the rails and canal as he moved from the southwest to the northeast within the canal. The second worker (Individual B) remained on the tracks and also moved from southwest to northeast and held a bag for debris picked from the floor by Individual A. During his movement from southwest to northeast, the worker walking on the floor of the canal (Individual A) unknowingly passed over a spot measuring 25 R/hr on contact and about 8 R/hr at waist level. At the northeast end of the canal (southeast side) Individual A, reached under the bellows and picked up debris then subsequently climbed over the fuel transfer cart rails at the northeast section of the canal and inspected the west northwest section of the canal. While at this end of the canal, Individual A noted bevel gears without grease, collected residual grease with his gloved hand from the area, and proceeded to grease the dry bevel gears with the residual grease.

Inspector Note: The greasing of the bevel gears had not been discussed as part of the work scope discussion and was considered to be outside the scope of the work description. In addition, the grease on the individual's gloves would allow highly radioactive contamination to adhere to the gloves. The NRC inspector also noted that the material retrieved from under the bellows was not surveyed. Also, the NRC inspector noted that the grease may have been highly radioactive and also was not surveyed by the worker prior to handling.

Individual A then proceeded from northeast to southwest along the fuel transfer rails by walking on the canal floor. Individual B also proceeded along the rails from northeast to southwest while holding the bag for Individual A. The workers collected miscellaneous debris from the fuel transfer canal area. In addition, on the way out of the canal, the workers observed two large paint "bubbles" (large chips) on the inside (northeast facing) wall of the coffer dam. Individual A requested Individual B to retrieve the paint chips. The paint chips and debris handled were not surveyed for radiation dose rates. Also, Individual B pulled off a large flake of rusted metal from the coffer dam wall. The paint chips and rust were not surveyed before being placed in placed in the plastic bag.

> Inspector Note: Based on discussion with the workers and radiological controls personnel, the peeling of paint chips and metal rust was not considered part of the description of work scope.

The workers then climbed out of the transfer canal, climbed over the coffer dam, traversed the reactor cavity, and exited the reactor cavity at about 8:55 a.m. Individual B carried the bag of debris and subsequently handed it to Individual A at the top of the reactor cavity stairs. Upon exiting the cavity, Individual A's electronic dosimeter alarmed. An HP technician (HP technician A) directed the worker to drop the bag, subsequently surveyed the bag with an ion chamber (Eberline RO-2A), and noted 20 R/hr on contact with the bag and 600 mR/hr at about twelve inches from the bag.

> Inspector Note: The bag was later surveyed with a small volume geiger mueller type survey (Teletector) instrument and measured about 60 R/hr on contact and 4 R/hr at 30 centimeters. The workers (Individual A and Individual B) were not provided extremity monitors. The amount of debris collected, by hand, by the workers was later determined to be about 3 pounds.

The technician (HP technician A) moved the bag to an isolated area near the steam generators. The bag was later placed in the reactor sump area, a posted High Radiation Area, and covered with shielding.

The workers removed their protective clothing, proceeded to the Containment Access control point whole body friskers, and performed a whole body frisk. The workers were not surveyed for hot particle contamination prior to their removal of their protective clothing. Both workers were found to exhibit contamination including contamination about the face, near the nose and mouth. Individual A was surveyed using hand held instrumentation (thin window GM probe) and found to have 1000 corrected counts per minute (ccpm) near the mouth (i.e., 10,000 disintegrations per minute (dpm) assuming a 10% frisker efficiency), and 300 ccpm (i.e., 3,000 dpm assuming same efficiency) on the fingers of the right hand. Individual A provided a nasal smear (blew into a towel and which, when measured with a thin widow GM probe, indicated 20,000 ccpm (i.e., about 200,000 dpm contamination in the nose assuming a 10% frisker efficiency). Individual B indicated 2000 ccpm (i.e., 20,000 dpm) near the mouth and also blew into a towel which, when surveyed, also indicated 20,000 ccpm (i.e., 200,000 dpm).

Inspector Note: Individual B indicated that apparently the initial nasal smear was discarded and not surveyed. Further, a beta attenuator of mass density of between 100 and 150 milligrams per square centimeter (mg/cm^2) was not used to determine if the contamination of the face (by direct frisk) was external or internal to the nasal area per procedure RPM 2.7-3. Step 3.3.11.

The clothes for Individual A were considered contaminated and taken, including the individual's shoes. The clothes for Individual B were also contaminated and this individual lost his tee shirt and shorts. Also, although his shoes were contaminated they were subsequently decontaminated. Both individuals' dosimetry was contaminated.

Inspector Note: The NRC inspector's review indicated that both individuals apparently alarmed virtually all detector locations on the whole body friskers at the HP control point. The inspector questioned the cause of these alarms since only facial and hand contamination was detected. The inspector determined that the individuals had contaminated clothing including dosimetry and that contaminated clothing survey and decontamination survey forms were not completed for these individuals as required by procedure RPM 2.7-4. Because of the lack of documentation, the inspector was not able to clearly ascertain the extent of clothing contamination. However, discussions with HP personnel indicated clothing was not extensively contaminated.

Individual A and Individual B were apparently not able to clear the whole body friskers at the HP control point. However, both individuals were surveyed with a thin window GM tube, found to indicate less than 100 ccpm and released from the main HP control point and directed to obtain whole body counts.

Inspector Note: The PCM 1Bs were previously checked by the licensee and found to respond to both internal and external contamination. The licensee's tests indicated that the PCM 1Bs could apparently detect 300 nanocuries of Co-60 activity within the lung and/or GI tract. The inspector noted that the individuals were apparently not able to clear these monitors for 3-4 days following the event. The inspector noted these results, in conjunction with negative frisker surveys of the individuals, indicated likely intakes of radioactive material.

Both individuals apparently showered once at the decontamination area and again at a shower facility in the clean locker room. The inspector noted that the survey results did not indicate any detectable residual contamination on the skin of the individuals. Consequently, a basis for supposing an intake of radioactive material existed.

The workers (Individual A and Individual B) signed out of the RWP at 9:04 a.m. and 9:50 a.m., respectively. Based on electronic dosimeter readout, Individual A sustained an accumulated external whole body radiation dose of 239 mR and Individual B indicated an accumulated dose of 155 mR for his entry.

The decontamination activities and workers traversing the hallway at the HP control point resulted in low level floor contamination. The area was subsequently decontaminated.

On their way outside the protected area to go to the Emergency Operations Facility (EOF) for a whole body count, both workers alarmed the portal walk-through whole body radioactive material monitor at the security station.

Inspector Note: The monitor apparently had a minimum detectable activity of 220 nanocuries for Cs-137 and was indicated to have a higher detection efficiency for Co-60. The alarm of this monitor also supported an intake of radioactive material.

There were no apparent station procedures that provided guidance to HP personnel regarding release of personnel from the protected area following an alarm of the monitor (attributable to an inplant event). The individuals were permitted to egress the protected area based on use of a medical isotope clearance procedure (e.g., for use by individuals who had received a diagnostic dose of radioactive material). The Radiation Protection Supervisor authorized the individuals to be placed on an egress authorization list maintained by security for individuals with internal medical isotopes. The individuals apparently continued to alarm the egress monitor, at the security building, for several days following the event, apparently due to internal deposition of radioactive material.

After the workers (Individual A and Individual B) exited the reactor cavity, an HP technician (HP technician A) checked the fuel transfer canal air sample using a hand-held frisker (apparently located in the reactor containment foyer) (about 9:05 a.m.) and found that the sample exhibited an elevated count rate, indicating potential airborne radioactivity.

Inspector Note: This air sample (No. 110201) indicated 0.82 DAC[1] beta and 24.18 DAC alpha.

Inspector Note: Subsequent licensee HP evaluation determined that the workers had been inadvertently exposed to airborne contamination, which resulted in an intake of radioactive material, as shown on whole body counts for each worker. No Airborne Radioactive Material signs were posted at the entrance to the canal or reactor cavity. A sign was apparently posted some time later.

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[1]The derived air concentration (DAC) means the concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhalation rate 1.2 cubic meters of air per hour), results in an intake of one ALI. An annual limit of intake (ALI) means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake by reference man that would result in a committed effective dose equivalent of 5 rems or a committed dose equivalent of 50 rems to any individual organ or tissue.

The acting Assistant Radiation Protection Supervisor (AARPS) was notified. Subsequently, the sample was transferred to the field counting area for counting and later to the counting room. The acting ARPS directed that backup air sampling be initiated to determine the source of the elevated airborne radioactivity.

A backup air sample was started in the reactor cavity at about 9:10 a.m. (sample No. 110203) and stopped at 9:25 a.m. The sample was checked in the field with a handheld frisker (apparently located on the reactor containment charging floor) by HP technician A. The technician did not identify any contamination and notified other HP personnel in the area that air within the reactor cavity was clean.

> Inspector Note: Unknown to the technician, the frisker used to perform the field check was malfunctioning and the air sample was later determined to indicate significant elevated airborne radioactivity concentrations of 3.47 DAC beta and 107.82 DAC alpha. In addition, the inspector later determined there was no quantitative means established to check the operability of the friskers in containment.

At about this time a second HP technician (HP technician B) was directed to enter the containment and relieve HP technician A.

HP personnel (HP technician A and HP technician B) authorized two other workers (Individual C and Individual D) to enter the reactor cavity and perform cleaning of two reactor stud holes using an HEPA filtered cleaning tool before determining that high airborne radioactivity existed in the area.

> Inspector Note: This was the first time this outage that HP technician B entered the reactor containment to support work activities. The individual indicated he was generally familiar with the radiological conditions in the reactor cavity based on previous outages. However, the individual could not provide specific radiological survey information for the work locations.

The workers entered the reactor cavity at about 9:30 a.m. and an air sample was started for that work activity at that time (air sample No. 110207) and subsequently stopped at 10:00 a.m. The air sample head was hung by a rope over one of the stud holes (southwest area of reactor).

> Inspector Note: The air sample collected while the workers (Individual C and Individual D) were in the reactor cavity indicated 1.52 DAC beta and 53.34 DAC alpha. Consequently, the inspector concluded the workers (Individual C and Individual D) were unknowingly directed by HP personnel to work, without respiratory protective equipment, in airborne radioactivity concentrations between about 54 DAC and 111 DAC (total beta and alpha) (based on the previous air sample collected in the reactor cavity prior to Individual C's and Individuals D's entry).

A backup air sample was also started in the transfer canal at 9:40 a.m. (air sample No. 110208) and subsequently stopped at 10:01 a.m. This sample was later counted and indicated a beta/gamma airborne radioactivity concentration of .99 DAC beta and 31.1 DAC alpha.

At 9:45 a.m., the workers (Individual C and Individual D) exited the cavity and two HP technicians (HP technician B and HP technician C) reentered the cavity and transfer canal to perform surveys.

> Inspector Note: The HP technicians unknowingly entered the reactor cavity and worked in elevated airborne radioactivity concentrations between about 31 DAC and 54 DAC (total beta and alpha). The technicians did not wear respirators. Further, despite knowledge that two individuals were involved in a contamination event within the fuel transfer canal and elevated airborne radioactivity had been detected, HP technician B entered the canal to perform surveys without use of respiratory protection. In addition, an air sample was not collected for his entry into the canal. The HP technician identified high levels of beta/gamma and alpha contamination within the fuel transfer canal. The HP technician (HP technician B) performed surveys on the floor of the canal.
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> The HP technician's (HP technician B) RWP (No. 408, Job Step 1) did not authorize entry into the fuel transfer canal and was only valid for containment building general areas.

The survey made in the transfer canal by HP technician B (dated November 2, 1996, 11:00 a.m) indicated high levels of removable contamination (up to 80 millirad/hr) and high levels of removable alpha contamination (up to 30,000 dpm/100 cm^2 alpha).

> Inspector Note: The inspector identified a radiation survey of the transfer canal, performed on August 7, 1996, which identified large area smears of the transfer canal measuring up to 120 mrad/hr removable contamination. However, the licensee was not able to provide any alpha contamination surveys of the entire transfer canal prior to the November 2, 1996, survey. The licensee could only provide alpha surveys of the northeast end of the cavity near the bellows.
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> HP technician B and HP technician C were performed personnel contamination surveys of their person with hand-held alpha probes for alpha contamination upon their exit from the reactor cavity and none was detected.

As a result of the airborne radioactivity concentrations within the reactor cavity, HP technician C informed station maintenance personnel at about 10:05 a.m. that further entry to the cavity was prohibited. The acting Assistant Radiation Protection Supervisor (AARPS) later notified station maintenance personnel at about 10:45 a.m. that entry to the cavity with respiratory protective equipment would be permitted.

Although shift HP personnel provided approval for a continuation of work activities using respirators, no further work was performed on the defueling sequence on November 2, 1996. Apparently, work continued to be delayed due to HP personnel estimates that decontamination activities would only take a couple of hours and would allow performance of the work without respirators. However, the decontamination activities became protracted due to insufficient HP resources to support the decontamination and also the support of other outage work.

Air samples were collected in the reactor cavity at 1:12 p.m. (sample No. 110210) and 1:38 p.m. (sample No.110211). Neither sample was counted for alpha radioactivity but gross beta counting indicated no elevated airborne radioactivity.

> Inspector Note: A radiation survey, performed by HP technician B, at 3:00 p.m. on November 2, 1996, indicated up to 250,000 dpm/100 cm^2 beta/gamma contamination and 3,000 dpm/100cm^2 alpha in the reactor cavity.

At about 4:00 p.m., HP personnel (HP technicians B, C, D, and E) entered the reactor cavity to perform wet mopping of the cavity following identification of elevated alpha contamination levels. As a result of the mopping activities airborne radioactivity was generated and measured (sample No. 110212) at 2.99 DAC beta and 26.85 DAC alpha within the reactor cavity. The technicians did not use respiratory protective equipment.

> Inspector Note: The increase in airborne radioactivity indicated an apparent propensity for the contamination to become readily airborne.

Although the containment was considered clean for work inside the cavity by about 5:00 p.m., HP personnel again deferred further work activity at 6:30 p.m. when HP surveys showed additional contamination in the cavity (later found to be due to dry out following the wet mopping). Also, contamination (maximum 5,000 dpm/100cm^2 beta/gamma) was identified on the charging floor based on an November 2, 1996, 8:30 p.m. survey.

> Inspector Note: The inspector's review of airborne radioactivity surveys and discussions with personnel indicated that the actual charging floor of the reactor containment did not exhibit airborne radioactivity.

Decontamination activities were completed, and activities in support of the core offload sequence were resumed at 1:00 a.m. on November 3, 1996. However, the Unit Director was not informed of the event or the subsequent delay until 10:00 a.m. on November 3, 1996.

The NRC resident inspector became aware of the contamination event at about 7:00 p.m. on November 2, 1996, while on site for backshift inspection of outage activities. The inspector reviewed the nature of the contamination event with HP personnel and the status

of actions taken to assess the worker exposure and to clean up contaminated areas. The inspector determined at about 8:30 p.m. on November 2, 1996, that the duty shift manager was not aware of the significance of the contamination event and the worker exposures, or that work on the core offload sequence had been stopped during the day shift and had not resumed.

The inspector discussed his concerns regarding the knowledge of and response to delays in the core offload sequence by licensee operations and management personnel. The concerns were discussed with the licensee duty officer (a management representative) on November 2, 1996, and with the Unit Director on November 3. 1996.

The licensee subsequently described the immediate corrective actions taken on November 3, 1996, in response to the contamination event. The licensee also described the action taken to ensure that plant personnel were cognizant of and responded to delays in the offload sequence. The licensee's corrective actions were also discussed in conference calls between NRC Management and the Executive Vice-President and the Unit Director on November 4, 1996.

I. Operations

O1 Operations

O1.1 Inspection Scope (71707, 83729)

The inspector selectively reviewed the organizational communications preceding, during, and subsequent to the November 2, 1996, contamination event; the control of outage activities; and plant staff sensitivity to shutdown risk and management expectations. The following findings, observations, and conclusions were developed based on the inspector's review of activities in progress on November 2 and 3, a review of plant schedules and procedures governing the defueling sequence, and on interviews with plant personnel. The inspector also reviewed applicable information contained in Updated Final Safety Analysis Report (UFSAR) Chapter 5, Reactor Coolant System; Chapter 9.1, Fuel Storage and Handling System; and Chapter 13. 5, Plant Procedures.

O1.2 Plant Conditions and Shutdown Risk

As discussed in Section II of this report, on November 2, 1996, the plant was in Mode 6 (i.e., refueling) and in day 78 of a refueling and maintenance outage. The RCS was depressurized with the pressurizer vented to the vent header. As part of the core offload sequence, the RCS had been drained to a level of 10 inches below the vessel flange with activities in progress to disconnect reactor attachments in preparation for lifting the head.

The inspector noted, that the reactor was in a configuration of high shutdown risk, relative to other shutdown conditions. Specifically, the reactor had reduced vessel inventory with a projected time of 78 minutes to heat up the reactor coolant to 200° F. Both RHR loops were operable with the B RHR pump operating and both heat exchangers in service. RCS temperature was about 100° F.

O1.3 Observations and Findings - Communications

The inspector's review indicated that vertical communications within the HP department were initially not adequate to convey the significance of the November 2, 1996, contamination event; to ensure that adequate resources were applied to evaluate the event and its consequences; or to complete the decontamination effort in a timely manner. A delayed integrated response began in the late evening hours on November 2, 1996, when the HP Manager responded to the site.

The inspector also determined that the communications between operations and HP activities during the day shift, during shift turnover, and during the swing shift on November 2, 1996, were inadequate to convey the significance of radiological conditions; the status of containment cleanup activities; and the impact of the contaminated cavity and charging floor on the defueling sequence.

The inspector further determined that communications between the operations, maintenance workers, and work center personnel were inadequate to track the progress of outage activities.

O1.4 Control of Outage Activities - Observations and Findings

The communication of plant status information within operations, and the responses to degraded conditions were inadequate. A day shift NSO, conducting checks inside the containment, was notified that a contamination problem occurred in the area of the cavity and charging floor. Operations offered assistance by starting a CAR fan, which was declined by the HP supervisor. The information was convened to the control room at about 9:30 a.m. that day (November 2, 1996), and was known by the reactor operator, the unit supervisor, and the Shift Manager.

The inspector determined that, based on information from the HP personnel, the containment problem was assessed by operations as a minor contamination event. However, once notified of the containment radiological conditions, the day and swing operation shifts were not aggressive in following the status of the containment conditions. The did not appreciate the impact of the problem on the defueling sequence or to assure adequate resources were being applied to recover plant conditions as rapidly as possible to minimize the time in a condition of high shutdown risk. Control room personnel appeared isolated from the plant activities.

The inspector noted that the response to the work in containment by work center personnel (the war room) was inadequate to appreciate that significant delays were being encountered, or to determine whether adequate resources were being applied to recover plant conditions as rapidly as possible to minimize the time in a condition of relatively high shutdown risk. The work control center was responsible for monitoring outage work activities and to assure that adequate plant resources were applied to critical work in the defueling sequence. The following was noted:

- War room personnel were notified of the contamination and cleanup activities at 10:45 a.m. and 3:30 p.m. on November 2, 1996. The initial reports from HP of an expected 2 hour delay was deemed acceptable because war room personnel knew that the plant activities were about 3 hours ahead of schedule.

- The day shift war room personnel did not aggressively pursue the status of corrective actions or the problems with work in containment which were believed to be causing a minor delay. The war room was not staffed for the night shift on November 2, 1996, due to an excused absence, and no coverage was provided.

The inspector concluded that the scheduling of outage activities in the Reactor Core Offload Schedule was inadequate to aid the proper planning and control of the fuel transfer canal and cart inspection. The following was noted:

- RP Section 9.1.10 required an inspection of the transfer canal and cart as part of the pre-floodup checks of the refueling equipment. Section 9.1.10 was changed (TPC 96-968) to require the canal to be inspected for debris, and for foreign material to be removed.

- Outage activity 496080070, "Fuel Handling System Maintenance and Dry Checks", was scheduled as part of the Reactor Core Offload Schedule, and tracked several line items that were required to be completed per step 9.1.10 of the CYW Refueling Procedure.

- The Reactor Core Offload Schedule did not contain a line item for the fuel transfer canal and cart inspection on the daily schedule for October 31 and November 1. The activity was not scheduled until a vendor representative received a oral request in the control room on November 1 to complete the inspection in preparation for canal floodup.

- The transfer canal and cart inspection was completed on November 2 at the initiative of the vendor representative, who requested (on November 2) the assistance of the maintenance supervisor. Although the work was coordinated with health physics on the morning of November 2, neither health physics, the work control center, nor maintenance personnel knew of the activity prior to Saturday morning. Thus, plant personnel (work center and principally health physics) did not have time to preplan or prepare for the canal inspection.

- The Reactor Core Offload Schedule was revised at 12:00 noon on November 2 to show a line item for the fuel transfer canal and cart inspection, which was entered as a completed activity.

In addition, the inspector determined that the scheduling of outage activities in the Reactor Core Offload Schedule was not fully effective to ensure the proper planning and focus on the completion of critical path activities to minimize the time in a condition of relatively high shutdown risk. The following was noted:

- The use of annotations to show the critical path activities in the Reactor Core Offload Schedule was terminated on October 9 when the pending permanent shutdown of Haddam Neck was announced, and a defined outage end date was eliminated. Although it was generally understood that all activities listed in the daily core offload were required to be completed for the offload sequence, the lack of a defined critical path sequence made the schedule a less effective tool to keep workers, the work control center and the operations focused on which activities were important for moving the plant out of a condition of relatively high shutdown risk. The licensee re-instituted critical path annotation on the Reactor Core Offload Schedule starting on November 8, 1996.

Based on the above observations and findings, the inspector identified that the reactor remained for an extended duration (about 15 hours) in a high risk state, relative to other shutdown conditions. The inadequate recognition and response to the November 2 contamination event resulted in unnecessary delays and in extending the operation of the plant in this state. The inspector noted that the reactor remained in a stable condition during the period of interest and was adequately cooled, with redundant means of decay heat removal available.

The inspector noted that 10 CFR 50, Appendix B, Criterion XVI (Corrective Action), requires, in part, that measures shall be established to assure that significant conditions adverse to quality are promptly identified and corrected.

The inspector noted that from 10:00 a.m. November 2 until 1:00 a.m. on November 3, a contamination event inside the refueling cavity transfer canal interrupted the reactor disassembly sequence at a time when the reactor was in a condition of relatively high shutdown risk with water level drained to the refueling reference level (10 inches below the vessel flange). Licensee control of outage activities was inadequate to recognize significant delays in the offload sequence and to take prompt actions to resume critical outage activities. This resulted in lack of prompt identification and corrective actions. The inadequate licensee control of outage activities was considered a significant condition adverse to quality. This is an apparent violation of 10 CFR 50, Appendix B, Criterion XVI.

O1.5 Plant Staff Sensitivity to Shutdown Risk and Management Expectations - Observations and Findings

The inspector review of the licensee's preliminary root cause investigation indicated the following:

- Although it was general knowledge that the plant was in a condition of high shutdown risk, relative to other shutdown conditions, the workers involved in the activities on November 2, 1996, did not clearly see their efforts as contributing to the sequence needed to move the plant to a lesser risk condition.

- The policy of having workers notify supervision and outage management of delays greater than 10 and thirty minutes was not effectively emphasized with the plant staff prior to lowering reactor level to the refueling reference level.

O1.6 Conclusion - Operations

This event was safety significant and revealed that plant management and staff failed to effectively plan and control work activities (inspection of the fuel transfer system and canal) on November 2, 1996. Further, for approximately 15 hours, control room operators were insensitive and inattentive to the significant delay in regaining control of work in the reactor cavity preventing reactor cavity floodup. Control room personnel did not exhibit questioning attitudes or seek to understand the significant delays despite the reactor being in an elevated risk state. Significant weaknesses in organizational communications were noted (both horizontal and vertical communications). Applied radiological controls for the work activity were poor as was the HP response to the discovery of elevated airborne radioactivity.

O8 Miscellaneous Operations Issues - Plant Management Response - Observations and Findings

08.1 Inspection Scope (71707)

The inspector reviewed plant management's response to the event. The inspector interviewed plant management and discussed actions following their identification of the event.

08.2 Observations and Findings

The inspector noted that the notification from the duty officer to the Unit Director was delayed because the duty officer believed the onsite activities were adequate to address the events. However, following notification of the event at 10:00 a.m. on November 3, 1996, the Unit Director began a series of actions that were an appropriate response to the events on November 2, 1996. The subsequent management actions included the following:

- Continuing the investigation of the radiological event with assistance from expertise outside the station.

- Assigning the outage and maintenance managers to review on November 3, the contamination events to establish the facts and a timeline regarding the communication of the contamination event, the cleanup and the tracking of outage activities.

- Initiating two apparent cause investigations, to be completed within 24 hours, to focus short term corrective actions. The preliminary reviews would be supplemented by a root cause evaluation to determine the appropriate long term actions.

- Management expectations regarding the coverage of outage activities were communicated to the plant staff regarding operations cognizance of plant condition (memo UD-96-064); notifications of work stoppages up the supervisory and management chain (NUD-96-061); and the quality of pre-job briefs regarding radiological conditions (NUD 96-063). These actions were also summarized in memo UD-96-062. The directors personally briefed the plant work shifts on expectations regarding the above matters.

- The refueling sequence was monitored by senior plant managers (directors and operations managers) until the cavity fill was completed; to provide 24 hour a day coverage. Further, senior plant manager coverage was provided for other significant activities in the defueling sequence (head lift, internals lift, start of offload).

- An independent review team was initiated and started a review on November 12, 1996, to evaluate the event and the factors that contributed to the responses by the plant staff.

The licensee completed the reactor disassembly to place the plant in a condition of lower shutdown risk by filling the reactor cavity on November 4, and by completing core offload on November 15.

In addition, the licensee committed to suspend high radiological risk work (except with specific management approval) pending evaluation of root causes and implementation of corrective actions.

IV. Plant Support

R1 Radiological Protection and Chemistry (RP&C) Controls

R1.1 Inspection Scope (83729)

The inspector reviewed the applied radiological controls provided for reactor cavity and fuel transfer canal work on November 2, 1996.

The following findings, observations, and conclusions were developed based on the inspector's reviews of activities in progress on November 2 and 3; the reviews of plant schedules and procedures governing the defueling sequence; the reviews of radiation protection procedures; the reviews of applicable radiation protection documentation; and the interviews of plant personnel. The inspector also reviewed information contained in UFSAR Chapter 12, Radiation Protection, and Chapter 13, Conduct of Operations.

R1.2 Radiological Controls for Entry Into the Reactor Cavity and Fuel Transfer Canal and Fuel Transfer Equipment - Observations and Findings.

The licensee did not provide adequate applied radiological controls and oversight for the reactor cavity and fuel transfer canal work. The inspector noted that 10 CFR 20.1501 requires that the licensee make radiological surveys as may be necessary to comply with the occupational exposure limits in 10 CFR 20.1201 10 CFR 20.1003 defines a survey as 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. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation or concentrations or quantities of radioactive material present.

The inspector noted that radiological surveys made in the reactor cavity and fuel transfer cavity, as necessary to comply with the occupational exposure limits outlined in 10 CFR 20.1201, were not adequate as follows:

- On November 2, 1996, two workers in the fuel transfer canal unknowingly collected, handled, and transported a small bag of radioactive material (debris) with contact radiation levels ranging from 20 to 60 R/hr. The debris was not surveyed as it was collected, handled or transported. Such surveys were necessary and reasonable to ensure conformance with the occupational dose limits of 10 CFR 20.1201.

- On November 2, 1996, airborne radioactivity surveys were not adequate to detect high concentrations of airborne radioactivity within the fuel transfer canal as workers collected highly radioactive debris therein. Such surveys were necessary and reasonable in that areas traversed and worked in by the workers exhibited loose surface contamination levels measuring up to 80 mRad/hr beta contamination and up to 30,000 dpm/100 cm^2 alpha contamination.

- On November 2, 1996, airborne radioactivity surveys were not adequate to detect high concentrations of airborne radioactivity within the reactor cavity to support reactor stud hole cleaning. As a result, two workers were permitted to enter the reactor cavity despite airborne radioactivity therein of between 50 DAC and 100 DAC (total beta and alpha).

- As of November 7, 1996, the licensee had not determined that a potential significant exposure of personnel to alpha emitters had occurred to two workers who had worked within the highly contaminated fuel transfer canal on November 2, 1996.

R1.3 Conclusion

The inspector concluded that adequate radiological controls were not provided for personnel entering the reactor cavity and fuel transfer canal as described above. In addition, the above findings represent four examples of failure to perform radiological surveys, as required by 10 CFR 20.1501, to ensure compliance with the occupational exposure limits of 10 CFR 20.1201. This is an apparent violation.

R3 RP&C Procedures and Documentation

R3.1 Inspection Scope (83729)

The inspector reviewed the licensee's implementation of radiological controls program procedures for reactor cavity and fuel transfer canal work on November 2, 1996.

The following findings, observations, and conclusions were developed based on the inspector's reviews of activities in progress on November 2 and 3, 1996; the reviews of plant schedules and procedures governing the defueling sequence; the reviews of radiation protection procedures; the reviews of applicable radiation protection documentation; and the interviews of plant personnel.

R3.2 Procedure Adherence (Observations and Findings)

The inspector noted that Technical Specification 6.11 requires that procedures for personnel radiation protection be prepared consistent with the requirements of 10 CFR 20 and be approved, maintained, and adhered to for all operations involving personnel radiation exposure. The inspector's review of the circumstances associated with the November 2, 1996, airborne radioactivity event indicated that the licensee did not adhere to the following radiation protection procedures.

- Radiation Protection Procedure RPM 2.1-2, requires in Step 3.1 that health physics supervision determine whether a new RWP/Jobstep must be initiated or if an existing RWP/Jobstep is adequate to provide the proper radiological protection, exposure tracking, and ALARA controls.

  The inspector noted that on November 2, 1996, health physics supervision authorized workers to enter the fuel transfer canal to perform inspections of the fuel transfer mechanism and perform housekeeping. The RWP and Jobstep used for this task were not adequate to provide proper radiological protection, exposure tracking and ALARA controls. The RWP failed to provide adequate external and internal exposure controls as well as ALARA controls. Further, the RWP and Job Step (RWP No. 411, Job Step 13) were not valid for entries into the fuel transfer canal.

- Radiation Protection Procedure RPM 2.5-4, requires in Step 3.2 that radiological controls personnel providing coverage of High Radiation Area work shall, during the course of the job, check conditions at the job site to ensure instructions are being properly followed.

  The inspector noted that radiological controls personnel did not provide health physics job coverage in accordance with procedure RPM 2.5-4, Step 3.2. Specifically, checks of workers were inadequate to ensure conformance with the understood work scope. Consequently, workers were unknowingly exposed to high concentrations of airborne radioactivity and handled debris measuring between 20 R/hr and 60 R/hr on contact.

- Radiation Protection Procedure RPM 2.1-1, requires in Step 3.1.6 that the job supervisor provide a description of the work to be performed.

  The inspector noted that on November 2, 1996, the job supervisor, responsible for inspection and housekeeping within the fuel transfer canal, did not provide health physics an adequate description of the work to be performed. Specifically, the job supervisor responsible for the inspection and

cleaning of debris from the fuel transfer canal did not inform the Health Physics Department that 1) excess grease found in the transfer canal would be used to grease dry bevel gears, 2) paint chips and associated metal rust would be peeled off the coffer dam walls, and 3) dry, dirt-like loose debris would be grabbed with the hand from the canal floor and deposited into a plastic bag.

- The inspector noted that Radiation Protection Procedure RPM 2.7-4, requires in Step 2.1 that clothing contamination reports be completed.

  The inspector noted that clothing contamination reports, as required per procedure RPM 2.7-4, Step 2.1, were not completed for contaminated workers who exited the fuel transfer canal on November 2, 1996.

The licensee did not adhere to radiation protection procedures as described above, and the above four examples, were an apparent violation of Technical Specification 6.11.

In addition, the inspector noted that the licensee did not establish and implement radiation work permits (RWPs) in accordance with Technical Specification 6.12.2. Technical Specification 6.12.2 requires, in part, that in addition to the requirements of Specification 6.12.1, areas accessible to personnel with radiation levels greater than 1000 mR/hr at 45 cm from the radiation source shall be provided with lock doors to prevent unauthorized entry and doors shall remain locked except during periods of access by personnel under an approved RWP and that the RWP shall specify the dose rate levels in the immediate work areas and the maximum allowable stay time for individuals in that area.

The inspector noted that on the morning of November 2, 1996, personnel entered a locked High Radiation Area (reactor cavity and fuel transfer canal) with accessible dose rates greater than 1000 mR/hr at 45 cm and the RWPs used for the entry did not specify the dose rate levels in the immediate work areas and the maximum allowable stay time for individuals in that area. This is an apparent violation of Technical Specification 6.12.2.

Based on the above, the inspector noted that the licensee's radiation work permit program, as applied to this event, did not meet the objectives outlined in Chapter 12.5.3 of the Updated Final Safety Analysis Report. These objectives were, in part, as follows:

- To provide a detailed assessment of the actual and potential radiation hazards associated with the job function and area.

- To ensure that proper protective measures are taken to safely perform the required tasks in the area and to maintain the total effective dose equivalent ALARA.

- To provide a mechanism for individuals to acknowledge their understanding of the radiological conditions, the protective and safety equipment and measures required, and willingness to follow the requirements designated on the RWP.

In addition to the above, the inspector noted that procedure RPM 2.4-3, Respirator Selection, requires that the Assistant Radiation Protection Supervisor or designee consider use of respiratory protection where contamination levels are greater than or equal to 100,000 dpm/100cm^2 and complete steps 3.2.3 through 3.2.7 of the procedure. Step 3.2.4 requires that the ALARA Coordinator evaluate the use of process or engineering controls to reduce expected airborne radioactivity. Further, procedure RPM 1.5-10, TEDE ALARA Evaluations, provides for an ALARA Review if the use of respiratory protection equipment is anticipated. The inspector noted that, although contamination levels in the fuel transfer canal were well in excess of 100,000 dpm/100cm^2, apparently, based on the understood work scope and previous entries into the canal, no respiratory protection equipment was provided. The inspector noted that considering the contamination levels present and the work space available in the fuel transfer canal, the lack of use of respiratory protection equipment appeared to be a non-conservative decision.

R3.3 Conclusion

Multiple examples of personnel not implementing radiation protection procedures were identified. Further, RWPs were not established in accordance with Technical Specification requirements. This is an apparent violation. In addition personnel were permitted to enter a highly contaminated area without provision of respiratory protective equipment.

R4 Staff Knowledge and Performance in RP&C

R4.1 Inspection Scope (83729)

The inspector reviewed the knowledge and performance of radiation workers and radiation protection personnel involved with the fuel transfer canal/reactor cavity work on the morning of November 2, 1996. The inspector interviewed various personnel involved with the November 2, 1996, entry into the fuel transfer canal/reactor cavity including, the HP supervisor who provided the initial briefing to the individuals (Individual A and B), the two individuals (Individual A and B) who performed the work activity in the fuel transfer canal/reactor cavity, the HP personnel who provided radiological controls for the canal entry, an individual (Individual C) involved with cleaning reactor stud holes after the event, and HP personnel involved in the cavity decontamination after the event.

The following findings, observations, and conclusions were developed based on the inspector's review of activities in progress on November 2 and 3, 1996; a review of plant schedules and procedures governing the defueling sequence and radiological controls; and on interviews with plant personnel.

R4.2 Radiation Workers

R4.2.1 Findings and Observations

The inspector's review determined that the two individuals (Individual A and Individual B) who entered the fuel transfer canal to inspect the canal and fuel transfer mechanism on the morning of November 2, 1996, were experienced radiation workers. The workers had received licensee-provided general employee training to allow for their unescorted access to the radiological controlled areas of the station. Further, each individual had previously entered fuel transfer canals to inspect and/or repair fuel transfer equipment/components therein.

The inspector reviewed the radiological controls information provided to the workers prior to their entry into the fuel transfer canal/reactor cavity. The inspector noted that 10 CFR 19.12 (a) requires that all individuals who, in the course of their employment, are likely to receive in a year an occupational dose of 100 mrem shall, among other matters, be kept informed of the storage, transfer, or use of radiation and/or radioactive materials and be informed of precautions or procedures to minimize exposure.

The inspector determined that the two individuals who entered the reactor cavity and fuel transfer canal were likely to receive a dose in excess of 100 mrem and the individuals were not adequately informed of the presence of high levels of removable radioactive contamination and radiation within the fuel transfer canal which they entered on November 2, 1996. Further, the workers were not adequately informed as to the precautions or procedures to minimize their occupational exposure. The inspector noted that the workers were led to believe that the fuel transfer canal was relatively clean as a result of its decontamination. However, the workers were not informed that the canal continued to exhibit relatively high levels of removable radioactive surface contamination (up to about 80 mrad/hr and up to about 30,000 dpm/100 cm^2 of removable alpha radioactive contamination) despite the recent (August 1996) decontamination effort. Individual A and Individual B indicated that neither was informed of removable alpha contamination within the cavity or informed of significant removable contamination therein. One worker indicated he believed the maximum radiation levels to be encountered were on the order of 60 mR/hr. (The maximum radiation levels entered by these individuals were on the order of several hundred millirem per hour and up to 8 R/hr at waist level.)

The inspector further noted that the individuals were not informed of an isolated hot spot on the floor of the transfer canal measuring up to 25 R/hr on contact (about 8 R/hr at waist level). At least one individual (Individual A) passed over the hot spot and walked through the elevated radiation levels. The inspector noted that because of the narrow dimensions of the cavity (about 36 inches wide), a worker on the floor tended to "shuffle" along with his back against the refueling cavity walls, an activity which appeared to be capable of generating airborne radioactivity.

The inspector noted that the workers were also not adequately informed regarding collection of debris and the ramifications of handling other debris not authorized to be collected. During the inspection in the transfer canal, the workers collected miscellaneous debris including dirt and paint chips. After exiting the transfer canal, the bag which contained the debris, collected and handled, measured about 20 R/hr to 60 R/hr on contact. In addition, one individual (Individual A) in the canal handled residual grease which had the potential to contain highly radioactive material. Further, Individual B peeled paint chips and rust off of the coffer dam wall.

The inspector also noted that two other individuals (Individual C and Individual D) entered the reactor cavity at about 9:30 a.m. on November 2, 1996. The workers were to perform stud hole cleaning of two stud holes on the reactor. The inspector noted that due to inadequacies in assessment of airborne radioactivity (i.e., a malfunctioning instrument was used to count the air sample) the workers unknowingly entered the reactor cavity during a period of elevated airborne radioactivity concentrations (50 DAC to 100 DAC)

R4.2.2 Conclusion - Radiation Workers

The radiation workers who entered the reactor cavity and subsequently entered the fuel transfer canal on November 2, 1996, were experienced radiation workers. However, the workers were not adequately informed of radiological conditions within these areas or precautions or procedures to minimize their exposure.

The inspector indicated that failure to adequately inform the workers (Individual A and Individual B) of the radiological conditions within the fuel transfer canal and of precautions or procedures to minimize their exposure was an apparent violation of 10 CFR 19.12. Further, the failure to notify the workers (Individual C and Individual D), who entered the reactor cavity to perform cleaning of reactor stud holes, of elevated airborne radioactivity was a second example of this apparent violation of 10 CFR 19.12.

R4.3 Radiation Protection Personnel

R4.3.1 Findings and Observations

The inspector reviewed the general knowledge and performance of the HP personnel who provided radiological coverage for the workers. The inspector noted that the licensee's Technical Specification 6.11 requires that personnel adhere to radiation protection procedures. The inspector noted that radiation protection procedure RPM 2.5-4, Revision 11, "Health Physics Job Coverage Requirements," specifies in Section 3.2 that workers be briefed on physical work limitations and that during the course of the job, the HP technician was to check conditions at the job site to ensure instructions are being properly implemented.

The inspector's review indicated that HP personnel did not provide an adequate briefing regarding the physical work limitations in that workers were not adequately informed of physical work limitations regarding handling material in the fuel transfer canal. As a result workers picked up and handled material from the fuel transfer canal measuring between 20 R/hr and 60 R/hr on contact. The workers were not informed that the material in the fuel transfer canal could exhibit high levels of radiation.

The inspector also noted that once the workers were inside the fuel transfer canal, a High Radiation Area, conditions at the job site were not adequately checked to ensure instructions were properly implemented. The inspector noted that the transfer canal area was an area partially covered by the charging floor and refueling bridge and only a small area of the canal was visible and that checking the area, by visual observation from the charging floor, was not an effective method to ensure personnel were adhering to instructions. The inspector noted one individual (Individual A) walked along the transfer canal floor inspecting and picking up debris.

R4.3.2 Conclusion - Radiation Protection Personnel

Radiation protection personnel did not provide effective radiological oversight of workers who entered the reactor cavity and fuel transfer canal on November 2, 1996. The inspector indicated that failure to follow radiation protection procedures and provide workers an adequate description of restricted activities and failure to provide adequate checks of work in progress to ensure instructions were being properly implemented was an apparent violation of Technical Specification 6.11.

R5 Staff Training and Qualification in RP&C

R5.1 Inspection Scope (83729)

The inspector selectively reviewed the qualifications and training of the radiological controls personnel providing radiological oversight of work within the reactor cavity and the fuel transfer canal. The review was against criteria contained in Technical Specification 6.3, Training and Qualification; and 10 CFR 50.120, Task Qualification.

R5.2 Findings and Observations

The inspector's review indicated that the HP technicians providing radiological controls were identified as qualified in accordance with the licensee's training and qualification program. The technicians received procedure and on-the-job training and were tested on general radiological controls knowledge. The on-the-job zone-specific training guide completions were recorded on Attachment C or equivalent as required by procedure RPM 1.2-1, Step 3.2.11.

The inspector noted that, as of November 8, 1996, training records of contracted radiation protection personnel, including those involved in the event, were not being maintained as specified in Radiation Protection Procedure RPM 1.2-1, Step 3.1, which requires completion of Attachment A to the procedure, Resume Validation and Position Assignments. The attachment provides for calculation and determination of maximum experience in various job categories including job coverage experience. The licensee did have documentation which was signed by a supervisor that indicated the contractors possessed adequate experience. However, the documentation did not identify maximum allowable experience for selected tasks as outlined within the procedure. This is an apparent violation.

The inspector reviewed the contractors' resumes and concluded the contractors possessed the minimum experience for their positions as required by Technical Specifications.

The inspector noted that one HP technician (HP technician A) inappropriately assumed on November 2, 1996, that a frisker on the reactor containment charging floor was operable. As a result, the technician authorized workers to enter high airborne radioactivity concentrations under the incorrect assumption that no airborne radioactivity was present after field checking an air sample with the frisker. This observation indicates weaknesses in licensee training of technicians regarding authorized instruments to be used to provide defensible survey results and weaknesses in technician training relative to identification of inoperable or malfunctioning instrumentation. The observation also indicates weaknesses in the licensee's QA program for field instrumentation.

R5.3 Conclusions

The inspector selectively reviewed the training and qualifications of the HP technicians providing radiological coverage for the reactor cavity and fuel transfer work. The technicians were qualified in accordance with Technical Specification requirements and 10 CFR 50.120. However, the licensee did not follow its radiation protection procedures when qualifying the technicians relative to documentation of qualifications. This is an apparent violation. Weaknesses were identified in the program for training technicians to perform field checks of air samples.

R6 RP&C Organization and Administration

R6.1 Inspection Scope (83729)

The inspector reviewed the radiation protection organization established for the outage. The review was against criteria contained within Technical Specifications and the Updated Final Safety Analysis Report (UFSAR).

R6.2 Observations and Findings

The inspector discussed the radiation protection organization and its structure prior to and during the November 2, 1996, airborne radioactivity event. The inspector noted that the radiation protection organization experienced a number of recent changes that had the potential to significantly impact overall performance as well as the adequacy and effectiveness of management oversight. For example, the licensee indicated that the organization has had three different Radiation Protection Managers (RPM) over the past three years and that the most recent replacement of the RPM occurred 6 days before the November 2, 1996, event.

During the recent RPM change, the Radiological Engineering Supervisor was selected to be the acting Radiation Protection Manger even though this individual continued to provide oversight of radiation protection engineering activities. In addition, a senior HP technician was upgraded (January 1996) to the acting Assistant Radiation Protection Supervisor following departure of the incumbent.

Regarding this upgrade, the inspector noted that the health physics manager/designee did not, as of November 8, 1996, issue a memo announcing the upgrade as specified in radiation protection procedure RPM 1.6-5, Step 3.1, dealing with upgrade of union personnel. Step 3.1 requires that the memo be issued including expected duration of upgrade. This is an apparent violation.

The inspector noted that, as a result of speculation regarding initiation of plant decommissioning, the licensee suspended planned outage work (e.g., steam generator activities) and placed (in mid-October 1996), the remaining radiation protection technicians in a "pool" to be drawn on when needed for work. Although this resulted in work coverage as needed, it provided for a lack of continuity of job coverage and lack of familiarity with specific radiological conditions in the station.

The inspector noted that on the morning of November 2, 1996, an HP technician from the primary auxiliary building (PAB) (HP technician B) was directed by HP technician C to cover radiological work in the reactor cavity. The individual had not covered outage work in the cavity this outage. Further, when questioned by the inspector, the HP technician from the PAB, assigned to cover the reactor cavity on November 2, 1996, did not know job specific radiation or contamination levels for the task (stud hole cleaning). He did indicate he had a general knowledge of conditions from previous outages.

The inspector noted that all individuals' appeared qualified for their assigned positions, however, the individuals' short duration in these positions appeared to impact overall performance.

The inspector noted that organizational communications during and following the event were weak. For example, despite the airborne radioactivity event, the suspension of critical path work and the intake of radioactive material by individuals, the acting RPM was not formally informed of the event. The acting RPM became aware of the event as a result of a side comment made by another employee who called the acting RPM on the evening of November 2, 1996. Further, the acting RPM did not inform his management.

The inspector also noted that the HP group had obtained a work order for decontaminating the reactor cavity on the afternoon of November 2, 1996. This work activity was also apparently to involve cleaning of the fuel transfer canal. The inspector noted the workers could have performed their inspections following the decontamination/cleaning effort by the health physics group. This would have significantly reduced their potential risk when entering the fuel transfer canal.

R6.3 Conclusion

The radiation protection organization experienced a number of changes shortly before the November 2, 1996, event which appeared to impact the overall performance of the organization. Further, organizational communications were weak affecting problem resolution.

R7 Quality Assurance in RP&C Activities

R7.1 Inspection Scope (83729)

The inspector selectively reviewed quality assurance activities within the radiation protection organization.

R7.2 Observations and Findings

The inspector noted that on the morning of November 2, 1996, the HP technicians, providing radiological controls for the cavity work used hand-held friskers on the reactor containment charging floor and containment foyer area to field check airborne radioactivity samples for initial screen purposes. The inspector noted that the technicians initially identified elevated airborne radioactivity within the fuel transfer canal by field checking the canal air sample (sample No. 110201) collected between 8:30 a.m. and 9:05 a.m. that morning. This sample was subsequently sent for field counting on a dedicated frisker at the containment HP control point and later sent for gamma spectroscopy analysis and alpha counting.

The inspector noted that a second air sample (sample No. 110203), collected in the reactor cavity between 9:10 a.m. and 9:30 a.m., was also checked by this method using a frisker at the reactor containment charging floor area. However, this frisker was apparently malfunctioning and indicated no apparent airborne activity within the reactor cavity. Based on this information, radiation protection personnel (HP technician A and HP technician B) authorized two individuals (Individual C and Individual D) to enter the reactor cavity to clean reactor head stud holes. Subsequent field counting of the air sample at the containment HP control point indicated elevated airborne radioactivity (3.47 DAC gross beta airborne radioactivity). The sample was later counted for alpha emitters and determined to exhibit about 107.8 DAC gross alpha airborne radioactivity. By the time this information was available, the individuals (Individual C and Individual D) had completed their work and had exited the reactor cavity.

The inspector noted that HP technician B was directed to enter the reactor cavity and the fuel transfer tc perform surveys to identify the source of airborne radioactivity on the morning of November 2, 1996. Upon exit from the cavity, this individual checked the smears of removable surface contamination collected and concluded that the frisker (previously used by HP technician A) was malfunctioning, in that the smears were expected to indicate high levels of contamination. Checking of the smears at the foyer area confirmed that the frisker was malfunctioning.

Subsequent inspector review indicated there was no apparent defined quantitative check program for friskers used in the reactor containment for field screening of airborne radioactivity samples. Procedure RPM 2.2-10, Step 3.15, did provide guidance for checking the friskers in a qualitative fashion (i.e., use of a check source) to verify meter deflection. Although there was no requirement to document this check, the check was apparently performed earlier in the shift on November 2, 1996.

The inspector's review of draft licensee internal findings following the event indicated that hand held portable radiation survey meters were not being source checked using a calibrator in accordance with procedure requirements. Further, the review indicated radiation protection personnel were apparently not collecting and processing air sample results in accordance with procedure requirements.

R7.3 Conclusion

The licensee did not have an defined quality assurance program for quantitatively checking friskers used in the reactor containment for field screening of airborne radioactivity samples. The inspector considered it a poor practice to authorize workers to enter areas using data from qualitative analysis results. Further, apparent licensee identified deficiencies in source checking of radiation survey meters and air sampling indicated weakness in internal quality assurance and supervisory oversight of on-going activities.

R8 Miscellaneous Issues

R8.1 Inspection Scope - Personnel Exposures (83729)

The inspector reviewed the occupational exposure results, based on electronic dosimetry results and whole body counting, for the individuals who entered the reactor cavity on the morning and early afternoon of November 2, 1996, during the elevated airborne radioactivity event. The inspector focused on the preliminary occupational exposure results for the two individuals (Individual A and Individual B) who entered the fuel transfer canal on November 2, 1996. In addition, the inspector reviewed the detection capabilities of the whole body counter relative to industry guidance outlined in applicable national standards (ANSI N343, 1978, American National Standard for Mixed Fission and Activation Products).

R8.2 Personnel Exposures (Observations and Findings)

The inspector's review of the exposure results indicated Individuals A and B, who entered the reactor cavity and fuel transfer canal on November 2, 1996, sustained external radiation doses of 239 mR (Individual A) and 155 mR (Individual B) respectively (based on electronic dosimeters). These exposures were within NRC exposure limits assuming all external exposure[2]. As discussed previously in this report, Individual A's alarming dosimeter (set at 200 mR) alarmed. However, notwithstanding the above, the inspector questioned potential non-uniform external radiation doses that the workers may have received and that were not necessarily measured by the TLD or electronic dosimetry (e.g., dose to the lower extremities, femur, hands, skin, or back). These doses would include non-uniform doses due to working in the canal and due to carrying the bag of debris.

As a result, the licensee initiated conservative calculations and time and motion studies to estimate external radiation exposure to the individuals that may not have been accurately reflected by dosimetry package. At the conclusion of the inspection, the licensee was continuing to calculate external exposure results. However, preliminary results did not indicate a shallow or deep dose equivalent in excess of NRC limits.

The inspector noted that the licensee's external monitoring program did not appear to consider suggested guidance presented in NRC Information Notice No. 90-47, Unplanned Radiation Exposures to Personnel Extremities Due to Improper Handling of Potential Highly Radioactive Sources, dated July 27, 1990. The information notice discussed the need for workers to understand the hazards of high extremity exposures associated with unidentified and possibly highly radioactive objects.

Regarding occupational exposures due to intakes of radioactive material, the inspector reviewed the internal exposure calculations made by the licensee for the two workers who entered the fuel transfer canal (Individual A and Individual B) as of November 7, 1996. The inspector noted that the licensee calculated the intake of radionuclides via back calculation (using whole body count data) to the time of the intake. From that calculation, the licensee determined an estimated exposure and subsequent committed effective dose equivalent. The calculation indicated that the workers (Individual A and Individual B) sustained limited intakes of Co-60 (less than 5% of the annual limit on intake (ALI) assuming inhalation of Class Y Co-60). The inspector noted, the licensee also calculated potential intake of alpha emitters using the highest alpha airborne radioactivity sample identified in the reactor cavity (Sample No. 110203 collected between 9:10 a.m and 9:25 a.m. on November 2, 1996).

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[2]10 CFR 20.1201 provides annual occupational dose limits for adults. These annual limits are 5 rem total effective dose equivalent, 50 rem total dose equivalent to any organ or tissue (excluding the lens of the eye), an eye dose equivalent of 15 rems, and a shallow-dose equivalent to the skin or to any extremity of 50 rem. The total dose equivalent is the sum of the deep dose equivalent (for external sources) and the committed effective dose equivalents (for intakes of radioactive material). The total organ dose equivalent is the sum of the deep-dose equivalent due to external sources and the committed dose equivalent due to intakes of radioactive material.

The licensee calculated a maximum of 36 DAC-hours[3] for this exposure. The licensee's calculation of expected committed effective dose equivalent, attributable to this intake of alpha emitters, indicated about 90 mrem. The inspector questioned this calculation for the following reasons:

- The sample (No. 110203), used to calculate personnel exposure to alpha airborne radioactivity, was collected in the reactor cavity and was not considered representative of the airborne radioactivity breathed by the workers in the fuel transfer canal.

- The workers' nasal smears (Individual A and Individual B) indicated 200,000 dpm (beta/gamma) indicating a significant inhalation.

- The actual air sample (No. 110201), collected in the northeast end of the fuel transfer canal, while Individual A and Individual B were in the canal, was considered not representative of the workers' breathing zones. The sample was collected in an area of the canal with significantly lower contamination than the major portions of the fuel canal traversed by the workers. Further, the sample results did not coincide with the high levels of nasal contamination detected in the individuals.

- Air samples collected within the reactor cavity and fuel transfer cavity indicated a relatively low beta to alpha ratio (e.g., 80/1).

- Estimation of intake of airborne radioactivity of the workers, based on comparing expected alpha airborne radioactivity intake with measured Co-60 intake (i.e., use of ratio techniques), indicated a potentially significant alpha airborne radioactivity intake.

- Also, the licensee did not calculate the apparent dose to the bone from the intake (i.e., committed dose equivalent) assuming a conservative intake based on available data.

The inspector discussed the above with licensee personnel who immediately restricted (on November 7, 1996) the workers from any additional radiation exposure pending an evaluation of both external and internal radiation exposures.

Inspector Note: Individual A and Individual B were electronically "locked out" of the radiological controlled area by HP personnel via the electronic dosimeter system on November 2, 1996, as a result of the individuals' inability to clear the PCM-1B whole body friskers. These individuals subsequently cleared the PCM-1B whole body friskers on Wednesday,

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[3]DAC-hr is the product of the concentration of radioactive material in air (expressed as a fraction or multiple of the derived air concentration for each radionuclide) and the time of exposure to that radionuclide, in hours. A licensee may take 2,000 DAC-hrs to represent one ALI, equivalent to a committed effective dose of 5 rems.

November 6, 1996, and were unlocked and permitted access to the RCA on that day. Individual A did not enter the RCA. However, Individual B made an entry into the containment on November 6, 1996, and received no measurable radiation exposure.

At the end of the inspection, the licensee was continuing to evaluate internal exposures (principally attributable to alpha emitters) for the two individuals who entered the fuel transfer canal. The licensee had contracted with outside personnel to perform internal dose assessments. The licensee had initiated fecal sampling of the two workers in order to better understand the potential intake of airborne radioactivity.

The inspector noted that the licensee's air sampling program did not appear to effectively consider suggested guidance presented in NRC Information Notice No. 92-75, Unplanned Intakes of Airborne Radioactive Material By Individuals At Nuclear Power Plants, dated November 12, 1992. The information notice discussed an airborne radioactivity event associated with inspection and housekeeping activities in the reactor cavity and fuel transfer canal, and highlighted the need for vigilance when conducting maintenance activities that could significantly increase airborne radioactivity.

The inspector also reviewed the whole body count results for the individuals who entered the reactor cavity and fuel transfer canal during the time period of elevated airborne radioactivity on November 2, 1996. The inspector noted that excluding the two individuals who initially entered the fuel transfer canal on November 2, 1996, at 8:30 a.m. no individual sustained any significant measurable intake of airborne radioactivity based on whole body count results. Further, the inspector's review of RWP sign-in and sign-out data indicated no individual sustained an apparent unplanned external radiation exposure.

The maximum internal and external exposures sustained by the two workers during their entry into the fuel transfer canal on November 2, 1996, is an unresolved item pending completion of the licensee's assessments and subsequent review by the NRC. **(UNR 50-213/96-12-01)**

V. Management Meetings

X1 Exit Meeting Summary

The inspector presented the preliminary inspection results to members of licensee management on November 8, and 22, 1996. In addition, the inspector held a telephone brief of licensee management on November 27, 1996. The licensee acknowledged the findings presented.

PARTIAL LIST OF PERSONS CONTACTED

Licensee

E. Annino, Senior Analyst-Unit Director Staff
G. Bouchard, Work Services Director
T. Cleary, Nuclear Licensing Engineer
W. Gates, Radiation Protection Supervisor
J. Goergen, Acting Health Physics Manager
I. Haas, Senior Engineer, Millstone Health Physics
J. Haseltine, Engineering Director
W. Heinig, Performance Evaluation Supervisor
J. LaPlatney, Unit Director
J. Pandolfo, Security Manager
R. Sachatello, Radiation Protection Manager
L. Silvia, Senior Scientist, Health Physics
J. Stanford, Operations Manager
M. Thomas, Acting Assistant Radiation Protection Supervisor
G. Waig, Maintenance Manager

NRC

J. Rogge, Chief, Projects Branch 8, Division of Reactor Projects
J. White, Chief, Radiation Safety Branch, Division of Reactor Safety

INSPECTION PROCEDURES USED

IP 71707: Plant Operations
IP 83729: Occupational Exposure During Extended Outages

ITEMS OPEN, CLOSED, AND DISCUSSED

Open

50-213/96-12-01	UNR	The maximum internal and external exposures sustained by the two workers during their entry into the fuel transfer canal on November 2, 1996, is an unresolved item.

Closed

None

Discussed

None

LIST OF ACRONYMS TYPICALLY USED

ACR	Adverse Condition Report
ALARA	As Low As Is Reasonably Achievable
ANSI	American National Standards Institute
AOP	Abnormal Operating Procedure
ASME	American Society of Mechanical Engineers
AWO	Authorized Work Orders
CAR	Containment Air Recirculation
Ci	Curie
CLIS	Cavity Level Indication System
CM	centimeter
CYAPCo	Connecticut Yankee Atomic Power Company
DAC	Derived Air Concentration
DAC-HR	Derived Air Concentration-Hours
DPM	Disintegrations Per Minute
EDG	Emergency Diesel Generator
EOP	Emergency Operating Procedure
F	fahrenheit
GL	Generic Letter
gpm	gallons per minute
HP	health physics
IRT	Independent Review Team
LER	Licensee Event Report
LPSi	Low Pressure Safety Injection
NDE	Nondestructive Examinations
NGP	Nuclear Generation Procedure
NOP	Normal Operating Procedure
NRC	Nuclear Regulatory Commission
NSO	Nuclear Side Operator
OSCR	Outage Sequence Change Request
PAB	Primary Auxiliary Building
PDCR	Plant Design Record
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RHR	Residual Heat Removal
RVLIS	Reactor Vessel Level Indication System
RWPs	Radiation Work Permits
RWST	Refueling Water Storage Tank
SE	System Engineer
SNM	Special Nuclear Material
SNs	Serial Numbers
SRP	Standard Review Plan
SUR	Surveillance Procedure
TS	Technical Specification
VCT	Volume Control Tank
WCC	Work Control Center