April 30, 2002

MEMORANDUM TO: Chairman Meserve
Commissioner Dicus
Commissioner Diaz
Commissioner McGaffigan
Commissioner Merrifield

FROM: William D. Travers ***/RA/***
Executive Director for Operations

SUBJECT: LESSONS LEARNED ABOUT MATERIAL CONTROL AND ACCOUNTING FROM THE MILLSTONE UNIT 1 LOSS OF TWO SPENT FUEL RODS

The purpose of this memorandum is to inform the Commission of lessons learned about material control and accounting (MC&A) at power reactors as a result of the investigation of Millstone Unit 1's loss of two spent fuel rods. The lessons learned concerning the power reactor MC&A program are discussed in greater detail in the following Attachment.

In summary, control over the two spent fuel rods failed because the licensee's MC&A procedures (and their implementation) were not adequate. No problems with the NRC regulations were identified; however, MC&A guidance could be improved and clarified. The MC&A inspection program at power reactors has been dormant since 1988. However, it is not clear that inspections would have detected this loss of accountability. Finally, the Nuclear Material Management and Safeguards System performed as it was designed to.

Staff plans to examine MC&A vulnerabilities as part of the top-to-bottom review of the Agency's safeguards and security program that is being undertaken in response to the terrorist activities of September 11, 2001. While the MC&A review will benefit from the broader view of the entire safeguards program, as a first step the staff intends to develop a Temporary Instruction (TI) to ascertain the breadth and scope of the MC&A issues which were identified at Millstone. The TI will be implemented over the next year at selected sites and, depending on how widespread the problem is, staff will consider the need for revised guidance and whether appropriately focused inspections are needed. Changes to the MC&A program will be evaluated as a whole and in the context of the overall safeguards program. Because recommendations will follow the review of the entire program and because the current risk to human health and safety from the missing fuel rods is negligible (see following Attachment), no recommendations concerning MC&A at power reactors are being made at this time.

Attachment:
Lessons Learned

cc: SECY
OGC
OCA
OPA
CFO

CONTACT: M. Williams, NMSS/FCSS
(301) 415-7878

MEMORANDUM TO: Chairman Meserve
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Attachment:
Lessons Learned

cc: SECY OGC OCA OPA CFO

CONTACT: M. Williams, NMSS/FCSS
(301) 415-7878

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LESSONS LEARNED CONCERNING MATERIAL CONTROL AND ACCOUNTING AT POWER REACTORS

Introduction

The inspection report for the special inspection at Millstone Unit 1 (Attachment A) summarizes the licensee's actions in response to the missing fuel rods and documents the results of the U.S. Nuclear Regulatory Commission's (NRC's) special team inspection. As discussed in the inspection report, the NRC team agreed with the licensee's conclusion that the missing fuel rods are most likely located in a licensed low-level radioactive waste disposal facility. The NRC team also concluded that it is highly unlikely the fuel rods, in their entirety, remain in the Millstone 1 spent fuel pool. Because of the radiological controls in place at any of the possible locations of the missing fuel rods there is, realistically, no current threat to public health. The NRC team agreed with the licensee's conclusion that there is no evidence to support the possibility of theft or diversion of the missing fuel rods, and that this is not a plausible scenario. The NRC staff concluded that there are presently adequate controls to account for all special nuclear material (SNM) at the Millstone Station, except for the missing fuel rods.

The NRC team concluded, as did the licensee's root-cause analysis, that management controls and supervision of Unit 1 fuel-handling activities had been inadequate. The team also identified two specific, apparent violations. These apparent violations involve failure to: (1) keep adequate records, establish adequate procedures for control and accounting, and conduct physical inventories of SNM; and (2) report missing radioactive material in a timely manner.

Four lessons were learned about NRC's material control and accounting (MC&A) program for power reactors as a result of the licensee's evaluation and the NRC team inspections. These lessons are discussed next.

1. Lesson Learned: MC&A regulations are adequate.

The major MC&A requirements pertaining to power reactors are in 10 CFR 70.51. The wording has changed slightly since 1972 (when Millstone Unit 1 removed the two spent fuel rods from their parent assembly), but the substance is the same. The licensee is required to:

- Establish MC&A procedures sufficient to account for all SNM in its possession;
- Keep records showing receipt, inventory (including location), disposal, acquisition, and transfer of all SNM;
- Conduct annual physical inventories of all SNM; and
- Complete reports concerning SNM received, produced, possessed, and transferred.

Control over the two spent fuel rods failed, not because of problems with the regulations, but because the licensee's MC&A procedures (and their implementation) were not adequate. Records were either never prepared or not retained, and physical inventories were not thorough. The reasons for loss of control are discussed in more depth in the inspection report.

If the licensee's procedures and practices had effectively implemented the regulations, control over the rods would likely have been maintained.

2. Lesson Learned: Guidance on MC&A could be clarified and improved.

MC&A guidance documents on establishing and implementing an MC&A program at power reactors are: (1) Regulatory Guide 5.29, "Nuclear Material Control Systems for Nuclear Power Plants"; (2) Regulatory Guide 5.49, "Internal Transfers of Special Nuclear Material"; and (3) ANSI N15.8-1974, "Nuclear Material Control Systems for Nuclear Power Plants." The ANSI standard was withdrawn in 1987, because no action had been taken within 10 years to revise or reaffirm it, and Regulatory Guide 5.29 was withdrawn in 1998. The guidance documents have several related shortcomings:

- They identify the assembly as the basic unit for control and provide no guidance on accounting for rods that have been removed from their parent assembly.
- They are not clear about what constitutes a "physical" inventory and fail to establish guidelines for conducting an inventory.
- They do not consider whether "spent fuel pool" is sufficient as the location of record.
- They do not address problems that may arise when spent fuel rods are stored outside the racks.
- They do not explain how to compare book inventory and physical inventory.

If the guidance had addressed these aforementioned topics, the licensee's inventory and control procedures might have been more comprehensive.

3. Lesson Learned: Even if an MC&A inspection program had been implemented, this loss of accountability might not have been identified.

The inspection program for MC&A at power reactors is guided by NRC Inspection Manual Chapter (IMC) 2515C, "Special and Infrequently Performed Inspections." The applicable Inspection Procedure (IP) is 85102, "Material Control and Accounting - Reactors" (Attachment B). This chapter and procedure were not considered during development of the revised Reactor Oversight Process. IMC 2515C states that this IP is "...implemented infrequently for special situations" and is "...not part of the baseline or supplemental inspection program elements." The MC&A inspection program at power reactors has been dormant since 1988, at which time responsibility for inspection of MC&A programs was split up, with responsibility for inspections at fuel cycle facilities being transferred to NMSS and responsibility for inspection of MC&A at reactors remaining in the Regions.

The absence of an inspection program in this area does not mean that loss of accountability for the two Millstone Unit 1 rods would have been identified if MC&A inspections had been conducted. MC&A inspections were conducted at Millstone before 1988, and the problem was not identified. The inspection guidance uses the MC&A guidance for power reactors, discussed in Lesson 2, as its standard. In particular, the inspection guidance defines the assembly as the basic unit for control and accounting and does not address the special circumstance of individual rods separated from their parent assembly. If the inspection procedure had addressed the topics noted as shortcomings under Lesson 2, inspections would have been more effective.

4. Lesson Learned: The Nuclear Materials Management and Safeguards System (NMMSS) performed as it was designed to.

10 CFR 70.53 and 10 CFR 70.54 require that the licensee follow the requirements set out in 10 CFR 74.13 and 74.15, to submit SNM balance reports and transfer and receipt reports to NMMSS. NMMSS is the national nuclear material database for tracking certain nuclear materials, is operated under a contract with the U.S. Department of Energy (DOE), and is jointly funded by DOE and NRC.

NMMSS does have information about the two rods, but the information is incorrect. NMMSS information places the two rods in the Millstone Unit 1 spent fuel pool in the parent assembly, because that is the information submitted to NMMSS by the licensee. NMMSS is a database (i.e. an information repository) and the information it contains is obtained from the licensee reports discussed above. Because the licensee thought the rods were in the spent fuel pool, no transfer report was made to NMMSS, and the rods continued to be carried on inventory.

NMMSS employs checks and balances to compare data reported to it by facilities shipping and receiving SNM. NMMSS also employs checks and balances that enable it to compare the algebraic total of beginning inventory, receipts, and shipments, with the total amount of material reported on the ending physical inventory. However, NMMSS was not designed to confirm that information a licensee submits about its inventory is correct, or that the licensee has reported all shipments to waste burial. In summary, NMMSS performed as it was designed to.

Attachments:
A. Inspection Report 50-245/2001-013
B. Inspection Procedure 85102

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
475 ALLENDALE ROAD
KING OF PRUSSIA, PENNSYLVANIA 19406-1415

February 27, 2002

Docket No. 05000245 License No. DPR-21
EA No. 02-014

Mr. J. Alan Price, Vice President
Nuclear Technical Services
c/o David A. Smith, Manager-Regulatory Affairs
Dominion Nuclear Connecticut, Inc.
Millstone Power Station
Rope Ferry Road
Waterford, CT 06385

SUBJECT: SPECIAL INSPECTION 05000245/2001013, DOMINION NUCLEAR CONNECTICUT, INC., MILLSTONE POWER STATION UNIT 1, WATERFORD, CONNECTICUT

Dear Mr. Price:

On October 9 - 18, 2001, Todd Jackson, John Hickman, and Martha Williams of the NRC conducted a special inspection at the above address of activities authorized by your NRC license. The inspection focused on your investigation into the loss of two spent fuel rods from Millstone Unit 1. Within this area, the inspection consisted of selected examination of procedures and representative records, observations of activities, and interviews with personnel. The inspection was continued in the Region I office until December 21, 2001, to review licensee records, and also records pertaining to General Electric Company's Vallecitos, California, nuclear fuel research facility. The findings of the site visit portion of the inspection were discussed with you and others of your staff on October 18, 2001, and all of the findings were also presented at a public exit meeting on January 15, 2002.

The NRC special inspection team determined that your investigation was thorough and complete, and the conclusions were reasonable and supportable. The NRC team concurred in your conclusion that the missing fuel rods are most likely located in a licensed low level radioactive waste facility. The NRC team also concluded that it is highly unlikely the fuel rods, in their entirety, remain in the Millstone 1 spent fuel pool. Because of the radiological controls in place at any of the possible locations of the missing fuel rods, realistically, there is no current threat to public health. The NRC team agreed with your conclusion that there is no evidence to support the possibility of theft or diversion of the missing fuel rods, and this is not a plausible scenario. The NRC staff concluded that there are presently adequate controls to account for all special nuclear material at the Millstone Station, except for the missing fuel rods.

ATTACHMENT A

Acknowledging realistically that the missing fuel rods are not in a location that poses immediate threat to public safety, nonetheless the loss of control of this material is of significant concern. An important part of your investigation of the missing fuel rods was assessment of root cause. The NRC team concluded, similarly to your root cause assessment, that management controls and supervision of activities related to handling of special nuclear material and irradiated fuel were insufficient at various periods over the past 20 years. We identified two specific, apparent violations. The apparent violations, which are described in the enclosed inspection report and executive summary, involve the failure to: (1) keep adequate records, establish adequate procedures for control and accounting, and conduct physical inventories of special nuclear material; and (2) report missing radioactive material in a timely manner. These apparent violations are being considered for escalated enforcement in accordance with the "General Statement of Policy and Procedure for NRC Enforcement Actions" (Enforcement Policy), NUREG 1600. Such action may involve issuance of a civil penalty.

Before the NRC makes its enforcement decision, we are providing you an opportunity to either (1) respond to the apparent violations addressed in this inspection report within 30 days of the date of this letter, or (2) request a predecisional enforcement conference. Please contact Ronald R. Bellamy at (610) 337-5200 within seven days of the date of this letter, to inform us as to which of the above two options you choose. If a predecisional enforcement conference is held, it will be open for public observation and will be announced to the public via a press release.

If you choose to respond in writing, rather than at a predecisional enforcement conference, your response should be clearly marked as a "Response to Apparent Violations in Inspection Report No. 05000245/2001013" and should include for each apparent violation: (1) the reason for the apparent violation, or, if contested, the basis for disputing the apparent violation, (2) the corrective steps that have been taken and the results achieved, (3) the corrective steps that will be taken to avoid further violations, and (4) the date when full compliance will be achieved. In describing your corrective action, you should be aware that the promptness and comprehensiveness of your actions will be considered in assessing any civil penalty for the apparent violations. Your response should be submitted under oath or affirmation and may reference or include previous docketed correspondence, if the correspondence adequately addresses the required response. If an adequate response is not received within the time specified or an extension of time has not been granted by the NRC, the NRC will proceed with its enforcement decision.

In addition, please be advised that the number and characterization of apparent violations described in the enclosed inspection report may change as a result of further NRC review. You will be advised by separate correspondence of the results of our deliberations on this matter.

In accordance with 10 CFR 2.790, a copy of this letter, its enclosure, and your response (if you choose to provide one) will be placed in the NRC Public Document Room (PDR) and will be accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. To the extent

possible, your response should not include any personal privacy, proprietary, or safeguards information so that it can be placed in the PDR without redaction.

Sincerely,

/RA/

George Pangburn, Director
Division of Nuclear Materials Safety

Enclosure: Inspection Report No. 05000245/2001013

cc:
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W. R. Matthews, Vice President and Senior Nuclear Executive
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U.S. NUCLEAR REGULATORY COMMISSION
REGION I

INSPECTION REPORT

Inspection No.	05000245/2001013
Docket No.	05000245
License No.	DPR-21
Licensee:	Dominion Nuclear Connecticut, Inc.
Location:	Millstone Power Station, Unit One Rope Ferry Road Waterford, CT 06385
Inspection Dates:	October 9-December 21, 2001
Inspectors:	Todd Jackson, CHP, Team Leader, Health Physicist, Region I John Hickman, Project Manager, NRR Martha Williams, Material Control & Accounting Inspector, NMSS

Approved By: ***/RA/*** February 26, 2002

Ronald Bellamy, Chief (date)
Decommissioning and Laboratory Branch

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EXECUTIVE SUMMARY

Dominion Nuclear Connecticut, Inc.
NRC Inspection Report No. 05000245/2001013

Millstone Unit 1 is currently in decommissioning status. The Unit received a full power operating license on October 7, 1970, and was shut down on November 4, 1995, in response to significant site-wide regulatory concerns. The licensee subsequently removed all fuel from the reactor vessel and placed it into the spent fuel pool. The licensee decided on July 17, 1998, to permanently cease any further operation of the plant and informed the NRC of the decision by letter dated July 21, 1998. Millstone Unit 1 is in a cold and dark SAFSTOR condition with an independently functioning spent fuel pool island being maintained for the safe storage of the spent nuclear fuel in the pool.

During records reconciliation and verification of the Millstone 1 spent fuel pool inventory in June 2000, the licensee identified that two full-length fuel rods were not in the locations reflected in special nuclear material records. Inventory cards indicated that the rods should be located in the spent fuel pool, however, the licensee determined the rods were not in the specified locations. Initially, the licensee considered the discrepancy to be a problem of failure to update records to reflect the actual location of the two spent fuel rods, and searched for the rods in the Unit 1 spent fuel pool. Not finding the missing rods, the licensee wrote a condition report in November 2000 to document that the rods could not be located.

The licensee determined that the two fuel rods had originally been part of fuel assembly MS-557, which was received at Millstone in 1969 and was part of the first core loading at the plant. In 1972, following a seawater intrusion event and exposure of all fuel assemblies in the core to an excessive chloride concentration in reactor water, fuel assembly MS-557 was disassembled for inspection. When MS-557 was reassembled in 1974, center spacer capture rod BK0136 and tie rod BP0406 (which had been damaged during disassembly/reassembly) were not included in the reconstructed assembly. The two rods were placed in a container for individual fuel rods and stored in the spent fuel pool. From 1974 to 1979 there was no documentation of the location of the two fuel rods. Records dated 1979 and 1980 show the fuel rods in the container stored in the spent fuel pool. Records prepared after 1980 do not mention the fuel rods or the container. Significant work, including two re-racks and shipments of miscellaneous irradiated components from the spent fuel pool, occurred between 1980 and 1992.

The licensee made a telephone report to the NRC Operations Center on December 14, 2000 and submitted a written Licensee Event Report on January 11, 2001. The licensee formed a dedicated investigative review team, as well as an independent management review team to concurrently review the overall investigation effort. The licensee's investigation expanded through January 2001 to a peak of about 25 full time personnel and continued until October 2001. Although the current licensee for Millstone Unit 1 is Dominion Nuclear Connecticut, the Fuel Rod Accountability Project (FRAP) was directed, staffed, and funded by Northeast Utilities, the former licensee for the Millstone Station. The continued involvement of Northeast Utilities was a condition of the purchase of the Millstone Station by Dominion, which occurred on March 31, 2001.

The licensee's investigation included identification and evaluation of possible scenarios for disposition of the two fuel rods, interviews of personnel who might have worked with the rods or been aware of activities involving the rods, searches of the spent fuel pool to determine if the two rods were still somewhere in the pool, and searches of records to determine if documentation existed describing the disposition of the rods. The licensee identified a total of 75 scenarios for evaluation. Of the 75 scenarios, 12 were considered implausible and not evaluated further. Twelve scenarios were investigated fully, through use of detailed action plans. Ten scenarios were addressed through one or more specific confirmatory investigative actions, and 41 scenarios were addressed through physical searches conducted in the Millstone 1 spent fuel pool or elsewhere on the Millstone Station. Personnel interviews and records reviews were the methods used in the action plans for detailed scenario investigation.

Dominion Nuclear Connecticut submitted the final report of the FRAP to the NRC on October 5, 2001. The licensee concluded that the fuel rods were safely located in a facility that is licensed to either store or dispose of radioactive material. Specifically, the investigation determined that the rods are: (a) in an undetermined location in the Unit 1 spent fuel pool; (b) at General Electric's Vallecitos, California nuclear fuel research facility; or (c) at one or both of the low-level radioactive waste disposal facilities in Barnwell, South Carolina (Barnwell) or the Hanford reservation in Richland, Washington (Hanford). Further, the FRAP concluded that the likelihood that the rods remain in the Unit 1 spent fuel pool or are at GE's Vallecitos nuclear facility was low, and that the low-level radioactive waste facility at Barnwell had the most significant opportunity to receive the rods.

Routine NRC inspections reviewed activities of the licensee's investigation throughout 2001. NRC Region I led a special inspection with staff from the Offices of Nuclear Reactor Regulation and Nuclear Material Safety and Safeguards, onsite in October of 2001, and continuing through December 2001. The focus of the special inspection was to perform a thorough and systematic review to determine the adequacy of the licensee's investigation. The special inspection team was also chartered to assess the licensee's root cause analysis, and to determine if the licensee was in compliance with NRC regulations.

The NRC special inspection team determined that the FRAP investigation was thorough and complete, and the conclusions were reasonable and supportable. As a result of the special inspection, the NRC team concurred in the licensee's conclusion that the low level radioactive waste facility at Barnwell had the most significant opportunity to receive the rods, with an opportunity also existing to some small degree for the inadvertent shipment of the fuel rods to Hanford. The NRC team also concluded that, while it is highly unlikely the rods in their entirety remain in the Millstone 1 spent fuel pool, it is possible that fuel pellets or fragments remain on the spent fuel pool floor as a result of the cutting methods used to process waste hardware. A layer of sediment exists over portions of the spent fuel pool floor. Inspection methods were sufficient to assure intact fuel rods or large segments would not be in the sediment. The inspection team did not concur with the licensee that GE Vallecitos was a potential location for the fuel rods, and determined that GE Vallecitos was not a plausible location.

The licensee commissioned a Root Cause Assessment Team to analyze the root cause and factors contributing to the loss of the two fuel rods. The team characterized the root cause as

being an “unrecognized over-reliance on Millstone 1 reactor engineers to compensate for organizational and process weaknesses in implementing the special nuclear material inventory and control procedures.” Contributing elements identified by the licensee’s team described weaknesses in special nuclear material inventory and radwaste characterization, weaknesses in coordination of spent fuel pool activities and in procedure compliance, and inconsistent supervision and oversight of spent fuel pool activities. Sixteen corrective and preventive actions were recommended by the root cause assessment team, and the licensee incorporated them into the Millstone Station corrective action program. The inspectors found the root cause analysis to be comprehensive and concurred with the conclusions. The inspectors also concluded that management controls and supervision of activities related to handling of special nuclear material and irradiated fuel were insufficient at the time to prevent the loss of the two fuel rods.

The current risk to human health from the missing fuel rods is negligible. If the rods were in and are still in any of the possible locations identified by the licensee, they would have been and still are subject to all of the controls for protecting workers and the public that are in place for handling and safeguarding radioactive material. If the rods were mistaken for some other non-fuel waste object, such as a local power range monitor, and were inadvertently shipped offsite, they would have been packaged in shielded shipping containers due to their high radiation levels, and would therefore have satisfied the shipping requirements for external exposure limits. Furthermore, the radiation detection instruments at the potential offsite locations would also have detected unshielded irradiated fuel. Although the burial sites at Barnwell and Hanford are not licensed to accept irradiated reactor fuel, the amount of radioactivity in the two spent fuel rods is a small part of the total inventory of several million curies at either disposal site. The long term risk presented at the burial sites by the presence of the two missing spent fuel rods, as well as whether there is a need for potential remedial actions, is currently being evaluated by the states of South Carolina and Washington in coordination with the NRC.

The licensee also analyzed the scenarios of theft or diversion and determined there was no evidence to support such a possibility. The inspectors reviewed the licensee’s analysis of this scenario and agreed with the conclusion. The very high radiation level of the material (contact radiation level of approximately 1600 R/hr in 1980) would have made theft difficult, dangerous, and highly unlikely. The licensee concluded that, whether shipped offsite or remaining in the spent fuel pool, the missing spent fuel rods were always properly controlled as radioactive material. This is true even if, as is most likely, the rods were incorrectly identified as waste. Since the two spent fuel rods contain 40 grams of plutonium and 100 grams of U-235, the missing material is defined by NRC regulations in 10 CFR 73.2 as special nuclear material of low strategic significance.

As a result of the NRC special inspection, apparent violations of NRC regulations were identified. These violations, which are being considered for escalated enforcement action, are summarized below:

Failure to adequately account for special nuclear material

Beginning in 1980 and continuing through November 2000, the licensee failed to keep adequate records of the special nuclear material in irradiated fuel rods BK0136 and BP0406; failed to establish adequate written material control and accounting procedures sufficient to account for all special nuclear material in his possession; and failed to identify through physical inventory that the two fuel rods were no longer in the location stated in the book inventory (the previous inventory updated by receipts and shipments). (**VIO 50-245/2001-013/001**)

As a result of the loss of control of the special nuclear material in the two spent fuel rods, there may have been several consequences resulting if the special nuclear material had been transferred to an unauthorized recipient. Specifically, during the period from March 1985 to December 1992, the licensee may have:

- transferred special nuclear material contained in two irradiated reactor fuel rods in an unauthorized manner to a low level waste burial site not licensed to receive the material (Barnwell and/or Hanford);

- shipped special nuclear material contained in irradiated reactor fuel to low level waste burial sites in Barnwell and/or Hanford. The irradiated reactor fuel exceeded the limit for Class C waste and is therefore not suitable for a low level waste burial site;

- incorrectly identified and characterized the special nuclear material in irradiated reactor fuel as other waste, and incorrectly certified in shipping manifests the composition of the waste as suitable for a low level waste burial site;

- transferred special nuclear material to one or more other locations (Barnwell and/or Hanford burial sites) without completing and submitting a Nuclear Material Transaction Report, DOE/NRC Form 741; and

- shipped irradiated reactor fuel without establishing and maintaining, or making arrangements for, and assuring the proper implementation of a physical protection system for the shipment(s).

Failure to report missing radioactive material in a timely manner

Lost or missing material is defined in 10 CFR 20.1003 as licensed material whose location is unknown. On September 12, 2000, with the examination of assembly MS-557 and physical verification of the northwest corner of the spent fuel pool completed, the licensee could not identify the location of the two fuel rods. Although the licensee did eventually report the missing licensed material to the NRC Operations Center on December 14, 2000, the licensee did not know the location of the two spent fuel rods as of September 12, 2000. As a result, the licensee failed to notify the NRC in a timely manner according to the requirements of 10 CFR 20.2201(a)(ii), which requires that

NRC be notified within 30 days after the occurrence of any lost, stolen, or missing licensed material exceeding specified quantities becomes known to the licensee. (**VIO 50-245/2001-013/002**)

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REPORT DETAILS

Introduction

Millstone Unit 1 is currently in decommissioning status. The Unit received a full power operating license on October 7, 1970, and was shut down on November 4, 1995, in response to significant site-wide regulatory concerns. The licensee subsequently removed all fuel from the reactor vessel and placed it into the spent fuel pool. The licensee decided on July 17, 1998, to permanently cease any further operation of the plant and informed the NRC of the decision by letter dated July 21, 1998. Millstone Unit 1 is in a cold and dark SAFSTOR condition with an independently functioning spent fuel pool island being maintained for the safe storage of the spent nuclear fuel in the pool.

According to Licensee Event Report 2001-002-00, during a records reconciliation and verification effort by the licensee in November 2000, it was identified that the location of two full-length fuel rods was not properly reflected in special nuclear material records. Inventory cards indicated that the rods should be located in the spent fuel pool; however, the licensee determined the rods were not in the specified locations. Initially the licensee considered the discrepancy to be a problem of failure to update records to reflect the actual location of the two spent fuel rods and searched for the rods in the Unit 1 spent fuel pool. Not finding the missing rods, the licensee wrote a condition report in November 2000 to document that the rods could not be located.

The licensee determined that the two fuel rods had originally been part of fuel assembly MS-557, which was received at Millstone in 1969 and was part of the first core loading at the plant. In 1972, all fuel assemblies in the core were exposed to an excessive chloride concentration in reactor water caused by seawater entering the reactor coolant system through condenser tube leaks. Fuel assembly MS-557 was disassembled for inspection following this chloride intrusion, and the fuel rods from the assembly stored in the spent fuel pool until replacement non-fuel components were received in 1974. When MS-557 was reassembled in 1974, center spacer capture rod BK0136 and tie rod BP0406 (which had been damaged during disassembly/reassembly) were not included in the reconstructed assembly. The two fuel rods were placed in a container for individual fuel rods and stored in the spent fuel pool. From 1974 to 1979 there was no documentation of the location of the two fuel rods. Records dated 1979 and 1980 show the fuel rods in the container stored in the spent fuel pool. Records prepared after 1980 do not mention the fuel rods or the container. Significant work, including two re-racks and shipments of miscellaneous irradiated components from the spent fuel pool, occurred between 1980 and 1992.

The licensee made a telephone report to the NRC Operations Center on December 14, 2000, and submitted a written Licensee Event Report on January 11, 2001. The licensee formed a dedicated investigative review team, as well as an independent management review team to concurrently review the overall investigation effort. The licensee's investigation expanded through January 2001 to a peak of about 25 full time personnel and continued until October 2001. Although the current licensee for Millstone

Unit 1 is Dominion Nuclear Connecticut, the Fuel Rod Accountability Project (FRAP) was directed, staffed, and funded by Northeast Utilities, the former licensee for the Millstone Station. The continued involvement of Northeast Utilities was a condition of the purchase of the Millstone Station by Dominion, which occurred on March 31, 2001.

The licensee's investigation included identification and evaluation of possible scenarios for disposition of the two fuel rods, interviews of personnel who might have worked with the rods or been aware of activities involving the rods, searches of the spent fuel pool to determine if the two rods were still somewhere in the pool, and searches of records to determine if documentation existed describing the disposition of the rods. Personnel interviews and records reviews were the methods used in the action plans for detailed scenario investigation onsite at Millstone.

Dominion Nuclear Connecticut submitted the final report of the Millstone Unit 1 FRAP to the NRC on October 5, 2001. The licensee concluded that the fuel rods were safely located in a facility that is licensed to either store or dispose of radioactive material. Specifically, the investigation determined that the rods are: (a) in an undetermined location in the Unit 1 spent fuel pool; (b) at General Electric Company's Vallecitos, California nuclear fuel research facility; or (c) at one or both of the low-level radioactive waste disposal facilities in Barnwell, South Carolina (Barnwell) or the Hanford reservation in Richland, Washington (Hanford). Further, the FRAP concluded that the likelihood that the rods remain in the Unit 1 spent fuel pool or are at GE's Vallecitos nuclear facility was low, and that the low-level radioactive waste facility at Barnwell had the most significant opportunity to receive the rods.

NRC Region I led a special inspection with staff from the Offices of Nuclear Reactor Regulation and Nuclear Material Safety and Safeguards, onsite in October of 2001, and continuing through December 2001. The focus of the special inspection was to perform a thorough and systematic review of the licensee's investigation to determine adequacy. The special inspection team was also chartered to assess the licensee's root cause analysis, and to determine if the licensee was in compliance with NRC regulations. As a result of the special inspection, the NRC team concurred in the licensee's conclusion that the low level radioactive waste facility at Barnwell had the most significant opportunity to receive the rods, with an opportunity also existing to some small degree for the inadvertent shipment of the fuel rods to Hanford. The NRC team also concluded that, while it is highly unlikely the rods in their entirety remain in the Millstone 1 spent fuel pool, it is possible that fuel pellets or fragments remain on the spent fuel pool floor as a result of the cutting methods used to process waste hardware. The inspection team did not concur with the licensee that GE Vallecitos was a potential location for the fuel rods, and determined that GE Vallecitos was not a plausible location.

The State of Connecticut has been involved in the monitoring of the licensee's activities since November 2000. The States of South Carolina and Washington were contacted when the licensee identified the transport of the fuel rods to the low-level waste sites at Barnwell and Hanford as potential scenarios. California was contacted when Vallecitos was identified as a potential scenario. Weekly conference calls involving these

stakeholders began in January 2001 and continued through December 2001. Routine NRC inspections were conducted by Region 1 inspectors during January, February, May, June, and August, including oversight of the licensee's spent fuel investigation. Dominion Nuclear Connecticut, Inc. (DNC) representatives visited Region I on April 23, 2001, to present a report on the status of their investigation.

Section 1. Review of Licensee's Fuel Rod Accountability Project (FRAP) Investigation Process

1.1 FRAP Project Management

a. Inspection Scope

The inspectors reviewed the method and approach of the licensee's FRAP, evaluated the process and procedures developed for the project, assessed the qualification and experience of the personnel selected to staff the project, and evaluated the effectiveness of management involvement and oversight.

b. Observations and Findings

The inspectors reviewed procedures M10063, "Project Plan;" M10063-1, "Guideline for Administrative Controls", and M10063-6, "Guideline for Project Training." The guidance documents provided sufficient controls for the overall project plan and process guidance, documentation criteria and documentation control, and training expectations and documentation.

The inspectors interviewed the FRAP Executive Sponsor (Vice-President, Northeast Utilities) and the Project Manager, who reported that the search for the missing fuel rods originally started as an effort under the supervision of the Unit 1 Operations Manager. As it became apparent that the goal of finding the two missing fuel rods would not be resolved expeditiously, the decision was made to form the FRAP, as well as an Independent Management Review Team. The Independent Management Review Team was composed of senior-level industry experts whose role was to provide oversight to the growing search effort and assure that all possibilities were addressed by the FRAP to explain what happened to the missing fuel.

The inspectors reviewed records documenting the qualifications of selected FRAP personnel for appropriate background, experience and training. Personnel had extensive background and experience in the nuclear power industry and experience in task force investigations such as the FRAP. All personnel files reviewed contained documentation indicating completion of the expected training.

c. Conclusions

The inspectors concluded the project was well managed. As the program expanded from the initial investigation to a dedicated project, the licensee developed appropriate

and satisfactory project plans, descriptions, and guidelines. Personnel with appropriate qualification and experience were selected to staff the Project, and the training required by licensee procedures was conducted. The Independent Review Team provided sufficient oversight and contributed to the completeness and thoroughness of the final investigation.

1.2 Licensee Physical Inspections

a. Inspection Scope

The inspectors reviewed the planning, execution and documentation of the physical inspections performed to locate the spent fuel rods.

b. Observations and Findings

The inspectors reviewed FRAP Procedure 10063-2, "Guidelines for Physical Inspection." The document was found to provide appropriate and complete guidance for the conduct and documentation of the physical inspection of the spent fuel pool. The document provided guidance on the review of prior inspections, identification of search areas, development of inspection techniques, and establishment of acceptance criteria. Incorporation of the inspection results into the scenario dispositions was also addressed.

The inspectors reviewed the FRAP document titled "Scenario Dispositions 5.1.1-5.1.38, Physical Inspections, Rev. 1." The document reflected an extensive review of all proposed scenarios involving the missing fuel rods still being located in the spent fuel pool. By FRAP management decision, all scenarios involving the rods being located in the spent fuel pool were investigated by physical inspection regardless of assessed likelihood.

The inspectors reviewed documentation related to the spent fuel pool free space inspection, "Memo FRAP-01-52", which included extensive documentation of the debris under the fuel racks. The inspection of spaces and gaps in the spent fuel pool utilized a combination of visual and radiation monitoring.

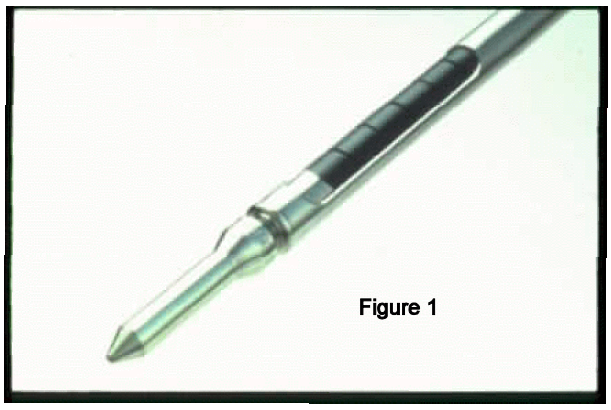
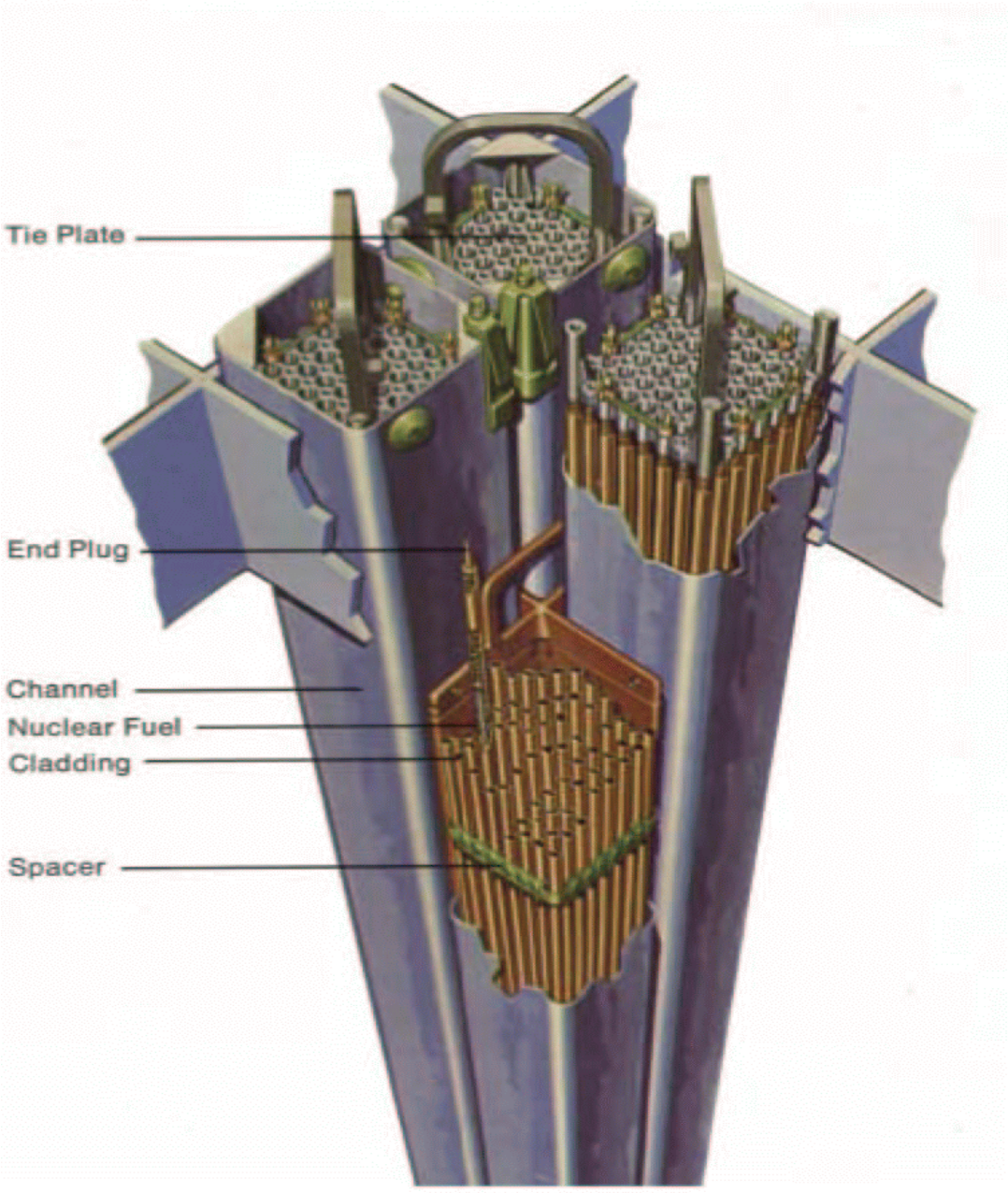


Figure 1

The inspectors interviewed FRAP staff concerning the conduct of spent fuel pool inspections. Licensee staff said that pool inspections addressed the possibility that the two missing fuel rods had been placed within another assembly in the storage racks and therefore were not readily visible in the racks. No record was found indicating such an action had occurred, and it could only have been accomplished by removing the tie plate from the top of

the assembly. Figure 1 is a cutaway illustration of a fuel rod, and Figure 2 illustrates the components of a fuel assembly. Removal of the tie plate would have disturbed the corrosion film covering the tie plate and fasteners, markedly changing the appearance of the assembly hardware and enabling clear identification of assemblies that had been

Figure 2



altered. The licensee concluded that only those assemblies on which these components were shiny and without a corrosion film could have been candidate assemblies within which to place an individual rod. Assemblies not showing evidence of disassembly were presumed to be intact and unchanged since discharge from the reactor. These inspections included observation of the tops of all 2884 assemblies in the pool for indication of prior disassembly. Twenty-nine assemblies showing evidence of disassembly were inspected by the FRAP to confirm that records for all fuel rods were as expected, including recorded high resolution video examination to view and count each rod in these assemblies. The licensee did have records indicating disassembly of some fuel in the spent fuel pool for a variety of reasons since the plant began operation. In all cases, assemblies identified by inspection that showed evidence of disassembly confirmed the records indicating that these assemblies had been altered, and additionally the number of fuel rods in each assembly was verified.

The inspectors reviewed selected videotape records of spent fuel pool and fuel assembly inspections. The videos documented a methodical search of all the fuel assemblies for indications of disassembly. Video documentation of the inspection of non-fuel areas was complete except for inaccessible areas (e.g., the spent fuel pool sump was covered by a plate with small openings, and was located under the fuel racks). Areas with loose sediment or silt were visible on the videotapes of the searches, in some places to a depth greater than the diameter of a fuel rod. The licensee had reached areas under the fuel racks using a crawler robot with a camera mounted on it, and had used a probe, also mounted on the crawler, to push through the silt layer while observing with the video camera. A plow-like attachment was also used to displace the sediment in some areas, to enable viewing through the camera for objects within or under the sediment. The probing instruments were designed to detect objects one foot or longer in length. The licensee concluded in the memo identified as “FRAP-01-0157" that the only remaining potential location in the spent fuel pool involves the rods having been cut into many small segments which would allow them to be in several locations in the spent fuel pool and not visually identifiable.

As noted in the FRAP report, the Project chose not to disassemble and inspect the rods in each assembly in the spent fuel pool due to radiation exposure considerations, the risk of a fuel handling accident, and difficulties associated with reading the serial numbers on the individual fuel rods. Project staff also stated that GE personnel were not able to retrieve serial number data for all the individual spent fuel rods at Millstone 1 because some records no longer existed. Based on the completeness of the inspection conducted on the fuel assemblies that showed evidence of disassembly and the very limited potential information to be gained, the licensee decided not to conduct an examination of all the individual fuel rods in the spent fuel pool.

c. Conclusions

The physical inspection process was thorough and comprehensive. The documentation of the spent fuel pool physical inspections was complete. The FRAP augmented and/or repeated earlier inspections where it was not clear that the earlier inspection had been

sufficiently thorough or rigorous. Video documentation was complete except where circumstances or accessibility made that impossible. The inspectors agree with the licensee's conclusion that the possibility of the missing fuel, either as intact rods or large segments, remaining in the spent fuel pool is limited and unlikely.

1.3 Licensee Scenario Investigation and Disposition

a. Inspection Scope

The inspectors reviewed the general approach to defining the possible scenarios for fuel pin disposition, evaluated the FRAP assessment of the scenarios for plausibility and for investigation, evaluated the process used to resolve uncertainties and differing opinions, and reviewed conclusions for reasonableness.

b. Observations and Findings

The inspectors reviewed Procedure M10063-5, "Guideline for Scenario Development and Investigation," which provided general guidance on the process to be followed for identifying the scenarios which could explain the loss of the fuel rods and the process for investigating those scenarios for plausibility. The document provided adequate guidelines to define the process, while allowing adequate flexibility to enable all potential scenarios to be identified.

The inspectors interviewed FRAP staff regarding the initial scenario development process. Following the initial development of the scenario population by a team brainstorm process, each scenario was further developed by a formula write-up of the basic questions: who, what, when, where, why, and how. Group meetings were held to review the write-ups. Two members were assigned to develop an initial assessment of each scenario. Group meetings were again conducted to review likelihood, plausibility, and required investigative actions for each scenario. Following appropriate investigative actions, which included inspections, interviews, and document reviews, the group reviewed the results. Documentation of the investigation into each scenario was prepared.

The inspectors reviewed summaries documenting meetings held to discuss FRAP scenarios. Review of these summaries indicated that detailed discussions were conducted for the scenario development process, with exhaustive and methodical consideration of possibilities. The licensee identified a total of 75 scenarios for evaluation. Of the 75 scenarios, 12 were considered implausible and not evaluated further. Twelve scenarios were investigated fully, through use of detailed action plans. Ten scenarios were addressed through one or more specific confirmatory investigative actions, and 41 scenarios were addressed through physical searches conducted in the Millstone 1 spent fuel pool or elsewhere at the Millstone Station.

The inspectors reviewed selected scenario documentation including: Scenarios 5.1.1 through 5.1.38, "Physical Inspections," which documented all the spent fuel pool

scenarios, 5.2.1 a & b, “Transfer and Storage at Low Level Waste Storage (Bunker)”, 5.4.1, 2 & 3, “Barnwell 1988, 1989 & 1990, & 1992”, 5.7.1, 2 & 3, “Theft or Diversion”, and 5.8.1 a & b, “Shipped Offsite but not GE, Barnwell, or Hanford.”

c. Conclusions

The scenario development and investigation process was good. Initial development was comprehensive and the investigative process was thorough and meticulous. The documentation and analysis of the scenarios were also thorough and complete.

1.4 Licensee Interviews

a. Inspection Scope

The inspectors reviewed the methodology and results of the interview process used by the licensee, and assessed the effectiveness of the methodology and the completeness and comprehensiveness of the results.

b. Observations and Findings

The inspectors reviewed Procedure M10063-4, “Guideline for Interviewing.” Extensive guidance was provided on the conduct and subject areas for the in-person interviews. Detailed and structured guidance was provided for the phone interviews, including a list of specific questions to be asked. The guidance provided was thorough and appropriate.

The inspectors discussed with FRAP staff the development process for selecting the personnel to be interviewed. Interviews were important elements in each of the detailed action plans developed for the scenarios designated by the FRAP as requiring full investigation. Candidates were classified as primary or secondary, with primary classification indicating a greater possibility for the individual to provide significant information. The initial selection of the primary and secondary interviewees was based on documented past work and likelihood of direct involvement of individuals with the missing fuel rods. This selection process was done as part of a group review by the FRAP team. Over 200 people were interviewed by the FRAP, with about 100 primary and 100 secondary interviews. The primary interviews were typically held face-to-face, with the interviewee and two interviewers from the project team. The number of two-person FRAP interview teams was limited to only two in order to maximize consistency in the interview process. Secondary interviews were typically conducted via telephone by a FRAP team member who used a scripted list of questions. Group meetings were conducted weekly to review interview results in order to maximize the dissemination of information and lessons learned among all members of the FRAP. Where the telephone interviews indicated a potential of an individual’s greater involvement than previously anticipated, these individuals were included in subsequent in-person interviews. The formalized interview process developed for the FRAP was effective and provided for consistent results and effective dissemination of the information obtained.

The inspectors reviewed documentation of selected interviews and spoke with several interviewees, one of whom had extensive involvement in packaging and shipping radioactive material from the spent fuel pool offsite. In discussions with the inspectors, this person provided additional information concerning the shipments to Barnwell in 2000. Based on this information, which was not recovered by the licensee's interview process, the inspectors concluded the shipments in 2000 did not contain the missing fuel rods (discussed in section 3.4 of this report).

c. Conclusions

The licensee's interview process was well planned and rigorously conducted. Documentation was extensive and indicated that the interviews were complete and thorough. Appropriate reviews of the results were conducted for lessons learned and potential new investigative directions, and information was effectively used to improve subsequent interviews. A question was raised regarding the completeness of information obtained from one interviewee. The inspectors concluded that the additional information obtained by the inspectors did not alter but supported the conclusion of the FRAP that Barnwell had the most significant opportunity to receive the fuel rods, and also that this example did not indicate a broader concern regarding the effectiveness of the FRAP interview process.

Section 2. Loss of Accountability

2.1 Investigation of Past Processing of Irradiated Hardware

a. Inspection Scope

The inspectors reviewed the licensee's investigation of past activities in the spent fuel pool to process various irradiated hardware components for shipment as waste. In particular, the review focused on the processing of items that appeared similar to fuel rods, which the licensee identified as including local power range monitors (LPRMs), source holders, and dry tubes.

b. Observations and Findings

The licensee described various items of irradiated hardware that do not contain fuel but do appear similar to fuel rods, that had been removed from the reactor core and placed in the spent fuel pool as waste during operations at Millstone 1. The missing fuel rods are 0.57 inches in diameter and 158 inches (13 feet, 2 inches) long. Portions of LPRMs are 0.7 inches in diameter, and full length LPRMs are 42.6 feet long. LPRMs include a "hot end" and a "cold end" (identified in these terms based on their radiation levels at the end of their useful service life). The "hot end" is located in the reactor core region during service, becoming activated by the neutron flux in the core and therefore significantly radioactive. LPRM hot end contact radiation exposure rates at Millstone have ranged from 10,000 to 25,000 R/h, which is substantially greater than the contact exposure rates of 1,600 R/hr in 1980 estimated by the licensee for each of the missing

spent fuel rods. The “cold end” of the LPRM was never exposed to the core neutron flux and therefore did not become activated, but is contaminated on its surface. At the end of its useful life, the LPRM is removed from the core and taken into the spent fuel pool for storage. Typical LPRM processing at Millstone 1 has included separating the hot end from the cold end, initially producing a hot segment just under 13 feet in length.

The licensee also identified source holders and dry tubes as other items in the spent fuel pool resembling the missing fuel rods. Source holders are 0.7 inches in diameter and 13 feet, 2 inches long, and dry tubes are similar. Licensee procedures for source holder removal did not specify where in the spent fuel pool source holders removed from the core were to be stored. Three source holders cannot be accounted for by the licensee, leading the licensee to conclude that they have been disposed of as waste. Source holders and dry tubes do not contain special nuclear material and there is no NRC requirement to account for these objects, only that they be controlled as radioactive material.

The FRAP investigators examined in depth the possibility that the two missing spent fuel rods were mistakenly processed as irradiated hardware, cut into segments along with LPRM hot ends or source holders or dry tubes, and shipped to a low level waste burial site for disposal along with other similar looking materials. The licensee identified three separate campaigns during which irradiated waste hardware in the spent fuel pool was processed, including the planned cutting of LPRMs into segments for disposal. These campaigns were conducted during September-October 1979, August 1984, and January-February 1985.

September-October 1979 Processing Campaign

A contractor company (Crouse) performed processing activities on irradiated hardware, including cutting of LPRMs, in the spent fuel pool during this period of time. The FRAP investigators characterized the contractor as having limited experience in identifying reactor components. Additionally, interviewees told the licensee that supervision of the contract workers by licensee personnel was not very rigorous, and the licensee’s supervisors were not experienced in refueling floor activities.

As noted previously, LPRM hot ends appear similar to the missing fuel rods. Personnel who are unfamiliar with the various hardware objects found in the spent fuel pool may not have distinguished between fuel rods and LPRM hot ends. The licensee also noted that contractor personnel did not have available visual aid equipment, such as a borescope or underwater video camera, to examine items in the pool more closely. Contractor personnel interviewed by the licensee also indicated that they expected that fuel would only be stored in the racks, and that they were told not to touch anything in the racks. Since the missing rods were apparently stored along the spent fuel pool wall in the northwest corner, outside the racks and tied to the railing, it seems plausible that the contractor workers could have mistaken the two fuel rods for other irradiated hardware. The licensee provided the inspectors with photographs from 1985 showing very crowded conditions, with numerous ropes or cables tied to the railing and leading

down into the spent fuel pool. The licensee stated that such a condition, with many items tied to the railing, was also common in the 1979-1980 time frame. The licensee has recognized the possibility for errors presented by such crowded storage and by mixing spent fuel/special nuclear material in with other items. While not specifically prohibited by procedure, the licensee stated that it has been standard practice at Unit 2 and Unit 3 not to store fuel anywhere in the spent fuel pool except in the fuel storage racks, and this is also current practice at Unit 1. The inspectors confirmed the licensee's current practice of restricting fuel storage to the racks.

The inspectors requested that the licensee obtain records for spent fuel pool water chemistry samples in 1979 and 1980 to determine if there was any information regarding radioactive material in spent fuel pool water during these years. The licensee was able to retrieve only one record (dated March 21, 1980) for the two year period, which provided gamma spectroscopy analysis results for a 500 ml sample of spent fuel pool water. The licensee was not required by the NRC to retain these records, and this single set of data provided little perspective on trends in spent fuel pool water radionuclide concentrations.

The licensee postulated that, if the rods had been processed during the 1979 cutting campaign, this could explain why no personnel interviewed recalled seeing the rods in the pool. According to the radiation work permit records obtained by the FRAP, LPRM cutting was performed for 19 days during September and October 1979. Based on licensee data, 23 LPRMs would have been available in September 1979 in the spent fuel pool for the contractor to cut. The radiation work permits indicate that the contractor cut the LPRMs and placed the segments into storage liners in the spent fuel pool for future shipment. Licensee investigators determined through interviews that cutting was performed during this campaign using a crimping shear, and possibly a saw. The licensee acknowledged that fuel pellets or pellet fragments could have fallen onto the floor of the spent fuel pool during the process of cutting the fuel rods. Use of a saw to cut the fuel rods would have made it more likely that fuel material could have fallen onto the spent fuel pool floor, although licensee personnel did not believe that whole fuel pellets would have easily slipped out of the fuel cladding tube without being noticed. If the crimping shear had been used for cutting, it is more likely fuel pellets and fragments would have been contained because the design of the shear was intended to crimp the ends of cut tubing to prevent materials from coming out of the tube.

August 1984 Processing Campaign

The August 7-8, 1984, LPRM cutting campaign was performed by Unit 1 Operations Department personnel. An experienced Senior Reactor Operator was responsible for refueling floor operations during this two-day campaign. Personnel interviewed by the licensee stated they were highly trained and intimately familiar with the fuel and fuel handling operations. No personnel interviewed recalled seeing the two fuel rods, or the 8-rod container used to store the two individual rods on the side of the spent fuel pool, during this time period.

January-February 1985 Processing Campaign

GE was the contractor performing LPRM cutting operations during the campaign from January 24 - February 1, 1985. A detailed procedure was written specifically for the work conducted during this campaign, and was approved by the Plant Operations Review Committee. The contractor cut 38 LPRM hot legs, and each one was a 23 foot long section at the start of the work. It is implausible these 23 foot long sections could have been mistaken for 13 feet, 2 inch long fuel rods. In addition, the licensee determined that the GE personnel on the project were experienced workers who would have been expected to recognize the differences between fuel rods and LPRM sections. The licensee also interviewed the Northeast Nuclear Energy Company project manager for the campaign, who recalled that the GE LPRM cutter was positioned 5-10 feet below the water surface of the spent fuel pool, which was close enough to the surface for good visibility of the items being cut. The licensee concluded that the available information for this campaign provides clear and convincing evidence that the fuel rods were not inadvertently cut during this project.

c. Conclusions

The licensee's evaluation of possibilities for inadvertent cutting of the missing spent fuel rods was thorough. The inspectors concluded that the licensee's assessment was reasonable, and the September - October 1979 irradiated hardware processing campaign in the spent fuel pool presented the most likely opportunity for the missing fuel rods to have been cut.

2.2 Control and Accounting of Special Nuclear Material

a. Inspection Scope

The inspectors reviewed the licensee's program and procedures for controlling and accounting for discrete items containing special nuclear material. The examination addressed the adequacy of the licensee's written material control and accounting procedures and included review of (1) historical procedures, (2) procedures currently in use, (3) general material control and accounting program implementation (including inventory practices and internal transfers), and (4) documentation of external transfers of special nuclear material. The inspectors also reviewed the licensee's reconciliation of various data sources regarding accounting of special nuclear material.

b. Observations and Findings

Historical procedures

The inspectors reviewed Operations Procedure No. 1001, "Fuel Inventory and Control" (dated January 1972), which was in effect when rods BK0136 and BP0406 were removed from assembly MS-557, and Reactor Engineering Procedure No. 1001, "SNM Inventory and Control" (dated September 1978), which was in effect when the rods were

identified and recorded in the Unit 1 Kardex® inventory card file. In both procedures, the fuel assembly is defined as the basic unit of special nuclear material. The 1972 procedure designates core instrumentation (source range monitors, intermediate range monitors, local power range monitors and traversing in-core probe monitors) as special nuclear material, and the 1978 procedure specifically defines fission detectors as special nuclear material, although these units contain significantly less special nuclear material than an individual fuel rod. Although individual fuel rods outside of an assembly are not specifically designated as units of special nuclear material in the two versions of Procedure 1001 reviewed, both also include the special nuclear material category "any other material designated by the Reactor Engineer." The Reactor Engineer is assigned responsibility for preparing and maintaining records of transfer and inventory of special nuclear material.

The procedures require periodic physical inventory of all special nuclear material, consisting of a piece count of the spent fuel pool contents and comparison with the most recent spent fuel pool map. This is also the current method of inventory. Performance of the piece count entails counting the number of items located in a specified area (such as a section of the spent fuel pool racks) and comparing the total count with the number of items shown on the map. The inspectors noted that procedures specify performance of a piece count inventory but provide no guidance on how to perform the piece count.

Loss of accountability of the two spent fuel rods from assembly MS-557 occurred because of several instances when personnel failed to follow the material control and accounting procedures in place at the time and due to inadequacies of the procedures themselves. The Reactor Engineer did not identify the two rods as "other special nuclear material bearing items" when the assembly was reconstituted without them (1974), although these were discrete items and clearly fit into the "other" category defined in the procedure. Inventory cards were not generated for the two fuel rods at that time, an error which was corrected in May 1979 when the Reactor Engineer noticed the two fuel rods in the spent fuel pool, positively identified them, and initiated Kardex® inventory cards. However, once Kardex® inventory cards were generated in May 1979, these Kardex® records were not subsequently maintained as required. In fact, when the FRAP investigators discovered the two cards in June 2000, they had not been updated since 1979.

Physical inventories (as defined in the written procedure) were not sufficient to identify that the two rods were no longer in the location indicated by the spent fuel pool maps. When the rods were omitted from the map after April 30, 1980, it was not recognized that a change from the previous map had occurred. No record was created to cause spent fuel rods BK0136 and BP0406 to be carried as separate items for comparison with subsequent inventory piece counts. Even though the Kardex® cards were generated, the data about these two fuel rods was not brought into the licensee's inventory process. The licensee has concluded that the two rods were misidentified and mistakenly processed as irradiated hardware, an action that would not have required use of a material transfer form, nor generated any special record when it occurred.

Therefore, the omission of the two rods from the spent fuel pool map created after April 30, 1980, assured that there would be no future inventory discrepancy.

Comments from licensee personnel indicated that in the 1980 time frame, staff would probably have viewed the two individual rods as part of the reconstructed MS-557 assembly. Once the rods were positively identified in May 1979, there would not have been an inventory discrepancy, since MS-557 was accounted for already and shown on the spent fuel pool map. The method of calculating and tracking the special nuclear material balance for spent fuel assemblies over time may have encouraged the mindset that individual rods remained part of an assembly regardless of the physical location within the spent fuel pool. The computerized tracking method uses a single decay factor, enabling a single calculation for decay correcting an entire assembly. To separately track each fuel rod in an assembly would require 49 individual calculations, a significant increase in number and complexity of calculations. While it is clearly possible to perform the additional calculations, the licensee indicated the inclination to avoid the need to perform calculations for individual rods. The licensee confirmed that, until the two missing fuel rods were determined to be missing in November 2000, the two rods had continued to be shown in the special nuclear material inventory accounting records as if they were still part of assembly MS-557.

Current Millstone Station material control and accounting program implementation (including current inventory practices and internal transfers)

The inspectors interviewed Reactor Engineering personnel from Units 2 and 3 in order to gain an understanding of the licensee's implementation of the material control and accounting and fuel handling procedures. Licensee personnel interviewed displayed a thorough understanding of the requirements and written procedures.

The inspectors reviewed the current material control and accounting procedures, which included the following improvements compared to earlier versions: provision for recording and tracking items of special nuclear material that are generated during fuel assembly reconstitution and other non-standard special nuclear material movement; an instruction to compare the results of a physical inventory with those of the previous physical inventory; and designation of fuel rods (in addition to assemblies) as units of special nuclear material.

Procedure MC5, "Special Nuclear Inventory and Control" (dated August 2001), is the overarching material control and accounting procedure. Each of the three Millstone Units has a written procedure that provides specific instructions on special nuclear material inventory and control. Each unit also includes in its fuel handling procedure references to the material control procedures. Additional procedures have been developed to cover the special nuclear material accounting program, preparation of required reports, accounting for sealed sources, and maintaining the master list of special nuclear material.

As described by Millstone personnel, there are three item control areas used to keep track of special nuclear material for special nuclear material accounting purposes: the new fuel storage area, the spent fuel pool, and the core (at Unit 1, the spent fuel pool is currently the sole active item control area). New fuel is received in sealed containers, for which the shipper generates a Form 741 at time of shipment, and submits the form to the Nuclear Materials Management and Safeguards System. (The Nuclear Materials Management and Safeguards System is operated by the U.S. Department of Energy, and is the official government database for tracking transfers of special nuclear material in the United States.) The nuclear material received is confirmed by the receiver, also by report to the Nuclear Materials Management and Safeguards System. At Millstone, a Kardex® file card (record) is then initiated for the item. After the new fuel containers are opened, assembly serial numbers are identified and verified. According to procedure, from this point on movements of fuel are to be identified and recorded on material transfer forms. An "executer" uses the material transfer form as instruction for movements to be performed, and a "verifier" follows the move as it is performed. Fuel movement is documented in accordance with applicable procedures. The material transfer forms for completed moves are later forwarded to the special nuclear material bookkeeper, who updates the Kardex® card file database and ShuffleWorks® computer map of special nuclear material locations.

The current spent fuel pool map is maintained and updated using the computer application ShuffleWorks®, not manually as it was in the past. As described by licensee personnel, physical inventory includes examination of individual cell locations in the storage racks and a count of the number of assemblies in the spent fuel pool. Items that do not contain special nuclear material, such as moveable in-core detectors and local power range monitors, are inventoried along with assemblies and other special nuclear material items. Per procedure MC5, a piece count inventory of the number of items in a discrete portion of the item control area (such as a rack within the spent fuel pool) is compared with the expected number of items shown in that area per the database as reflected on the current spent fuel pool map. The physical inventory does not include visual verification of the identity of all spent fuel pool contents, but compares the total number of items in a rack area with the corresponding number of items shown on the spent fuel pool map.

The inspectors reviewed video taped records of the Millstone Unit 1 spent fuel pool contents inventory, which were prepared by licensee personnel during the most recent survey. The inspectors compared the assembly locations specified in the official record of the September 2001 special nuclear material inventory (map) with the locations shown in the video record for a sample of items. There were no discrepancies.

Past practices at Unit 1, such as hanging fuel rod containers from the spent fuel pool rails, had created the potential for misidentification of individual fuel rods. The licensee stated the practice at Units 2 and 3 has always been to restrict fuel storage only to the racks. Based on interviews of Reactor Engineering personnel, the inspectors noted that current practice is to store all special nuclear material items in distinct and specific locations, defined as the spent fuel pool racks for spent fuel. There are procedural

controls for storage of both spent fuel assemblies and individual rods that require approval of Millstone Station management before material could be stored in different spent fuel pool locations (MC-5, Rev. 3 and EN 21001, Rev. 021-01 are examples). This approach has been successful in controlling the location of spent fuel (including individual fuel rods) at Millstone Units 2 and 3.

Documentation of external transfers of special nuclear material (Form 741)

A nuclear transfer report, form NRC/DOE-741, must be completed for each shipment or receipt of special nuclear material. Procedure MP-13-SNM-PRG, "Millstone Special Nuclear Material Control and Accountability Program," assigns responsibility for preparation of 741 reports to the Special Nuclear Material Accountant.

The inspectors examined a sample of 741 forms for shipments and receipts of special nuclear material. Back-up documents were also reviewed and were found to support the information in the 741 forms. No concerns were identified with the special nuclear material transfer forms in this sample.

The national Nuclear Material Management and Safeguards System had prepared a report for Millstone of all shipments and receipts documented using Form 741 for the period February 1969 through March 2000. The report lists individual line items that appear in all Forms 741 for the specified period. Using the report, the licensee confirmed that all known historical shipments of individual fuel rods, including shipments of segmented test rod segments, were documented in 741 forms. NRC independently confirmed that all shipments and receipts in the Nuclear Material Management and Safeguards System records balanced. Rods BK0136 and BP0406 were not listed in the report, indicating they had not knowingly been shipped from Millstone identified as special nuclear material.

Several 741 forms of importance to the investigation were also reviewed, including the 741 form documenting the shipment of four segmented test rod segments to GE-Vallecitos Nuclear Center in April 1980 (FRAP Report Scenario 5.5.1). The inspectors noted that this 741 form listed the address of the receiver (GE-Vallecitos) as Waterford, CT and included the remark, "Material transferred to General Electric FOB Waterford, Connecticut." According to GE representatives, NRC license SNM-1270 authorized receipt of material by GE of special nuclear material at Millstone (Waterford, CT) for transport. Transported material was then delivered to GE-Vallecitos and accepted by GE under NRC license SNM-960.

Reconciliation of Various Data Sources

The licensee had identified a number of sources of data regarding what special nuclear material was expected to be contained in the Unit 1 spent fuel pool, and had analyzed special nuclear material data for Millstone 1 contained in the following sources:

- Kardex® card file
- Spent fuel pool maps
- Millstone special nuclear material accountability system
- Nuclear Material Transaction Records (Forms 741)
- Millstone material transfer forms
- GE records
- Fuel assembly reconstitution records
- ShuffleWorks® computerized database display output

The licensee had determined there were numerous differences between the various sources of special nuclear material data, and stated that a focus of the spent fuel pool data reconciliation work during 2000 was to resolve these differences. The reconciliation work had first identified that the two spent fuel rods were not accounted for, as well as other record discrepancies which had been resolved. After resolution of data discrepancies, the licensee had visually verified the identity and location of spent fuel in the Unit 1 spent fuel pool and compared the data with the expected location of special nuclear material from the records. This verification confirmed that there was no special nuclear material unaccounted for other than the two missing rods; however, eight fuel assemblies were found to be in different rack locations than indicated in the records. Of these eight discrepancies, some were the result of misplaced Kardex® cards (which were later found), some were due to transcription errors, and some were erroneous database entries. The licensee stated these location discrepancies did not constitute special nuclear material accounting discrepancies because the item control area is defined as the entire spent fuel pool, and there was complete and balanced accounting of special nuclear material within the spent fuel pool item control area.

The licensee conducted a similar physical verification of the database during 2001 for Unit 2 and Unit 3. No discrepancies in spent fuel positions within the spent fuel pools were identified on either Unit 2 or 3 as a result of this review.

Spent fuel pool maps were, and continue to be, the record used during piece count inventories of the spent fuel pool. The inspectors reviewed selected Unit 1 spent fuel pool maps and noted the following regarding the two spent fuel rods:

Date of Spent Fuel Pool Map	Description
March 8, 1978	No notation of separate fuel rods.
March 13, 1979	A block drawn in the lower right corner of page is labeled “fuel rods”, although it is shown as outside of the spent fuel pool (near the southwest corner of the pool).
February 26, 1980	A block shown in northwest corner of the spent fuel pool, labeled “2 fuel rods MS-557".
April 30, 1980	Identified as “Rev. 1". Apparent updated photocopy of previous map, showing the fuel rods in the same position in the northwest corner.
September 18, 1980	Identified as “Rev. 2". No notation of separate fuel rods.

The licensee's material control procedures (Procedure 1001, "Fuel Inventory and Control," dated January 1972; Procedure 1001, "Special Nuclear Material Inventory and Control," dated September 1978; and Procedure MC5, "Special Nuclear Material Inventory and Control," dated July 2001) defined when preparation of a material transfer form was required for movement of special nuclear material. The procedural requirements have become more stringent over time. The 1972 procedure required the form to be used for movement "across the boundaries of a material balance area"; the 1978 procedure required the form to be used for movement "within or across the boundaries of an item control area"; and the 2001 procedure required the form to be used for movement "into, out of, or within item control areas."

According to FRAP investigators, no material transfer form could be found describing the disassembly of MS-557 on October 6, 1972. Material transfer forms were expected to have been generated to reflect the movement of all the individual fuel rods from the MS-557 assembly and into a total of seven eight-rod storage containers elsewhere in the spent fuel pool. Investigators concluded that the material transfer forms were not generated for the individual rod moves, nor were spent fuel pool maps updated to show the stored rods. The same conclusion was reached for the subsequent reassembly of MS-557 fuel rods (excepting two rods) on May 4, 1974. No record apparently exists of these two sets of fuel rod movements, therefore not generating any record of the two fuel rods that were not incorporated into the new "scrap" assembly of MS-557 fuel rods. Licensee personnel did not follow the existing procedure requirements in effect at the time for recording and tracking movement of special nuclear material. Other examples of failure to follow procedures were demonstrated by the presence of Kardex® cards in the file indicating positions in the spent fuel pool for items that were actually no longer in the spent fuel pool.

The inspectors requested information regarding those Kardex® cards, if any, remaining after all items physically verified as present in the Unit One spent fuel pool had been

accounted for. The licensee identified 32 cards remaining in the card file with outdated and incorrect entries, determined by visual inspection and review of records. The cards indicated the items were in the spent fuel pool, although the licensee verified that the items were not in the spent fuel pool. The licensee was able to account for all special nuclear material in question. The problem was determined to be record-keeping: the cards had not been properly updated. No additional discrepancies of special nuclear material were identified.

c. Conclusions

The inspectors concluded that accountability of the fuel rods BK0136 and BP0406 was lost sometime after 1979 because Millstone Unit 1 failed to follow procedures, and because the procedures that were in place when the rods were entered into the inventory system were not adequate. A complete physical inventory of special nuclear material, sufficient to account for all special nuclear material in the licensee's possession, was not performed at Millstone Unit 1 between 1980 and 2001. Moreover, Unit 1 failed to properly carry out the limited "physical" inventory called for in the written procedure in that they did not update the book inventory properly.

The inspectors found that the special nuclear material accountability reports appeared complete, except for the material contained in the two missing fuel rods. Accountability personnel rely on the Reactor Engineer to provide the special nuclear material data used to construct the nuclear material transfer (Form 741) and inventory (Form 742) reports. Accountability personnel do not judge the correctness and completeness of data provided by the Reactor Engineer, but accept it as provided.

The licensee's past practice of marking up previous spent fuel pool maps rather than redrawing the entire map also makes it likely that the spent fuel pool map records are unreliable sources of data. The April 30, 1980, map noted the fuel rods in the northwest corner of the pool; however the map notation appeared to be a photocopy of the previous map. This map therefore may not reflect verification of the actual presence of the fuel rods, but rather the practice of marking up map copies to show changes. The map dated September 18, 1980, appears to be a freshly drawn map (not a photocopy of the previous) and has no notation for the two fuel rods. Based on the unresolved discrepancies between the past maps, the inspectors conclude the past spent fuel pool map records are of limited value to resolve discrepancies or prove any conclusion regarding disposition of the two missing spent fuel rods.

10 CFR 70.51 requires that the licensee keep records showing receipt, inventory (including location), disposal, acquisition, and transfer of all special nuclear material in his possession; establish written material control and accounting procedures that are sufficient to enable the licensee to account for all special nuclear material in his possession; conduct annual physical inventories of all special nuclear material in his possession; and complete reports concerning special nuclear material received, produced, possessed and transferred.

Contrary to the requirements, the licensee failed to keep adequate records of the special nuclear material in irradiated fuel rods BK0136 and BP0406; failed to establish adequate written material control and accounting procedures sufficient to account for all special nuclear material in his possession; and failed to identify through physical inventory that the two rods were no longer in the location stated in the book inventory (the previous inventory updated by receipts and shipments). The inspectors informed the licensee that this was an apparent violation of regulatory requirements (**VIO 50-245/2001-013/001**)

Section 3. Transfer of Missing Fuel Offsite

3.1 Shipments from Millstone to Vallecitos Nuclear Center during 1980

a. Inspection Scope

The inspectors reviewed the licensee's investigation and conclusions concerning the possibility that the rods were shipped to GE-Vallecitos. The inspectors also contacted knowledgeable GE representatives and examined licensee data and records related to shipments of spent fuel from Millstone station to GE-Vallecitos.

b. Observations and Findings

The inspectors discussed with the licensee the supporting documents for the investigation scenario addressing the possibility that the two missing spent fuel rods had been shipped to GE-Vallecitos. Review of the available records confirmed that no records provide any evidence establishing that the missing rods were shipped to GE-Vallecitos. There were, however, some contemporaneous activities and occurrences at Millstone 1 in the 1979-1980 time frame that are not readily explained by the available records. These activities are described in the FRAP Final Report. For example, four segmented test rods were removed from assembly MSB-125 on May 5, 1979, and on the same day assemblies MS-557 and MS-330 were both moved to the fuel prep machine for the first time since MS-557 had been reconstructed in 1974. The two assemblies remained in the fuel prep machine for about 24 hours, in the midst of a refueling outage. There is no record available describing what activities, if any, occurred involving the assemblies while in the fuel prep machine. One week later, on May 12, 1979, GE personnel read the serial numbers on the two fuel rods contained in the 8-rod storage container located in the northwest corner of the spent fuel pool, and concluded that these were the two rods removed from MS-557 in 1972. The May 15, 1979, memo from the Reactor Engineer concurred in GE's conclusion.

The FRAP also concluded there is basis for uncertainty in the documentation of some items shipped to GE-Vallecitos. The basis for this conclusion described in the FRAP Final Report is the difference between the GE inventory of received reactor hardware (dated May 8, 1980) and the GE inventory of non-fuel hardware packed in the shipment (dated April 10, 1980). While this discrepancy indicates uncertainty in the

completeness of the records, it does not indicate that the two rods were cut up and sent in the shipment.

During the records review, the inspectors identified a GE plan dated March 20, 1980, describing the expected uses of the GE 1603 shipping cask, and discussed with the licensee how the plans described had been implemented. The licensee followed up on these discussions and determined that the same shipping cask used for the April 30, 1980, Millstone shipment to GE-Vallecitos had also been used to transport non-fuel materials from another nuclear power plant to GE-Vallecitos. Licensee personnel also determined that at another facility GE had cut spent fuel rods in the spent fuel pool, loaded the segments into the GE 1603 shipping cask, and shipped them to GE-Vallecitos in April 1979. This information showed that GE had previously cut spent fuel rods in spent fuel pools, shipped segments to GE-Vallecitos, and that personnel at GE-Vallecitos were accustomed to receiving cut segments of spent fuel rods. No additional information was identified, however, indicating that any fuel other than the four test rod segments were included in the shipment from Millstone to GE-Vallecitos, received at GE-Vallecitos on May 7, 1980.

Review of GE procedures showed that the receipt and subsequent processing of shielded cask shipments arriving at GE-Vallecitos were governed by detailed procedures. GE- Vallecitos inventories of special nuclear material have been maintained and periodically reviewed, including inspection by NRC. Inventory discrepancies between the special nuclear material materials received versus the materials anticipated to be received would have been expected to be documented in accordance with GE procedures in effect at the time. No indications of the two missing spent fuel rods from Millstone have been identified in the special nuclear material inventory and logs at GE-Vallecitos.

Three shipments of spent fuel from Millstone to GE-Vallecitos were completed as part of a joint fuel development project using segmented test rods. During the investigation of data regarding the possibility of shipping the missing fuel rods to GE-Vallecitos, the licensee noted that the reported value for the quantity of spent fuel shipped from Millstone to GE-Vallecitos during the period 1979-89 in NRC technical report NUREG-0725, revision 7, dated January 1991, was different than it had been in previous revisions of the report. Total spent fuel shipped from Millstone to GE-Vallecitos in the three shipments was listed as 36 kg in revision 6 to NUREG-0725, and listed as 43 kg in revision 7.

The licensee contacted the NRC office that published the NUREG-0725 data to determine why the value had been changed, and documented their findings in the FRAP Final Report. According to the NRC, the person responsible for originally recording the data had made limited and cryptic notes indicating a telephone call from GE and a value of 8.8 kg on pages related to the shipment that left Millstone on April 30, 1980. The official record of special nuclear material transfer, the DOE/NRC Form 741, for the shipment shows 2.4 kg shipped by Millstone and was confirmed as received by GE. In 1990 a different NRC employee apparently used the handwritten 8.8 kg value as the

basis for changing the data reported in NUREG-0725, although no documentation exists explaining this decision. Management of the Spent Fuel Project Office in the NRC Office of Nuclear Material Safety and Safeguards investigated the circumstances for the change of published values and determined that there had been no valid basis for changing the value in 1991, and that the value reported should be 36 kg for the 3 shipments. The Spent Fuel Project Office also indicated that the NUREG-0725 data is not the official record of spent fuel shipped; the official record is based on the Nuclear Material Transaction Report submitted by the shipper and receiver (also known as Form 741) to the Nuclear Materials Management and Safeguards System.

c. Conclusions

The inspectors did not identify any information showing that the two missing spent fuel rods had been shipped from Millstone to GE-Vallecitos. The NRC Spent Fuel Project Office has concluded that the change to the record of spent fuel shipped, published in NUREG-0725 in 1990, was an error, and the correct value for material shipped from Millstone to GE-Vallecitos in three shipments between 1979 and 1989 is 36 kg as originally published. The inspectors therefore concluded it is implausible that the missing rods were sent to GE-Vallecitos.

3.2 Shipments from Millstone to Hanford during 1985

a. Inspection Scope

The inspectors reviewed the licensee's investigation and conclusions regarding the possibility that spent fuel from Millstone was shipped to the low level waste burial site in Hanford in packages containing radioactive waste for disposal.

b. Observations and Findings

FRAP investigators identified three shipments from Millstone to Hanford, occurring during 1985, that could have contained segments of the two missing fuel rods. These shipments were performed by GE as part of a spent fuel pool waste processing contract and occurred on March 20, May 29, and July 31, 1985. Documentation describing LPRM sections included in these shipments indicated that these LPRM sections were positively identified as related to the 1985 GE LPRM cutting campaign, thus making it less likely that unidentified materials would be mixed in with the sections. The March 20 and May 29 shipment contents were described in the FRAP Final Report as being well-characterized; however, in each case the shipping liner was open and available in the spent fuel pool for someone to have added material without recording the addition. The investigators also noted that two older liners (designated as PB-1 and AP-101/ANEFCO) had been stored in the spent fuel pool and contained unidentified hardware items. These two liners were being unloaded and contents examined concurrently with loading of the liner shipped to Hanford on May 29, 1985. While addition of older, unidentified materials may have been feasible, there is no information to indicate that anyone took any action to add materials to these two Hanford shipments.

The shipment made on July 31, 1985 may have been more likely than the other 1985 Hanford shipments to have included materials identified as LPRM sections. The FRAP investigators determined that these containers held LPRM and hardware sections cut by Crouse nuclear workers during the LPRM cutting campaign in September-October 1979. As discussed in Section 2.1, it is plausible that the missing fuel rods were sectioned along with LPRM hot ends during the 1979 cutting campaign, and therefore it is possible that some of the fuel rod sections could have been included in this third waste shipment to Hanford.

c. Conclusions

The inspectors identified no information that would refute or alter the licensee's conclusion that some of the missing fuel rods could have been sent to the Hanford low level waste burial site along with irradiated hardware.

3.3 Shipments from Millstone to Barnwell during 1988 through 1992

a. Inspection Scope

The inspectors reviewed the licensee's investigation and conclusions concerning the possible inadvertent shipment of the irradiated fuel rods to the low-level radioactive waste burial site in Barnwell, in packages containing radioactive waste for disposal.

b. Observations and Findings

1988 Spent Fuel Pool Cleanup and Waste Shipments to Barnwell

The licensee hired a contractor in January 1988 to clean out waste in the spent fuel pool in preparation for a planned 1989 project to install new fuel storage racks. This cleanup work disposed of irradiated hardware, as well as other contaminated materials and filters stored in the spent fuel pool. Uncertainty in the identification and characterization of some of the waste materials was described in the FRAP Final Report.

In the detailed discussion of Scenario 5.4.1, the licensee stated that the November 11, 1987 bid specification for the 1988 spent fuel pool clean up project described, in the scope of work, five containers in the spent fuel pool with hot end segments from 96 LPRMs. The LPRMs that had most recently been discharged from the core typically had contact radiation readings of "tens of thousands of R/h on contact." In the post-project report provided to the licensee, the contractor stated that 12 baskets and inserts were found by the contractor in the spent fuel pool during the project (FRAP Report Reference #66, "1988 Cleanup Final Report"). According to the licensee, prior to the 1988 cleanup there was no accurate list of radwaste contained in the spent fuel pool. Supporting this statement is a 1988 memo from the licensee's cleanup project manager, which indicated that the work specification description of material to be processed was based upon "old memos, notes and recollection of plant personnel" (Northeast Utilities Memo #RAD3-99-49, dated May 31, 1988).

The licensee determined that the contractor accepted Northeast Nuclear Energy Company's description of the material in the containers as LPRMs, and did not try to independently identify or verify identity of LPRM serial numbers or segments. In the 1988 Cleanup Final Report, the contractor described radiation surveys of the baskets and did not individually survey each item within the baskets and liners. The "Liner/basket Radiation Profile" sheets for each of the baskets and liners provide radiation survey measurements made underwater, 6 inches away from the container, and each sheet states in the bottom comments section, "Presumed to be all LPRMs - hot and cold sections." (1988 Cleanup Final Report). This notation also indicates that personnel apparently expected the items in the containers to have various diameters, since hot ends have 0.7 inches maximum diameter and cold ends have 1.4 inches maximum diameter. It therefore seems possible that sections of fuel rods, source holders or dry tubes could have been inadvertently processed and identified as LPRM segments, if they had been cut with LPRMs and placed into the containers before this February 1988 packaging and loading work.

The 1988 project contractor reported shipping a quantity of LPRM segments equivalent to 90 LPRMs, although the licensee's 1987 bid specification for the project had described five containers holding hot ends from 96 LPRMs. The FRAP investigation team independently evaluated the linear feet of LPRMs reported as processed during the 1988 cleanup, and also compared the inventory of LPRMs processed and shipped during various cleanup campaigns (including the 1988 project) versus the total number of LPRMs received at Millstone 1 during the operating life of the plant. The FRAP analysis of the data determined that no more than 83 LPRM hot ends could have been available in the spent fuel pool during February 1988. The licensee estimated for the inspectors that the equivalent of at least 7 LPRM hot ends must have been other objects misidentified as LPRMs, and that the amount of misidentified material could have been as much as the equivalent of 22 LPRM hot ends. Each LPRM hot end section was estimated to be just over 13 feet long. The inspectors therefore noted that between approximately 92 linear feet and 289 linear feet of material incorrectly identified as LPRM sections, with appearance similar to LPRMs and fuel rods, was processed and shipped during this campaign.

1989 and 1990 Waste Shipments to Barnwell

The FRAP Final Report described four shipments from Millstone to Barnwell in late 1989 and 1990, following a spent fuel pool cleanup campaign subsequent to the reracking project. One of these shipments, on May 7, 1990, included a container from the spent fuel pool that the FRAP investigators determined may have contained LPRM segments that were not shipped in 1988. The container, designated FC-1, was identified in the project scope documents as containing 184 LPRM fission detectors, which had been removed from LPRMs and segregated for disposal. A letter from the contractor to the licensee (WasteChem to Northeast Utilities Service Company, dated May 1, 1990) states that some "extra" LPRM segments were removed from FC-1 and processed. As was the case in 1988, each individual item in the container was not examined and packaged for shipment. Characterization was based on item type and in-core exposure

time, and therefore precise information on each and every item in the container was not verified and documented through individual visual examination and handling.

1992 Waste Shipments to Barnwell

The licensee used the same contractor to make three shipments in 1992 that it used to perform the 1988 and 1990 shipments. The FRAP investigators noted there were three shipments to Barnwell during this campaign and concluded that only the December 8, 1992, shipment "presented a reasonable opportunity" for inclusion of segments of the missing fuel rods. The basis for the conclusion is that the shipment included a box containing material identified as "miscellaneous trash", the characterization of which included a description of the items as cut-up LPRMs. As with the identified previous shipments, individual items in the container were not surveyed, but the container as a whole was surveyed in preparation for shipment. The individual responsible for characterizing the waste in the shipment described the box contents as including the equivalent of three LPRMs, which would have been older remnants remaining from processing campaigns such as the one conducted in September-October 1979.

The FRAP concluded that the other two shipments in 1992 were sufficiently characterized that they did not contain unidentified or misidentified items. It therefore is possible that the December 8, 1992 shipment could have included pieces of the missing fuel rods, for the same reasons applicable to the 1988 and 1990 shipments.

c. Conclusions

The inspectors agreed with the licensee's conclusion that the scenarios postulating shipment of sections of the spent fuel rods to Barnwell, misidentified as other waste could not be ruled out. The most likely shipments were in 1988, although shipments in 1990 and 1992 could also have contained some or all of the fuel segments.

3.4 Waste Shipments to Barnwell during 2000

a. Inspection Scope

The inspectors reviewed licensee Scenario 5.4.4, describing waste shipments to Barnwell during 2000. The review included records reviews and interviews of licensee personnel involved in the spent fuel pool waste processing and shipping campaign.

b. Observations and Findings

During 2000, the licensee conducted a campaign to dispose of irradiated waste materials in the spent fuel pool and clean out much of the waste materials in the pool. The project was part of the overall effort to prepare for proposed movement of spent fuel into casks for dry storage.

The FRAP Final Report, Section 4.1.2.3 concluded that two of the 2000 shipments to Barnwell could have included remnants of the two spent fuel rods. The Final Report stated, "...the evidence is not sufficiently clear and convincing..." that the final two shipments in 2000 using TN-RAM casks did not include fuel remnants.

The inspectors interviewed Millstone Station staff responsible for the 2000 Unit 1 spent fuel pool clean-up project and discussed the characterization of materials processed and shipped during this campaign, focusing on the last two shipments which occurred on June 7 and July 17, 2000. Millstone staff referred to logs and project records, focusing on materials placed into a container and referred to in the Final Report as a "bucket of debris". The licensee pointed out that the materials in the bucket were boron tube sections generated during the 2000 project while cutting control rod blades. No other materials were put into the bucket during the project, and project staff had verified that the bucket was empty when they began work. The licensee was certain no unidentified components were put into the bucket, including additional boron tubes found scattered on the spent fuel pool floor from previous control rod blade cutting campaigns. They stated that all such items on the spent fuel pool floor had been moved aside to clear an area to place the shipping casks on the floor of the pool for this project.

The licensee stated that all LPRMs processed for the 2000 shipments were full-length (about 43 feet long) and had been bent into "hairpin" configurations, enabling positive verification of the items as LPRMs and not sections of other tube-like hardware. Licensee staff were able to refer to project records from 2000 as the basis for concluding that no unidentified or unverified materials were included in either of the subject shipments. Additionally, the project engineer's log contained an entry dated June 23, 2000, describing examination of shipping containers in the spent fuel pool and concluding no unidentified debris had been packaged for the shipment. The licensee representative had also been involved in shipping materials to Barnwell in 1988, and noted that the NRC guidance issued in 1995 (Final Branch Technical Position on Concentration Averaging and Encapsulation, Revision in Part to Waste Classification Technical Position, dated January 17, 1995) had resulted in improvements to the characterization methods used at Millstone. As a result, the licensee's efforts to characterize the waste materials shipped in 2000 was more thorough and complete than prior to 1995.

The FRAP Final Report also identified a questionable radiation survey record of the "bucket of debris" as a source of additional uncertainty in characterization of material in the bucket. Millstone staff responsible for the shipment stated to the inspectors that the recorded survey date of July 26, 2000 on the survey form appeared to be an error, with an actual survey date of June 26, 2000. The "bucket of debris" was the only entry on the data sheet, which had a fax date-stamp at the top showing "JUN-28-00 WED" and

recorded the material as placed into liner 96813-02[1]. Other records in the report, showing transmittal of shipping documentation for liner 96813-02 and listing the "bucket of debris", are dated June 30, 2000, and the shipment was made on July 17, 2000. Consistent with the Millstone staff comments, the vendor's final report of the waste shipping campaign described liner 96813-02 contents as including the "bucket of boron tubes".

c. Conclusions

Based on personal recollections of Millstone personnel, observations and documents reviewed, the inspectors concluded the characterization of waste shipped to Barnwell during 2000 was sufficiently detailed and complete to identify the "bucket of boron tubes" generated during the related waste processing campaign. Therefore the inspectors concluded remnants of the two missing fuel rods could not have been included in the shipments made during 2000, a conclusion which is different than is stated in the FRAP Final Report.

3.5 Overall Conclusions Concerning Transfer of Missing Fuel Offsite

The inspectors agree with the licensee's conclusion that the most likely explanation for disposition of the two missing spent fuel rods is they were cut during the September - October 1979 spent fuel pool cleanup campaign and that the low level radioactive waste disposal facility at Barnwell had the most significant opportunity to receive the rods, with some small opportunity to ship the fuel rods to Hanford. The most likely shipments were the 1988 shipments to Barnwell, although shipments to Barnwell in 1990 and 1992 could also have contained some or all of the fuel segments. The lesser quantity of candidate waste materials sent to Hanford, the timing of shipments, and the type of casks used, all make Hanford a less likely recipient of the rods than Barnwell; however, the possibility of the rods being shipped as waste to Hanford in 1985 cannot be ruled out.

If the licensee shipped the two spent fuel rods to Barnwell and/or Hanford, then the fuel rods were not identified as either special nuclear material or irradiated reactor fuel. Therefore, as a result of the loss of accountability and control of the two fuel rods, the licensee could have, on one or more occasions during the period from March 1985 to December 1992:

- transferred special nuclear material contained in two irradiated reactor fuel rods in an unauthorized manner to a low level waste burial site not licensed to receive the material (Barnwell and/or Hanford);

- shipped special nuclear material contained in irradiated reactor fuel to low level waste burial sites in Barnwell and/or Hanford. The irradiated reactor fuel

[1]WMG, Inc. report WMG-20016-9092, "Packaging and Disposal of Irradiated Hardware at Millstone Unit 1 During 2000," dated August 2000.

exceeded the limits for Class C waste and is therefore not generally acceptable for a low level waste burial site;

- incorrectly identified and characterized the special nuclear material in irradiated reactor fuel as other waste, and incorrectly certified in shipping manifests the composition of the waste as suitable for burial at a low level waste site;

- transferred special nuclear material to one or more locations (Barnwell and/or Hanford burial sites) without completing and submitting a Nuclear Material Transaction Report, DOE/NRC Form 741; and

- shipped irradiated reactor fuel without establishing and maintaining, or making arrangements for, and assuring the proper implementation of a physical protection system for the shipment(s).

Section 4. Review of Root Cause Analysis Report

4.1 Root Cause Analysis

a. Inspection Scope

The inspectors reviewed activities of the licensee's Root Cause Assessment Team, including methods and staffing, and the licensee's Root Cause Analysis Report, which was submitted to the NRC on October 29, 2001.

b. Observations and Findings

In addition to the FRAP team and the Independent Management Review Team, the licensee contracted with expert personnel to analyze the root cause behind the loss of the two fuel rods. Two individuals comprised the Root Cause Assessment Team, and they performed a root cause analysis of the missing fuel rods to determine why they had become lost and what actions were necessary to prevent a similar occurrence in the future. The Team members performed their activities independently of the FRAP team.

The Root Cause Assessment Team concluded that:

> "...the root cause of the event was an unrecognized over-reliance on Millstone Unit 1 Reactor Engineers to compensate for organizational and process weaknesses in implementing the special nuclear material inventory and control procedures."

The Root Cause Assessment Team report further described the elements of the root cause contributing to the event as:

- Process weaknesses associated with special nuclear material inventory and control and radwaste characterization;

- Weaknesses in coordination of spent fuel pool activities and procedural adherence; and

- Inconsistent supervision and inconsistently applied oversight of spent fuel pool activities by knowledgeable individuals.

The authors of the Root Cause Analysis Report also concluded that the licensee had maintained physical control of the missing fuel rods as radioactive material. In other words, the Root Cause Analysis Report states (and the FRAP Final Report concludes) that Millstone may have misidentified the missing fuel rods as something other than spent fuel rods, but maintained controls appropriate for the radiation hazard presented by the fuel rods.

Finally, the Root Cause Analysis Report contained a description of lessons learned, as well as recommended corrective and preventive actions. The identified lessons learned are:

- Important material that is stored near waste might inadvertently be considered just that (i.e. waste).

- Without clear line management ownership and involvement, station programs might take their own potentially undesirable course.

- An effective special nuclear material control and accountability program is needed to ensure physical accountability of all special nuclear material entities.

- Periodic special nuclear material inventory records reconciliation is essential to demonstrate that accountability has been maintained.

- Performance areas not covered by 10 CFR 50, Appendix B may still warrant oversight commensurate with their importance to the organization.

Sixteen recommended corrective and preventive actions were presented to the licensee in the Root Cause Analysis Report. The licensee reviewed the Root Cause Analysis Report provided by its contractor and stated that corrective actions had been entered into the Millstone Station Corrective Action Program. Although the Root Cause Analysis Report was not completed during the onsite NRC inspection, the inspectors observed that some corrective action recommendations made by the Root Cause Analysis Report authors were already being implemented by the licensee at the time of the onsite inspection.

c. Conclusions

The licensee used experienced and knowledgeable personnel to analyze the root cause and contributing factors which allowed the events resulting in the loss of two spent fuel rods to occur. The inspectors concurred that the practices and procedures in use

through at least 1979 (when the missing fuel rods were last referenced, in a memorandum from the Reactor Engineer) were implemented in a manner that required sustained high quality performance by Millstone personnel, and when personnel errors or lapses occurred, the procedures and programs were inadequate to prevent the loss of the two fuel rods. The Root Cause Analysis Report was comprehensive, and provided extensive corrective action recommendations, which the licensee entered into the Millstone Corrective Action Program.

Although the licensee's Root Cause Analysis Report was not complete at the time of the NRC onsite inspection, the inspectors independently reached many of the same conclusions as the Root Cause Assessment Team. The inspectors noted that licensee personnel did not always follow procedures during the 1970s; procedures defined fuel as assemblies, not individual rods; the licensee relied too heavily on individual performance, with success dependent on people consistently doing more than the procedures required; and the licensee's failure to segregate fuel from non-fuel items in the spent fuel pool created confusion. The inspectors concluded that management controls and supervision of activities related to handling of special nuclear material and irradiated fuel were insufficient at the time to prevent the loss of the two fuel rods.

The inspectors noted that the recommendations of the Root Cause Assessment Team had been incorporated into the licensee's corrective action program as they were identified.

Section 5. Event Reporting

5.1 Licensee Reporting to NRC

a. Inspection Scope

The inspectors reviewed the licensee's reporting of the two missing spent fuel rods to NRC. Included in the review was the content of the reports filed and the timeliness of those reports.

b. Observations and Findings

The inspectors reviewed a number of reports concerning the inability to account for the two spent fuel rods missing from the Millstone 1 spent fuel pool. A Condition Report (CR M1-00-0548) was initiated internally at Millstone by the licensee on November 16, 2000. The licensee first informed NRC via telephone on November 16, 2000, and followed up on December 14, 2000, with a 30 day call to the NRC Operations Center in accordance with 10 CFR 20.2201(a)(ii) . The licensee submitted Licensee Event Report 05000245/2000-002-00 on January 11, within 30 days of calling the Operations Center as required by 10 CFR 20.2201(b) and 10 CFR 50.72(b)(2)(vi). Subsequent revisions to the Licensee Event Report were submitted, dated on March 30, 2001 (2000-002-01) and November 2, 2001 (2000-002-02).

The inspectors determined that licensee personnel were aware of the inability to account for the two spent fuel rods significantly sooner than November 16, 2000, the date of the first telephone contact with the NRC on the subject. The NRC Office of Investigations performed an investigation (Case No. 1-2001-007) of whether the licensee willfully failed to report the missing or lost fuel rods to the NRC in a timely manner. Millstone staff told NRC investigators that the May 15, 1979, memo describing the two individual fuel rods that were removed from assembly MS-557 was discovered during June 2000. The licensee began searching for the two fuel rods reflected in the Kardex® file in June 2000. Over the summer licensee personnel reviewed records of material transfer forms, which gave no evidence of activity with bundles that would have explained the missing rods. The licensee staff informed a licensee manager in August 2000 of the discrepancy and apparent recordkeeping problem, and continued to research the records of objects in the spent fuel pool and to search areas of the spent fuel pool in their effort to locate the two fuel rods. From August 29 to September 12, an assembly serial number verification process was undertaken by the licensee. As part of that process, on September 12, 2000 the licensee performed a visual examination of MS-557, which confirmed that two fuel rods were missing from the assembly. Licensee staff who performed the physical searches told the NRC investigator that they did not consider the fuel rods to be missing at that time because a comprehensive search of the spent fuel pool had not been performed, only of the locations indicated in the records. On November 16, 2000, the licensee initiated a condition report, and informed the NRC of the issue.

Lost or missing licensed material is defined in 10 CFR 20.1003 as licensed material whose location is unknown. On September 12, 2000, with the examination of MS-557 and physical verification of the northwest corner of the spent fuel pool completed, the licensee could not identify the location of the two fuel rods. The only documentation of their location, contained in the May 1979 memo from the Reactor Engineer and the two spent fuel pool maps prepared in 1980, were at this time shown to be incorrect. The inspectors concluded that although the licensee did eventually report the missing licensed material to the NRC Operations Center on December 14, 2000, the licensee did not know the location of the rods on September 12, 2000, and, therefore, the timeliness of the report did not satisfy 10 CFR 20.2201(a)(ii).

The NRC Office of Investigations focused on when the licensee became aware that the fuel rods were missing or lost and whether there was any deliberate intent to delay reporting that information to the NRC. The investigation determined that while some licensee personnel/contractors were aware of the possibility that the two fuel rods were missing as early as June 2000, they initially thought the problem was poor recordkeeping, and that the fuel rods were simply misplaced within the spent fuel pool. The investigation did not substantiate that either licensee personnel or contractors deliberately delayed reporting to the NRC that two fuel rods were unaccounted for/missing/lost from the Millstone 1 spent fuel pool.

On October 5, 2001, the licensee, based upon review of the FRAP Final Report provided by the licensee's contractor, determined that the fuel rods could not be located

and were considered lost. The licensee notified the NRC Operations Center of this conclusion on October 5, 2001, in accordance with 10 CFR 70.52(a).

c. Conclusions

The inspectors noted that the licensee failed to notify the NRC in a timely manner according to the requirements of 10 CFR 20.2201(a)(ii), which requires that NRC be notified within 30 days after the occurrence of any lost, stolen, or missing licensed material exceeding specified quantities becomes known to the licensee. The two missing spent fuel rods exceed the quantity specified in the regulations. The inspectors informed the licensee that failure to notify the NRC within 30 days of when it became known to the licensee that the fuel rods were missing was an apparent violation of NRC requirements.(**VIO 50-245/2001-013/002**)

Section 6 Meetings

6.1 Exit Meeting

The NRC conducted an exit meeting for the inspection on January 15, 2002. The meeting, which was open for observation to the public, was held at the Millstone Station simulator building and was attended by representatives of the licensee, NRC, public and media. An opportunity to ask questions of the NRC and the licensee was available to the public following the close of the exit meeting.

6.2 Other Meetings

The NRC attended several other meetings related to this special team inspection and NRC inspection activities concerning the spent fuel missing from the Millstone 1 spent fuel pool. NRC personnel, including management and inspectors, presented information at public meetings of the Connecticut Nuclear Energy Advisory Committee on May 17 and November 29, 2001, and at public meetings of the Millstone 1 Decommissioning Activities Committee on February 1, and May 17, 2001. A debriefing of the licensee was conducted at Millstone on October 18, 2001 at the conclusion of the special inspection team's onsite inspection activities.

PARTIAL LIST OF PERSONS CONTACTED

Licensee

W. Matthews, Executive Vice President
A. Price, Vice President, Technical Services
F. Rothen, FRAP, Vice President, Northeast Utilities
H. McKenney, Lead Reactor Engineer
B. Borchert, Reactor Engineer
K. Cook, Nuclear Analyst, Reactor Engineering
J. Guerci, Process Owner, Nuclear Fuel
R. Fairbank, Project Manager, Fuel Rod Accountability Project (FRAP)
R. Harnal, Lead Engineer
M. Hills, FRAP
L. Hill, Team Lead, Nuclear Fuel Supply
C. Mandigo, Nuclear Fuel
R. Radasch, FRAP
D. Meekoff, Operations Manager-Unit 1
M. Rutkoske, Engineer
D. Smith, Process Owner, Regulatory Affairs
P. Willoughby, Team Lead, Regulatory Affairs
S. Bazinet, Team Lead, Records Management
J. Laine, Acting Process Owner, Radiation Protection
R. Swanson, Root Cause Team
P. Reagan, Root Cause Team

Others

E. Wilds, Director, Division of Radiation, State of Connecticut, Dept. of Environmental Protection
D. Galloway, Division of Radiation, State of Connecticut, Dept. of Environmental Protection

ITEMS OPENED, CLOSED, AND DISCUSSED

Opened

VIO 01-013-01 Failure to adequately account for special nuclear material

VIO 01-013-002 Failure to report missing radioactive material in a timely manner

Closed

None

Discussed

VIO 01-013-01 Failure to adequately account for special nuclear material

VIO 01-013-002 Failure to report missing radioactive material in a timely manner

LIST OF ACRONYMS USED

FRAP Fuel Rod Accountability Project
DNC Dominion Nuclear Connecticut, Inc.
GE General Electric
NRC Nuclear Regulatory Commission
LPRM Local Power Range Monitor

APPENDIX

References for Docket Number 50-00245, Millstone Power Station Unit 1

Document Title	Document Date	ADAMS Accession Number
Millstone Nuclear Power Station, Unit No. 1, Docket No. 50-245 Licensee Event Report (LER) 2000-02-00	January 15, 2001 (submitted on January 11, 2001)	ML010170440
Millstone Nuclear Power Station, Unit No. 1, Docket No. 50-245 Licensee Event Report (LER) 2000-02-01	March 30, 2001	ML011010081
Millstone 1: Issuance of Final Report Pertaining to Unaccounted for Spent Fuel Rods	October 5, 2001	ML012850396
Investigation of Millstone Nuclear Power Station, Unit 1: Issuance of Root Cause Investigation Pertaining to Unaccounted for Spent Fuel Rods	October 29, 2001	ML013390308
Millstone Nuclear Power Station, Unit No. 1, Docket No. 50-245 Licensee Event Report (LER) 2000-02-02	November 2, 2001	ML020150002

NRC INSPECTION MANUAL

INSPECTION PROCEDURE 85102

MATERIAL CONTROL AND ACCOUNTING - REACTORS

PROGRAM APPLICABILITY: 2513, 2515, and 2525

85102-01 INSPECTION OBJECTIVES

01.01 Determine whether the licensee has limited his possession and use of special nuclear material (SNM) to the locations and purposes authorized under license.

01.02 Determine whether the licensee has implemented an adequate and effective program to account for and control the SNM in his possession.

85102-02 INSPECTION REQUIREMENTS

02.01 Possession and Use of SNM

a. Review inventory, receipt, and shipment records (NRC Forms 741 and 742) to determine whether the licensee has limited his possession and use of SNM to the location and purpose authorized under license.

b. Conduct a random spot-check of new fuel, irradiated fuel in spent fuel pool, sources, test specimens, etc., by comparing actual location with that indicated on loading diagrams, transfer forms, or other accounting records, as applicable. Check ten assemblies or bundles of new and irradiated fuel, and one source, test specimen, etc.

02.02 Control and Accounting of SNM. Determine whether the licensee has prepared, maintained, and implemented an adequate and effective program and procedures to control and account for the SNM in his possession, as required by 10 CFR 70.41(a); 70.42; 70.51(b), (c), and (d); 70.52; 70.53; 70.54; and 73.71(b).

85102-03 INSPECTION GUIDANCE

03.01 Inspection Requirement 02.02 - Possession and Use of SNM. When conducting physical verification of fuel bundles or assemblies, verify that there are bundles or assemblies in racks identified as containing same. Do not verify by serial numbers unless discrepancies surface that warrant an extensive verification.

ATTACHMENT B

03.02 Inspection Requirement 02.02 - Control and Accounting of SNM. Material Control and Accounting (MC&A) inspections at reactors involve primarily a review of the licensee's programs and procedures for controlling and accounting for discrete accountable items. The review should address the adequacy of the licensee's written and implemented program for controlling and accounting of receipt, storage, internal transfers, inventory, burnup-related measurements and calculations, shipments, and records and reports.

The inspector should consider whether the licensee's methods for controlling possession and use of SNM include the following elements:

a. Item control areas established and described in such a manner as to ensure that physical and administrative control of SNM is maintained.

b. Written MC&A procedures established and maintained to ensure knowledge of the quantity, identity, and location of fuel assemblies, sealed sources, fission chambers, and other items containing SNM in the licensee's possession. Also, licensee management approval of the procedures.

c. Written statements of responsibility and authority for those positions responsible for SNM receiving, shipping, inventory, storage, internal transfers, burnup-related measurements, records, and reports.

d. Assurance that MC&A personnel are trained and qualified.

e. Method of computing uranium depletion and plutonium production in each fuel assembly, region, and entire core of the reactor. Method should include decay of 241Pu. Reports and summation of data should be generated on semiannual Material Status Report (Form NRC-742).

f. Incoming material transfer documents (Form NRC-741) receipted within 10 days and returned to the shipper.

g. Material transfer forms (Form NRC-741) filed as required.

h. Transfers of SNM restricted to authorized recipients.

i. Material status reports (Form NRC-742) accurately reflect the licensee's activities for that period.

j. Subsidiary accounting records for each item control area, supported by documentation.

k. Facility central control records, supported by properly authorized documentation and the facility's records system, provide enough information to comply with record requirements to substantiate information provided on Form NRC-742.

l. Shipments and receipts of nuclear fuel at the reactor site, confirmed by piece count and serial number and reported to the central accounting office.

m. Records and procedures support reporting of accidental criticality or loss or theft of an identifiable item containing SNM.

n. The licensee's most recent physical inventory, performed within 12 months of the previous one.

o. Inventory procedures provide for management review of MC&A system at intervals not to exceed 12 months, and records document management followup action based on results of the annual reviews.

p. Inventory documentation includes review of the applicable NRC Forms 741, 742, and 742C for cold fuel storage area; irradiated fuel assemblies in the reactor and in storage; fission chambers; sealed sources; test specimens; etc., such as:

   1. Internal card files or log books, source documents, and any other records that include serial number identification, location, and amount of SNM contained in fission chambers, sealed sources, test specimens, etc., until the Commission authorized their disposition.

   2. Operating logs and core loading diagram for irradiated fuel assemblies in the reactor (trace listings of assemblies to the source documents).

   3. Loading diagrams and source documents for irradiated fuel assemblies in storage.[2]

q. Records retained for the period specified by the appropriate regulation or license condition. If a specific retention period was not otherwise required by regulation or license condition, records should have been maintained until the Commission authorized their disposition.

85102-04 REFERENCES

Regulatory Guide 5.29, Nuclear Material Control Systems for Nuclear Power Plants.

Regulatory Guide 5.49, Internal Transfers of Special Nuclear Material.

NUREG Guide BR-0006, Instructions for Completing Nuclear Material Transaction Reports.

NUREG Guide BR-0007, Instructions for Completing Material Balance Report, Physical Inventory Listing and Concise Note Forms.

END

[2]Perpetual inventory records are maintained for in-reactor and storage showing the identity and location of all items containing the SNM. If the records do not also include SNM quantitative data, supporting records should be available.