PNL--7436

DE91 004966

WEST VALLEY FACILITY SPENT FUEL HANDLING, STORAGE, AND SHIPPING EXPERIENCE

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November 1990

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830
and the Electric Power Research Institute
Palo Alto, California
under Research Project 2062-11

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Richland, Washington 99352

ABSTRACT

The results of a study on handling and shipping experience with spent fuel are described in this report. The study was performed by Pacific Northwest Laboratory (PNL) and was jointly sponsored by the U.S. Department of Energy (DOE) and the Electric Power Research Institute (EPRI). The purpose of the study was to document the experience with handling and shipping of relatively old light-water reactor (LWR) fuel that has been in pool storage at the West Valley facility, which is at the Western New York Nuclear Service Center at West Valley, New York and operated by DOE. A subject of particular interest in the study was the behavior of corrosion product deposits (i.e., crud) deposits on spent LWR fuel after long-term pool storage; some evidence of crud loosening has been observed with fuel that was stored for extended periods at the West Valley facility and at other sites.

The West Valley facility handled and reprocessed fuel from nine different reactors during 28 campaigns during the period from 1966 to 1972. The reprocessing operations were terminated in 1972. From 1973 to 1975, 756 spent LWR fuel assemblies were shipped to the West Valley facility and placed in pool storage. Since that time, most of the spent fuel assemblies have been removed from the pool and shipped back to reactor sites. Currently, 125 fuel assemblies remain in the pool; of those, 85 are boiling water reactor (BWR) assemblies and 40 are pressurized water reactor (PWR) assemblies. The 125 fuel assemblies have been in storage at the West Valley facility since 1973 to 1974. A visual inspection in May 1989 indicates that 7 of the 125 fuel assemblies contain failed fuel rods. It is DOE's plan to ship the 125 fuel assemblies, for which DOE has the title, to the Idaho National Engineering Laboratory (INEL) in the near future for storage. The upcoming experience in handling, shipping, and storing of these 125 fuel assemblies will be of particular interest to this DOE/EPRI-sponsored study.

Conclusions associated with the experience to date with old spent fuel that has been stored at the West Valley facility are presented. The conclusions are drawn from these subject areas: a general overview of the

West Valley experience, handling of spent fuel, storing of spent fuel, rod consolidation, shipping of spent fuel, crud loosening, and visual inspection. A list of recommendations is provided.

SUMMARY

The West Valley reprocessing facility handled and processed spent fuels from nine different reactors during 28 campaigns over the six-year period from 1966 to 1972.(1) The experience with handling, storing, and shipping those first-generation spent nuclear fuel assemblies resulted in considerable changes to equipment, systems, procedures, and concepts; those changes were made after the plant was shut down and cleaned up in 1972. From February 1973 to December 1975, 756 spent LWR fuel assemblies were shipped to the West Valley facility for storage in the pool. With Congressional enactment of the West Valley Demonstration Project Act, it became necessary to remove the 756 fuel assemblies from the pool. Currently, 125 fuel assemblies (26 MTU) are still left in the pool, and they are planned to be moved in the near future to the Idaho National Engineering Laboratory (INEL) for storage.(1) The upcoming experience in handling, shipping, and storing of these 125 fuel assemblies will be of particular interest (e.g., checking for evidence of crud loosening) to this DOE/EPRI-sponsored study.

Conclusions associated with the experience to date with old spent fuel that has been stored at the West Valley facility are described below. The conclusions relate to these subject areas: handling and storing of spent fuel, rod consolidation, shipping of spent fuel, crud loosening, and visual inspection of spent fuel.

Handling and Storing of Spent Fuel - Spent fuel assemblies and fuel rods are quite sturdy; spent fuel rods can withstand considerable abuse in handling without rupture or breakage. Spent fuel pools can accommodate failed fuel rods and the inadvertent breaking of fuel rods (including prepressurized rods).(2,3) At the West Valley facility, fuel assemblies with damaged fuel rods or distorted or misshapened spacer grids were placed in special failed fuel canisters for handling. Some fuel assemblies may be difficult to grapple for handling. Moving noticeably warped (i.e., bowed and/or twisted) fuel assemblies into and out of close-fitting enclosures can apparently be difficult in some cases. There are not strong reasons for concern about hydriding (i.e., as a result of galvanic coupling) of Zircaloy that is stored in aluminum alloy storage canisters; however, there are some remaining

stored in aluminum alloy storage canisters; however, there are some remaining questions about the possibility of slow, but progressive, hydriding of the Zircaloy over an extended period when the couple exists.[4]

Rod Consolidation - Spent PWR fuel rods were found to be much more flexible than expected in rod consolidation operations.[5] Some fuel rods may be difficult to grapple during rod consolidation because fuel rod ends may not be chamfered as shown on drawings. Bowed fuel rods will apparently be no problem in rod consolidation operations once the fuel rods are removed from the assembly. Spent fuel assemblies with failed or damaged fuel rods can be consolidated; however, a broken fuel rod in a spent fuel assembly can be overlooked in rod consolidation operations unless appropriate procedures are implemented. The rod consolidation demonstrations involving spent PWR fuel that had been stored at the West Valley facility provided additional evidence that rod breakage is a relatively infrequent occurrence, even when fuel assemblies known or suspected to contain failed or damaged fuel rods are intentionally chosen for examination, reconstitution (i.e., the removal and replacement of failed or damaged fuel rods before to return to reactor service), or rod consolidation. Rod consolidation operations also demonstrated that the control rod guide tubes in PWR fuel assemblies are tough, strong, and capable of bearing the weight of the assemblies during lifting. Guide tubes are the load-bearing members when a PWR fuel assembly is lifted (e.g., out of the reactor core, a spent fuel storage rack, or a shipping cask).

Shipping of Spent Fuel - Radioactivity levels in the cask coolant consistently increased in nearly all shipments for which before and after measurements were available.[6] Casks containing known leaking fuel assemblies showed the largest radioactivity increase (as much as four orders of magnitude). Large differences in radioactivity changes were noted between shipments of intact and breached stainless-steel-clad fuel. Though few cases were available for comparison at the time of a 1980 study,[6] the increase in radioactivity level for a dry shipment was six times greater than that of a wet shipment of intact fuel from the same plant.[a]

<u>Crud Loosening</u> - Crud loosening was detected on spent BWR fuel assemblies that were shipped in 1985 (the assemblies had been stored at the West Valley facility since 1971-1974). Visibility for loading spent fuel assemblies in the same cask was greatly reduced, which made subsequent cask loadings very difficult and time consuming. Also, the crud was drawn into the cask drain hose and, because connecting the hose is a hands-on operation, the radiation dose to operating staff increased when that operation was performed.

In one case involving spent PWR fuel assemblies, which had been shipped from the West Valley facility to the reactor, there was some evidence of crud loosening after the fuel assemblies were placed in the reactor's spent fuel storage pool.

<u>Visual Inspection</u> - The subjective nature of results from visual inspections of spent fuel is illustrated by comparing the results from the three inspections performed on the 125 fuel assemblies that are still in storage at the West Valley facility. The assemblies were inspected in 1985, 1987, and 1989. The 1985/1987 results indicated that there might be as many as 40 assemblies with failed or damaged fuel rods. The videotape from the 1989 inspection shows that seven assemblies contain failed fuel rods.

(a) The increase with the dry shipment was 0.00137 μCi/ml; the increase with the wet shipment was 0.00027 μCi/ml. The maximum radioactivity level after transportation was 0.0021 μCi/ml with the dry shipment and was 0.00075 μCi/ml with the wet shipment. For comparison purposes, the maximum radioactivity level of the receiving basin at the GE Morris Operation was stated to be 0.003 μCi/m.[6]

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1.0 INTRODUCTION

The U.S. Department of Energy (DOE) and the Electric Power Research Institute (EPRI) jointly sponsored a project that involved documenting the experience with handling and shipping of relatively old boiling water reactor (BWR) and pressurized water reactor (PWR) spent fuel that has been in pool storage at the facility in West Valley, New York. The project was completed by Pacific Northwest Laboratory (PNL).[a] The West Valley facility, which is owned by the New York State Energy Research and Development Authority, is currently being decontaminated and decommissioned by the DOE, which assumed control of the site in 1982. The facility, which was originally a reprocessing faculity, started reprocessing spent fuel in 1966, and has reprocessed no irradiated fuel since November 1971.[7] In past years, fuel has been shipped from the West Valley site to several utilities leaving a balance of 125 fuel assemblies (85 BWR and 40 PWR type)[b] at West Valley as shown in Table 1. The remaining 125 fuel assemblies, for which DOE has had title since 1986, are to be shipped from the West Valley facility to the Idaho National Engineering Laboratory (INEL) as shown in Table 2.

The shipment of the 125 fuel assemblies is associated with EG&G's Nuclear Fuel Services Spent-Fuel Shipping/Storage Cask Demonstration Project at INEL.[8] The purpose of that project at INEL is to demonstrate the feasibility of packing, transporting, and storing commercial spent fuel in dual-purpose transport/storage casks. Shipping of the fuel assemblies to INEL was initially expected to start in late FY 1990 (i.e., start in the April to June 1990 period). In November 1989, EG&G Idaho indicated[8] that the

(a) Pacific Northwest Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy under contract DE-AC06-76RLO 1830.

(b) The terms "fuel assembly" and "fuel bundle" are used interchangeably by the nuclear industry, although generally the former term is associated with fuel for PWRs and the latter term with fuel for BWRs. A BWR fuel assembly consists of a fuel bundle and the open-ended channel that encloses the bundle.

TABLE 1. Inventory of Spent Fuel Assemblies at the West Valley Facility

Year	No. of Fuel Assemblies			References
	BWR	PWR	As of	
1988	85	40	12/31/88	9
1986	85	40	12/31/86	10, 11
1985	85	120	12/31/85	10-15
1984	310	121	12/31/84	14, 15
1983	418	235	12/31/83	14
1978	515	235	1978	20
1973	515	241	1973	20

TABLE 2. West Valley Spent Fuel Shipment[15]

Date	Destination	No. of Fuel Assemblies[b]	No. of Shipments	Cask Type (Capacity, No. of Fuel Assemblies)	Comments
1990	INEL[a]	85 BWR and 40 BWR	4[8]	Two Transnuclear-designed transportable and storage demonstration casks,[8][c] TN-BRP (85 BWR) and TN-REG (40 PWR)	To be shipped by rail
1985-1986	Ginna	81[d] PWR	81	NLI-1/2 (1 PWR)	Shipped by truck
1985	Oyster Creek	224 BWR	32	TN-9 (7 BWR)	Shipped by truck
1985	Dresden	1 BWR[e]	1	NC-1 or NLI-1/2[f]	One grossly distorted (bowed and twisted) fuel assembly was shipped on 6/20/85[1]
1985	Dresden	1 BWR[e]	1	--	The failed fuel assembly was shipped on 6/6/85[15]
1983-1984	Point Beach	114 PWR	114	NLI-1/2 (1 PWR)	Shipped by truck
1983-1984	Dresden	205 BWR[e]	30	TN-9 (7 BWR)	Shipped by truck

(a) Idaho National Engineering Laboratory (INEL).
(b) Boiling water reactor (BWR) or pressurized water reactor (PWR).
(c) The casks weigh 100 and 105 tons.[15] The TN-BRP holds 85 Big Rock Point (BRP) fuel assemblies; the TN-REG holds 40 R. E. Ginna (REG) fuel assemblies.[8]
(d) Two reports[13,15] say 81 assemblies and two reports[10,11] say 80 assemblies. The shipments included unconsolidated fuel and consolidated fuel [from the demonstration performed by Nuclear Assurance Corporation (NAC)]; NAC was also the shipping agent.[15] The shipments of fuel from the West Valley facility to Ginna were relatively free of major institutional issues and concerns.[15]
(e) Of the 206 assemblies, 109 went to Dresden-1[14] and 97 to Dresden-2.[15]
(f) The reference[1] shows NC-1 on p. 6-2 and NLI-1/2 on p. 7-9.

schedule for shipping the 125 assemblies was being assessed by DOE and that the shipments would not be made in FY 1990.

Loosening of the crud on fuel assemblies has been observed to occur at two (possibly three) sites as a result of storage and/or shipment.[a][18,19] From experience with wet storage, rod consolidation, transportation, and dry storage, it appears crud spallation can be managed effectively, posing no significant radiological problems.[18]

Cruds on BWR and PWR fuel assemblies can be of several types. In a recent report,[18] five classes of crud proposed by A. B. Johnson, Jr., are described. Class I involves a thick, hard copper oxide crud, principally CuO with embedded particles of magnetite and is primarily limited to early Big Rock Point fuel. Class II is the general case for BWR crud involving three subclasses: 1) a duplex layer of flocculent reddish brown Fe_2O_3 and a tenacious, inner layer; 2) a single layer, largely reddish brown Fe_2O_3; and 3) a thin, sometimes darker layer of Fe_2O_3. Class II crud frequently occurs with a loose outer layer and a tenacious inner layer. Class III represents the crud-induced localized corrosion (CILC) case; the crud is mostly Fe_2O_3 with areas of CuO, involves BWRs including Browns Ferry, Hatch-1 and 12, Limerick-1, and Vermont Yankee, and occurs at plants with copper alloy condensers and powered resin demineralizer systems. Class IV crud represents early PWRs such as Ginna, Robinson-2, Oconee, and Point Beach; the effects of Class IV crud are probably a function of the crud's thickness, not its composition. Class V crud is associated with recent BWRs and PWRs (little crud has been found on fuel rods at these plants and no crud problems have been observed). Hence, for the fuel assemblies listed in Table 2, the crud classes are: I for Big Rock Point, IV for Ginna, II for Oyster Creek, and IV for Point Beach fuel.

Described on the following pages are 1) the conclusions and recommendations from this study, 2) a description of the West Valley facility, and 3) some of the experiences with handling (including rod consolidation) and shipping of spent light-water reactor (LWR) fuel that has been stored at the West Valley facility.

(a) See the section entitled "Shipping Experience."

2.0 CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations derived from this study are presented in Sections 2.1 and 2.2, respectively.

2.1 CONCLUSIONS

The conclusions from this study are described below and involve these subject areas: an overview of experience, handling of spent fuel, storing of spent fuel, rod consolidation,[a] shipping of spent fuel, and loosening on spent fuel, and visual inspection of spent fuel.

2.1.1 Overview of Experience

- The West Valley reprocessing facility handled and processed fuels from nine different reactors during 28 campaigns over the six-year period from 1966 to 1972.[1] The experience with handling, storing, and shipping those first-generation spent nuclear fuel assemblies resulted in considerable changes to equipment, systems, procedures, and concepts; those changes were made after the plant was shut down and cleaned up in 1972.
- From February 1973 to December 1975, 756 spent LWR fuel assemblies were shipped to the West Valley facility for storage in the pool. With the Congressional enactment of the West Valley Demonstration Project Act, it became necessary to remove the 756 fuel assemblies from the pool.[1] Currently, there are 125 (85 BWR and 40 PWR) fuel assemblies left in the pool, and it is planned to ship these DOE-owned fuel assemblies to the Idaho National Engineering Laboratory (INEL) for storage.[8]

2.1.2 Handling of Spent Fuel

- Spent fuel assemblies and fuel rods are quite sturdy; spent fuel rods can withstand considerable abuse in handling without rupture or breakage.[1,25] Breaking of fuel rods (including prepressurized rods) can be accommodated in spent fuel storage pools.[2,3]

(a) Rod consolidation involves mechanically removing the fuel rods from the fuel assembly hardware (i.e., the nonfuel-bearing structural components) and placing them either in another grid with closer spacing or in a close-packed array in a canister without a spacer grid.

- Some fuel assemblies in storage may be difficult to grapple for handling. For example, it was noted in early inspections of the 125 fuel assemblies that are still at the West Valley facility that eight BWR fuel assemblies (CC-14, CC-39, and D-50 through D-55) were difficult to grapple.

  Grappling problems with BWR and PWR fuel assemblies have also occurred at other sites.[26]

  Sticking of fuel rods (e.g., to the lower tie plate of BWR fuel assemblies) has been noted during fuel reconstitution operations at other sites.[25]

- Moving noticeably warped (i.e., bowed and/or twisted) fuel assemblies into and out of close-fitting enclosures can apparently be difficult in some cases. The West Valley facility encountered a dozen such BWR assemblies in one shipment that required special handling and storage.[1] One fuel assembly stuck in an encapsulation container.

  Problems have also occurred at other sites and involved bowed PWR fuel rods or distorted PWR fuel assemblies.[27]

- Some special failed fuel canisters may be needed. Several fuel assemblies at the West Valley facility were found to contain damaged fuel rods, or distorted or misshapened spacer grids. Those fuel assemblies were placed in special failed fuel canisters, which were then used to handle and ship the assemblies.[1]

2.1.3 Storing of Spent Fuel

- The spent fuel assemblies at the West Valley facility are stored in aluminum canisters. From the standpoint of fuel integrity, the galvanic couples that exist within fuel assemblies and between fuel assemblies and other pool components, e.g., racks, are not expected to present problems with the possible exception of contacts with aluminum alloys.[4] It has been concluded[4] that there are no major reasons for concern about hydriding of Zircaloy that is stored in aluminum alloy storage canisters; however, there are some lingering questions about the possibility of slow, but progressive, hydriding of the Zircaloy over an extended period when the galvanic couple exists.

- The aluminum storage canisters at the West Valley facility have been in the pool for over 20 years. The staff at the West Valley site have indicated[9] that they have found the aluminum to be very sensitive to water quality and pH control. If the water becomes too acidic (pH less than 6.0), then oxide barnacles form and become contaminated, which makes the aluminum difficult to decontaminate and handle.

2.1.4 Rod Consolidation

- The spent PWR fuel rods were found to be much more flexible than expected.[5] Though a rod remains straight when hanging vertically from a grapple, any compressive load (e.g., contact with other rods, the side of the canister, or the bottom of the canister) causes it to bow. On several occasions during the rod consolidation demonstration at the West Valley facility, attempts to load a spent fuel rod into a nearly full canister resulted in a fuel being bent into a flattened "C" shape.[5]
- Some fuel rods may be difficult to grapple. In the rod consolidation demonstration at the West Valley facility, the rods in one PWR fuel assembly (A-20) were more difficult to grapple than those in another PWR fuel assembly (A-41) because the fuel rod ends were not chamfered (even though the drawings show the rods were to be chamfered).[5] In the rod consolidation demonstration at Battelle Columbus Laboratories (BCL), the upper third of one fuel rod with collapsed cladding was deformed (bowed) to the extent that it was difficult to grapple for removal.
- The experience with the rod consolidation demonstration at the West Valley facility indicates that bowed fuel rods will not be a problem once removal of those rods from a fuel assembly begins.
- A broken fuel rod can be overlooked. In the rod consolidation demonstration at BCL, which involved PWR fuel assemblies that had been in storage at the West Valley facility and contained failed and damaged fuel rods, a broken rod was inadvertently overlooked and left in the nonfuel-bearing structural components of the fuel assembly.
- The rod consolidation demonstration at the West Valley facility showed that the resiliency exhibited by the fuel rod has an advantage and a disadvantage. The advantage is that fuel rods can withstand considerable

abuse in handling without rupture or breakage. The disadvantage is that directional and alignment control during stacking operations is extremely difficult. This indicates that rods must be constrained during rod consolidation operations if high compaction ratios are to be achieved.

- During the rod consolidation demonstration at BCL, the cladding on fuel rods with collapsed cladding regions had sufficient ductility (it was considerably better than demonstration project personnel had anticipated) so that the flattened areas could be reformed to make the rod cross sections more circular. This configuration increased the probability that the rods would pass through the consolidation funnel and in the canister.

- The volume reduction operation on the nonfuel-bearing components from the rod consolidation demonstration at the West Valley facility demonstrated that the control rod guide tubes are tough, strong, and capable of bearing the weight of the PWR fuel assembly during lifting. The guide tubes are the load-bearing members when a PWR fuel assembly is lifted (e.g., out of the reactor core, a spent fuel storage rack, or a shipping cask).

- Spent fuel assemblies with failed or damaged fuel rods can be consolidated. The rod consolidation demonstrations at the West Valley facility and at BCL provide encouraging results for rod consolidation operations with such fuel. Although the probability for rod breakage is potentially higher for fuel rods with large cladding defects, fuel assemblies deliberately chosen with known or suspected failed or damaged fuel rods demonstrated relatively infrequent rod breakage.

2.1.5 Shipping of Spent Fuel

- Radioactivity levels in the cask coolant consistently increased in nearly all shipments for which before and after measurements were available.[6] The radioactivity increase could be the result of migration of fission products from the fuel rod interior through cladding breaches to the cask coolant; it could also be caused by ion exchange of fission products absorbed on the crud deposits found on the fuel rod exteriors.

- Though few cases were available for comparison at the time of a 1980 study,[6] the increase in radioactivity level for a dry shipment was six times greater than that of a wet shipment of intact fuel from the same plant.
- Casks containing known leaking fuel assemblies showed the largest radioactivity increase (as much as four orders of magnitude).[6]
- Large differences in radioactivity increases were noted between shipments of intact and breached stainless-steel-clad fuel.
- There were over a dozen cases at the West Valley facility involving casks that had external removable contamination that exceeded the limit of 22,000 disintegrations per minute per 100 square centimeters of package surface that is specified in 10 CFR 20.205.

2.1.6 Crud Loosening

- Evidence of crud loosening was noted with some spent BWR and PWR fuel when it was unloaded from casks and placed in spent fuel storage pools.
- The loosened crud can greatly reduce visibility in the pool water and make operations (e.g., cask loading) difficult and time consuming. The loosened crud can also increase the radiation dose to operating staff in certain operations (e.g., connecting a cask drain hose, if it is a hands-on operation).

2.1.7 Visual Inspection of Spent Fuel

- There can be considerable variation in the results from several visual inspections of the same groups of fuel assemblies. The 125 fuel assemblies that are still in storage at the West Valley facility were visually inspected in May 1989 and also in 1987 and 1985. The videotape from the 1989 inspection shows seven fuel assemblies with failed rods. The visual inspections in 1987 and 1985 indicated that possibly as many as 40 of the 125 assemblies contain or may contain failed or damaged fuel rods; however, there were differences in the written observations from 1987 and 1985 concerning the condition of 24 of the 40 fuel rods. For example, the hole observed in May 1989 in a rod of BWR assembly D-60 was not noted in 1987 or 1985. The hole in a rod in PWR assembly C-19 was noted in 1985 and 1989 but not in 1987. The hole observed in 1989 in a rod in PWR assembly C-23 was not detected in the 1987 and 1985 inspections. The three inspections yielded different results for PWR assembly C-30. For PWR assembly C-34, the results from 1985 are different than those from 1987 and 1989.

- Conclusions drawn about visual inspection from an NRC study(28) in 1980 and 1981 of six pool-side inspection techniques are as follows: "Visual inspection is not a primary tool in the detection of failed fuel. Fuel vendors and utilities consider visual inspection at best a very poor technique for even verifying which fuel rods, from a fuel assembly flagged as a leaker by sipping, and leaking. Small cladding cracks and perforations can be very difficult to see, although pinholes can be seen if bubbles are being emitted during the visual inspection. One fuel vendor estimated that of those fuel rods ultimately determined to be failed, probably only 10% or less are detected by visual inspection of the fuel assembly. Only a small percentage of the total surface of the fuel rod is visible in a fuel assembly that is not disassembled, which makes the identification of a leaking fuel rod difficult even when a large perforation or discoloration is present."
- A recent report(29) indicates that fuel rod failures in PWR fuel assemblies tend to occur in two places: the periphery of the assembly, and the interior (directly adjacent to the central instrument tube) of the assembly. Visual inspection may identify some of the failed rods on the assembly exterior but most likely will not detect the failed rods in the assembly interior.
- A recent paper(30) reports that the spent fuel least likely to have been inspected is the fuel most likely to be the first to be consolidated or placed into dry storage.

2.2 RECOMMENDATIONS

The recommendations from this study are described below.

- Handling, storing, and shipping operations with spent fuel need to be under continuing surveillance to keep track of a) the experience failed and damaged fuel, especially old fuel (but also newer, high-burnup fuel); b) the experience with spent fuel (especially old fuel) that has substantial amounts of crud (e.g., look for evidence of crud loosening after extended storage); and c) the experience with examination, reconstitution, and rod consolidation with spent fuel, including old fuel and newer, high-burnup fuel.

- If only visual inspection is performed to separate intact fuel assemblies with presumably sound fuel rods from damaged fuel assemblies and from fuel assemblies with failed or damaged fuel rods, then it would help to develop a set of uniform definitions, visual standards, lighting requirements, etc.[28] Visual inspection is considered to be highly subjective and no "book of standards" appears to exist; however, equipment and procedures for visual inspection are usually well-documented as unpublished data (these are usually the proprietary property of the fuel vendor or utility).[28]
- It would be useful for facility operators to know the number, identity, and location of a) fuel assemblies with significant warp (i.e., bow and/or twist), especially those fuel assemblies that require special loading and storage, b) fuel assemblies with distorted or misshapened spacer grids or with fuel rods that extend beyond the fuel assembly envelope.
- It is important to check for evidence of any galvanically-induced hydriding of the fuel cladding among the 125 fuel assemblies that are still in the pool at the West Valley facility. Those fuel assemblies contain Zircaloy-clad fuel rods and have been stored in aluminum canisters since 1973 to 1974.
- There is need to reduce the demand for manual dexterity in some rod consolidation techniques.
- If rod consolidation is planned, it would be useful to know if any of the fuel assemblies contain fuel rods with collapsed cladding (a result of irradiation-induced fuel densification and the coolant pressure on the cladding exterior). In one rod consolidation demonstration, a fuel rod with collapsed cladding was bowed to the extent that it was difficult to

grapple. Also, rods with collapsed cladding can become stuck in fuel assemblies or consolidation equipment.

- In rod consolidation operations, there is a need to provide assurance in existing procedures that <u>all</u> fuel rods (i.e., intact, damaged, failed, and broken rods) are completely removed from the fuel assembly.
- If rod consolidation is planned, it could be important to exclude fuel rods with significantly hydrided Zircaloy cladding. Appropriate limits on hydride concentration and orientation may need to be established. Hydrided Zircaloy cladding could exhibit structural weakness and make handling and consolidation operations more difficult.

3.0 WEST VALLEY FACILITY

The West Valley facility, which is at the Western New York Nuclear Service Center at West Valley, New York, is currently under the West Valley Demonstration Project and is operated by West Valley Nuclear Service Company, Inc. (i.e., Westinghouse Electric Corporation) for DOE. The facility, which was formerly a nuclear fuel reprocessing center, was built and previously operated by Nuclear Fuel Services (NFS). The facility consists of a shutdown reprocessing plant, a shutdown commercial burial ground, and a spent fuel storage facility.[20] The spent fuel storage facility is called the Fuel Receiving Station (FRS) or Fuel Receiving and Storage (FRS) Facility in the documentation[21] and is shown in Figure 1. The FRS consists of two parts, a pool and an enclosing building. The pool (Figure 2) is an embedded structure consisting of a cask unloading cell, fuel storage cell, and water treatment cell. Figure 3 provides a section view of the FRS pool showing the storage rack area. The enclosing building covers the pool and work areas. Key features of the facility are listed below:

- The spent fuel storage pool is 23 m (75 ft) long, 12 m (39 ft) wide, and 8.8 m (29 ft) deep, and normally filled with demineralized water to a depth of 8.5 m (28 ft).[20] The spent fuel pool has concrete walls that are painted with "Carboline."
- The walls of the cask unloading pool (CUP), which adjoins the spent fuel storage pool, are clad with stainless steel. The CUP cell floor has two levels. The upper level is even with the fuel storage cell and the lower level is 4.9 m (16 ft lower); this cell is normally filled with water, but occasionally it is drained so the cell can be cleaned.[21]
- The fuel storage racks consist of an aluminum beam structure that provides a total capacity of 924[a] fuel storage canisters.[20] The aluminum storage canisters (Figure 5) have an inside diameter of 31.8 cm (12.5 in.) and a center-to-center spacing of 51.4 cm (20.25 in.).[14]

(a) A 1979 reference[21] lists the pool capacity as 1,092 canisters. The 1982 reference[20] indicates that each row will accommodate 22 canisters, but normally only 21 are stored in a row for operating convenience.

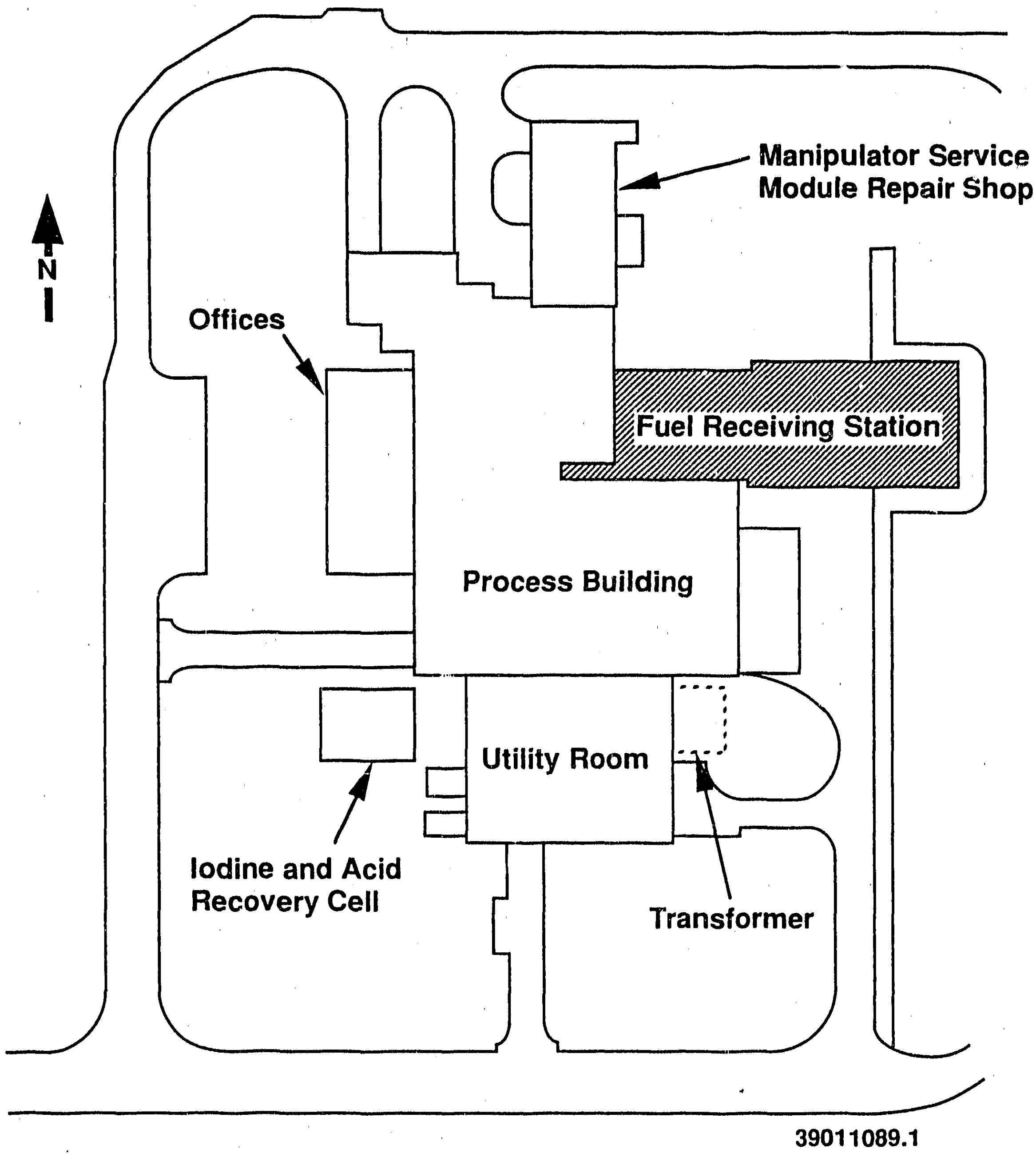

FIGURE 1. Plan View of the West Valley Facility Showing the Location of the Fuel Receiving Station (FRS)(21)

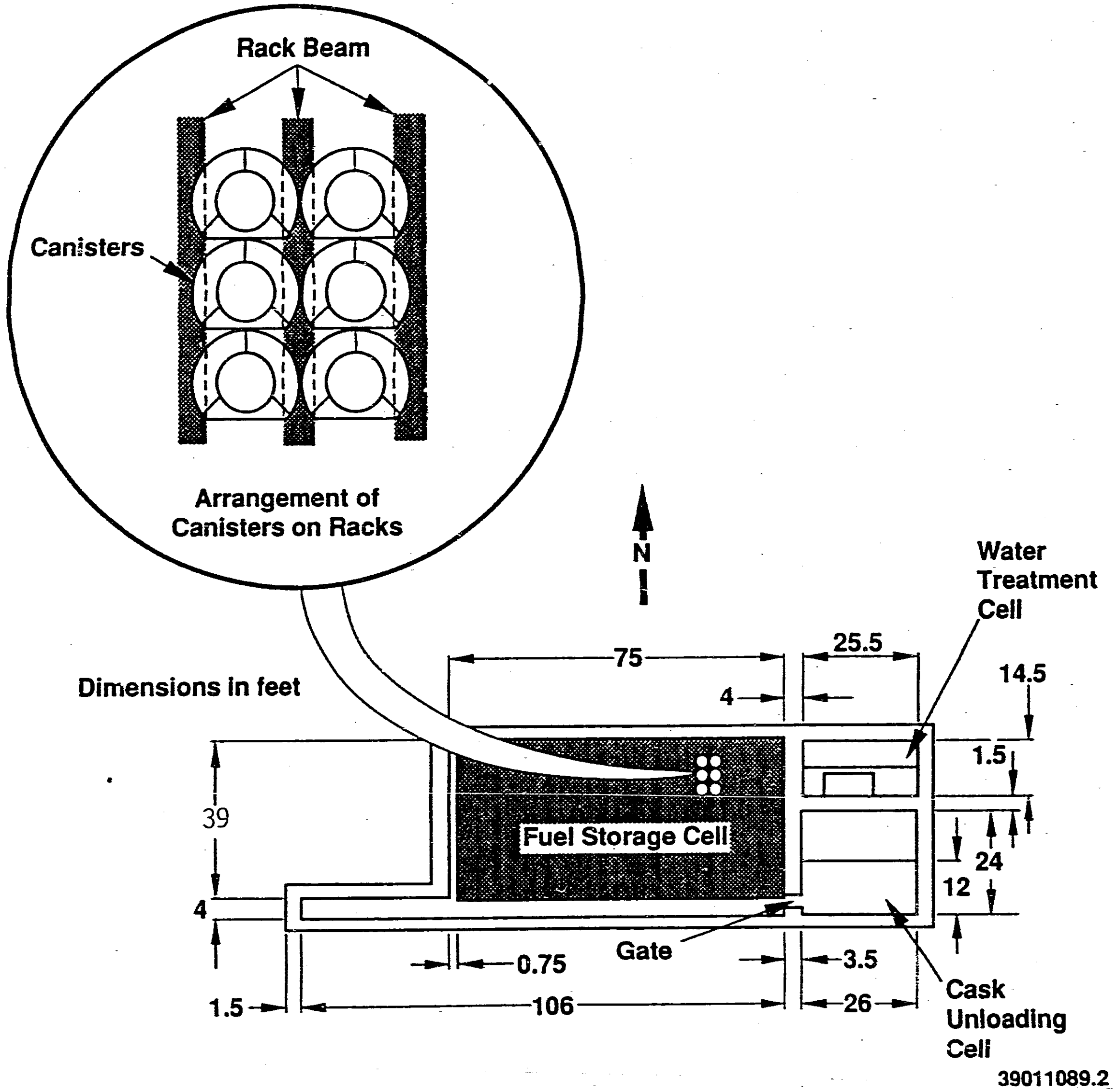

FIGURE 2. Plan View of the Fuel Receiving Station (FRS) Spent Fuel Storage Pool and Close-Up of the Canister Arrangement(21)

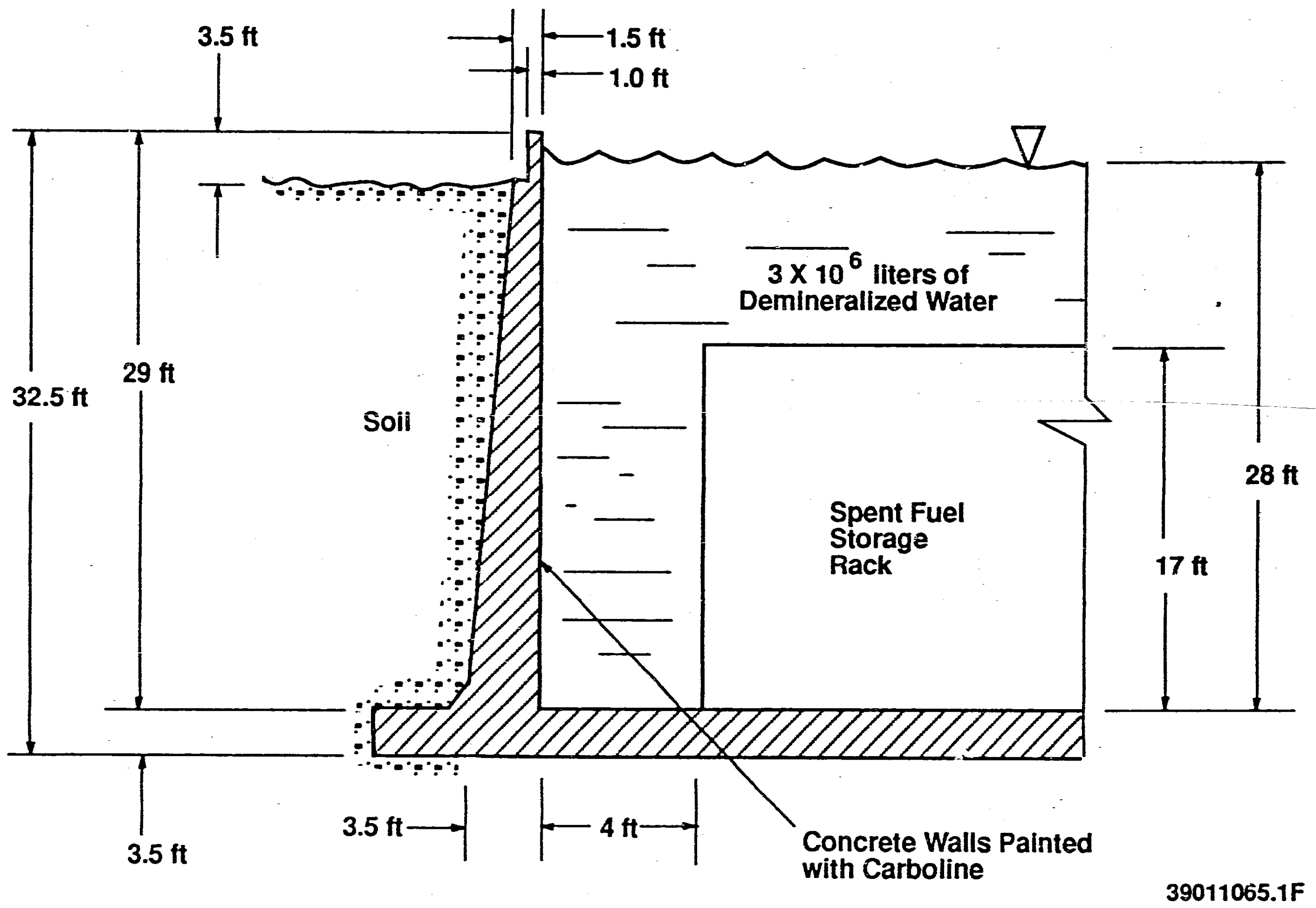

FIGURE 3. Section View of the Fuel Receiving Station (FRS) Pool Showing Storage Rack Area[21]

A storage canister is up to 4.9 m (15 ft 10 in.) long and can accommodate one PWR fuel assembly or two or three BWR fuel bundles.[20] Each canister weighs approximately 1,200 pounds when filled with fuel and is supported by two rack beams as shown in Figure 5.

- The aluminum storage canisters have been in the pool for over 20 years. The staff at the West Valley site have indicated[20] that they have found the aluminum to be very sensitive to water quality and pH control. If the water becomes too acidic (pH less than 6.0), oxide barnacles form and become contaminated and make the aluminum difficult to decontaminate and handle.

- A 1987 report[1] indicates that the cooling system regulates the pool water temperature at approximately 12.4°C (80°F) but less than 29.1°C (110°F). The pool depth of 28 ft may be equated with a water boiling temperature of 245°F at the bottom.[16] If the pool water should ever come to boiling, the integrity of the fuel cladding would not be jeopardized and the radioactivity would be contained in the fuel assembly.[22]

- The pool cannot be inadvertently drained. The pool contains 3.0×10^6 liters of water.[23] The withdrawal of pool water by the cooling system would terminate leaving about 8½ to 10 ft of water above the stored fuel and the shielding is adequate to reduce the radiation levels from the fuel (e.g., with a burnup of 40,000 MWd/MTU, a power density of 40 kW/kg, and 150 days cooling time) to less than 25 mR/h.[22]

- Leakage of pool water into the cooling system is readily detectable. The monitor should be able to detect a leak as small as 3 liters per hour even when the pool water activity is as low as 1×10^{-3} μCi/ml.[22]

- A 1979 letter[24] contains a list of standard operating procedures (SOPs) for the Fuel Receiving Station (FRS). Included in the list are procedures for the cask unloading crane (SOP 1-8), operation of the fuel pool crane (SOP 1-9), operation of the fuel pool service bridge (SOP 1-10), fuel pool water system (SOP 1-12), operation of the cast unloading pool lift rack (SOP 1-16), FRS filter medium and resin disposal and replacement (SOP 1-35), operation of the new FRS pool cooling system

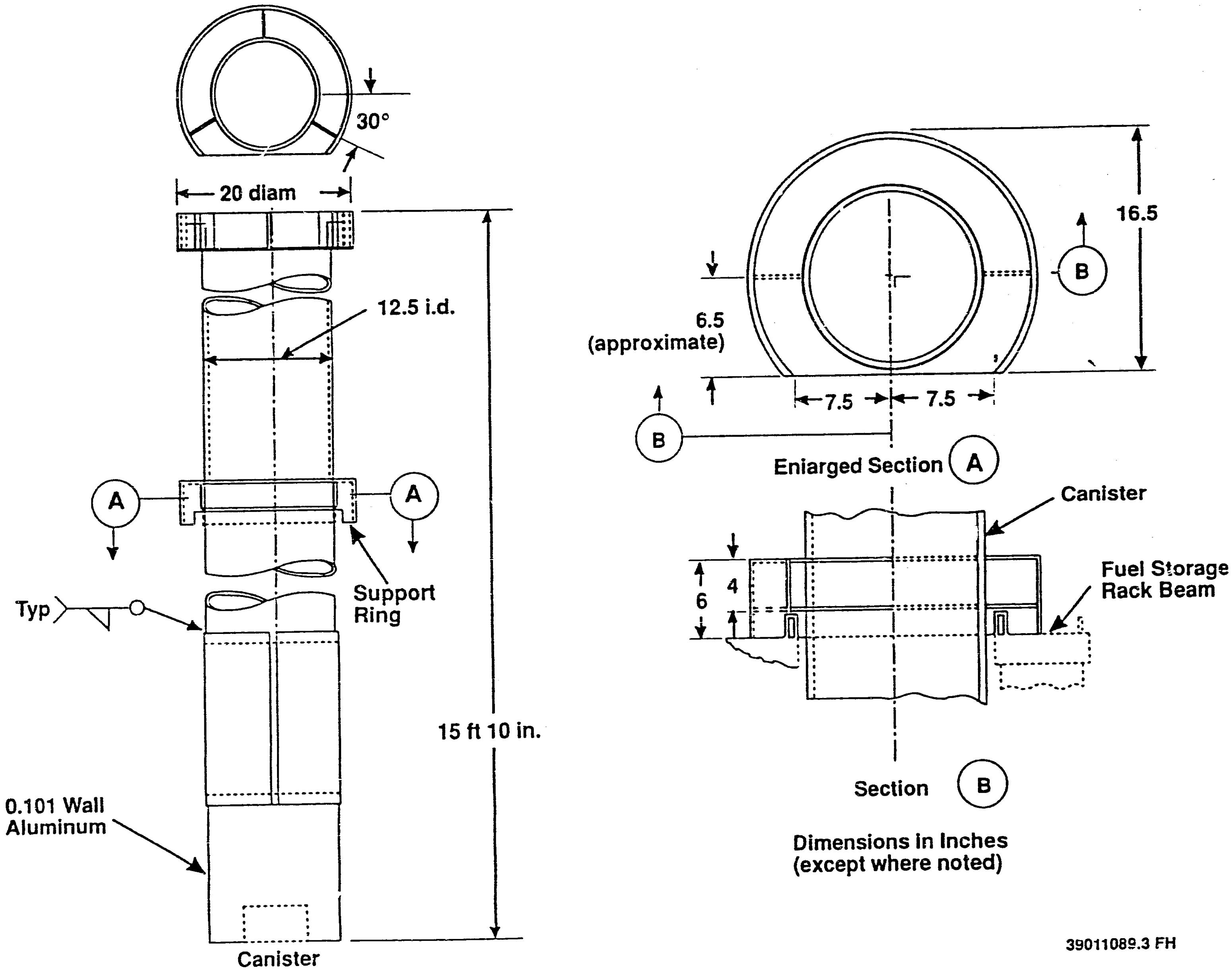

FIGURE 4. Detailed Drawings of Fuel Canister and Support System(21)

(SOP 1-36), operation of the FRS ventilation system (SOP 1-38), and NFS-4 cask handling (SOP 1-39).

- After shutdown of operations in November 1972, the storage pool was emptied, decontaminated to 50 to 500 dpm[a] alpha/100 cm^2 and/or 500 to 50,000 dpm beta/100 cm^2 surface contamination levels, inspected, and repaired. A 1.8 m (6 ft) to 2.4 m (8 ft) bulge in the lower sections of the stainless steel liner in the southwest corner of the pool's cask handling area was repaired at that time.

(a) Disintegrations per minute (dpm).

4.0 EXPERIENCE WITH HANDLING AND SHIPPING OF RELATIVELY OLD SPENT FUEL THAT HAS BEEN IN POOL STORAGE AT THE WEST VALLEY FACILITY

4.1 HANDLING EXPERIENCE

This section describes the following: a) spent fuel handling experience at West Valley; b) rod consolidation experience with Ginna fuel assemblies at West Valley; and c) rod consolidation with Ginna fuel assemblies at Battelle Columbus Laboratory. The Ginna fuel assemblies had been stored at the West Valley facility for about 13 years.

4.1.1 Handling Experience at the West Valley Facility

The West Valley Plant was designed as a multi-purpose plant with a capability of reprocessing a number of different types of spent fuel.(31) During the time that reprocessing was in progress, the spent fuel was received, by rail and by truck, in specially designed and shielded shipping casks. The larger casks were cooled with demineralized water. If it was determined during the course of cask unloading that any of the fuel assemblies contained therein were ruptured,[1] such assemblies were placed in canisters (if such was warranted) and the canisters subsequently placed in storage cans. During the reprocessing campaigns, several fuel assemblies with damaged fuel rods were noted during the underwater visual inspections; also, some fuel assemblies were observed to have distorted and misshapened spacer grids. Fuel assemblies with damaged fuel rods and fuel assemblies with distorted spacer grids were inserted into special failed fuel canisters, which were used to handle and ship these fuel assemblies.(1) The plant was also prepared to receive spent fuel assemblies that had been placed in canisters before shipment and to vent and purge such canisters into the ventilation off-gas system of the plant. The loaded fuel storage canisters were transferred from the cask unloading pool to the storage pool, one at a time, using a bridge crane that spanned the entire cask unloading and spent fuel storage area.

Pertinent handling experience at the West Valley Plant during various periods between October 1966 and October 1975 is described below.

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1 This was determined, for example, by underwater video visual inspection(1) or by analysis of water samples.

(a) <u>October 1966 through January 1967</u>

Moving warped and/or twisted fuel assemblies into or out of close-fitting enclosures (e.g., the shear magazine,[a] a canister, or a spent fuel storage rack position) can be difficult in some cases. During the period from October 1966 through January 1967, it was found that "...12 of 20 fuel assemblies received from Dresden (shipment no. 13) had serious warpage and twisting"; these BWR assemblies required special handling and storage.[32] During the same period, fuel jamming occurred within the shear magazine during initial processing of Dresden (BWR) fuel in the process mechanical cell.

In preparing to reprocess Dresden fuel, several problems occurred during fuel handling: a) there were two times when fuel assemblies jammed in the shear magazine, b) three times there was difficulty in charging fuel assemblies into the shear magazine, c) one fuel assembly stuck in the encapsulation container, and d) there was difficulty in removing the lid from an encapsulation container that contained a fuel assembly.[31] Also, during preparations for reprocessing of Yankee Rowe (PWR) fuel, there were three times when fuel assemblies jammed in the shear feed mechanism.[31]

(b) <u>January through March 1969</u>

During the period January through March 1969, a significant number of ruptured New Production Reactor (NPR) fuel assemblies were detected.[33] The two-piece, Zircaloy-clad uranium fuel assemblies were from Hanford's NPR. At the start of NPR Lot XII, five ruptured fuel assemblies were found in the first two storage canisters. As the reprocessing run continued, the frequency of detecting ruptures increased, and the type of rupture was different from those detected in previous NPR campaigns. The ruptures observed in this period occurred at the weld area on the end of the outer core with the cladding expanded or torn an average of one-half the length of the fuel element. In some cases, the cladding was torn the entire length. Because facility operators found ruptures more frequently and observed that the

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[a] One component at the head end of the West Valley reprocessing system was a hydraulic shear that was used to reduce fuel assemblies to short lengths for leaching. The shear magazine was a close-fitting enclosure used to guide the fuel assemblies into the shear.

radioactivity in the Fuel Receiving and Storage (FRS) pool was increasing, they usually inspected the top end of the storage canisters containing the NPR fuel in the storage pool. At least eight ruptures were visible. NFS concluded that the ruptures were probably a caused by a combination of high radiation exposure, damage during discharge from the reactor, and vibration during shipping.

(c) April through June 1969

During the period April through June 1969, the detection of ruptured NPR fuel assemblies continued throughout NPR Lot XII. The ruptures number 31 outer assemblies and 10 complete assemblies.(34) The ruptured assemblies were loaded into scrap drums and buried after encasement in concrete. During the period, the FRS pool had radiation levels of 30 to 100 mR/h at the surface.

The average activity of the FRS pool water increased from 5×10^{-3} μCi/ml in 1968 to 1×10^{-1} μCi/ml in 1969, with most of the activity being radioactive cesium. The permanently installed filtration and demineralization systems were ineffective for total cleanup; as a result, a two-phase program was initiated during the period April through June 1969 to reduce the pool activity to the 1968 concentration. First, the pool was to be vacuumed and second, special demineralizers were to be added. The totally submersible vacuum system had a capability of collecting 60-micron particles. Most pool areas where ruptured assemblies were stored were vacuumed during the period.

(d) July through September 1969

During the period July through September 1969, samples taken of the primary coolant of the NFSX-1 cask indicated that ruptured NPR fuel was present; sample results were in the 10^{-3} Ci/ml range.(35) The facility operators planned to encapsulate the ruptured fuel assemblies for return to the U.S. Atomic Energy Commission (AEC).

During the July through September 1969, the FRS pool water activity decreased from a high of 1×10^{-1} μCi/ml at the beginning of the quarter to a low for the year of 6×10^{-3} μCi/ml at the end of the quarter.(35) The totally submersible vacuum system continued in operation during this period; all suspected source areas for contamination were vacuumed.

(e) October through December 1969

During the period October through December 1969, the NFS Plant Safety Committee approved a method of removing coolant activity in the NFSX-1 cask to the waste storage tank. The coolant removal operation had to be suspended when the cavity drainage port plugged.[36] The NFSX-1 cask was placed in the cask unloading pool for temporary storage.

During the October through December 1969 quarter, the FRS pool water activity reached a low for the year of 3.5×10^{-3} μCi/ml.[36]

(f) January through March 1970

The NFSX-1 cask remained in temporary storage in the pool during the January through March 1970 quarter.[37]

During this quarter, a new containment, zinc-65, caused an increase in pool activity.[37]

(g) April through June 1970

Unloading of the NFSX-1 cask began during the April through June 1970 quarter. A total of 29 baskets of NPR fuel were moved from the FRS pool to the process mechanical cell and visually checked for ruptures.[38] A total of 61 outer and 19 inner fuel assembly sections were confirmed as being ruptured. Thirty outer and 11 inner assembly sections were encapsulated; the remainder were temporarily stored until additional cans could be fabricated.

Despite special precautions, such as transferring the NFSX-1 coolant directly to high level waste storage and unloading while vacuuming, the FRS pool water activity increased to 3.37×10^{-1} μCi/ml.[38] An additional 10 resin beds using a different resin were placed in service; pool activity at the end of the April-June 1970 quarter was 8.9×10^{-2} μCi/ml (beta).

(h) November 1972

An unanticipated problem was encountered in November 1972 with the cask unloading pool liner of the Fuel Receiving and Storage Area.[39] Certain lower sections of the stainless steel liner in the southwest corner of the cask unloading pool were found bulged 6 to 8 in. out from the concrete wall at a level approximately 4 ft from the floor. In addition, several other plates had slight bulges at the 4-ft level. Several small leaks in the liner were also observed during this inspection. Samples of the water behind the liner were analyzed for gross gamma activity and cesium-137; the results showed that the water originated from the storage pool. There was no release of radioactivity resulting from the bulged liner or the repair of the bulge. It was concluded that the leakage occurred as a result of a nonvisible crack at the seam between the liner and the storage pool seal. The bulged plates were repositioned and seal welded.

(i) July 1975

NRC inspectors witnessed the unloading of spent fuel from Oyster Creek from the NFS-4 spent fuel cask on July 17, 1975.[40] A potential problem, which involved the release of gas from a cask, was identified during overview of the unloading procedures. Upon close examination, the inspectors found that this potential problem should present no safety problems. Also, a procedure for checking the cask lid seal was not followed. Details about the release of gas from a cask and the pressure check of double O-rings on the cask lid are discussed separately below.

Release of Gas from a Cask - When the cask lid was removed under water, bubbles of trapped air (gas) rose to the surface of the pool directly under the location where operators were working. This could cause a possible problem with airborne radioactivity contamination.

A free space is left in the cask during loading to accommodate expansion during transport. Flushing of the water surrounding the fuel for one hour before to opening does not always eliminate all of this free space. However, most if not all of the air space should be filled with water during the flushing operation. As far as NFS could determine, no problems have arisen because of this release of air space (i.e., no air radiation monitors have ever gone off after a release of this kind).

Gas bubbles known to be coming directly from fuel rods were analyzed. The bubbles contained about 10^{-7} microcuries of krypton plus xenon, which was well within the limit specified in 10 CFR 20, Appendix B, Table 1, Columns as adjusted by 10 CFR 20.203(d),(1). The gas released during fuel unloading should not be as potentially hazardous as that indicated in the foregoing illustration.

Pressure Check of Double O-Rings on Cask Lid - NFS did not follow their own approved procedure while checking the seal of the double O-rings between the cask lid and the cask body. The procedure called for pressurizing the annulus between the O-rings, after the lid is bolted to the cask, to 10 to 15-psig air. The air pressure is to be held for 10 minutes with no drop in pressure apparent. The actual check made involved a pressure of 110 psig with the check time of about three minutes. NFS indicated that they would change the procedure to provide the use of the higher air pressure and shorter time during the check of the seal.

(j) October 1975

During Inspection No. 75-06 in October 1975, the licensee (NFS) indicated that the procedure for checking the seal of the double O-rings between the cask lid (i.e., on the closed empty NFS-4 cask) and cask body would be changed to coincide with the operation as being performed.[41] The procedure as of the inspection date did not explicitly provide for isolation of the air supply space being checked for leakage from the pressurized air supply. The procedure was revised on July 22, 1975 to avoid any question.

In October 1975, all the irradiated fuel stored in the storage pool appeared to be stored in canisters as required.[41]

In October 1975, the cooler for the fuel storage pool water was keeping the water in the pool at about 75°F.[41]

4.1.2 Rod Consolidation Experience with Ginna (PWR) Fuel Assemblies at the West Valley Facility

A rod consolidation demonstration involving pulling all the fuel rods from six PWR fuel assemblies was conducted in late December 1985 and in February 1986 at the West Valley facility in the 14-m (45-ft) deep cask unloading pool, which adjoins the spent fuel storage pool.[5,42,43] The fuel assemblies had been irradiated in Rochester Gas and Electric Corporation's (RG&E) Ginna plant and then stored at the West Valley facility. Rod consolidation involves mechanically removing the fuel rods from the fuel assembly hardware (i.e., the nonfuel-bearing structural components) and placing them either in another grid with closer spacing or in a close-packed array in a canister without a spacer grid. The rod consolidation demonstration was performed by Nuclear Assurance Corporation (NAC).

Described below are the selection of fuel assemblies for consolidation, positioning of rods in a canister, rod characteristics, rod grappling, rod sticking, release of a fission gas bubble, exposure, crud, nonfuel-bearing components, and the assumption for shipping consolidated fuel rods.

(a) Selection of Fuel Assemblies for Consolidation

The six fuel assemblies had been stored in the pool at the West Valley facility since 1973.[20] Each fuel assembly contained 179 fuel rods. The fuel assembly burnups were in the 20,000 to 22,000 MWd/MTU range. All of the fuel rods (a total of 1,074) were pulled from the assemblies and placed in consolidation canisters. According to RG&E's position, failed fuel should be consolidated first, because once the failed fuel is consolidated and placed in containers the failed fuel is much less of a concern and in fact should be no different than unfailed fuel for future storage and handling.[42]

Among the fuel rods were some with collapsed cladding, which was a result of in-reactor fuel densification.[44] RG&E indicated that the fuel assemblies selected for the consolidation demonstration did not include fuel rods with hydrided cladding.[42] Hydrided cladding could exhibit structural weakness and make handling and consolidation activities more difficult.

(b) Positioning of Rods in a Canister

In this consolidation demonstration, the fuel rods were pulled manually one at a time from the fuel assemblies and placed in the canister one at a time. The procedure for maneuvering the rods into a close-packed array in the canister was difficult. RG&E has determined that control of the rod during its insertion into the canister is extremely important and is an area that needs considerable engineering attention.[42] NAC also indicates that their experience at the West Valley facility provides clear evidence of the need for mechanical rod constraint and direction to lessen the demand upon human skills.

(c) Rod Characteristics

A comment by operators during the consolidation demonstration was that the fuel rods behaved like "wet spaghetti" and were much more flexible than expected.(5) On several occasions, attempts to load a rod into a nearly full canister resulted in a fuel rod being bent into a flattened "C" shape. The fuel rods were quite flexible, and while they remained straight when hanging vertically from a grapple, any compressive load (e.g., contact with other rods, the side of the canister, or the bottom of the canister) caused them to bow. According to RG&E, the unexpected flexibility and resiliency of the fuel rods create a problem in achieving compaction ratios close to 2:1 with rod consolidation techniques that do not employ a transition device (such as the technique used at the West Valley facility). A transition device helps hold the rods in a closely packed array as the rods enter the canister. The resiliency exhibited by the rod 1) has the advantage of providing confidence that fuel rods can withstand considerable abuse in handling without rupture or breakage, 2) has the disadvantage that directional and alignment control during stacking operations is extremely difficult. This indicates that rods must be constrained during rod consolidation operations if high compaction ratios are to be achieved. Because of the inherent flexibility, a bowed rod in a fuel assembly is likely to straighten out somewhat when it is removed from the assembly and suspended vertically from its end. Therefore, RG&E concludes that the evidence from the rod consolidation operations at the West Valley facility indicates that bowed rods will not be a problem once removal of those rods from a fuel assembly begins.

(d) Rod Grappling

Grappling of the fuel rods in one fuel assembly (A-20) was more difficult than grappling rods in another fuel assembly (A-41) because the fuel rod ends were not chamfered.(5) This was unexpected because the drawings of the fuel rods show a chamfer.

(e) Rod Sticking

No rods were broken or dropped during the demonstration at the West Valley facility but several rods stuck because of flat spots (areas where the cladding had collapsed) after they had been partially pulled from the assemblies. However, those rods were freed by slightly twisting them to align the long (transverse) dimension of the flattened cross section along the diagonal of the spacer grid.[42]

(f) Release of Fission Gas Bubble

During the rod consolidation demonstration, a rod with collapsed cladding interfered with a spacer grid and caused the release of a bubble of fission gas. Operators visually estimated the bubble to be baseball-to-grapefruit size and were able to vacate the working platform by the time the bubble broke the surface of the pool water.[42] Alarms were triggered. RG&E reported that no significant consequence resulted from the release of fission gas and that operators resumed work after vacating the working platform and taking necessary precautions. There was no inordinate pulling force being exerted on the rod at the time the release occurred.[5] Failure of the rod was limited to cracking of the edges of flattened zone of the cladding, and the cladding did not separate or allow fuel material to escape. The operator actually operating the grapple at the time the rod cracked was the only one to show a trace exposure to tritium and that was at the lower level of detection of the test requirement.[5]

(g) Exposure

The rod consolidation activities at the West Valley facility did not result in significant exposure to the personnel. An exposure level of 0.6 mrem/h in a 1- to 2-mrem/h background was experienced.[42]

(h) Crud

Much attention and concern have been given to crud release during rod consolidation operations, because of the experience by Duke Power and Westinghouse during the rod consolidation demonstration with Oconee fuel.[45] Crud that came loose or was scraped loose from the rods during the consolidation demonstration at the West Valley facility did not result in an increase in pool water radioactivity; water clarity was also maintained.[5,42] There was a two-stage filtration system located at the bottom of the fuel assembly holding rig to collect any released particulates. A downward flow swept the released crud into the filter system.[46] A video camera, focused on each rod as it was withdrawn, showed that a black stream of crud scraped from the rod was formed as it passed through the upper grid. This stream would rise several inches over the top of the assembly before being drawn down into the canister, which enshrouded the assembly. Water was pumped from the bottom of this canister, at approximately 30 gpm through two filters with 80 mesh and 30 mesh filter cartridges. The discharge water was returned to the pool about 30 feet from the consolidation equipment but never showed noticeable contamination. The canister shroud extended from the bottom of the assembly up to the level of the upper grid, so that the upper rod ends were exposed to the rod grapple after the upper end fitting was removed. The water inside the rod consolidation canister did become cloudy because of crud released from fuel rods as they were inserted into the canister.

(i) Nonfuel-Bearing Components

RG&E indicated that during the crushing and shearing operations on the nonfuel-bearing components[42] an unexpected phenomenon occurred. The guide tubes broke apart in an explosive manner rather than in a smooth shearing manner, as was expected. NAC explained this phenomenon as follows. The NAC video tapes document that the guide tubes exhibited significant ductility during the extreme crushing operations (the tubes could be bent 90 degrees by misaligned shear blades without breaking). During shearing operations, the crushed tubes were first compressed into an almost solid mass. Then the actual cut began with a smooth shear of the tubes first touching the advancing blade, followed almost immediately by fracture of the rest of the tube mass. This fracture was indeed brittle, almost "explosive" in nature, with small suspended particles and crud "shooting" to the rear of the crusher/shear operations. Even so, a later view of the sheared guide tubes always showed an even, smooth cut line with no cracks evident.

Subsequent NAC investigations with various shear manufacturers and DOE-Idaho indicated that the phenomenon observed is a classic shear cutting behavior for relatively "thick" material (such as the compressed mass of sixteen guide tubes and one instrument tube). With material of this thickness, the cut starts with a smooth shear and continues to fracture. NAC stated that the video tapes of the shearing are indeed striking (and indicate a major cause of the debris created) but normal. If anything, the operation demonstrated that the guide tubes are tough, strong, and capable of bearing the weight of the fuel assembly during lifting. The control rod guide tubes are the load-bearing numbers when a PWR fuel assembly is lifted (e.g., out of the reactor core, a spent fuel storage rack, or a shipping cask).

(j) Assumption for Shipping Consolidated Fuel Rods

All of the rods handled during the rod consolidation demonstration were considered failed fuel for shipping purposes. The Nuclear Regulatory Commission (NRC) allows fuel rods with cladding breaches no larger than "pinhole leaks or hair-line cracks" to be shipped in the same manner as intact fuel rods. In this demonstration, no attempt was made to sort the fuel rods by cladding defect size. The NRC definition of "pinhole leaks or hairline cracks" was not adhered to since all the consolidated fuel was shipped as failed fuel.

4.1.3 Rod Consolidation Experience with Ginna (PWR) Fuel Assemblies at BCL

A rod consolidation demonstration using five Ginna spent fuel assemblies known to contain failed fuel rods (some rods had collapsed cladding, a result of in-reactor fuel densification, a phenomenon observed in the early 1970s) was conducted during August to October 1986 by U.S. Tool and Die, Inc. (UST&D).[47] This demonstration was performed for RG&E in the spent fuel storage pool at Battelle Columbus Laboratory (BCL) in West Jefferson, Ohio. This demonstration was a follow-on program to the earlier rod consolidation demonstration at the West Valley Demonstration Project in West Valley, New York, which was described above. The five fuel assemblies that were consolidated at BCL had burnup levels in the 20,000 to 22,000 MWd/MTU range. Seven Ginna fuel assemblies were shipped from the West Valley facility to the BCL pool for the demonstration; however, two of the seven were not consolidated due to time and budget constraints. The seven assemblies had been stored at the West Valley facility since 1973. Each fuel assembly contained 179 fuel rods. Of the seven RG&E assemblies at BCL, one (B-40) was considered by UST&D and RG&E to be the least likely candidate for consolidation because it had several visibly deformed fuel rods; the rods had short sections, 2.5 to 7.5 cm (1 to 3 in.) long, with collapsed cladding.

The rod consolidation demonstration involved pulling the fuel rods from the fuel assemblies. With the UST&D underwater technique, the fuel rods are pulled from the bottom of the vertically oriented fuel assembly and guided into the consolidated rod canister using a funneling device. A multiple-rod pulling method was employed.

As noted above, A. A. Fuierer of RG&E stated[42] that in his opinion failed fuel should be the first to be consolidated. As a result, the rod consolidation demonstration with RG&E fuel specifically and intentionally involved the disassembly (consolidation) of failed fuel. The fuel selected for consolidation at West Valley and BCL, as far as was known, included fuel with hydrided cladding, which could exhibit structural weaknesses. However, the fuel selected included fuel rods with collapsed cladding that could interfere with movement of the rods through the fuel assembly spacer grids or with entry of those rods into the rod gripper jack (the device used to pull the fuel rods from the fuel assembly) or the funnel (the transition device between the fuel assembly and the canister that aids in obtaining high compaction ratios of fuel rods in canisters). The demonstration project personnel did not expect any fuel rods to break during consolidation operations.

The demonstration at BCL provided encouraging results for rod consolidation operations on damaged fuel. It also provided additional evidence that rod breakage is relatively infrequent, even when fuel assemblies containing failed or damaged fuel rods are intentionally chosen for examination, reconstitution, or rod consolidation. The likelihood for rod breakage is potentially higher for fuel rods with large cladding defects. This demonstration involved 895 PWR fuel rods, among which there were some known damaged rods (over 50 had collapsed cladding); no rods were broken or dropped during the demonstration. The upper third of one rod with collapsed cladding was deformed (bowed) to the extent that it was difficult to grapple for removal. Following the consolidation of the first assembly, it was discovered that UST&D personnel had placed the nine fuel rods with collapsed cladding from the first assembly into the failed fuel canister unsupported, which was contrary to their own preferred procedure. A procedural change was then made requiring that all rods placed in the failed fuel canister must be supported by inserting the rods into tubes within the failed fuel canister. It was during the process of removing the nine unsupported rods from the failed fuel canister and placing these rods in support tubes in the canister that BCL personnel broke one reformed rod (the reforming operation is described in the following paragraph) into several pieces. Breaking of that fuel rod created no operational problems. The rod pieces were removed from the canister and encapsulated. Another broken rod was found (it was still in the assembly after the rest of the rods had been removed and consolidated) during post-demonstration cutting operations on the nonfuel-bearing structural components from the five assemblies; evidence indicates it was broken before any rod consolidation operations. BCL indicated that when the cut portions of the rod were pieced together, the section appeared to be about 325 cm (128 in.) long. The as-fabricated rod length was about 3.80 m (149.7 in.).

Rods with collapsed cladding would not enter the funnel. Reforming of the flattened areas of the cladding on those rods was attempted to make the rod cross sections more circular; some of the reformed rods passed through the funnel and into the canister. It was encouraging to observe that the cladding on fuel rods with collapsed cladding regions had sufficient ductility (it was considerably better than demonstration project personnel had anticipated) so that the flattened areas could be reformed to make the rod cross sections more circular, which increased the probability that the rods would pass through the consolidation funnel and into the canister. During reforming, one or two rods appeared to release some small gas bubbles, but the radioactivity of the bubbles was below the detection limit necessary to set off detector alarms at the pool surface.

The crud that came loose from or was scraped off the rods increased the beta-gamma activity of the pool water by a factor of 10. When the fuel rods were being simultaneously vibrated and pulled, fine particles of crud were observed in the water outside the underwater fuel assembly enclosure. UST&D personnel commented that all the crud in the water appeared to be white.

During the demonstration, operators observed "shiny spots" at a few locations on rod surfaces. These spots indicate that the scraping had penetrated the black oxide layer through to the underlying metal (Zircaloy-4). It is not yet known whether the metal was scratched more than superficially.

4.2 SHIPPING EXPERIENCE

This section describes the following: experience with shipping Big Rock Point fuel to West Valley; shipping Oyster Creek, Ginna, and Point Beach fuel from West Valley; two occasions (November 1967 and August 1971) when operators at West Valley were exposed to airborne contamination during operations on casks; preparations to ship failed fuel from West Valley; and receipt of externally contaminated casks at West Valley.

4.2.1 Shipments of Big Rock Point (BWR) Fuel to the West Valley Facility

The integrity of spent fuel during transportation was the subject of a 1980 study.(6) The study included fuel with Zircaloy and stainless steel cladding that was shipped from various reactors to spent fuel storage facilities at Morris, Illinois, and West Valley, New York. In that study, the movement of fuel to Morris mainly involved wet and/or dry shipments of PWR fuel; however, the movement of fuel to West Valley in 1973 involved 84 Big Rock Point fuel assemblies (Zircaloy-clad fuel), some of which contained leaking fuel rods. The maximum radioactivity levels within the casks before and after the five shipments to West Valley were 0.09 and 1.8 μCi/ml, respectively.

The study(6) indicated that although mechanical damage from over-the-road shock and vibration had been postulated, no reports of damage from this mechanism were found. However, radioactivity levels in the cask coolant consistently increased in nearly all shipments for which before and after measurements were available. The radioactivity increase could be the result of migration of fission products from the fuel rod interior through cladding breaches to the cask coolant or ion exchange of fission products absorbed on the fuel rod exterior's crud deposits. Casks containing known leaking fuel assemblies showed the largest radioactivity increase (as much as four orders of magnitude). Though few cases were available for comparison at the time of the 1980 study, the increase in radioactivity level for a dry shipment was six times greater than that of a wet shipment of intact fuel from the same plant.[a] Large differences in radioactivity changes were noted between shipments of intact and breached stainless-steel-clad fuel.

4.2.2 Shipments of Oyster Creek (BWR) Fuel from the West Valley Facility

Crud was released from BWR spent fuel assemblies following their shipment from the West Valley facility to the spent fuel storage pool at Oyster Creek (Table 2) and return of the cask to the West Valley facility.[18] The Oyster Creek fuel assemblies had been in the West Valley spent fuel storage pool since 1971-1974.[20] The cask was dried before shipping. In some cases, a reddish crud cloud ("bloom") formed while the shipping cask was opened under water at Oyster Creek for removal of the fuel assemblies; no cloud, however, was previously seen in the West Valley pool when the fuel was inspected and prepared for shipment. Before return of the cask to the West Valley facility, it was thoroughly flushed; but when the cask was reopened underwater at the West Valley facility, crud clouded the water in the cask and the crud again emerged, reddening a large area of the cask unloading pool.[1] Visibility for loading the spent fuel assemblies in the same cask was greatly reduced, which made cask loading very difficult and time consuming.

Following his trip to the West Valley facility in March 1985, A. B. Johnson, Jr. commented on the causes and effects of the crud release event described above.[18] The activity spikes, principally from ^{60}Co and ^{137}Cs, occurred when the returned casks were opened at the West Valley facility; this contamination could lead to increased activity in the "bathtub ring" on the pool wall. Before each shipment, the cask was drained to the pool and dried at 40 mbar (0.6 psia). Crud was drawn into the cask drain hose during the operation, which raised radiation levels. Because connecting the hose is a hands-on operation, the radiation dose to operating staff increased when this operation was performed.

(a) The increase with the dry shipment was 0.00137 μCi/ml; the increase with the wet shipment was 0.00027 μCi\ml. The maximum radioactivity level after transportation was 0.0021 μCi/ml with the dry shipment and was 0.00075 μCi/ml with the wet shipment. For comparison purposes, the maximum radioactivity level of the receiving basin at the GE Morris Operation was stated to be 0.003 μCi/ml.[6]

Reasons for the crud loosening are described in two reports. A report by Connors et al.[1] indicates that the crud loosening was a result of the vacuum drying process. Johnson, as quoted in a report by Hazelton,[18] provides possible explanation for the crud phenomena: a) some of the normally tenacious BWR Fe_2O_3 crud (sometimes 25 to 50 μm thick) may have loosened during extended wet storage; b) dry conditions and vibration during shipping may have further loosened crud from fuel rods; c) water ingress during refitting of the cask may also have loosened some crud and redeposited it as a pasty layer on the cask surfaces and on surfaces of the fuel basket, and only a fraction of the crud was removed by flushing; d) partial drying of the crud and vibration during the cask's return trip to the West Valley facility may have loosened crud from the cask and basket surfaces; or e) water flooding of the cask on its placement into the West Valley pool and turbulence in the cask when another set of fuel assemblies was inserted may have suspended crud, causing the subsequent turbidity in the pool.

The cloud of crud was most severe following the first shipment of fuel to Oyster Creek (out of a total of 32); lesser amounts of crud were noted in the other shipments. In the case of the first shipment, the TN-9 cask sat loaded with fuel for several weeks with the fuel in a dry environment before it was shipped. Subsequent shipments were more prompt and a better flushing technique was used on the casks. A hydrolasing[b] technique was tried on the Oyster Creek fuel at the West Valley facility, but the crud did not come off easily. No quantitative data on crud release from these shipments is available. The qualitative information and possible impacts presented for a specific situation may, however, be representative for other spent fuel that has been in wet storage for a long time and then shipped dry.

4.2.3 Shipments of Ginna (PWR) and Point Beach (PWR) Fuel from the West Valley Facility

After being discharged from the reactors, fuel assemblies from Ginna and Point Beach were placed in pool storage at the respective plants, shipped wet (i.e., in a water-filled cask) to the West Valley facility and stored in the pool, shipped dry to the respective plants, and placed in the pools at the

(b) The hydrolasing technique involves the use of a high-velocity water jet.

respective plants. In one case, there was some evidence of crud loosening after the fuel was placed back into a reactor's spent fuel storage pool.[18]

4.2.4 Airborne Contamination in November 1979 at the West Valley Facility

On November 15, 1969, six persons at West Valley may have been exposed to airborne radioactive materials in excess of the limits specified in Appendix B, Table 1, of 10 CFR Part 20. During attempts to transfer and flush the NFS-1 cask, a small quantity of liquid was released into the worker's environment. The continuous air monitor triggered an immediate evacuation of the area. Following the initial rapid clearance of the respiratory areas, the maximum body burden on any of these individuals was less than 10% of the allowable irradiation exposure. Only four persons showed residual activity in their chests; the three persons showing the highest residuals were in-vivo counted.

4.2.5 Airborne Contamination in August 1971 at the West Valley Facility

An event at West Valley involving inhalation exposure occurred on August 10, 1971.[31,48] Following unloading of ruptured fuel from the NFSX-1 cask, the cask was removed from the cask unloading pool and placed in the decontamination pit. Following extensive decontamination of the outer surfaces of the cask, the primary coolant cavities of the cask were flushed with water and drained into the pool until a clear effluent was observed from the cask. Two cask cavities had been drained and operators were preparing to drain the water from the third cavity. A rubber hose had been connected to the drain line of the third cavity and the effluent end was placed in the pool. When the valve on the air supply was "cracked" open, the discharge end of the hose came out of the pool, resulting in a spill of contaminated solution in the vicinity of the railroad track adjacent to the pool. At this point, the area radiation monitor alarmed both locally and at its remote readout in the control room. An employee put the hose back in the pool. The radiation monitor detected an increase in air activity; radiation measurements of the spill area indicated a high beta dose rate. Future flushing of cask cavities were to be routed into the pool through piping that was to be permanently attached to the pool wall.

4.2.6 Preparations to Ship Failed Fuel from the West Valley Facility

In May 1972, NFS prepared to return to the AEC in Richland, Washington, failed NPR fuel assemblies, which contained about one tonne of irradiated uranium.(49) The fuel was to be shipped in AEC's LMF casks. The aluminum canisters containing the NPR failed fuel were to be vented; the canisters were then to be remotely loaded into a stainless steel carrier, which would then be remotely sealed, purged with argon, and leak tested.

4.2.7 Receipt of Externally Contaminated Casks at the West Valley Facility

The West Valley plant received casks on some occasions that had external removable contamination that exceeded the limit of 22,000 dpm per 100 square centimeters of package surface that is specified in 10 CFR 20.205. A list of those shipments is shown in Table 3.

4.2.8 Receipt of Externally Contaminated Cask at Another Facility

On July 27, 1978, a receiving facility in NRC Region II (see Table 3) received an empty cask originating from the West Valley facility (it is in NRC Region I) that had smearable contamination readings ranging from 25,000 to 50,000 dpm/100 cm^2.(50) The West Valley facility had received the empty cask a week earlier and had installed a different liner in the cask. The as-received cask had general smearable contamination of about 6,000 dpm/100 cm^2, with the highest reading being 17,000 dpm/100 cm^2. The liner was changed in the cask while the cask was in the pool at the West Valley facility. The cask was removed from the clear well bucket, which is used in the pool, and was washed two times using the cleaning shroud designed for this washing operation. After the first cleaning, the results of the smear surveys were typically 1,600 dpm/100 cm^2, with the highest reading being 5,100 dpm/100 cm^2. After the second cleaning, the results of the smear surveys were typically 750 dpm/100 cm^2, with the maximum reading being 1,800 dpm/100 cm^2. The licensee for the West Valley facility had no explanation for the smearable contamination found on the cask by the receiving facility in NRC Region II.

4.2.9 Deviations from Approved Cask Design

On April 6, 1979, the NRC issued an order that required that all casks designated as Model NSF-4 (NAC-1) should be withdrawn from use until the exact

TABLE 3. Shipments Involving Casks With External Radioactive Contamination That Exceeded the 10 CFR 20.205(B)(2) Limit

Date	Reference	Comment
07/02/74	(51)	
09/03/74	(52)	Received from Dresden-1
11/06/74	(53)	
11/07/74	(54)	
02/05/75	(55)	
02/22/75	(56)	Received from Wisconsin Electric Power Co. (WEPCo)[(a)]
03/13/75	(40, 57)	Received from WEPCo
04/14/75	(40, 58)	Received from WEPCo
04/24/75	(40)	Received from WEPCo
07/27/75	(40)	Received from Oyster Creek
08/22/75	(59)	Received from Jersey Central Power & Light
10/13/75	(60)	Received from Jersey Central Power & Light
05/19/78	(50)	Received from a facility in NRC Region II[(b)]
07/27/78	(50)	Received from a facility in NRC Region II[(c)]

(a) It is postulated that condensed moisture or rain water collected in the cask valve pit and ran out from beneath the cover plate when the cask was raised to a vertical position during off-loading at the NFS site. NFS believed that the cask was probably within 20.205 limits during shipment from WEPCo to NFS.
(b) Five of 18 smears showed contamination above the limit of 22,000 dpm per 100 square centimeters of package surface.
(c) Shipped from the West Valley facility. See Section 3.2.8 in the text.

nature of any deviations from the approved design could be determined and the safety significance of such deviations could be assessed.(24) The NRC initiated the order after it was determined that one or more of the cask shells was warped or bowed and additional shielding material was being added to the outer shell of a cask in fabrication and thus, the cask(s) may not have been fabricated in accordance with the approved design in NRC Certificate of Compliance No. 6698.(24)

Through subsequent investigations, cask users determined that several of the casks had a bow of about 0.170 to 0.180 in., and some casks had an ovality of about 0.17 to 0.18 in.; the specifications for bow and ovality are 0.130 in. and 0.135 in., respectively.(24) As a result, the cask users were required to have all cask fabrication records audited by the NRC and were required to submit a new analysis (evaluation) showing that exceeding these specified tolerance levels would not adversely affect safety of the cask before being allowed to use the casks.

Also, upon issue of the original approval to use these casks, the NRC determined that analysis of cask buckling under accident conditions was not adequately addressed and required that it be reevaluated before next use of the casks.(24)

4.3 INFORMATION ON AND EXPERIENCE WITH THE 125 SPENT FUEL ASSEMBLIES THAT REMAIN TO BE SHIPPED FROM THE WEST VALLEY FACILITY

PNL received information twice from DOE-ID on the condition of the 125 spent fuel assemblies that are to be shipped. The information received first consisted of a video tape and two pieces of documentation. Shown on the video tape are seven fuel assemblies (4 BWR and 3 PWR), one of which (a BWR assembly) is said to represent the worst case as far as fuel assembly condition is concerned. One(61) of the documents contains data from the 1985 and 1987 preshipment visual assessments of the fuel assemblies. That document also indicates that another video tape was made and given to R. Licata of Transnuclear, Inc., in 1985 to show the 12 different bail configurations that are present among the fuel assemblies (the bail is the arched, hoop-like handle on the fuel assembly's upper end fitting that is used to pick up the assembly). The information received the second time consisted of a video tape showing seven fuel assemblies (two BWR and five PWR type) that contain failed fuel rods. The video tape was made during an inspection of the fuel assemblies in May 1989. Summarized below are the results from the preshipment visual assessment and the video tape from the 1985 and 1987 inspections, the results from the video tape from the May 1989 inspection, and a comparison of the results from all three inspections.

4.3.1 1985 and 1987 Inspection Results

Information from the document[61] containing the written results from the 1985 and 1987 inspections is summarized in Table 4.

The video tape[a] shows the condition of seven fuel assemblies (four BWR and three PWR). Scaling (flaking of crud deposits and/or corrosion layers) is evident on one BWR fuel assembly (BRP-VA-4/CF-24). Several suspected fuel rod defects (larger than pinholes or hairline cracks) are said to be on one BWR fuel assembly (BRP-VA-6/CE-60). One BWR fuel assembly (BRP-VA-1/CE-17) is said to represent the "worst" case as far as condition of the 125 fuel assemblies is concerned. This fuel assembly exhibits large amounts of scaling.

There appear to be 40 fuel assemblies (23 BWR and 17 PWR) that have or may have failed or damaged fuel rods. Of those 40 fuel assemblies, 24 assemblies (16 BWR and 8 PWR) show differences in the results that will need to be resolved to determine the true condition of the fuel assemblies (i.e., does the given fuel assembly contain failed fuel rods and if so, are any of the failure sites larger than pinholes or hairline cracks?). The 24 fuel assemblies are:

BWR	PWR
CE-03	C-03
CE-17	C-04
CE-24	C-10
CE-31	C-19
CE-42	C-28
CE-53	C-30

(a) The video tape is labeled as follows: "West Valley Nuclear Services, TN-BRP and TN-REG Fuel Assemblies Visual Assessment Overview (27:45), Duplicate October 24, 1988."

TABLE 4. Summary of Information from the Inspections in 1985 and 1987

BWR Fuel Assemblies:

No. of Fuel Assemblies	Comment(s)
2	Could not determine condition of fuel rods because of the large amounts of scaling (i.e., loosening of crud and corrosion layers on the exterior surfaces of the fuel rods).
7	Have fuel rods with cladding damage (i.e., defects that are greater than pinholes or hairline cracks); however, only 3 were marked as physically damaged.
5	These assemblies were originally classed in the 1985 visual assessment as having fuel rod cladding damage; however, the assemblies were reexamined in 1987 and the fuel rods were found to be undamaged.
8	These fuel assemblies are hard to grapple.
12	These fuel assemblies have crud deposits and/or corrosion layers on the fuel rods.

PWR Fuel Assemblies:

No. of Fuel Assemblies	Comment(s)
1	This fuel assembly has fuel rod cladding damage (i.e., defects greater than pinholes or hairline cracks).
10	These fuel assemblies were originally classed in the 1985 visual assessment as having fuel rod cladding damage; however, the assemblies were reexamined in 1987 and the fuel rods were found to be undamaged.
11	These fuel assemblies have fuel rods with collapsed cladding.
1	This fuel assembly has crud deposits and/or corrosion layers on the fuel rods.

BWR	PWR
CE-56	C-34
CE-58	C-36
CE-66	
CE-74	
CE-83	
CE-84	
CE-85	
CEP-3	
CF-03	
CF-14	

4.3.2 1989 Inspection Results

The video tape (about eight minutes long) from the May 1989 inspection of the 125 assemblies was reviewed. The video tape shows seven fuel assemblies with failed fuel rods: two BWR assemblies (CE-50 and D-60) and five PWR assemblies (C-12, C-34, C-30, C-19, and C-23). CE-50 has a broken fuel rod; the shortened rod length indicates that part of the rod is missing. D-60 has a slot-like hole in the cladding of one fuel rod. C-12 has one failed fuel rod; the bottom end plug on that rod is missing. C-34 has one failed fuel rod; the failure site is just below a grid spacer. C-30 has one fuel rod on which the cladding has split and bulged; C-30 also has several fuel rods that have collapsed cladding (a result of fuel densification during reactor service) and the collapsed area on one rod extends outward beyond the fuel assembly envelope. C-19 has a slot-like hole in the cladding of one fuel rod. The cladding on one fuel rod in C-23 has a hole that is about one-half the rod diameter in size.

4.3.3 Comparison of Results from All Three Inspections

A comparison of the data from the preshipment visual assessments performed by West Valley Nuclear Services Company, Inc. (WVNS) in 1985 and 1987, the data on fuel failure/damage categorizations [using the EIA[a] categories] furnished by WVNS to EIA in connection with the submittal of CY 1987 Nuclear Fuel Data Form RW-859, and the information from the video tape from the May 1989 inspection is provided in Table 5. The burnup for each fuel assembly

(a) DOE's Energy Information Administration.

is also listed in Table 5. The burnup valves were taken from the RW-859 forms.

Several visual inspections of the same group of fuel assemblies can yield a variety of results. For example, the hole noted in May 1989 in a fuel rod of BWR assembly D-60 was not detected in 1987 or 1985. The hole in a rod in PWR assembly C-19 was noted in 1985 and 1989 but not in 1987. The hole observed in 1989 in a rod in PWR assembly C-23 was not detected in the 1985 and 1987 inspections. The three inspections yielded different results for PWR assembly C-30. For PWR assembly C-34, the results from 1985 are different than those from 1987 and 1989.

TABLE 5. Fuel Assemblies (85 BWR and 40 PWR) Stored at the West Valley Site that are to be Shipped to INEL

Fuel Assembly Number	Preshipment Visual Assessments by West Valley		DOE Energy Information Administration Category			Results from May 1989 Inspection	Burnup (Reactor Cycle No.), MWd/MTU (Cycle No.)	
	1985	1987	1(a)	5(b)	7(c)		from Reactor	from West Valley
BWR Fuel:(d,e)								
B-04							___(10)	20,292
B-16							___(10)	20,126
CC-10							___(10)	22,683
CC-14	(f)						___(10)	20,644
CC-25							___(10)	22,233
CC-39	(f)						___(10)	12,695
CE-01							___(10)	12,271
CE-03	(g)				X		___(09)	12,275
CE-10							___(10)	10,627
CE-11							___(10)	10,877
CE-16							___(10)	10,643
CE-17	(h)	(i)			X		___(10)	11,652
CE-22							___(10)	11,491
CE-23							___(10)	10,809
CE-24	(j)				X		___(10)	12,515
CE-29	(k)				X		___(10)	9,119
CE-31	(l)				X		___(10)	10,483
CE-32							___(10)	9,662
CE-33	(m)				X		___(10)	10,351
CE-35							___(10)	10,411
CE-36							___(10)	9,979
CE-37							___(10)	11,519
CE-41							___(10)	10,218
CE-42	(n)				X		___(10)	10,617
CE-50	(o)		X			(ss)	___(09)	9,225
CE-51							___(10)	12,579
CE-52							___(10)	12,438
CE-53	(p)	(i)	X		X		___(09)	8,238
CE-54							___(10)	12,496
CE-56	(q)	(i)	X				___(10)	13,942
CE-57	(r)		X				___(10)	12,356
CE-58	(s)	(i)	X				___(10)	13,030
CE-59							___(10)	13,144
CE-60	(t)		X				___(10)	13,937
CE-61							___(11)	16,390
CE-62							___(11)	16,662
CE-63							___(10)	13,500
CE-64	(u)						___(10)	12,887
CE-66					X		___(11)	11,635
CE-67							___(11)	11,956
CE-69							___(09)	8,928
CE-70							___(11)	7,346
CE-71							___(11)	11,667
CE-73							___(10)	10,216
CE-74							___(11)	14,360
CE-75	(u)				X		___(11)	12,669
CE-76							___(09)	4,993
CE-77							___(09)	9,637
CE-79							___(12)	15,901
CE-80							___(12)	15,204
CE-81							___(11)	14,067
CE-82							___(12)	14,961
CE-83	(u)				X		___(11)	12,669
CE-84	(u)				X		___(11)	13,966

TABLE 5. Continued

Fuel Assembly Number	Preshipment Visual Assessments by West Valley 1985	1987	DOE Energy Information Administration Category 1(a)	5(b)	7(c)	Results from May 1989 Inspection	Burnup (Reactor Cycle No.), MWd/MTU (Cycle No.) from Reactor	from West Valley
CE-85	(j)				X		___(11)	12,388
CE-86	(v)		X				___(10)	8.727
CE-87							___(10)	9,954
CEP-1							___(11)	15,416
CEP-2							___(11)	15,712
CEP-3	(w)	(i)	X				___(12)	17,352
CF-01							___(11)	6,654
CF-02							___(11)	10,418
CF-03	(x)	(i)	X				___(12)	13,677
CF-06	(y)		X				___(12)	8,146
CF-12							___(11)	6,289
CF-13							___(12)	12,700
CF-14	(z)	(i)	X				___(12)	13,815
CF-18							___(11)	8,748
CF-19							___(11)	6,547
CF-23							___(12)	12,695
CF-24							___(11)	6,289
CF-25							___(12)	12,787
CF-26							___(12)	8,947
CF-35							___(12)	10,576
CF-42							___(12)	11,135
D-50	(f)						___(08)	6,377
D-51	(f)						___(07)	1,874
D-52	(f)						___(07)	1,449
D-53	(f)						___(07)	1,448
D-54	(f)						___(07)	1,534
D-55	(f)						___(07)	1,533
D-60						(tt)	___(10)	8,588
D-61							___(11)	12,333
D-62							___(11)	12,418
D-63							___(11)	11,837
PWR Fuel (aa, bb):								
C-01	(cc)			X			8,712(1A)	8,712
C-02							8,516(1A)	8,516
C-03	(dd)	(ee)	X				10,081(1A,1B)	10,195
C-04	(ff)	(gg)	X				8,703(1A)	8,703
C-05	(hh)			X			8,577(1A)	8,577
C-06	(hh)			X			8,403(1A)	8,403
C-07							8,561(1A)	8,561
C-08	(hh)			X			8,858(1A)	8,858
C-09							5,582(1A)	5,592
C-10	(ii)	(ee)	X				10,268(1A,1B)	10,385
C-11	(hh)			X			8,815(1A)	8,815
C-12	(jj)		X			(uu)	13,588(1A,1B)	13,748
C-13							13,749(1A,1B)	13,909
C-14							9,939(1A,1B)	10,059
C-15							10,066(1A,1B)	10,182
C-16							13,830(1A,1B)	13,998
C-17							13,612(1A,1B)	13,770
C-18							9,664(1A,1B)	9,774
C-19	(kk)	(i)	X			(vv)	13,606(1A,1B)	13,763
C-20	(cc)	(i)		X			5,899(1A)	5,899
C-21							9,785(1A,1B)	9,899
C-22	(ll)	(cc)		X			12,269(1A,1B)	12,432
C-23						(ww)	14,129(1A,1B)	14,293
C-24							6,069(1A)	6,069
C-25							9,670(1A,1B)	9,775

TABLE 5. Continued

Fuel Assembly Number	Preshipment Visual Assessments by West Valley 1985	1987	DOE Energy Information Administration Category 1(a)	5(b)	7(c)	Results from May 1989 Inspection	Burnup (Reactor Cycle No.), MWd/MTU (Cycle No.) from Reactor	from West Valley
C-26							9,664(1A,1B)	9,776
C-27	(mm)		X				9,764(1A,1B)	9,869
C-28	(nn)	(i)	X	X			10,156(1A,1B)	10,269
C-29							10,208(1A,1B)	10,321
C-30	(oo)	(i)		X		(xx)	11,070(1A,1B)	11,188
C-31							13,680(1A,1B)	13,842
C-32							10,234(1A,1B)	10,348
C-33							10,333(1A,1B)	10,450
C-34	(pp)	(ee)	X			(yy)	9,463(1A,1B)	9,568
C-35							9,649(1A,1B)	9,758
C-36	(qq)	(rr)	X				9,709(1A,1B)	9,812
C-37							9,515(1A,1B)	9,622
C-38							10,455(1A,1B)	10,572
C-39							5,875(1A)	5,875
C-40							10,410(1A,1B)	10,526

(a) Visually observed failure or damage.
(b) Physically deformed.
(c) Cladding damage (mechanical, chemical, or other--possibly detectable by ultrasonic testing).
(d) The fuel assembly identification numbers for 21 of the BWR fuel assemblies are CE-03, CE-17, CE-24, CE-29, CE-31, CE-33, CE-42, CE-50, CE-53, CE-56, CE-57, CE-58, CE-60, CE-75, CE-83, CE-84, CE-85, CE-86, CF-03, CF-06, and CF-14 or E-03, E-17, E-24, E-29, E-31, E-33, E-42, E-50, E-53, E-56, E-57, E-58, E-60, E-75, E-84, E-86, F-03, F-06, and F-14, respectively. The batch identity is unknown for the 85 BWR fuel assemblies.
(e) Initial enrichment in all 85 BWR fuel assemblies was 3.634 wt% uranium-235; other fabrication information is shown below:

BWR Fuel Assembly Number	Drawing Number	Fuel Assembly Type
B04, B06	237E599	11GBR
CC-10, CC-14, CC-25, CC-39	731E248	11GBR
CEP-1, CEP-2, CEP-3	Not Available	09GBR
D-50 through D-55	Not Available	07GBR
The other 70 assemblies	731E245	09GBR

(f) Very hard to grapple
(g) Some scaling observed. [Note: The term "scaling" was used in the inspection reports; presumably "scaling" means deposits of corrosion products (called "crud" in the nuclear industry).]
(h) Badly scaled rod, cannot determine amount of damage--unacceptable, rods may be brittle.
(i) No defects noted.
(j) Some scaling noted; no other abnormalities noted.
(k) Large amount of scaling on rods--unacceptable. No distortion noted.
(l) A little scaling damage on one rod.
(m) Scaling on cladding and defects in cladding; unable to determine amount of damage.
(n) Slight scaling on one rod; no other damage noted.
(o) One broken rod (~3 in. above bottom end fitting)--some probable leaks.
(p) Pinhole in corner rod and a few possible others; one bottom end cap is lying on the bottom end fitting.
(q) Small hole seen on fuel rod approximately halfway down the fuel assembly.
(r) Possible pinhole about halfway down the fuel assembly.
(s) Pinhole at bottom; large hole on corner rod.
(t) Two large holes in fuel rod.
(u) Some scaling present on lower portion of rods.
(v) Pinhole in rod at bottom.
(w) Hole in rod.
(x) One pinhole at top of assembly.
(y) Hole in one rod that is about one-third the diameter of the rod.
(z) Large hole in one rod.

TABLE 5. Continued

(aa) Batch identities for the 40 PWR fuel assemblies are as follows:

Batch Number	Number of Fuel Assemblies
RGAF32	12 (C-01, C-02, C-04 through C-09, C-11, C-20, C-24, and C-39)
RGAF31	28

(bb) Initial enrichment for 2 PWR fuel assemblies (C-01 and C-02) was 3.413 wt% uranium-235 and for the other 38 PWR fuel assemblies was 3.473 wt% uranium-235. The fabrication information for all 40 PWR fuel assemblies indicates that the drawing number is W685J888/675C628 and the assembly type is 14WZS.
(cc) Has some rods with collapsed cladding.
(dd) Piece of fuel rod missing.
(ee) Exhibits no damage but has one rod with collapsed cladding.
(ff) Pinholes on outside corner rod.
(gg) No defects noted; lots of corrosion.
(hh) Has a few rods that appear to be collapsed.
(ii) Small piece of rod missing.
(jj) One rod looked like it has a piece missing.
(kk) Hole observed in rod under first grid strap.
(ll) Has seven damaged rods.
(mm) Holes seen in two rods.
(nn) One rod has a hole; one rod has what seems to be a large dent.
(oo) Damaged rod next to bottom end fitting; rod looks dimpled.
(pp) Small hole in one rod.
(qq) Holes seen in three rods.
(rr) Exhibits no damage but has some rods with collapsed cladding.
(ss) Has a broken rod; the shortened rod length indicates that part of the rod is missing.
(tt) Has a slot-like hole in the cladding of one fuel rod.
(uu) Has one failed rod; the bottom end plug on that rod is missing.
(vv) Has a slot-like hole in the cladding of one rod.
(ww) The cladding on one fuel rod has a hole that is about one-half the rod diameter in size.
(xx) Has one fuel rod on which the cladding has split and bulged; also has several fuel rods that have collapsed cladding (a result of fuel densification during reactor service and the coolant pressure on the cladding exterior) and the collapsed area on one rod extends outward beyond the fuel assembly envelope.
(yy) Has one failed fuel rod; the failure site is just below a spacer grid.

5.0 REFERENCES[a]

1. Conners, B. J., et al. March 1987. Spent Nuclear Fuel Removal Program at the West Valley Demonstration Project. DOE/NE/44139-37.

2. Vesterlund, G., and T. Olsson. January 1978. Degraderingsmeckanismer Vid Bassanglagering och Hantering av Utbrant Kraftreaktorbransle. RB 78-29, ASEA-ATOM, Vasteras, Sweden (English translation, "Degradation Mechanisms During Pool Storage and Handling of Spent Power Reactor Fuel." BNWL-TR-320, Pacific Northwest Laboratory, Richland, Washington, May 1978).

3. Lindgren, P. et al. 1981. "Fuel Reconstitution as a Method for Improving Uranium Utilization." In Trans. Am. Nucl. Soc. 39:136-137 (November - December 1981).

4. Johnson, A. B., Jr. 1977. Behavior of Spent Nuclear Fuel in Water Pool Storage. BNWL-2256, Pacific Northwest Laboratory, Richland, Washington.

5. Bonnett, R. C., et al. 1988. Spent Nuclear Fuel Consolidation and Characterization at West Valley, New York. EP85-4, Empire State Electric Energy Research Corporation, New York, New York. (NRC Public Document Room Accession No. 8809060212.)

6. Funk, C. W., and L. D. Jacobson. 1980. Spent Fuel Integrity During Transportation. HEDL-TME 78-58, Hanford Engineering Development Laboratory, Richland, Washington.

7. Nelson, P. R. (AEC), Letter to R. N. Miller (Nuclear Fuel Services, Inc.), "Inspection Report No. 50-201/72-03," February 5, 1973. (Accession No. 7810300343, Docket No. 50-201.)

8. Eslinger, L. E., and R. C. Schmitt. 1989. "Spent-Fuel Storage Cask Testing and Operational Experience at the Idaho National Engineering Laboratory." In Trans. Am. Nucl. Soc. 60:124 (November 1989). (Also see EGG-M-89478.)

9. Richland Operations Office. 1989. Spent Fuel Storage Requirements 1989-2020. DOE/RL-89-30, U.S. Department of Energy, Richland, Washington.

10. Richland Operations Office. 1988. Spent Fuel Storage Requirements 1988. DOE/RL-88-34, U.S. Department of Energy, Richland, Washington.

(a) The following unpublished documents are available to the public and located in the NRC Public Document Room in Washington, DC: 5, 7, 21-24, 32-41, 48-60.

11. Richland Operations Office. 1987. Spent Fuel Storage Requirements 1987. DOE/RL-87-11, U.S. Department of Energy, Richland, Washington.

12. Richland Operations Office. 1986 Spent Fuel Storage Requirements (An Update of DOE/RL-85-2). DOE/RL-86-5, U.S. Department of Energy, Richland, Washington.

13. Richland Operations Office. 1985. Spent Fuel Storage Requirements (An Update of DOE/RL-84-1). DOE/RL-85-2, U.S. Department of Energy, Richland, Washington.

14. Richland Operations Office. 1984. Spent Fuel Storage Requirements (An Update of DOE/RL-83-1). DOE/RL-84-1, U.S. Department of Energy, Richland, Washington.

15. The Aerospace Corporation. 1987. Case Histories of West Valley Spent Fuel Shipments. NUREG/CR-4847 [WPR-86(6811)-1], U.S. Nuclear Regulatory Commission, Washington, D.C. (See pp. 2-2, -9, -55, -56, -57, and -59; 3-7, -8, -10, -25, -32, -45, -47, -49, and 5-1.)

16. Richland Operations Office. 1983. Spent Fuel Storage Requirements (An Update of DOE/RL-82-1). DOE/RL-83-1, U.S. Department of Energy, Richland, Washington.

17. Richland Operations Office. 1982. Spent Fuel Storage Requirements (An Update of DOE/SR-0007). DOE/RL-82-1, U.S. Department of Energy, Richland, Washington.

18. Hazelton, R. F. 1987. Characteristics of Fuel Crud and Its Impact on Storage, Handling, and Shipment of Spent Fuel. PNL-6273, Pacific Northwest Laboratory, Richland, Washington.

19. Bailey, W. J., and A. B. Johnson, Jr. 1983. Wet Storage Integrity Update. PNL-4726, Pacific Northwest Laboratory, Richland, Washington.

20. Duckworth, J. P. 1982. "Spent Fuel Storage at the Western New York Nuclear Service Center." In Proceedings of the Am. Nucl. Soc. Topical Meeting on Spent Fuel Storage Options. Savannah, Georgia, September 26-29, 1982.

21. Rouse, L. C. (NRC). 1979. Letter to R. W. Deuster (Nuclear Fuel Services, Inc.), "...Effect of an Earthquake on the Fuel Receiving Station Pool at West Valley, New York...," May 14, 1979. (Docket No. 50-201).

22. Clark, J. R. (Nuclear Fuel Services, Inc.), Letter to S. H. Smiley (AEC), "Safety Evaluation of the Proposed Modification of the Fuel Receiving and Storage Area Cooler...," May 17, 1972. (Docket No. 50201-120).

23. Costanzi, F. A. (NRC), Memorandum for L. C. Rouse (NRC) and J. Surmeier (NRC), "Transmittal of West Valley U.S.G.S. Water-Resources Investigations Reports 85-4308, 85-4309, 85-4145," October 1, 1987. (Docket No. 50-201, Category P).

24. Smith, G. H. (NRC), Letter to R. W. Deuster (Nuclear Fuel Services, Inc.), "...Inspection...on August 28-30, 1979, at Your Reprocessing Plant in West Valley, New York...," September 25, 1979. (Docket No. 50-201, Category Q).

25. Lindquist, K. O., and T. C. Haley. March 1990. Considerations for the Consolidation of BWR Fuel. EPRI NP-6783, a report prepared by Northeast Technology Corporation and published by the Electric Power Research Institute.

26. Bailey, W. J., et al. 1982. Arrival Condition of Spent Fuel After Storage, Handling, and Transportation. PNL-3582, Pacific Northwest Laboratory, Richland, Washington. [p. A.2 (Ref. 21 entry), p. A.7 (Ref. 78 entry), and p. A.9 (Ref. 90 entry)].

27. Bailey, W. J., et al. 1982. Arrival Condition of Spent Fuel After Storage, Handling, and Transportation. PNL-3582, Pacific Northwest Laboratory, Richland, Washington. [p. A.1 (Ref. 4 entry), p. A.3 (entry associated with Refs. 30, 32, and 34-38)].

28. Bailey, W. J., C. J. Morris, F. R. Reich, and K. L. Swinth. 1980 and 1981. Assessment of Current Onsite Inspection Techniques for Light-Water Reactor Fuel Systems. NUREG/CR-1380 (PNL-3325), Vol. 1 - Executive Summary (July 1980) and Vol. 2 - Discussion of Inspection Techniques (January 1981), U.S. Nuclear Regulatory Commission.

29. Mayer, J. T., T. D. Pyecha, J. T. Willse, and T. P. Papazoglou. March 1989. Evaluation of Fuel Performance at Oconee Unit 2. EPRI NP-6285M, a report prepared by Babcock & Wilcox Company for Duke Power Company and the Electric Power Research Institute (EPRI) and published by EPRI.

30. File, P. 1990. "A Utility Perspective on Fuel Integrity As a Spent Fuel Storage Issue," a paper presented at the Seventh Annual Spent Fuel Management Seminar sponsored by the Institute of Nuclear Materials Management (INMM) in Washington, D. C., January 17-19, 1990.

31. E. R. Johnson Associates, Inc. 1981. Review of the Operating History of the Nuclear Fuel Services, Inc., West Valley, New York Irradiated Fuel Reprocessing Plant. ORNL/Sub-81/31066/1, Oak Ridge National Laboratory, Oak Ridge, Tennessee. (See pp. 3-6, -9, and -10; 10-1; and D-3, -7, -13, and -14.)

32. Lewis, W. H. (Nuclear Fuel Services, Inc.), Letter to J. A. McBride (AEC), "Quarterly Report for October 20, 1966, through January 19, 1967," February 19, 1967. (Docket No. 50201-02, Category R.)

33. Lewis, W. H. (Nuclear Fuel Services, Inc.), Letter to J. A. McBride (AEC), "Quarterly Report for January 1, 1969 through March 31, 1969," May 8, 1969. (Docket No. 50201-14.)

34. Duckworth, J. P. (Nuclear Fuel Services, Inc.), "Quarterly Report for April 1, 1969, through June 30, 1969," July 25, 1969. (Docket No. 50201-15.)

35. Duckworth, J. P. (Nuclear Fuel Services, Inc.), Letter to J. A. McBride (AEC), "Quarterly Report for July 1, 1969, through September 30, 1969," October 31, 1969. (Docket No. 50201-34, Category S.)

36. Duckworth, J. P. (Nuclear Fuel Services, Inc.), "Quarterly Report for October 1, 1969, through December 31, 1969." January 21, 1970. (Docket No. 50201-35.)

37. Duckworth, J. P. (Nuclear Fuel Services, Inc.), "Quarterly Report for January 1, 1970, through March 31, 1970." April 20, 1970. (Docket No. 50201-33.)

38. Duckworth, J. P. (Nuclear Fuel Services, Inc.), Letter to L. Johnson (AEC), "...Seventeenth Quarterly Report Summarizing the Operation of the NFS Processing Plant During the Period April 1, 1970 through June 30, 1970," July 24, 1970. (Docket No. 50201-40.)

39. Duckworth, J. P. (Nuclear Fuel Services, Inc.), Letter to J. P. O'Reilly (AEC), "...Unanticipated Problem Recently Encountered with the Cask Unloading Pool Liner...," January 8, 1973. (Docket No. 50201-04, Category S.)

40. Martin, W. G. (NRC), Letter to R. W. Deuster (Nuclear Fuel Services, Inc.), "License No. CSF-1, Inspection No. 75-06, Docket No. 50-201," August 19, 1975. (Docket No. 50201-170.)

41. Nelson, P. R. (NRC), Letter to R. W. Deuster (Nuclear Fuel Services, Inc.), "License No. CSF-1, Inspection No. 75-08, Docket No. 50-201," December 1, 1975. (Docket No. 50201-173.)

42. Fuierer, A. 1986. "Lessons Learned and Results of Consolidation R&D Program to Date." In Proceedings of the Third International Spent Fuel Technology Symposium/Workshop. Vol. 2, pp. W-238 to W-248, Pacific Northwest Laboratory, Richland, Washington.

43. Bailey, W. J. 1986. Rod Consolidation at the West Valley Demonstration Project. PNL-5946, Pacific Northwest Laboratory, Richland, Washington.

44. Hellman, J. M. ed., "Fuel Densification Experimental Results and Model for Reactor Application," WCAP-8219, October 1973.

45. Bassler, E. A. 1984. "Westinghouse Fuel Consolidation Experience." In Proceedings of the Institute of Nuclear Materials Management Spent Fuel Management Seminar I, which was held in January 1984 in Washington, D.C. (Also see Duke Power Company and Westinghouse Electric Corporation. 1983. Spent Fuel Consolidation Demonstration-Oconee Nuclear Station, Fall 1982.)

46. Johnson, C. R. 1986. "Videotape of West Valley Rod Consolidation Projects." A videotape presented at the "Rod Consolidation Technology" Workshop during the Third International Spent Fuel Storage Technology Symposium/Workshop, CONF-860417, 2:W-224, April 8-10, 1986, Seattle, Washington.

47. Bailey, W. J. 1987. Rod Consolidation of RG&E's Spent PWR Fuel. PNL-6162, Pacific Northwest Laboratory, Richland, Washington.

48. Nuclear Fuel Services, Inc., "Category S: Reportable Occurrences, Related Correspondence December 18, 1969, to September 25, 1972," Docket No. 50201-03, Category S.

49. Clark, J. R. (Nuclear Fuel Services, Inc.), Letter to R. B. Chitwood (AEC), "...Return to AEC, Richland, Washington, Approximately One Metric Tonne of Irradiated Uranium Contained in NPR Failed Fuel Assemblies," May 8, 1972. (Docket No. 50-201.)

50. Smith G. H. (NRC). 1978. Letter to R. W. Deuster (Nuclear Fuel Services, Inc.), "Inspection 50-201/78-07," September 1, 1978. (Docket No. 50-201, Category Q.)

51. Wenstrand, T. K. (Nuclear Fuel Services, Inc.), Letter to J. Lubenow (AEC), "...Receipt of Cask Shipment with External Smearable Contamination in Excess of the Limits Specified in 20.205," July 2, 1974. (Docket No. 50-201.)

52. Duckworth, J. P. (Nuclear Fuel Services, Inc.), Letter to W. Kinney (AEC), "...Receipt of Cask Shipment [from Dresden-1]...with External Smearable Contamination in Excess of Limits Set Forth in 10 CFR 20.205," September 4, 1974. (Docket No. 50-201.)

53. Wenstrand, T. K. (Nuclear Fuel Services, Inc.), Letter to J. Lubenow (AEC), "...Receipt of Cask Shipment with External Smearable Contamination in Excess of the Limits Specified in 20.205," November 7, 1974. (Docket No. 50-201.)

54. Wenstrand, T. K. (Nuclear Fuel Services, Inc.), Letter to J. Lubenow (AEC), "...Receipt of Cask Shipment with External Smearable Contamination in Excess of the Limits Specified in 20.205," November 8, 1974. (Docket No. 50-201.)

55. Wenstrand, T. K. (Nuclear Fuel Services, Inc.), Letter to J. Lubenow (NRC), "...Receipt of Cask Shipment with External Smearable Contamination in Excess of the Limits Specified in 20.205," February 5, 1975. (Docket No. 50-201.)

56. Wenstrand, T. K. (Nuclear Fuel Services, Inc.), Letter to J. Lubenow (NRC), "...Cask Shipment [from NFS] with External Smearable Contamination in Excess of the Limits Specified in 20.205," February 24, 1975. (Docket No. 50-201.)

57. Wenstrand, T. K. (Nuclear Fuel Services, Inc.), Letter to J. Lubenow (NRC), "...Cask Shipment with External Contamination in Excess of the Limits Specified in 10 CFR 20.205," March 14, 1974. (Docket No. 50-201.)

58. Wenstrand, T. K. (Nuclear Fuel Services, Inc.), Letter to Bill Allen (NRC), "...Cask Shipment with External Contamination in Excess of the Limits Specified in 10 CFR 20.205," April 14, 1975. (Docket No. 50-201.)

59. Knight, R. E. (Nuclear Fuel Services, Inc.), Letter to J. P. O'Reilly (NRC), "...Receipt of Cask Shipment with External Smearable Contamination in Excess of the Limits 10 CFR 20.205," August 22, 1975. (Docket No. 50-201.)

60. Oldham, W. A. (Nuclear Fuel Services, Inc.), Letter to J. P. O'Reilly (NRC), "...Receipt of Cask Shipment with Smearable Contamination in Excess of the Limits Specified in 10 CFR 20.205," October 14, 1975. (Docket No. 50-201.)

61. Abbott, D. G. (EG&G Idaho, Inc.). November 7, 1985. "Engineering Design File: Subject--Receipt of Information--NFS Owned RG&E and BRP Pre-Shipment Visual Assessments." (Project File No.: NFS, EDF Serial No. CT-160, Project/Task: NFS Project, Subtask: Fuel Loading at West Valley.)

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