PROTOTYPICAL CONSOLIDATION DEMONSTRATION PROJECT - FINAL FUEL RECOMMENDATION REPORT

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ABSTRACT

The Prototypical Consolidation Demonstration (PCD) Project will, in it's final phase, conduct a demonstration of the equipment's ability to consolidate actual spent commercial fuel. Since budget and schedule limitations do not allow this demonstration to include all types of fuel assemblies, a selection process was utilized to identify the fuel types that would represent predominate fuel inventories and that would demonstrate the equipment's abilities. The Pressurized Water Reactor (PWR) fuel assemblies that were suggested for use in the PCD Project Hot Demonstration were Babcock and Wilcox (B&W) 15 x 15's, and Westinghouse (WE) 15 x 15's. The Boiling Water Reactor (BWR) fuel suggested was the General Electric (GE) 8 x 8.

INTRODUCTION

The PCD Project has as its purpose the development and demonstration of production-scale equipment for the dry consolidation and packaging of spent fuel rods contained in BWR and PWR spent fuel assemblies. This equipment will be the basis for future equipment that will be installed at a geologic repository or at the Monitored Retrievable Storage (MRS) Facility.

The PCD project is broken down into phases as follows: (1) Phase I - Preliminary Design, Phase II - Final Design, Phase III - Fabrication and Cold Demonstration, and Phase IV - Hot Demonstration. Phases I through III will be completed by private sector equipment designers at their facilities. Phase IV - Hot Demonstration will demonstrate the operation of the equipment with actual spent commercial fuel assemblies, and will be completed at Test Area North (TAN) of the Idaho National Engineering Laboratory (INEL).

The ideal situation for Phase IV - Hot Demonstration would be to test all types of fuel assemblies that the equipment was designed to consolidate. Since this ideal testing program is beyond the budget and schedule of the project, a process of eliminating the least favorable fuel elements and selecting the most beneficial was employed. The evaluation was performed with input from Pacific Northwest Laboratories (PNL), published reports, contact with reactor sites and other knowledgeable sources.

METHOD OF SELECTION

The method used to select the spent fuel sizes was to document the requirements which the fuel must/should meet in order to be considered as a candidate for selection; identify all of the types of commercial spent fuel available in storage; analyze each type with respect to the requirements, and select the most attractive candidates.

The requirements for the fuel selection consider the following factors:

- Financial
- Time
- Logistical
- Technical

Each of these factors result in a number of specific requirements that are detailed in the following sections and that enter into the final recommendations of this report.

SELECTION REQUIREMENTS

The following specific requirements were identified to act as selection criteria to choose the fuel types for use in the PCD Project:

1) A square canister with internal dimensions of 21.59 cm (8.5 in.) by 21.59 cm (8.5 in.) will be used for BWR and PWR fuel consolidation in the PCD Project. A consolidation ratio of 2:1 for PWR fuel and 4:1 for BWR fuel will be assumed.

2) The PWR and BWR fuel types selected should represent a significant percentage of the spent fuel inventory in the year 2000 and in the year 2020.

3) Fuel types selected should show a projected continued growth in usage from the present through year 2020.

4) The PWR and BWR fuel types selected must be available for inspection and shipment to meet the PCDP schedule.

5) No research or special use fuels will be considered.

6) Approximately 100 PWR fuel elements and 100 BWR fuel elements will be required for Hot Demonstration testing.

7) Selected fuel should represent a typical range of characteristics with respect to:

   Burn up,
   Radioactivity,
   Thermal power,
   Age after discharge,
   Enrichment,
   Cleanliness.

8) Fuel that represents typical types of materials used for construction should be used.

9) *Fuel that* is selected must not be damaged and must pass a visual and sip inspection prior to shipping from a reactor site.

10) Fuel must have documented irradiation histories to substantiate that it has not been subjected to off-normal reactor excursions.

11) Packing factor (the number of fuel pins that fit into the canister identified in Requirement 1) should be maximized. This will test the equipments ability to pack a canister full of rods.

12) Fuel must have a thermal power range so that heat loads imposed upon the shipping and storage casks by both intact and consolidated assemblies will be within the cask design limits.

TYPES OF FUEL ASSEMBLIES CONSIDERED

The following types of fuel assemblies, taken from the PNL spent fuel data base, (2) were considered as possible candidates for the PCD Project:

PWR	BWR
BW 14 x 14	AC 10 x 10
BW 15 x 15	EX 6 x 6
BW 17 x 17	EX 8 x 8
CE 14 x 14	EX 9 x 9
CE 15 x 15	EX 10 x 10
CE 16 x 16	EX 11 x 11
EX 14 x 14	GE 6 x 6
EX 15 x 15	GE 7 x 7
EX 17 x 17	GE 8 x 8
GU 17 x 17	GE 9 x 9
WE 13 x 13	GE 11 x 11
WE 14 x 14	NF 9 x 9
WE 15 x 15	UN 6 x 6
WE 17 x 17	

AC = Allis Chalmers
BW = Babcock & Wilcox
CE = Combustion Engineering
EX = Exxon Nuclear Co.
GE = General Electric Co.
GU = Gulf United Nuclear
NF = Nuclear Fuel Services
UN = United Nuclear Corp.
WE = Westinghouse Electric Corp.

EVALUATION OF PWR FUEL ASSEMBLIES

Table I provides a generic breakdown of the total fuel assemblies for operating and planned reactors for the years 1985, 2000, and 2020. From this table it can be seen that in year 1985 all of the 15 x 15 type assemblies comprise 46.9% of the fuel inventory followed by the 14 x 14 assemblies with 31.3% and the 17 x 17 assemblies with 19%. These three types of fuel assemblies are the most dominant (typical) in the inventory and will be the only types of PWRs considered. Looking at the projected amounts for the year 2000, it can be seen that the pattern established above will change. The 15 x 15 assembly will dwindle to 32.8% of inventory as will the 14 x 14 to 18.3%. This is due to the overwhelming presence of the 17 x 17 assemblies at 40.1%. The trend will continue to the year 2020 where the 15 x 15 will represent only 28.8%, the 14 x 14 only 14% while the 17 x 17 will control the majority of the inventory at 46.9%. The 17 x 17 will become the most typical fuel assembly in the future, forcing the current leader (15 x 15) into the second most dominant position.

It is necessary to begin acquiring the spent fuel for the PCD Project at this time. Therefore, an examination of the <u>current</u> spent fuel status of the two dominant types of assemblies (present: 15 x 15 and future: 17 x 17) with respect to the project's requirements, becomes essential.

<u>15 x 15 Fuel Assembly</u>

The 15 x 15 assembly is currently the most significant type of spent fuel in the commercial inventory and has a projected continued growth in usage through year 2020. This assembly was introduced during the mid to late 1960's and is in sufficient supply at each of a considerable number of reactor sites to satisfy the PCD Project's needs. This fact aids in a sole site selection of non-damaged fuel without encountering unacceptable operational transients. The wide spread and long-term use of the 15 x 15 assembly ensures a range of nuclear characteristics (i.e., burnup, radioactivity, thermal power, age, etc.) necessary to achieve a "typical" fuel stock. This assembly also offers a consolidation ratio of 2:1 (Fig. 1) with a canister packing factor of sufficient difficulty to test the consolidation equipment.

TABLE I

Total Fuel Assemblies By Generic Design (2)
Operating And Planned

PWR	Year 1985	% Total	Year 2000	% Total	Year 2020	% Total
13 x 13	160	0.8	160	0.2	160	0.1
14 x 14	5,637	31.3	12,652	18.3	18,607	14.0
15 x 15	8,491	46.9	22,813	32.8	38,391	28.8
16 x 16	355	2.0	5,960	8.6	13,580	10.2
17 x 17	3,431	19.0	27,849	40.1	62,642	46.9
BWR	**Year 1985**	**% Total**	**Year 2000**	**% Total**	**Year 2020**	**% Total**
6 x 6	1,170	4.2	1,170	1.2	1,170	0.7
7 x 7	9,925	35.3	14,819	15.0	19,306	10.3
8 x 8	16,484	58.6	81,882	82.7	165,846	88.3
9 x 9	165	0.6	165	0.1	165	0.1
10 x 10	255	0.9	579	0.6	717	0.4
11 x 11	106	0.4	424	0.4	424	0.2

An additional advantage of this fuel type is that a number of WE 15 x 15 fuel assemblies are currently available at the INEL, and these fuel assemblies can be used in the PCD Project consolidation.

<u>17 x 17 Fuel Assembly</u>

The 17 x 17 assembly is quickly surpassing the 15 x 15 as the most dominant spent fuel assembly type and is projected to maintain that position in the foreseeable future. This assembly was introduced for commercial use during the mid-1970's and for that

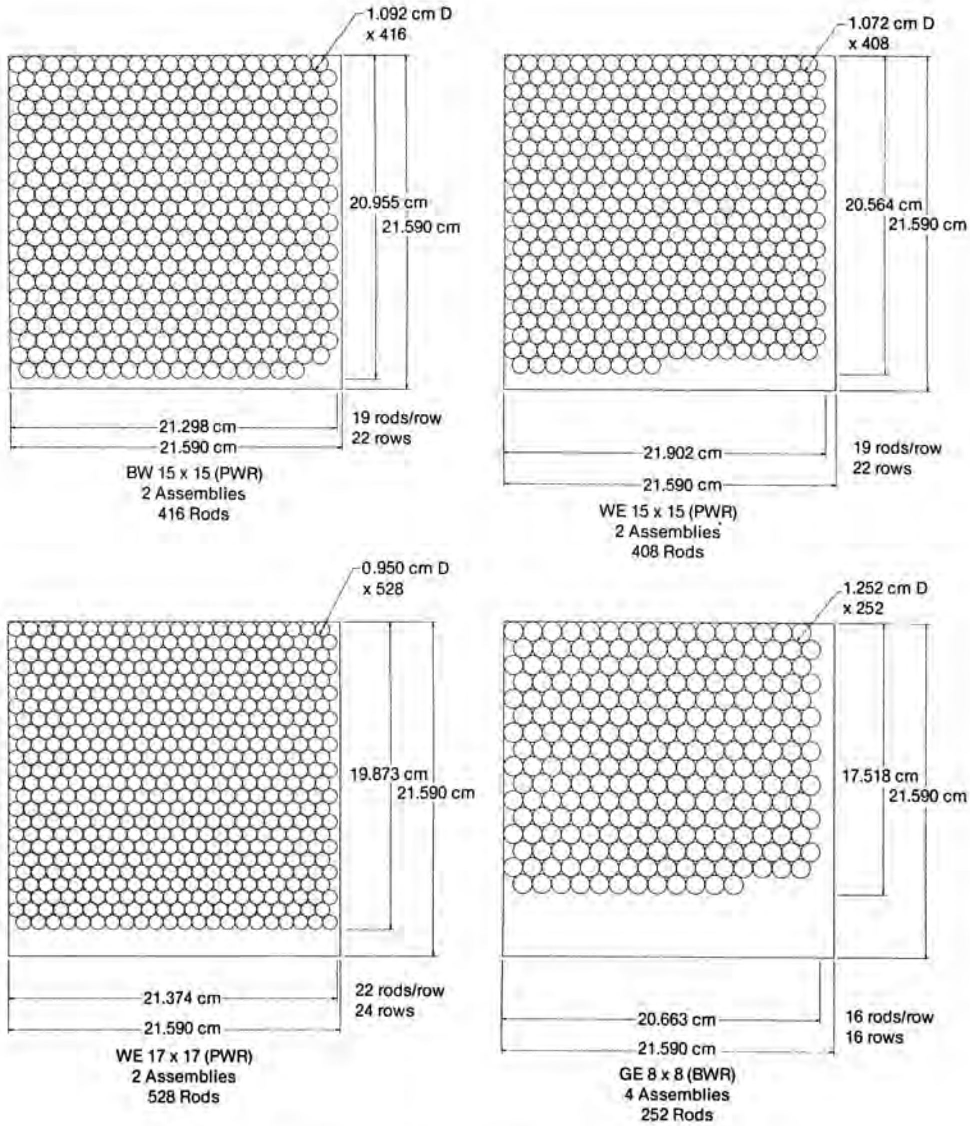

Fig. 1 Cross-Sectional View, Fuel Rods and Canisters.

reason has a limited number (11) of reactor sites which can supply a sufficient quantity of spent fuel for the Hot Demonstration. Some of these sites have a small number of assemblies above that which is needed and may impose an unacceptable project delay if an inordinate number of damaged fuel is encountered. The narrow range of spent fuel characteristics due to the recent initial discharge dates (earliest--1978) is not conducive to a selection of "typical" spent fuel. A limited quantity of typical spent fuel with representative burn up and decay heat loads may be obtained from some utilities which do not pursue a policy of extended burn up (>30,000 MWd/MTU). The canister packing factor of this fuel assembly (Fig. 1) is more lenient than other types because of the small diameter of the rods. However, the large number of rods (264) will surely test the rod handling capabilities of any consolidation equipment. Since the availability of this fuel type was in question, it was decided to utilize mockup fuel of this type at the equipment vendors facilities in the Cold Test only. This will provide the information about the equipment's ability to handle the large number of rods while avoiding possible project delays due to problems in spent fuel acquisition.

<u>PWR Fuel Vendor Selection</u>

To select the PWR fuel vendors, reference to Fig. 2 should be made. This figure shows the manufacturers and expected growth in PWR fuel assemblies through year 2020. The BW 15 x 15 assembly places second in 1985, falling just behind the WE 15 x 15 assembly. However, the BW is projected to become more abundant than the WE 15 x 15 by the year 1990 and when compared to the other assemblies, it clearly becomes the most dominate 15 x 15 assembly in the year 2020. In examining further, the BW 15 x 15 fuel assemblies are found to be in sufficient supply at a number of reactors to meet the PCD Project schedule for shipment; can be obtained to cover the typical range of burn up, radioactivity, thermal power, age, enrichment, and cleanliness; exists in sufficient quantities to select non-damaged fuel from one reactor site with unacceptable operational transients; and are constructed of materials that are typical of PWR fuel assemblies. As mentioned previously, WE 15 x 15 assemblies are available at the INEL for use in this project without a need to ship the fuel from any utility. This fortunate situation

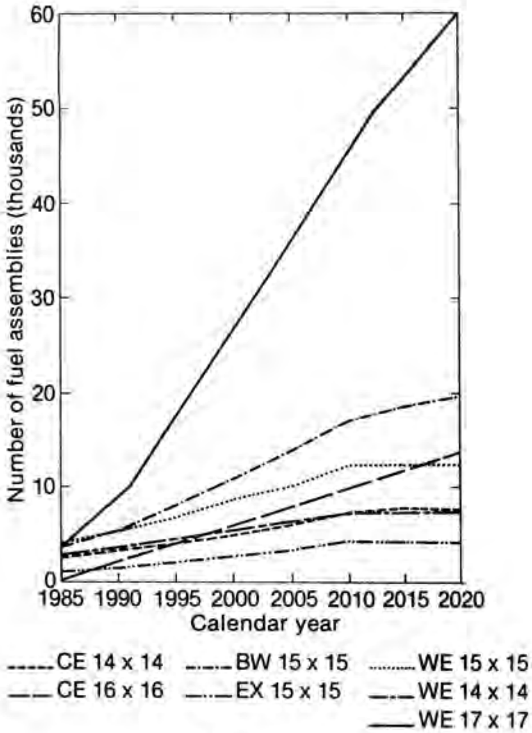

Fig. 2 Spent PWR Fuel Projections, Operating and Planned.

allows the PCD Project to use both Westinghouse and B&W spent fuel for the PCD Project.

For the 17 x 17 assembly, Fig. 2 clearly shows Westinghouse Electric Corporation as being the manufacturer of the most abundant (projected) quantity of that type of fuel. Therefore, Westinghouse Electric Corporation was selected as the vendor for the mockup 17 x 17 fuel that will be used in Cold Testing.

EVALUATION OF BWR FUEL ASSEMBLIES

Selection of the BWR fuel and fuel vendor is straightforward. Table I shows that the 8 x 8 fuel assembly represents 58.6%, 82.7%, and 88.3% of all BWR fuel in the years 1985, 2000, and 2020. Fig. 3 shows the present and future dominance of the General Electric 8 x 8. Since this fuel has been used by a large number of BWRs from as early as 1969, (1) spent fuel with a wide variety of characteristics is readily available. Adequate amounts exist at enough reactor sites to ensure sole site selection of non-damaged

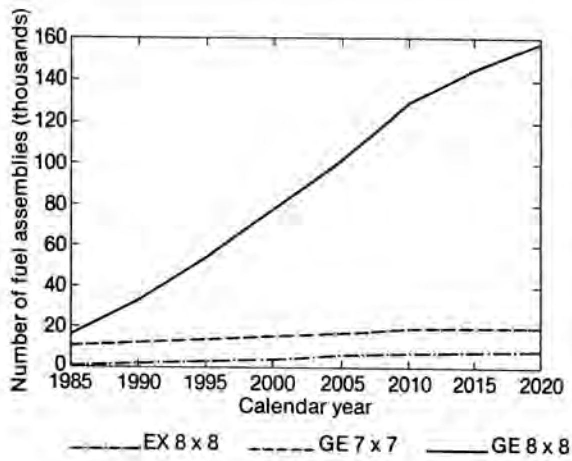

Fig. 3 Spent BWR Fuel Projections, Operating and Planned.

fuel without experiencing project delays. The GE 8 x 8 is constructed of typical material and can be consolidated at a 4:1 ratio into a 8.5" by 8.5" cross-sectional canister (Fig. 1). For the preceding reasons the GE 8 x 8 fuel assembly is recommended as the specific BWR spent fuel type for the PCD Project.

CONCLUSION

The PCD Project requires commercial spent fuel to complete the Hot Demonstration phase of the project. To meet this need, technical and project requirements were defined. Fuel size and type were identified and evaluated against the requirements. As a result of these evaluations, it was suggested that PWR fuel BW 15 x 15 and WE 15 x 15 be used for Hot Demonstration with WE 17 x 17 mockup fuel being used for Cold Demonstration. BWR fuel suggested for Hot Demonstration was GE 8 x 8.

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