ORNL/TM-10902
Dist. Category
UC-85

Chemical Technology Division

ORNL/TM--10902

DE89 015645

PHYSICAL CHARACTERISTICS OF GE BWR FUEL ASSEMBLIES

R. S. Moore*
K. J. Notz

*Automated Sciences Group, Inc., Oak Ridge, Tennessee

June 1989

Prepared for the
U. S. Department of Energy
Office of Civilian Radioactive Waste Management
Washington, D. C. 20585
(Activity No. DB 04 02 11 H)

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U. S. DEPARTMENT OF ENERGY
under
Contract No. DE-AC05-84OR21400

DISCLAIMER

PREFACE

This work was done under the auspices of the U.S. Department of Energy Office of Civilian Radioactive Waste Management. The work was carried out at Oak Ridge National Laboratory (ORNL) with the assistance of Automated Sciences Group, Inc.

ACKNOWLEDGEMENTS

The authors would like to express their appreciation to Ron Ashline and Tim Welch, both of ORNL, for their review of this document, and to Helen Brown of the Y-12 Technical Library for her patience and assistance with the collection of much of these data from the NRC Federal Docket.

CONTENTS

CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

ANF	Advanced Nuclear Fuels, Inc.
BWR	Boiling-water Reactor
CDB	Characteristics Data Base
EIA	Energy Information Administration
GE	General Electric Co., Inc.
LHGR	Linear Heat Generation Rate
LOCA	Loss-of-Coolant Accident
LTA	Lead Test Assembly
MAPLHGR	Maximum Average Planar Linear Heat Generation Rate
MTIHM	Metric Tons of Initial Heavy Metal
NRC	Nuclear Regulatory Commission
OFA	Optimized Fuel Assembly
PCI	Pellet-Clad Interaction
PWR	Pressurized-water Reactor

PHYSICAL CHARACTERISTICS OF GE BWR FUEL ASSEMBLIES

R. S. Moore and K. J. Notz

ABSTRACT

The physical characteristics of fuel assemblies manufactured by the General Electric Company for Boiling-water reactors are classified and described. The classification into assembly types is based on the GE reactor product line, the Characteristics Data Base (CDB) assembly class, and the GE fuel design. Thirty production assembly types are identified. Detailed physical data are presented for each assembly type in an appendix. Descriptions of special (nonstandard) fuels are also reported.

---

1. INTRODUCTION

The Characteristics Data Base (CDB) of potential repository wastes contains the physical, chemical, and radiological characteristics and quantities of spent fuel, high-level waste, and other radioactive wastes that may require long-term isolation.[1,2] An important part of this data base is the physical description of the various types of LWR fuel assemblies.

For those fuel assemblies manufactured by Advanced Nuclear Fuels (formerly Exxon), Babcock & Wilcox, Combustion Engineering, and Westinghouse, this information was obtained directly from those vendors via a series of subcontracts. Efforts to place a similar subcontract with General Electric (GE) were not successful. Therefore, to obtain the needed information for GE fuel assembly types, an in-depth literature and docket search was undertaken. This report documents the results of that search.

The systematic classification and description of GE fuel assemblies for boiling-water reactors (BWRs) is more complex than for pressurized-water reactors for two major reasons: (1) a given BWR reactor or assembly class can use more than one array size and (2) GE fuel designs that have evolved over time can be and are used in more than one GE product line. These product lines have also evolved, but on a different time scale. The organizational approach of this report is as follows:

GE PRODUCT LINES are designated as BWR/1, BWR/2, BWR/3, BWR/4, BWR/5, and BWR/6. Each product line, except BWR/1, designates a generic reactor design with common characteristics. The BWR/1 line consists of three reactors, each of which is one-of-a-kind in terms of major assembly characteristics. The other product lines each include more than one reactor with similar characteristics. Different product lines distinguish evolving reactor designs.

CDB ASSEMBLY CLASSES are controlled by core configuration - the basic fuel assembly envelope and control rod/blade configuration. Each of the three BWR/1 reactors constitutes a separate assembly class. On the other hand, BWR/2 and BWR/3 product line reactors use nearly identically sized assemblies and constitute one assembly class, designated BWR/2,3. BWR/4, BWR/5, and BWR/6 product line reactors also use nearly identically sized assemblies and constitute another assembly class, designated BWR/4,5,6.

GE FUEL DESIGNS, designated as GE-1 (or early fuels), GE-2 (7x7), GE-3 (improved 7x7), GE-4 (8x8), GE-5 (8x8 Retrofit), Prepressurized (nominally GE-6), Barrier (nominally GE-7), GE-8, and GE-9, have evolved separately from product lines. A fuel design can be used in more than one product line.

The GE product line is focused on overall reactor design; the GE fuel design is focused on the detailed assembly design. A fuel design

has a fixed array size. For reasons explained in the text, we have used the terms "prepressurized" and "barrier" instead of GE-6 and GE-7.

Other fuel performance optimization factors include "lattice types," enrichment variations, and burnable neutron absorbers, but these do not alter the basic assembly characteristics. The lattice type, which may be D, C, or S, relates to the spacing between the assembly and the control blade. The burnable neutron absorbers and enrichment variations are tailored to optimize fuel performance.

2. GENERAL DESCRIPTION OF GE FUEL ASSEMBLIES[3]

A GE fuel assembly, illustrated in Fig. 1, consists of a fuel bundle and the channel that surrounds it. Although GE has made fuel bundles with 6x6, 7x7, 8x8, 9x9, 11x11, and 12x12 fuel rod arrays, 7x7 and 8x8 fuels account for approximately 95% of the boiling-water reactor (BWR) fuel discharged to date. The 6x6, 9x9, 11x11, and 12x12 fuels were all fuels used in BWR/1 reactors and are designated the "early reactors fuel design." Advanced Nuclear Fuels, Inc. (ANF) has recently introduced a 9x9 fuel design for GE's BWR/2-6 reactors. This ANF 9x9 fuel is not similar to the 9x9 fuels used at the BWR/1 reactor, Big Rock Point.

GE's 7x7 and 8x8 fuels are also designed for BWR/2-6 reactors and are designated as GE-2 (7x7), GE-3 (improved 7x7), GE-4 (8x8), GE-5 (8x8 Retrofit), Prepressurized, Barrier, GE-8, and GE-9. (See Sect. 3 for details of these fuel designs. Parameters for different fuel assembly types are given in Appendix A.) The GE-2 (7x7) and GE-3 (improved 7x7) fuel bundles contain 49 fuel rods, one of which is segmented. The GE-4 (8x8) fuel bundle contains 63 fuel rods and one water rod. The GE-5 (8x8 Retrofit), Prepressurized, and Barrier fuel bundles contain 62 fuel rods and two water rods. The GE-8 fuel bundles contain 2 to 6 water rods and 58 to 62 fuel rods. No information is currently available on GE-9 fuel bundles.

The rods of all 7x7 or 8x8 bundles are spaced and supported in a square array by the upper and lower tie plates, as well as by fuel-rod spacers. The lower tie plate has a nose piece whose function is to support the fuel assembly in the reactor. The upper tie plate has a handle for transferring the fuel bundle from one location to another. An identifying assembly serial number is engraved on the top of the handle with no two assemblies bearing the same serial number. A boss projects from one side of the handle to aid in ensuring proper fuel assembly orientation. Both upper and lower tie plates are fabricated from Type-304 stainless steel. Zircaloy-2 fuel-rod spacers, equipped with Inconel-X750 springs, are employed to maintain rod-to-rod spacing.

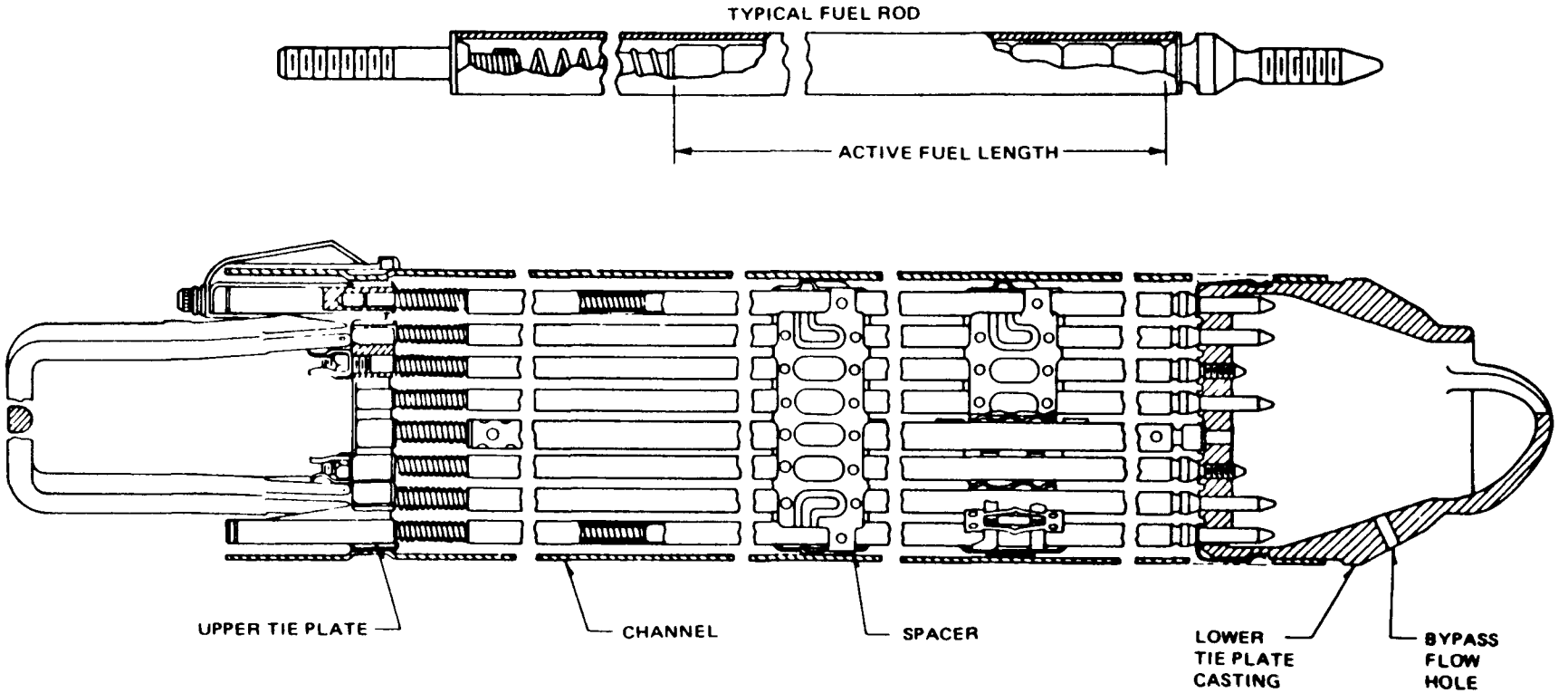


Fig. 1. Schematic of GE fuel assembly. (Source: ref. 3)

Finger springs located between the lower tie plate and the channel are utilized on some fuel assemblies to control the bypass flow through that flow path.

2.1 FUEL RODS

Current fuel rods consist of high-density uranium dioxide fuel pellets stacked within Zircaloy-2 cladding tubes. During fabrication, the fuel rods are evacuated, backfilled with helium, then sealed with Zircaloy-2 end plugs welded in each end. For the "Barrier", GE-8, and GE-9 fuel designs, the cladding consists of the same base material (Zircaloy-2) with an inner lining of pure zirconium. This lining or "barrier" is mechanically bonded to the base material during manufacture. The helium backfill pressure is 1 atm for the GE-2 (7x7), GE-3 (improved 7x7), GE-4 (8x8), and GE-5 (8x8 Retrofit) fuel designs, 3 atm for the "Prepressurized" and "Barrier" fuel design, and 5 atm for the GE-8 and GE-9 fuel designs. The fuel pellets are manufactured by compacting and sintering uranium dioxide powder into right cylindrical pellets with flat faces and chamfered corners. Some pellets in early fuels, GE-2 (7x7), and possibly GE-3 (improved 7x7), are dished concave on the faces.

Ceramic-grade uranium dioxide is chemically inert to the cladding at operating temperatures and is resistant to attack by water. Several U-235 enrichments are used in the fuel assemblies to level out the local peak-to-average fuel rod power ratios. Selected fuel rods within each reload bundle also incorporate small amounts of gadolinium oxide as a burnable neutron absorber. Since Gd_2O_3 forms a solid solution with UO_2, it is uniformly distributed throughout the fuel pellet.

The fuel-rod cladding thickness is adequate to be essentially free-standing in the BWR environment. The pellet-to-cladding gap and the plenum region at the top of the fuel rod accommodate thermal and irradiation expansion of the UO_2 and the internal pressure resulting from the helium fill gas, impurities, and gaseous fission products liberated over the design life of the fuel. A plenum spring, or

retainer, is provided in the plenum space to minimize movement of the fuel column inside the fuel rod during shipping and handling. In the improved 7x7 design and later designs, a hydrogen getter is also incorporated in the plenum space. This prevents chemical attack from moisture or hydrogenous impurities inadvertently admitted into a fuel rod during manufacturing. The hydrogen getter consists of small chips of a zirconium alloy[4], loosely packed in a stainless steel tube. One end of the tube is capped, and the other end is covered by wire screening.

Two types of fuel rods are used in most fuel bundles: tie rods and standard rods. The tie rods in each bundle have lower end plugs that thread into the lower tie plate casting and threaded upper end plugs which extend through the upper tie plate casting. A stainless steel hexagonal nut and locking tab are installed on the upper end plug to hold the fuel bundle together. These tie rods support the weight of the bundle only during fuel handling operations when the assembly is held by the handle. During reactor operation, the fuel assembly is supported by the lower tie plate. Early fuel, GE-2 (7x7), and GE-3 (improved 7x7) fuel designs also contain a segmented fuel rod. This segmented fuel rod was used to position the fuel-rod spacers, a function currently performed by the spacer-capture water rod.

The end plugs of the standard rods have shanks that fit into bosses in the tie plates. An expansion spring is located over the upper end plug shank of each rod in the assembly to keep the rods seated in the lower tie plate while allowing independent axial expansion by sliding within the holes of the upper tie plate.

2.2 WATER RODS

The GE-4 (8x8) fuel bundle contains one water rod, and the GE-5 (8x8 Retrofit), Prepressurized, and Barrier fuel bundles contain two water rods. The GE-8 design can contain from two to six water rods. These rods are Zircaloy-2 tubes with several holes punched around the circumference near each end that accommodate coolant flow. Three holes

are located at the bottom of the water rod, and eight holes are located at the top.

One water rod in all 8x8 bundles positions the Zircaloy-4 fuel-rod spacers axially. This spacer-positioning water rod is equipped with a square bottom end plug and spacer positioning tabs that are welded to the exterior. The rod and spacers are assembled by sliding the water rod through the appropriate cell of the spacer with the welded tabs oriented in the direction of the corner of the cell. The water rod is then rotated so that the tabs are above and below the spacer structure. Once in position, the water rod is prevented from rotating by the engagement of its square, lower end plug with the lower tie plate hole.

2.3 CHANNELS

The BWR Zircaloy-2 fuel channel performs the following functions:

1. forms the fuel bundle flow path outer periphery for bundle coolant flow;
2. provides surfaces for control rod guidance in the reactor core;
3. provides structural stiffness to the fuel bundle during lateral loadings applied from fuel rods through the fuel spacers;
4. minimizes, in conjunction with the finger springs and bundle lower tie plate, coolant bypass flow at the channel/lower tie plate interface;
5. transmits fuel assembly seismic loadings to the top guide and fuel support of the core internal structures;
6. provides a heat sink during loss-of-coolant accident (LOCA); and
7. provides a stagnation envelope for in-core fuel sipping.

The channel is open at the bottom and makes a sliding seal fit on the lower tie plate surface. The upper end of the fuel assemblies in a

four-bundle cell are positioned in the corners of the cell against the top guide beams by the channel fastener springs. At the top of the channel, two diagonally opposite corners have welded tabs, one of which supports the weight of the channel from a threaded raised post on the upper tie plate. One of these raised posts has a threaded hole. The channel is attached using the threaded channel fastener assembly, which also includes the fuel assembly positioning spring. Channel-to-channel spacing is provided for by means of spacer buttons located on the upper portion of the channel adjacent to the control rod passage area.

The fuel channel enclosing the fuel bundle has a square cross section with rounded corners. For BWR/2, 3, 4, and 5 reactors, it has a (nominal) inside width of 5.278 in. and 5.215 in. for BWR/6 reactors. The nominal length of the fuel channel is 162.156 in. for BWR/2 and 3 reactors, 166.906 in. for BWR/4 and 5 reactors, and 167.36 in. for BWR/6 reactors. Channels for BWR/1 reactors are sized to properly fit the fuels for those reactors. Three types of channels having different wall thicknesses (0.080 in., 0.100 in., and 0.120 in.) are currently in production.

2.4 OTHER FUEL ASSEMBLY COMPONENTS

The primary function of the fuel-rod spacers is to provide lateral support for and maintain the spacing of the fuel rods, with consideration of thermal-hydraulic performance, fretting wear, strength, neutron economy, and fabrication requirements. The spacers are made of Zircaloy-4; the springs in the spacer are Inconel X-750.

Finger springs are made of Inconel X-750 and are employed to control the bypass flow through the channel-to-lower tie plate flow path for some fuel assemblies. These springs have been used in the initial core and reload fuel of one BWR/3 and all BWR/4, 5, and 6 plants. They have also been employed with some reload fuel in additional BWR/2,3 plants. These finger spring seals, located between the lower tie plate and the channel, provide control over the flow through this path due to

channel wall deflections. The seals maintain a nearly constant flow area as the channel wall deforms.

The upper and lower tie plates are stainless steel 304 and serve the functions of supporting the weight of the fuel and positioning the rod ends during all phases of operation and handling. All BWR/4, 5 and 6 reactors and one BWR/3 (Pilgrim) will have two alternate path bypass flow holes located in the lower tie plate. Other operating BWR/2,3 plants may or may not have similar bypass holes drilled. These holes augment flow in the bypass region.

3. CLASSIFICATION

The classification of GE fuel assemblies is complicated by the development of new reactor product lines and changing fuel designs and requirements. These factors have resulted in fuel assembly types with both major and minor differences. This section outlines the differences in GE product lines, identifies the CDB assembly classes applicable to GE reactors, describes GE fuel designs, and lists the fuel assembly types that have been identified.

3.1 GE PRODUCT LINES

As GE has gained experience with BWRs since their introduction at Dresden-1, many design changes have occurred in nuclear power reactors. Reactors have increased greatly in size, both physically and in power output. Power densities have increased, and economic factors have changed. Over the years, GE has introduced six BWR product lines, designated BWR/1, BWR/2, BWR/3, BWR/4, BWR/5, and BWR/6. These product lines reflect major changes in the reactor design. Fuel changes have sometimes been involved in these new product lines but have not always been the driving force behind their introduction. Table 1 gives the primary characteristics of the BWR product lines and a list of the reactors in each product line that have been, are, or are expected to be, operational in the United States.

These product lines encompass five different assembly configurations, three for the BWR/1 series (one for each reactor), one for the BWR/2 and 3 series, and one for the BWR/4, 5, and 6 series. Because of the lengthy construction period for nuclear power reactors, many of the advances introduced in later product lines have been incorporated into reactors of earlier lines. For example, 8x8 fuel was introduced as a BWR/6 feature, but 8x8 fuel has been used as reload fuel for all BWR/2, BWR/3, BWR/4, and BWR/5 reactors. In fact, 8x8 fuel was used for the initial core loading in all BWR/5 plants and some BWR/4 plants.

Table 1. GE BWR product lines and characteristics

Product line	First plant Announced	Online	Characteristics	Plants
BWR/1	1955	1960	Initial commercial BWRs First internal steam separation	Big Rock Point Dresden-1 Humboldt Bay
BWR/2	1963	1969	First turnkey plant Elimination of dual cycle	Nine Mile Point 1 Oyster Creek
BWR/3	1965	1970	First jet pump application Improved emergency core cooling system	Dresden-2,3 Millstone 1 Monticello Pilgrim Quad Cities-1,2
BWR/4	1966	1972	Increased power density 20%	Browns Ferry-1,2,3 Brunswick-1,2 Cooper Duane Arnold Fermi-2 Fitzpatrick Hatch-1,2 Hope Creek Limerick-1,2 Peach Bottom-2,3 Shoreham Susquehanna-1,2 Vermont Yankee
BWR/5	1969	1982	Improved safeguards Valve flow control	LaSalle-1,2 Nine Mile Point-2 WNP-2
BWR/6	1972	1983	8X8 fuel bundle Added fuel bundles Improved recirculation system performance Improved ECCS performance Reduced fuel duty	Clinton Grand Gulf-1 Perry-1 River Bend

Source: ref. 5.

3.2 CDB ASSEMBLY CLASSES

With over 100 light-water nuclear reactors designed by four primary vendors operating nationwide, and with reload fuel manufactured by these vendors and additional suppliers, a wide variety of fuel assembly types are in existence. The evolutionary nature of these fuels further complicates attempts to describe and characterize them.

To facilitate the understanding of similarities and differences between the fuel assemblies on a systematic basis, the CDB introduced the "assembly class" concept.[6] The CDB assembly class is determined by the core configuration. Within a given class, there may be (and usually are) multiple "assembly types." Twenty-two assembly classes for commercial light water reactors have been identified. These assembly classes are listed in Table 2. For a more detailed description of this assembly classification scheme, see ref. 6.

For pressurized water reactors (PWRs), the assembly class is determined by the reactor vendor, the fuel assembly size (length and width), and the fuel assembly array size. The array size is an important factor in PWRs because the location of the guide tubes in the fuel assembly is determined by the locations of the control rods in the reactor.

For BWRs, the assembly class is determined by the reactor vendor and the fuel assembly size. Since BWRs use cruciform blades external to the fuel assembly for reactor control, the fuel assembly array size can change. Most, if not all, GE-manufactured BWRs have, in fact, changed array sizes one or more times since their startup.

Five CDB Assembly Classes are applicable to GE reactors. Each BWR/1 reactor (Dresden-1, Humboldt Bay, and Big Rock Point) has uniquely sized assemblies. Thus, each reactor is placed in a separate assembly class. The assemblies for BWR/2 and BWR/3 plants are all approximately 171 in. long and approximately 5.5 in. wide. All of these assemblies are grouped into the GE BWR/2,3 assembly class. Likewise, the assemblies for BWR/4, BWR/5, and BWR/6 plants are all approximately 176

Table 2. CDB assembly classes

	Envelope Length (in.)	Envelope Width (in.)	Array sizes used
Boiling-water reactors			
Single reactor classes			
Big Rock Point	82-84	6.5	11X11,9X9,12X12
Dresden-1	134	4.3	6X6,7X7
Elk River*	82	3.5	5X5
Humboldt Bay	95	4.7	6X6,7X7
Lacrosse*	102	5.6	10X10
Multiple reactor classes			
GE BWR/2,3 Reactors	171	5.4	7X7,8X8,9X9
GE BWR/4,5,6 Reactors	176	5.4	7X7,8X8,9X9
Pressurized-water reactors			
Single reactor classes			
Fort Calhoun	147	8.1	14X14
Haddam Neck	137	8.5	15X15
Indian Point 1	138	6.3	13X14
Palisades	149	8.3	15X15
Saint Lucie 2	158	8.1	16X16
San Onofre 1	137	7.8	14X14
South Texas 1&2	199	8.4	17X17
Yankee Rowe	112	7.6	15X16,17X18
Multiple reactor classes			
B&W 15x15	166	8.5	15X15
B&W 17x17	166	8.5	17X17
CE 14x14	157	8.1	14X14
CE 16x16	178	8.1	16X16
WE 14x14	160	7.8	14X14
WE 15x15	160	8.4	15X15
WE 17x17	160	8.4	17X17

*These BWRs were designed by Allis-Chalmers.

Source: ref. 6.

in. long and 5.5 in. wide and are grouped into the GE BWR/4,5,6 assembly class.

3.3 GE FUEL DESIGNS

Independently of the introduction of new reactor product lines, GE has effected many design changes and improvements to their initial core and reload fuel. Some of these changes have been introduced individually; others have been introduced into fuel assemblies in combinations. For the most part, these changes have represented the traditional method of describing GE fuel assemblies, regardless of the variations within a single fuel design (length, active fuel length, etc.).

The term "fuel design" is used to designate particular design changes in fuel which may apply to more than one fuel assembly type. For instance, the Optimized Fuel Assembly (OFA) is a Westinghouse fuel design. Westinghouse manufactures OFA fuel for its reactors with 14x14, 15x15, and 17x17 fuel rod arrays. The features of each of these assemblies are similar (all-Zircaloy grids, smaller diameter fuel rods, removable bottom nozzles, etc.), even though the fuel assembly types belong to different assembly classes.

In order to provide for the identification of different fuel designs, GE established a numbering system that is used with fuels of recent design. Although allowance was made within the system to accommodate historical fuels, older fuels are not generally known or described by this system. In this report, we use the GE numbering system, followed by the more commonly used designator in parenthesis. A summary of GE fuel designs is given in Table 3.

Fuels developed before 1969 are designated GE-1. These early fuels have been used only in BWR/1 product line reactors (Dresden-1, Big Rock Point, and Humboldt Bay).

The original fuel assemblies for BWR/2, some BWR/3, and some BWR/4 reactors are fuel design GE-2 (7x7). These assemblies have a fuel rod

Table 3. GE fuel designs

Name	Year Introduced	Where Used	Description
Early Fuels (GE-1)	First Use: 1959 Continuing at Big Rock Point	Dresden 1 Hum. Bay Big Rock	Fuels for BWR/1 reactors
GE-2	First Use: 1969 Last Discharge: 1979	BWR/2 BWR/3 BWR/4	Original 7x7 Array
GE-3	First Use: 1972 Last Discharge: 1982	BWR/2 BWR/3 BWR/4	Improved 7x7 Array Thicker cladding, hydrogen getter, chamfered pellets
GE-4	First Use: 1974 Monticello;Quad Cities-1 Last Discharge: 1986	BWR/2 BWR/3 BWR/4	Original 8x8 Array Introduction of water rod,
GE-5	First Use: 1975 P. Bottom-2; V. Yankee	BWR/2 BWR/3 BWR/4 BWR/5	8x8 Retrofit Two water rods, axial natural uranium blankets
Prepressurized (GE-6 & GE-7)	First Use: 1977 Peach Bottom-2	BWR/2 BWR/3 BWR/4 BWR/5 BWR/6	Retrofit fuel with fuel rods pre-pressurized to 3 atm helium
Barrier (GE-6 & GE-7)	First Use: 1979 Quad Cities-1	BWR/2 BWR/3 BWR/4 BWR/5 BWR/6	Prepressurized Retrofit fuel with zirconium barrier on clad interior.
GE-8	First Use: 1981 Brown Ferry-3	BWR/2 BWR/3 BWR/4 BWR/5 BWR/6	Increased number of water rods; larger diameter fuel pellets; higher stack density; axial gadolinia distribution; improved upper tie plate; 5 atm helium.
GE-9	First Use: 1987 Hatch-1		Undetermined; Suspected single large water rod and ferrule-type spacers

diameter of 0.563 in. and a clad thickness of 0.032 in. The fuel pellets for these assemblies are long (0.600 in.); some pellets in some rods were dished. These fuel assemblies contain between 190 and 197 kg initial heavy metal. The active fuel length is 144 in. [NOTE: One group of 7x7 fuel assemblies, manufactured for Oyster Creek, Nine Mile Point-1, and Millstone-1, have been at times considered to be fuel design GE-1. Since the primary difference between these assemblies and other GE-2 assemblies for BWR/2 and BWR/3 reactors is a slightly (0.007 in.) larger fuel rod, they are considered to be of the GE-2 fuel design.]

In 1971, GE introduced fuel design GE-3 (improved 7X7) with improvements designed to reduce or eliminate fuel failures due to hydriding. This fuel was fabricated using thicker cladding (0.037 in. vs. 0.032 in. in the original 7X7 fuel); increased cladding heat treatment temperatures; shorter, chamfered fuel pellets; and a hydrogen "getter" in the gas plenum region. The getter material is a zirconium alloy in the form of small chips. These getter chips are loosely packed in a stainless steel tube on which one end is capped and the other end is covered by wire screening.[3] The increased cladding thickness of this fuel causes a decrease in the fuel pellet diameter and, consequently, the amount of uranium per assembly. The active fuel length is 144 or 146 in. (the longer active fuel length was used only in BWR/4 reactors).

In 1972, GE introduced the BWR/6 product line and fuel configured in an 8X8 array. This fuel is fuel design GE-4. Because of the lengthy times required for reactor construction and the rapidly advancing state-of-the-art of fuel design, GE-4 fuel was irradiated only in BWR/2, BWR/3, and BWR/4 reactors. It has 63 Zircaloy-clad fuel rods and a single Zircaloy water rod. The water rod in the center of the assembly provides nonboiling water for neutron moderation. Because it also serves as a spacer capture rod, the water rod eliminated the need for the segmented fuel rod used in the 7X7 fuel designs. The fuel rod diameter is 0.493 in. The active fuel length is 144 or 146 in. (the longer active fuel length was used only in BWR/4 reactors).

In 1976, GE introduced four lead test assemblies (LTA) of GE-5 (8X8 Retrofit) fuel at Peach Bottom-2. This fuel design introduced a second water rod and natural uranium blankets to reduce axial neutron leakage. The active fuel lengths of retrofit fuel are somewhat longer than the earlier fuels. For BWR/2 and BWR/3 reactors, the active fuel length, including the natural uranium blankets, is 145.24 in. The active fuel length for BWR/4, BWR/5, and BWR/6 reactors, also including the blankets, is 150 in.

In the spring of 1977, an LTA containing 24 prepressurized fuel rods was inserted in Peach Bottom-3. These fuel rods were evacuated and filled with helium to a pressure of 3 atm. This prepressurization decreased fission gases released from the pellets and reduced pellet-clad interaction (PCI) by improving heat transfer within the fuel rod. This 8X8 assembly also incorporated the features of GE-5 fuel.

In 1979, the first LTAs of barrier fuel were irradiated at the Quad Cities-1 reactor. Barrier fuel was introduced by GE as an answer to the PCI fuel failure mechanism. It is essentially prepressurized fuel with a pure zirconium layer on the interior of the Zircaloy cladding. This layer is mechanically bonded to the cladding and constitutes approximately 10% of the cladding thickness. Since pure zirconium is softer than Zircaloy, the barrier material effectively inhibits PCI crack formation.

Special barrier bundles with enrichment distributions designed to increase local power peaking of individual fuel rods were inserted in the Quad Cities-2 for cycle 6 operations in December 1981. This enabled the ramping of a limited number of fuel rods to significantly higher linear heat generation rates (LHGRs) than normally possible. This feature was desirable for the in-core power ramping at the end of cycles 6 and 7, which demonstrated the resistance of this fuel to PCI. Barrier fuel was offered commercially by GE beginning in 1983. By 1986, GE expected that 100% of the fuel produced at their Wilmington, North Carolina, would be barrier fuel.[7]

Prepressurized fuel and barrier fuel do not correspond exactly to the fuel designs that GE labels GE-6 and GE-7. Prepressurization is one

change inherent in the GE-6 fuel design; others may also exist. However, barrier fuel was apparently not the primary difference between the GE-6 and GE-7 fuel designs since both barrier and non-barrier versions of both fuel designs are known to exist (GE-6B and GE-7B have barrier clad; GE-6 and GE-7 do not). For this reason, we have not used the designations GE-6 and GE-7 for these fuel designs, but have called these designs "Prepressurized" and "Barrier" in Table 3.

LTAs of fuel design GE-8 were inserted in the Brown's Ferry-3 reactor in 1981. This fuel design retained the 8X8 array size, but has several mechanical and nuclear improvements. Mechanical improvements include increased pre-pressurization (to 5 atm) for increased exposure capability, an increased pellet diameter (resulting in a smaller pellet-clad gap), a variable (2 to 6) number of larger diameter water rods, single diameter upper end plug shafts, and a streamlined upper tie plate to reduce the two-phase pressure drop. Some of the nuclear features include higher bundle enrichments for longer operating cycles and increased discharge burnup, axially zoned gadolinium and the variable number of water rods mentioned earlier. Overall these features allow for improved fuel cycle costs, increased flexibility and improved operating margins including an increase in the LHGR limit from 13.4 to 14.4 kW/ft.[8,9]

The lead use of fuel design GE-9 was at the Hatch-1 reactor, beginning in 1987. No particular design details are available. However, advanced versions of BWR fuel designed by Toshiba, Hitachi, and GE,[10] have ferrule-type spacers (rather than grid-type spacers) and a large centralized water rod that replaces four fuel pins in an 8X8 array. The diameter of this large water rod appears to be about 1.4 in. A water rod with this diameter would provide over 50% more nonboiling water than four standard GE-7 water rods (0.591 in. diameter).

Prior to 1987, LTAs with improved design features were inserted in Peach Bottom-3 (1983) and Duane Arnold (1984). Two of the Peach Bottom LTAs use an improved, low-pressure-drop spacer[11]. The weights of heavy

metal for the Duane Arnold LTAs (164 and 154 kg U/assembly) suggest the use of several (9 and 12) water rods, respectively.[12]

In 1988, LTAs were inserted in the Cooper Station reactor[13]; these may be the initial usage of GE-10 fuel.

3.4 CDB FUEL ASSEMBLY TYPES

The term "assembly type", as used in the CDB, describes a set of individual fuel assemblies with similar physical characteristics. The assembly type is, in general, a breakdown of the CDB assembly class into various fuel designs. In cases where other differences between fuel assemblies exist within the same assembly class and fuel design, additional fuel assembly types have been identified. Assemblies of a particular assembly type typically have identical (or nearly identical) lengths, widths, cladding material, active fuel lengths, hardware (parts and materials), and weights of heavy metal. Factors that may not be identical include initial enrichment, enrichment distributions, and/or neutron absorbers used. Using these criteria, thirty fuel assembly types of GE production fuels have been identified. Fuel assembly types of the early fuel designs (for BWR/1 reactors) are listed in Table 4. Fuel assembly types of later fuel designs for BWR/2-6 reactors are listed in Table 5. Detailed fuel assembly data sheets are presented in Appendix A. Only assemblies manufactured in production-sized runs are designated as fuel assembly types. Special assemblies and lead test assemblies that did not become production assembly types have been identified and described to the extent possible in Sect. 4.

3.4.1 Fuel Assembly Types Used at Dresden-1

Five assembly types of GE fuel for the Dresden-1 reactor have been identified. Four of these assembly types are Zircaloy-clad, the fifth is stainless steel-clad fuel. These assembly types were designated Type I, II, III, III-F, and V by GE. All but Type II were 6X6 fuel arrays with Zircaloy-2 cladding. Type II was a 7X7 array with stainless steel

Table 4. CDB assembly types of "early fuels"

(GE product line BWR/1)

Assembly type	EIA code	CDB class	Comments
GE 6X6	06G11	Dresden-1	Type I - Reprocessed
GE 7X7	-----	Dresden-1	Type II - Reprocessed
GE 6X6	06G11	Dresden-1	Type III (Type III-B)
GE 6X6	06G11	Dresden-1	Type III-F
GE 6X6	06G11	Dresden-1	Type V
GE 7X7	-----	Humboldt Bay	Type I - Reprocessed
GE 7X7	06G12	Humboldt Bay	Type II
GE 6X6	07G13	Humboldt Bay	Type III
GE 12X12	----	Big Rock	Reprocessed
GE 11X11	11GBR	Big Rock	"B" and "BC" fuel
GE 9X9	09GBR	Big Rock	"E", "F", and "EG" fuel

Table 5. CDB assembly types of later GE fuel designs

Assembly Type	EIA Code	CDB Class	Fuel Design	Comments
GE 7x7 GE-2, V1a	07G14	BWR/2,3	GE-2	0.570 in. FR[a] Diameter
GE 7x7 GE-2, V1b	07G21	BWR/2,3	GE-2	0.563 in. FR[a] Diameter
GE 7x7 GE-2, V2	07G22	BWR/4,5,6	GE-2	
GE 7x7 GE-3, V1	07G31	BWR/2,3	GE-3	
GE 7x7 GE-3, V2a	07G32	BWR/4,5,6	GE-3	144 in. AF[b] Length
GE 7x7 GE-3, V2b	07G33	BWR/4,5,6	GE-3	146 in. AF[b] Length
GE 8x8 GE-4, V1	08G41	BWR/2,3	GE-4	
GE 8x8 GE-4, V2a	08G42	BWR/4,5,6	GE-4	144 in. AF[b] Length
GE 8x8 GE-4, V2b	08G43	BWR/4,5,6	GE-4	146 in. AF[b] Length
GE 8x8 GE-5, V1	08G51	BWR/2,3	GE-5	
GE 8x8 GE-5, V2	08G52	BWR/4,5,6	GE-5	
GE 8x8 Pres., V1	08G61	BWR/2,3	Prepressurized	
GE 8x8 Pres., V2	08G62	BWR/4,5,6	Prepressurized	
GE 8x8 Barrier, V1	08G71	BWR/2,3	Barrier	
GE 8x8 Barrier, V2	08G72	BWR/4,5,6	Barrier	
GE 8x8 GE-8, V1a	08G81	BWR/2,3	GE-8	145.24 in. AF[b] Length
GE 8x8 GE-8, V1b	-----	BWR/2,3	GE-8	142.24 in. AF[b] Length
GE 8x8 GE-8, V2a	08G82	BWR/4,5,6	GE-8	150 in. AF[b] Length
GE 8x8 GE-8, V2b	-----	BWR/4,5,6	GE-8	147 in. AF[b] Length

[a] FR - Fuel Rod
[b] AF - Active Fuel

304 cladding. Only one Type I fuel assembly remains unreprocessed; it has been described in the section on special fuels.

Type II fuel was a stainless steel clad 7X7 fuel array. The Nuclear Fuel Data Form RW-859[12] data base does not list any of these fuel assemblies. However, the Integrated Data Base[14] identifies intact fuel assemblies from Dresden-1 in the listing of atypical, highly radioactive wastes stored at the Savannah River Plant. The number of assemblies is not listed, but 2543 kg of heavy metal (73% Th, 27% U) is reported.

Type III fuel (also called Type III-B) uses a 6X6 Zircaloy-clad fuel rod array. Each fuel rod is slightly doped (0.15%) with a neutron absorbing material, erbium oxide. Type III-F fuel assemblies modify the use of neutron absorbers, replacing one fuel rod with a burnable absorber rod containing aluminum oxide (95.3%) and gadolinium oxide (4.7%). Type V fuel assemblies have 36 fuel rods with gadolinium mixed with the uranium oxide fuel pellets in selected rods.

3.4.2 Fuel Assembly Types Used at Big Rock Point

Three assembly types of GE fuel for the Big Rock Point reactor have been identified. Two types are Zircaloy-clad, the third was stainless steel-clad fuel. The stainless steel-clad fuel (designated "A") was the original core load. This fuel was a 12X12 array and has apparently all been reprocessed at West Valley. The first Zircaloy-clad fuel is an 11X11 array and is designated "B" (sometimes "BC") fuel. Fuel types "E," "F," and "EG" are all 9X9 arrays and have been grouped together in the GE 9X9 Big Rock Point fuel assembly type.

3.4.3 Fuel Assembly Types Used at Humboldt Bay

Three assembly types of GE fuel for the Humboldt Bay reactor have been identified. GE manufactured two types of production Zircaloy-clad fuel, they also manufactured a production model of stainless steel-clad fuel. According to the number of fuel rods[15], both of the Zircaloy-clad

fuels are a 6X6 array. However, the fuel rod diameters differ greatly (0.486 and 0.563 in.), and Humboldt Bay's data submittal to the EIA[12] indicates that the first model is a 7X7 array. The fact that the stainless steel-clad fuel was a 7X7 array and had a 0.463 in. fuel rod diameter indicates that the first reload was 7X7 fuel. All of the stainless steel-clad fuel and some of the Zircaloy-clad 7X7 fuel has been reprocessed at West Valley. Therefore, two versions of Humboldt Bay fuel, GE 7X7 Type II and GE 6X6 Type III, still exist. All of this remaining fuel has been canned in borated aluminum canisters.[16]

4. OTHER VARIATIONS IN GE FUEL ASSEMBLIES

4.1 GE CORE LATTICE DESIGNATIONS

Three different core lattices have been used by GE in their BWR/2-6 reactors and they are designated by the letters D, C, and S. These designations are based on the relative size of the water gap between adjacent fuel assemblies and dimensional characteristics of the basic fuel assembly and channel.[3] The water gap between assemblies on the sides adjacent to the control blade is greater than the gap on the sides away from the control blade in D-lattice cores. In both C- and S-lattice cores, the water gaps between assemblies are equal, regardless of the position of the control blade. S-lattice cores have slight dimensional differences--the fuel channels are 0.120 in. thick and the fuel assembly width (without the channel) is reduced slightly. All reactors in the BWR/2 and BWR/3 product lines and about half of the BWR/4 reactors have D-lattice cores. The other half of the reactors in the BWR/4 product line and all BWR/5 reactors have C-lattice cores; BWR/6 reactors have S-lattice cores. While significant from an operations standpoint, differences in lattice designations do not appear to be significant from an assembly classification perspective.

4.2 GE BUNDLE DESIGNATIONS

GE has developed designations for its fuel bundles.[3] Table 6 reproduces these designations for GE-4, GE-5, Prepressurized, Barrier, and GE-8 fuel.

4.3 RADIAL AND AXIAL ENRICHMENT DISTRIBUTIONS

Because the gaps between fuel assemblies are filled with water (increasing the thermal neutron flux in the edges of an assembly)[17], radial and axial enrichment variations are used to reduce power peaking across the fuel assembly.

Table 6. Bundle designations for GE fuels

Bundle designations with different enrichments for the GE-4 (8x8) fuel design are designated by 8DxxxA, where:

- 8 - designates the 8x8 fuel bundle design;
- D - denotes that the bundle is designed for D-lattice cores;
- xxx - is the bundle average enrichment (U-235 weight percent); and
- A - is a letter suffix to differentiate between bundles with the same average enrichment that are different in some other respect, such as enrichment distribution or gadolinium content and distribution.

For the GE-5 (8x8 Retrofit) fuel design, which contains axially distributed enrichments, two types of enrichment designations are used--one for the lattice or fuel bundle cross section at a particular elevation and one for the bundle. An example of the bundle and lattice designations used is 8DRBxxxAA, where:

- 8 - designates the fuel bundle design;
- D - may actually be D,C, or S and denotes that the design is for a D, C, or S lattice type core;
- R - denotes the 8x8 retrofit design;
- B - is B or L designating bundle or lattice;
- xxx - is the bundle or lattice average enrichment (weight percent U-235); and
- AA - is a one- or two-letter suffix which differentiates between lattices with the same average enrichment but which are different in some other respect, such as enrichment distribution or gadolinium content and distribution.

For the pressurized 8x8 retrofit fuel design, a P is placed in front of the bundle and lattice description. For the pressurized retrofit fuel with barrier, the letters BP are placed in front of the bundle and lattice description (BP8DRBxxxA and BP8DRLxxxAA).

The GE-8 fuel designs are described using the designation BDxxxA, where:

- B - designates the barrier option and is blank for the non-barrier option;
- D - is D, C, or S and denotes that the design is for a D, C, or S lattice type core;
- xxx - is the bundle or lattice average enrichment (weight percent U-235); and
- A - is a one-letter suffix which differentiates between lattices with the same average enrichment but which are different in some other respect, such as enrichment distribution or gadolinium content and distribution.

Source: ref. 3.

GE began utilizing radial enrichment distributions in the early reload fuels at Dresden-1, Big Rock Point, and Humboldt Bay. At first, these distributions were primarily in the form of lower enrichments in the corner rods of the fuel assemblies. With increased operating experience, radial enrichment variations have become more sophisticated (and complicated). Factors leading to these more complicated radial distributions include (1) the advent of the use of burnable neutron absorbers, (2) the appearance of the water rod in BWR assemblies, and (3) the D-, C-, and S-lattice variations. Axial enrichment variations in production fuels were introduced with the GE-5 (8x8 Retrofit) fuel design. Retrofit fuel improved the neutron economy through the use of natural uranium axial blankets. Fuel bundles (specifically P8SRB176, -200, -219; P8CRB219, -248; and P8DRB175) of the prepressurized fuel design have used axial enrichment variations in addition to the natural uranium blankets. GE's advertising indicates that their use of axial enrichment variations has increased. In addition, for the GE-8 fuel design, the maximum average planar linear heat generation rate (MAPLHGR) curves used in the technical specifications for commercial power reactors have an axial variation, an indication of axial enrichment variations.

4.4 RADIAL AND AXIAL GADOLINIUM DISTRIBUTIONS

Burnable neutron absorbers (in the form of erbium oxide) were introduced by GE in the second Dresden-1 reload core. GE switched to gadolinium oxide for the third reload and has used it since that time. The earliest assemblies with gadolinia absorbers used a single, nonfueled rod with approximately 5% gadolinium oxide and 95% aluminum oxide. Subsequent versions have incorporated the gadolinia directly into the fuel rods, which contain a solid solution of gadolinia and uranium dioxide. The gadolinia content in the earlier uses seems to have been in the range of 2 to 4%. To satisfy the need for fuel assemblies capable of higher burnup, average U-235 enrichments for BWR fuel assemblies have been raised. While enrichments for the initial

core loadings for the first large BWRs were in the 2.19 to 2.50% range, enrichments in later cores (both initial and reload) gradually increased to the 2.63 to 2.84% range. Current fuel assemblies designed for high burnup contain average enrichments in the 3.00 to 3.20% range. To compensate for this excess reactivity during the first cycles of use, the use of burnable neutron absorbers has increased. Although GE regards information on gadolinia concentrations and distributions as proprietary for fuel designs GE-5 and higher, GE released some information on the GE-4 (8x8) fuel. Those assemblies have 3, 4, or 5 fuel rods that contain gadolinia. The assemblies with average enrichments of 2.19% typically contain three fuel rods with gadolinia; of 2.50%, four; and of 2.74%, five. Although no data are available, we expect that as enrichments have continued to increase, the number of gadolinia-doped fuel rods and the content of the gadolinia in these rods has also increased. Additionally, axially zoned enrichment variations have given rise to axially zoned gadolinia concentrations.[8,9]

5. SPECIAL FUELS

Several special types of fuel assemblies have been identified. These include test assemblies that were not the forerunners of production fuel designs, the remnants of early fuels that have largely been reprocessed, and mixed oxide fuels. These fuels do not seem to warrant extensive discussion, but their unique characteristics do merit their identification.

5.1 DRESDEN-1 TYPE I FUEL

Dresden-1 Type I fuel was the initial core loading for the Dresden-1 reactor. It had a 6x6 fuel rod array, utilized Zircaloy-2 for the cladding, was approximately 135 in. long and 4.4 in. wide. From records submitted by Commonwealth Edison to the EIA, only one of these assemblies remains intact.[12] We conclude that the other assemblies have been reprocessed. The number of assemblies used at Dresden-1 and the amount of Dresden-1 fuel reprocessed at West Valley tend to support this assumption, but detailed verification of this has not yet been obtained.

5.2 DRESDEN-1 PF FUEL

In 1961, 12 prototype fuel (PF) assemblies were fabricated and inserted into the Dresden-1 reactor.[18] Of these twelve assemblies, only the one designated PF-10 remains intact. PF-10 is a Zircaloy-4 clad, 8x8 fuel assembly with erbium oxide in each fuel rod. This seems to be the only usage of Zircaloy-4 for cladding in BWRs. The assembly had an initial weight of uranium of 99.7 kg and attained a burnup of 25,300 MWd/Metric Ton of Initial Heavy Metal (MTIHM).[12]

5.3 BIG ROCK POINT 7X7 AND 8X8 CENTERMELT FUEL

In 1970, Big Rock Point loaded four 7x7 "advanced" and two 8x8 "intermediate" centermelt fuel assemblies.[19] Like other Big Rock Point

fuels, these assemblies were approximately 82 in. long and 6.3 in. wide. Some of the fuel rods in these bundles had fuel rods with U-235 enrichments of up to 6.5% (extremely high for light-water reactors). In the 7x7 arrays, pellets of depleted uranium were used at each end of the fuel rods. Annular pellets of enriched uranium filled the central region of the fuel rod. The average enrichment of both types of fuel was 3.6%. The 7x7 assemblies reached a burnup of only 1500 MWd/MTIHM. One 8x8 assembly had a burnup of 1900 MWd/MTIHM; the other reached 6400 MWd/MTIHM. The 7x7 assemblies initially contained 131 kg of uranium, the 8x8 assemblies initially contained 112 kg.[12]

5.4 MIXED OXIDE FUELS

GE-manufactured mixed oxide fuels have been used in at least two commercial boiling water reactors--Big Rock Point and Quad Cities-1. The mixed oxide is uranium dioxide plus plutonium dioxide. At Big Rock Point, mixed oxide fuel assemblies were designed with the features of both the GE 11x11 and GE 9x9 Big Rock Point fuel assembly types, but with some UO_2-PuO_2 fuel rods. At Quad Cities-1, five mixed oxide fuel assemblies, with the features of the GE-3 (Improved 7x7) fuel design were used starting in 1974. These assemblies have either 8 (1 assembly) or 10 (4 assemblies) mixed oxide fuel rods with between 115 and 171 g of PuO_2/rod. The mixed oxide fuel rods have 0.032 in. thick cladding, similar to the GE-2 (7x7) fuel design. These fuel assemblies use annular pellets for the mixed oxide fuel rods.

6. REFERENCES

1 U.S. Department of Energy, Characteristics of Spent Fuel, High-Level Waste, and Other Radioactive Wastes Which May Require Long-Term Isolation, DOE/RW-0184, December 1987, vol. 1-6.

2 U.S. Department of Energy, Characteristics of Spent Fuel, High-Level Waste, and Other Radioactive Wastes Which May Require Long-Term Isolation, DOE/RW-0184, June 1988, vol. 7-8.

3 General Electric Co., General Electric Standard Application for Reactor Fuel, NEDO-24011-A-8, May 1986.

4 Jones, J. A., Carolina Power & Light, letter to B. C. Rusche, U. S. Nuclear Regulatory Commission, November 26, 1975, DOCKET 50-324-461.

5 Fuller, E. D., J. R. Finney, and H. E. Streeter, BWR/6 Nuclear System from General Electric - A Performance Description, NEDO-10569A, April 1972.

6 Moore, R. S., D. A. Williamson, and K. J. Notz, A Classification Scheme for LWR Fuel Assemblies, ORNL/TM-10901, November 1988.

7 Charnley, J. S., General Electric, letter to C. H. Berlinger, U.S. Nuclear Regulatory Commission, Aug. 13, 1986, Docket 8608190099.

8 Mills, L. M, Tennessee Valley Authority, letter to H. R. Denton, U.S. Nuclear Regulatory Commission, Nov. 4, 1981, DOCKET 811110658.

9 Silady, J.A., Commonwealth Edison, letter to T. E. Murley, U.S. Nuclear Regulatory Commission, Sept. 18, 1987, DOCKET 8709240422.

10 Oi, N., et al., "BWR Fuel Performance and Recent Trend of R&D in Japan," In Proceedings of the International Topical Meeting on LWR Fuel Performance, Williamsburg, VA April 17-20, 1988.

11 General Electric Co., Supplemental Reload Licensing Submittal for Peach Bottom Atomic Power Station Unit 3 Reload 5, Y-1003-J01A54, December 1983

12 U.S. Department of Energy, Energy Information Administration, Nuclear Fuel Data Form RW-859, Washington, D.C. (data as of December 31, 1987).

13 Trevors, G. A., Nebraska Public Power District, letter to U. S. Nuclear Regulatory Commission, Jan. 21, 1988, DOCKET 8801270467.

14 U.S. Department of Energy, Integrated Data Base for 1988: Spent fuel and Radioactive Waste Inventories, Projections, and Characteristics, DOE/RW-0006, Rev. 4, September 1988.

15 Elkins, R. B., Experience with BWR Fuel Through December 1976, NEDO-21660, July 1977.

16 Mote, N., Nuclear Assurance Corporation, letter to K. J. Notz, Oak Ridge National Laboratory, NAC Reference NM/044/RAD, February 7, 1989.

17 Kneif, R. A. Nuclear Energy Technology: Theory and Practice of Commercial Nuclear Power, Hemisphere Publishing Corporation, Washington, 1981.

18 Commonwealth Edison Company, Annual Report Year 1963, Dresden Nuclear Power Station, Docket 50-010-037, 1964.

19 Walke, G. J., Consumer's Power Company, letter to P. A. Morris, U. S. Atomic Energy Commission, December 21, 1970, DOCKET 50-155-057.

APPENDIX A

FUEL ASSEMBLY DATA SHEETS

CONTENTS

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 6 X 6 Dresden 1, Type III-B BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 06GD1
CDB Assembly Code..... G06B
CDB Assembly Class..... Dresden-1

Initial Year of Manufacture..... 1963

Final Year of Manufacture..... 1963

Total Number Fabricated to Date..... 192*

Assembly Width (inches)..... 4.3**

Assembly Length (inches)..... 134**
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches)..... 0.71**

Total Assembly Weight (lbs).....

Weight of Heavy Metal (lbs).....

Metric Tons Initial Heavy Metal (metric tons).... 0.099 - 0.103

Enrichment Range (% U235)..... 1.83

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM).....

Linear Heat Rating (KW/foot)..... 15.4

Comments:
This assembly manufactured for use at Dresden 1 only.

* Thirty of these fuel assemblies have been reprocessed at West Valley.

** Dimensions based on the dimension of similar Dresden 1 assemblies and rounded to two (or three) signifigant figures.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 6 X 6 Dresden 1, Type III-B BWR

EIA Assembly Code..... O6GD1
CDB Assembly Code..... G06B
CDB Assembly Class..... Dresden-1

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction

Drawing Numbers Associated With Assembly:

References Associated With Assembly:

Bolger 1977
Bower 1966
Commonwealth Edison 1957
GE 1961
GE 1973

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 6 X 6 Dresden 1, Type III-B BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code	06GD1
CDB Assembly Code	G06B
CDB Assembly Class	Dresden-1
Type of Rod	Fuel Rod
Fuel Rod Positions per Assembly	36
Typical Number of Fueled Rods per Assembly	36
Rod Diameter (inches)	0.555
Rod Length (inches)	(114)*
Active Length (inches)	109
Weight per Rod (lbs)	
Clad Material	Zircaloy-2
Clad Thickness (inches)	0.035**
Clad Final Conditioning	
Fuel-Clad Gap (inches)	0.075
Fill Gas Used	
Initial Gas Pressure (psig)	
Nitrogen Content of Fill Gas (percent)	

Comments:

All fuel rods have 0.15% Er_2O_3.

* The fuel rod length is estimated from the fuel rod length for other Dresden 1 assembly types. The fuel rod length for other assemblies is 114.22 inches. This does not include the length of the end pins.

** Cladding thickness of 5 special corner rods is 0.055".

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 6 X 6 Dresden 1, Type III-B BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code	06GD1
CDB Assembly Code	G06B
CDB Assembly Class	Dresden-1
Fuel Pellet Material	Uranium Oxide
Fuel Pellet Shape	
Fuel Pellet Diameter (inches)	0.478*
Fuel Pellet Length (inches)	
Fuel Pellet Weight per Rod (lbs)	
Open Porosity (percent)	
Grain Size (microns)	
Fuel Density (% theoretical)	
O/U Ratio	
Smear Density	
Spacer Pellet Material	
Spacer Pellet Length (inches)	
Plenum Spring Material	
Plenum Spring Weight per Assembly (lbs)	
Plenum Length (inches)	
Plenum Volume (cubic inches)	

Comments:
* Fuel pellets for corner rods have diameter of 0.438".

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 6 x 6 Dresden 1, Type III-F BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code	O6GD2
CDB Assembly Code	G06C
CDB Assembly Class	Dresden-1
Initial Year of Manufacture	1964
Final Year of Manufacture	1964
Total Number Fabricated to Date	104*
Assembly Width (inches)	4.3**
Assembly Length (inches) with Control Rod Inserted including Holddown Device, etc	134**
Rod Pitch (inches)	0.71**
Total Assembly Weight (lbs)	
Weight of Heavy Metal (lbs)	
Metric Tons Initial Heavy Metal (metric tons)	0.096 - 0.103
Enrichment Range (% U235)	
Average Design Burnup (MWd/MTIHM)	
Maximum Design Burnup (MWd/MTIHM)	
Linear Heat Rating (KW/foot)	15.5

Comments:
Special test assemblies with special poison rods, plutonium rods, and powder rods exist.

* Ten of these fuel assemblies appear to have been reprocessed at West Valley.

** These dimensions are based on the dimensions of similar Dresden 1 assemblies and rounded to two (or three) signifigant figures.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 6 x 6 Dresden 1, Type III-F BWR

EIA Assembly Code..... O6GD2
CDB Assembly Code..... G06C
CDB Assembly Class..... Dresden-1

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction

Drawing Numbers Associated With Assembly:

References Associated With Assembly:

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 6 x 6 Dresden 1, Type III-F BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 06GD2
CDB Assembly Code..... G06C
CDB Assembly Class..... Dresden-1

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 36

Typical Number of Fueled Rods per Assembly..... 35

Rod Diameter (inches)..... 0.5625

Rod Length (inches)..... (114)*

Active Length (inches)..... 108.25

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.035

Clad Final Conditioning.....

Fuel-Clad Gap (inches)..... 0.010

Fill Gas Used.....

Initial Gas Pressure (psig).....

Nitrogen Content of Fill Gas (percent).....

Comments:

These assemblies have a single, nonfueled rod containing pellets of aluminum oxide (95.3%) and gadolinium oxide (4.7%). The pellet diameter is 0.465".
* The fuel rod length is estimated from the fuel rod length for other Dresden 1 assembly types. The actual fuel rod lengths for other assemblies is 114.22 inches. This length does not include the length of the end pins.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 6 x 6 Dresden 1, Type III-F BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code	06GD2
CDB Assembly Code	G06C
CDB Assembly Class	Dresden-1
Fuel Pellet Material	Uranium Oxide
Fuel Pellet Shape	
Fuel Pellet Diameter (inches)	0.482
Fuel Pellet Length (inches)	
Fuel Pellet Weight per Rod (lbs)	
Open Porosity (percent)	
Grain Size (microns)	
Fuel Density (% theoretical)	
O/U Ratio	
Smear Density	
Spacer Pellet Material	
Spacer Pellet Length (inches)	
Plenum Spring Material	
Plenum Spring Weight per Assembly (lbs)	
Plenum Length (inches)	
Plenum Volume (cubic inches)	

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 6 x 6 Dresden 1, Type V BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code	06GD3
CDB Assembly Code	G06D
CDB Assembly Class	Dresden-1
Initial Year of Manufacture	1966
Final Year of Manufacture	1966
Total Number Fabricated to Date	106
Assembly Width (inches)	4.3*
Assembly Length (inches) with Control Rod Inserted including Holddown Device, etc	134.34
Rod Pitch (inches)	0.71*
Total Assembly Weight (lbs)	
Weight of Heavy Metal (lbs)	
Metric Tons Initial Heavy Metal (metric tons)	0.106**
Enrichment Range (% U235)	2.26
Average Design Burnup (MWd/MTIHM)	
Maximum Design Burnup (MWd/MTIHM)	
Linear Heat Rating (KW/foot)	15.5

Comments:
Four assemblies are "thin clad" assemblies.
Two assemblies used Zircaloy spacer grids and have dished pellets in selected fuel rods.

* These dimensions are based on the dimensions of similar Dresden 1 assemblies and rounded to two (or three) signifigant figures.

** Average weight.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 6 x 6 Dresden 1, Type V BWR

EIA Assembly Code..... 06GD3
CDB Assembly Code..... G06D
CDB Assembly Class..... Dresden-1

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction

Drawing Numbers Associated With Assembly:

References Associated With Assembly:

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 6 x 6 Dresden 1, Type V BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 06GD3
CDB Assembly Code..... G06D
CDB Assembly Class..... Dresden-1

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 36

Typical Number of Fueled Rods per Assembly..... 36

Rod Diameter (inches)..... 0.5625

Rod Length (inches)..... 114.22*

Active Length (inches)..... 108.25

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.035**

Clad Final Conditioning.....

Fuel-Clad Gap (inches)..... 0.010

Fill Gas Used.....

Initial Gas Pressure (psig).....

Nitrogen Content of Fill Gas (percent).....

Comments:

Selected rods contain small amounts of gadolinia as a burnable neutron adsorber.

* Length of fuel rod does not include the length of the end pins.

** Four assemblies have a cladding thickness reduced to 0.026".

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 6 x 6 Dresden 1, Type V BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code	06GD3
CDB Assembly Code	G06D
CDB Assembly Class	Dresden-1
Fuel Pellet Material	Uranium Oxide
Fuel Pellet Shape	
Fuel Pellet Diameter (inches)	0.482*
Fuel Pellet Length (inches)	
Fuel Pellet Weight per Rod (lbs)	
Open Porosity (percent)	
Grain Size (microns)	
Fuel Density (% theoretical)	
O/U Ratio	
Smear Density	
Spacer Pellet Material	
Spacer Pellet Length (inches)	
Plenum Spring Material	
Plenum Spring Weight per Assembly (lbs)	
Plenum Length (inches)	5.27
Plenum Volume (cubic inches)	

Comments:
Pellets in special "thin clad" assemblies have a pellet diameter of 0.498".

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 7 X 7 Humb. Bay, Type II BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 07G13
CDB Assembly Code..... G07A
CDB Assembly Class..... Humboldt Bay

Initial Year of Manufacture..... 1965

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches)..... 4.662

Assembly Length (inches)..... 95
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches)..... 0.631

Total Assembly Weight (lbs)..... 276

Weight of Heavy Metal (lbs)..... 168

Metric Tons Initial Heavy Metal (metric tons).... 0.0763

Enrichment Range (% U235)..... 2.08-2.30

Average Design Burnup (MWd/MTIHM)..... 14000

Maximum Design Burnup (MWd/MTIHM)..... 23000

Linear Heat Rating (KW/foot)..... 12.1

Comments:
This assembly was manufactured for use at Humboldt Bay only. The weight of the fuel assembly inlcudes the weight of the fuel channel. The width is the outside dimension of the 0.060" fuel channel.

This assembly is also known as Humboldt Bay Type II fuel. Some of these assemblies were reprocessed at West Valley.

The initial core at Humboldt Bay was a 7 x 7, stainless steel clad fuel array. These assemblies have all been reprocessed at West Valley.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 7 X 7 Humb. Bay, Type II BWR

EIA Assembly Code..... 07G13
CDB Assembly Code..... G07A
CDB Assembly Class..... Humboldt Bay

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	49	0.0000	TOP		0.00000
T. TIE PLATE	1	0.0000	TOP		0.00000
SPACERS	3	0.0000	IN CORE		0.00000
B. TIE PLATE	1	0.0000	BOTTOM		0.00000

Drawing Numbers Associated With Assembly:

731E272

References Associated With Assembly:

Crane 1976b
GE 1973
PG&E 1968
Peterson 1969

Comments:

Drawing number taken from EIA RW-859 data base.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 7 X 7 Humb. Bay, Type II BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 07G13
CDB Assembly Code..... G07A
CDB Assembly Class..... Humboldt Bay

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 49

Typical Number of Fueled Rods per Assembly..... 49

Rod Diameter (inches)..... 0.486

Rod Length (inches)..... 83.2

Active Length (inches)..... 79.0

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.033

Clad Final Conditioning.....

Fuel-Clad Gap (inches)..... 0.005

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 0

Nitrogen Content of Fill Gas (percent).....

Comments:

The fuel rod length does not include the length of the end pins. The central fuel rod is segmented.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 7 X 7 Humb. Bay, Type II BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code	07G13
CDB Assembly Code	G07A
CDB Assembly Class	Humboldt Bay
Fuel Pellet Material	Uranium Oxide
Fuel Pellet Shape	
Fuel Pellet Diameter (inches)	0.411
Fuel Pellet Length (inches)	
Fuel Pellet Weight per Rod (lbs)	
Open Porosity (percent)	
Grain Size (microns)	
Fuel Density (% theoretical)	94.3
O/U Ratio	
Smear Density	
Spacer Pellet Material	
Spacer Pellet Length (inches)	
Plenum Spring Material	
Plenum Spring Weight per Assembly (lbs)	
Plenum Length (inches)	3.5
Plenum Volume (cubic inches)	

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 6 X 6 Humb. Bay, Type III BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 06G12
CDB Assembly Code..... G06A
CDB Assembly Class..... Humboldt Bay

Initial Year of Manufacture..... 1971

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches)..... 4.662

Assembly Length (inches)..... 95
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches)..... 0.740

Total Assembly Weight (lbs)..... 270

Weight of Heavy Metal (lbs)..... 168

Metric Tons Initial Heavy Metal (metric tons).... 0.0764

Enrichment Range (% U235)..... 2.36-2.50

Average Design Burnup (MWd/MTIHM)..... 18750

Maximum Design Burnup (MWd/MTIHM).....

Linear Heat Rating (KW/foot).....

Comments:
The assembly manufactured for use at Humboldt Bay only.
Weight of fuel assembly includes weight of fuel channel.
Width is outside dimension of 0.060" fuel channel.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 6 X 6 Humb. Bay, Type III BWR

EIA Assembly Code..... 06G12
CDB Assembly Code..... G06A
CDB Assembly Class..... Humboldt Bay

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	36	0.0000	TOP		0.00000
T. TIE PLATE	1	0.0000	TOP		0.00000
SPACERS	3	0.0000	IN CORE		0.00000
B. TIE PLATE	1	0.0000	BOTTOM		0.00000

Drawing Numbers Associated With Assembly:

731E228

References Associated With Assembly:

Crane 1976a
Crane 1976b
GE 1973
PG&E 1961
Peterson 1969
Peterson 1970

Comments:

Drawing number taken from EIA RW-859 Data Base.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 6 X 6 Humb. Bay, Type III BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 06G12
CDB Assembly Code..... G06A
CDB Assembly Class..... Humboldt Bay

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 36

Typical Number of Fueled Rods per Assembly..... 36

Rod Diameter (inches)..... 0.563

Rod Length (inches)..... (83)*

Active Length (inches)..... 77.5

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.032

Clad Final Conditioning.....

Fuel-Clad Gap (inches)..... 0.0055

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 0

Nitrogen Content of Fill Gas (percent).....

Comments:

Segmented central fuel rod; corner rods have reduced enrichments to reduce local power peaking; up to 2 gadolinia-poisoned fuel rods.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 6 X 6 Humb. Bay, Type III BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code	06G12
CDB Assembly Code	G06A
CDB Assembly Class	Humboldt Bay
Fuel Pellet Material	Uranium Oxide
Fuel Pellet Shape	Dished
Fuel Pellet Diameter (inches)	0.488
Fuel Pellet Length (inches)	
Fuel Pellet Weight per Rod (lbs)	
Open Porosity (percent)	
Grain Size (microns)	
Fuel Density (% theoretical)	94.3
O/U Ratio	
Smear Density	
Spacer Pellet Material	
Spacer Pellet Length (inches)	
Plenum Spring Material	
Plenum Spring Weight per Assembly (lbs)	
Plenum Length (inches)	5.2
Plenum Volume (cubic inches)	

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 11 X 11 Big Rock Point BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 11G16
CDB Assembly Code..... G11A
CDB Assembly Class..... Big Rock Point

Initial Year of Manufacture.....

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches).....

Assembly Length (inches).....
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches)..... 0.577

Total Assembly Weight (lbs).....

Weight of Heavy Metal (lbs).....

Metric Tons Initial Heavy Metal (metric tons)....

Enrichment Range (% U235).....

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM).....

Linear Heat Rating (KW/foot).....

Comments:
This assembly is "B" & "C' fuel for the Big Rock Point Reactor.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 11 X 11 Big Rock Point BWR

EIA Assembly Code..... 11G16
CDB Assembly Code..... G11A
CDB Assembly Class..... Big Rock Point

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	121	0.0000	TOP		0.00000
T. TIE PLATE	1	0.0000	TOP		0.00000
SPACERS	3	0.0000	IN CORE		0.00000
B. TIE PLATE	1	0.0000	BOTTOM		0.00000

Drawing Numbers Associated With Assembly:

References Associated With Assembly:

GE 1973

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 11 X 11 Big Rock Point BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 11G16
CDB Assembly Code..... G11A
CDB Assembly Class..... Big Rock Point

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 121

Typical Number of Fueled Rods per Assembly..... 121

Rod Diameter (inches)..... 0.449

Rod Length (inches).....

Active Length (inches)..... 70

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.034

Clad Final Conditioning.....

Fuel-Clad Gap (inches).....

Fill Gas Used..... He

Initial Gas Pressure (psig).....

Nitrogen Content of Fill Gas (percent).....

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 11 X 11 Big Rock Point BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 11G16
CDB Assembly Code..... G11A
CDB Assembly Class..... Big Rock Point

Fuel Pellet Material..... Uranium Oxide

Fuel Pellet Shape.....

Fuel Pellet Diameter (inches).....

Fuel Pellet Length (inches).....

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical)..... 94

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

Plenum Length (inches).....

Plenum Volume (cubic inches).....

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 9 X 9 Big Rock Point BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 09G15
CDB Assembly Code..... G09A
CDB Assembly Class..... Big Rock Point

Initial Year of Manufacture.....

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches).....

Assembly Length (inches).....
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches)..... 0.707

Total Assembly Weight (lbs)..... 465

Weight of Heavy Metal (lbs)..... 305

Metric Tons Initial Heavy Metal (metric tons).... 0.138

Enrichment Range (% U235).....

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM).....

Linear Heat Rating (KW/foot).....

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 9 X 9 Big Rock Point BWR

EIA Assembly Code..... 09G15
CDB Assembly Code..... G09A
CDB Assembly Class..... Big Rock Point

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	81	0.0000	TOP		0.00000
T. TIE PLATE	1	0.0000	TOP		0.00000
SPACERS	3	0.0000	IN CORE		0.00000
B. TIE PLATE	1	0.0000	BOTTOM		0.00000

Drawing Numbers Associated With Assembly:

731E245

References Associated With Assembly:

GE 1973
Walke 1970

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 9 X 9 Big Rock Point BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 09G15
CDB Assembly Code..... G09A
CDB Assembly Class..... Big Rock Point

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 81

Typical Number of Fueled Rods per Assembly..... 81

Rod Diameter (inches)..... 0.5625

Rod Length (inches).....

Active Length (inches)..... 70

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.040

Clad Final Conditioning.....

Fuel-Clad Gap (inches).....

Fill Gas Used..... He

Initial Gas Pressure (psig).....

Nitrogen Content of Fill Gas (percent).....

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 9 X 9 Big Rock Point BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code	09G15
CDB Assembly Code	G09A
CDB Assembly Class	Big Rock Point
Fuel Pellet Material	Uranium Oxide
Fuel Pellet Shape	
Fuel Pellet Diameter (inches)	0.471
Fuel Pellet Length (inches)	
Fuel Pellet Weight per Rod (lbs)	
Open Porosity (percent)	
Grain Size (microns)	
Fuel Density (% theoretical)	94
O/U Ratio	
Smear Density	
Spacer Pellet Material	
Spacer Pellet Length (inches)	
Plenum Spring Material	
Plenum Spring Weight per Assembly (lbs)	
Plenum Length (inches)	
Plenum Volume (cubic inches)	

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 7 X 7 GE-2; VERS. 1a BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 07G14
CDB Assembly Code..... G07B
CDB Assembly Class..... GE BWR/2,3

Initial Year of Manufacture..... 1969

Final Year of Manufacture.....

Total Number Fabricated to Date..... 1672

Assembly Width (inches)..... 5.438

Assembly Length (inches)..... 171.125
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches)..... 0.738

Total Assembly Weight (lbs).....

Weight of Heavy Metal (lbs)..... 433

Metric Tons Initial Heavy Metal (metric tons).... 0.196

Enrichment Range (% U235)..... 2.11

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM).....

Linear Heat Rating (KW/foot)..... 17.5

Comments:
This assembly was used at Nine Mile Point 1, Oyster Creek, and Millstone 1 only. The width is the outside dimension of the 0.080" fuel channel.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 7 X 7 GE-2; VERS. 1a BWR

EIA Assembly Code..... 07G14
CDB Assembly Code..... G07B
CDB Assembly Class..... GE BWR/2,3

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	49	0.0000	TOP		0.00000
T. TIE PLATE	1	2.0480	TOP		0.00000
SPACERS	7	2.0270	IN CORE	Undt. Inconel	0.00000
				Undt.St.Steel	0.00000
B. TIE PLATE	1	4.3610	BOTTOM		0.00000

Drawing Numbers Associated With Assembly:

729E183
731E377

References Associated With Assembly:

Brosnan 1971
GE 1973
Raymond 1973

Comments:

Drawing numbers taken from the EIA RW-859 Data Base.

The weights of the SFD hardware for this assembly type are estimates based on the weights of the SFD hardware for similar assembly types.
The weight of the compression springs may be included in the weight of the top tie plate.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 7 X 7 GE-2; VERS. 1a BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 07G14
CDB Assembly Code..... G07B
CDB Assembly Class..... GE BWR/2,3

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 49

Typical Number of Fueled Rods per Assembly..... 49

Rod Diameter (inches)..... 0.570

Rod Length (inches)..... (160)*

Active Length (inches)..... 144.0

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.0355

Clad Final Conditioning.....

Fuel-Clad Gap (inches)..... 0.0055

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 0

Nitrogen Content of Fill Gas (percent).....

Comments:

* The tip-to-tip length of the fuel rod is estimated from the lengths of the fuel rods for other CLASS 23 assembly types. The actual fuel rod length for other assemblies is 158.95 inches for fuel rods, and 159.33 inches for tie rods.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 7 X 7 GE-2; VERS. 1a BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code	07G14
CDB Assembly Code	G07B
CDB Assembly Class	GE BWR/2,3
Fuel Pellet Material	Uranium Oxide
Fuel Pellet Shape	
Fuel Pellet Diameter (inches)	0.488
Fuel Pellet Length (inches)	
Fuel Pellet Weight per Rod (lbs)	
Open Porosity (percent)	
Grain Size (microns)	
Fuel Density (% theoretical)	94-95
O/U Ratio	
Smear Density	
Spacer Pellet Material	
Spacer Pellet Length (inches)	
Plenum Spring Material	
Plenum Spring Weight per Assembly (lbs)	
Plenum Length (inches)	11.25
Plenum Volume (cubic inches)	

Comments:
Some fuel pellets are dished.

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 7 X 7 GE-2; VERS. 1b BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code	07G21
CDB Assembly Code	G07C
CDB Assembly Class	GE BWR/2,3
Initial Year of Manufacture	
Final Year of Manufacture	
Total Number Fabricated to Date	
Assembly Width (inches)	5.438
Assembly Length (inches) with Control Rod Inserted including Holddown Device, etc	171.2
Rod Pitch (inches)	0.738
Total Assembly Weight (lbs)	678.9
Weight of Heavy Metal (lbs)	425-434
Metric Tons Initial Heavy Metal (metric tons)	0.192-0.197
Enrichment Range (% U235)	2.12-2.63
Average Design Burnup (MWd/MTIHM)	
Maximum Design Burnup (MWd/MTIHM)	
Linear Heat Rating (KW/foot)	17.5

Comments:
The weight of the fuel assembly includes the weight of the fuel channel. This assembly was used at BWR/2 and BWR/3 class reactors only. The width is the outside dimension of the 0.080" fuel channel.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 7 X 7 GE-2; VERS. 1b BWR

EIA Assembly Code..... 07G21
CDB Assembly Code..... G07C
CDB Assembly Class..... GE BWR/2,3

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	49	0.0000	TOP		0.00000
T. TIE PLATE	1	2.0480	TOP	St.Steel 304	1.00000
SPACERS	7	2.0290	IN CORE	Zircaloy-4	0.84000
				Inconel X-750	0.16000
B. TIE PLATE	1	4.3610	BOTTOM	St.Steel 304	1.00000

Drawing Numbers Associated With Assembly:

731E614
732E169G6000
814E757

References Associated With Assembly:

Brosnan 1971
GE 1973
Lee 1974
Mayer 1973a
Mayer 1973b
Raymond 1973

Comments:

Drawing numbers taken from the EIA RW-859 Data Base.

The weight of the compression springs may be included in the weight of the top tie plate.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 7 X 7 GE-2; VERS. 1b BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 07G21
CDB Assembly Code..... G07C
CDB Assembly Class..... GE BWR/2,3

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 49

Typical Number of Fueled Rods per Assembly..... 49

Rod Diameter (inches)..... 0.563

Rod Length (inches)..... (159)*

Active Length (inches)..... 144.0

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.032

Clad Final Conditioning.....

Fuel-Clad Gap (inches).....

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 0

Nitrogen Content of Fill Gas (percent).....

Comments:

The tip-to-tip fuel rod length is estimated from the fuel rod length for other CLASS 23 assembly types. The actual fuel rod length for other assemblies is 158.95" for fuel rods, 159.33" for tie rods, and 159.82" for gadolinia-doped fuel rods.

There are up to 4 gadolinia-doped fuel rods per assembly.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 7 X 7 GE-2; VERS. 1b BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 07G21
CDB Assembly Code..... G07C
CDB Assembly Class..... GE BWR/2,3

Fuel Pellet Material..... Uranium Oxide

Fuel Pellet Shape.....

Fuel Pellet Diameter (inches)..... 0.487

Fuel Pellet Length (inches)..... 0.8

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical)..... 93-95

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

Plenum Length (inches)..... 11.24

Plenum Volume (cubic inches).....

Comments:
The highest power, highest exposure rods have dished fuel pellets.

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 7 X 7 GE-2; VERS. 2 BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code	07G22
CDB Assembly Code	G07E
CDB Assembly Class	GE BWR/4,5,6
Initial Year of Manufacture	
Final Year of Manufacture	
Total Number Fabricated to Date	
Assembly Width (inches)	5.438
Assembly Length (inches) with Control Rod Inserted including Holddown Device, etc	175.87
Rod Pitch (inches)	0.738
Total Assembly Weight (lbs)	682.5
Weight of Heavy Metal (lbs)	426-432
Metric Tons Initial Heavy Metal (metric tons)	0.193-0.196
Enrichment Range (% U235)	1.1-
Average Design Burnup (MWd/MTIHM)	
Maximum Design Burnup (MWd/MTIHM)	
Linear Heat Rating (KW/foot)	

Comments:
The weight of the fuel assembly includes the weight of the fuel channel. This assembly type used at BWR/4 class reactors only. The width is the outside dimentsion of the 0.080" fuel channel.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 7 X 7 GE-2; VERS. 2 BWR

EIA Assembly Code..... 07G22
CDB Assembly Code..... G07E
CDB Assembly Class..... GE BWR/4,5,6

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	49	0.0000	TOP	Inconel X-750	1.00000
T. TIE PLATE	1	1.9150	TOP	St.Steel 304	1.00000
SPACERS	7	2.0290	IN CORE	Zircaloy-4	0.84000
				Inconel X-750	0.16000
B. TIE PLATE	1	4.4080	BOTTOM	St.Steel 304	1.00000
FINGER SPRINGS	4	0.0480	BOTTOM	Inconel X-750	1.00000

Drawing Numbers Associated With Assembly:

731E910 +SHARED
814E754P2
814E756 *SHARED
814E882 +SHARED
829E845 +SHARED

References Associated With Assembly:

Bauer 1973
CP&L 1972
PSE&G 1970
Phil. Elec. 1970
Reder 1971

Comments:

The weight of the compression springs may be included in the weight of the top tie plate.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 7 X 7 GE-2; VERS. 2 BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 07G22
CDB Assembly Code..... G07E
CDB Assembly Class..... GE BWR/4,5,6

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 49

Typical Number of Fueled Rods per Assembly..... 49

Rod Diameter (inches)..... 0.563

Rod Length (inches)..... (159)*

Active Length (inches)..... 144.0

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.032

Clad Final Conditioning.....

Fuel-Clad Gap (inches)..... 0.006

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 0

Nitrogen Content of Fill Gas (percent).....

Comments:

Central fuel rod is segmented. Gadolinia poisons are used in some fuel rods.

* The tip-to-tip fuel rod length is estimated from the fuel rod length for other CLASS 23 assembly types. The actual fuel rod length for other assemblies is 158.95 inches for fuel rods, and 159.33 inches for the tie rods, and 159.81 inches for the gadolinia-doped rods.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 7 X 7 GE-2; VERS. 2 BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 07G22
CDB Assembly Code..... G07E
CDB Assembly Class..... GE BWR/4,5,6

Fuel Pellet Material..... Uranium Oxide

Fuel Pellet Shape.....

Fuel Pellet Diameter (inches)..... 0.487

Fuel Pellet Length (inches)..... 0.75

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical)..... 93-95

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

Plenum Length (inches)..... 16

Plenum Volume (cubic inches).....

Comments:
The highest power, highest exposure rods have dished fuel pellets.

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 7 X 7 GE-3; VERS. 1 BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 07G31
CDB Assembly Code..... G07D
CDB Assembly Class..... GE BWR/2,3

Initial Year of Manufacture..... 1972

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches)..... 5.438

Assembly Length (inches)..... 171.125
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches)..... 0.738

Total Assembly Weight (lbs).....

Weight of Heavy Metal (lbs).....

Metric Tons Initial Heavy Metal (metric tons)....

Enrichment Range (% U235)..... 2.3-2.5

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM).....

Linear Heat Rating (KW/foot).....

Comments:
This assembly used at BWR/2 and BWR/3 class reactors only. The width is the outside dimension of the 0.080" fuel channel.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 7 X 7 GE-3; VERS. 1 BWR

EIA Assembly Code..... 07G31
CDB Assembly Code..... G07D
CDB Assembly Class..... GE BWR/2,3

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	49	0.0000	TOP		0.00000
T. TIE PLATE	1	1.9150	TOP	St.Steel 304	1.00000
SPACERS	7	2.0290	IN CORE	Zircaloy-4	0.84000
				Inconel X-750	0.16000
B. TIE PLATE	1	4.3610	BOTTOM	St.Steel 304	1.00000

Drawing Numbers Associated With Assembly:

731E912
814E710
814E833

References Associated With Assembly:

GE 1976c
Lee 1974
Mayer 1973a
Mayer 1973b
Raymond 1973

Comments:

Drawing numbers taken from the EIA RW-859 Data Base.

The weight of the compression springs may be included in the weight of the top tie plate.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 7 X 7 GE-3; VERS. 1 BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 07G31
CDB Assembly Code..... G07D
CDB Assembly Class..... GE BWR/2,3

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 49

Typical Number of Fueled Rods per Assembly..... 49

Rod Diameter (inches)..... 0.563

Rod Length (inches)..... (164)*

Active Length (inches)..... 144.0

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.037

Clad Final Conditioning.....

Fuel-Clad Gap (inches)..... 0.006

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 0

Nitrogen Content of Fill Gas (percent).....

Comments:

Proprietary hydrogen getter in plenum region of each fuel rod. Up to four gadolinia-poisoned fuel rods per assembly.

* The tip-to-tip fuel rod length is estimated from the fuel rod length for other CLASS 456 assembly types. The actual fuel rod length for other assemblies is 163.71 inches.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 7 X 7 GE-3; VERS. 1 BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 07G31
CDB Assembly Code..... G07D
CDB Assembly Class..... GE BWR/2,3

Fuel Pellet Material..... Uranium Oxide

Fuel Pellet Shape..... Chamfered

Fuel Pellet Diameter (inches)..... 0.477

Fuel Pellet Length (inches)..... 0.5

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical)..... 94-95

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

Plenum Length (inches)..... 11.0

Plenum Volume (cubic inches).....

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 7 X 7 GE-3; VERS. 2a BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 07G32
CDB Assembly Code..... G07F
CDB Assembly Class..... GE BWR/4,5,6

Initial Year of Manufacture.....

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches)..... 5.438

Assembly Length (inches)..... 175.87
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches).....

Total Assembly Weight (lbs)..... 674.4

Weight of Heavy Metal (lbs)..... 413

Metric Tons Initial Heavy Metal (metric tons).... 0.1875

Enrichment Range (% U235).....

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM).....

Linear Heat Rating (KW/foot).....

Comments:
The weight of the fuel assembly includes the weight of the fuel channel. This assembly type used at BWR/4 class reactors only. The width is the outside dimension of the 0.080" fuel channel.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 7 X 7 GE-3; VERS. 2a BWR

EIA Assembly Code..... 07G32
CDB Assembly Code..... G07F
CDB Assembly Class..... GE BWR/4,5,6

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight (kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	49	0.0000	TOP	Inconel X-750	1.00000
T. TIE PLATE	1	1.9150	TOP	St.Steel 304	1.00000
SPACERS	7	2.0290	IN CORE	Zircaloy-4	0.84000
				Inconel X-750	0.16000
B. TIE PLATE	1	4.4080	BOTTOM	St.Steel 304	1.00000
FINGER SPRINGS	4	0.0480	BOTTOM	Inconel X-750	1.00000

Drawing Numbers Associated With Assembly:

731E910 +SHARED
814E754P1
814E754P3
814E815
814E876
814E882 +SHARED
814E891
829E191
829E845 +SHARED

References Associated With Assembly:

Bauer 1973

Comments:

The weight of the compression springs may be included in the weight of the top tie plate.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 7 X 7 GE-3; VERS. 2a BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 07G32
CDB Assembly Code..... G07F
CDB Assembly Class..... GE BWR/4,5,6

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 49

Typical Number of Fueled Rods per Assembly..... 49

Rod Diameter (inches)..... 0.563

Rod Length (inches)..... (164)*

Active Length (inches)..... 144.0

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.037

Clad Final Conditioning.....

Fuel-Clad Gap (inches)..... 0.006

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 0

Nitrogen Content of Fill Gas (percent).....

Comments:

A proprietary hydrogen getter is used in the plenum region of fuel rods. Gadolinia poisons are used in some fuel rods.

* The tip-to-tip fuel rod length is estimated from the fuel rod length for other CLASS 456 assembly types. The actual fuel rod length for other assemblies is 163.71 inches.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 7 X 7 GE-3; VERS. 2a BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code	07G32
CDB Assembly Code	G07F
CDB Assembly Class	GE BWR/4,5,6
Fuel Pellet Material	Uranium Oxide
Fuel Pellet Shape	Chamfered
Fuel Pellet Diameter (inches)	0.477
Fuel Pellet Length (inches)	0.5
Fuel Pellet Weight per Rod (lbs)	
Open Porosity (percent)	
Grain Size (microns)	
Fuel Density (% theoretical)	94
O/U Ratio	
Smear Density	
Spacer Pellet Material	
Spacer Pellet Length (inches)	
Plenum Spring Material	
Plenum Spring Weight per Assembly (lbs)	
Plenum Length (inches)	15.8
Plenum Volume (cubic inches)	

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 7 X 7 GE-3; VERS. 2b BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code	07G33
CDB Assembly Code	G07G
CDB Assembly Class	GE BWR/4,5,6
Initial Year of Manufacture	
Final Year of Manufacture	
Total Number Fabricated to Date	
Assembly Width (inches)	5.438
Assembly Length (inches) with Control Rod Inserted including Holddown Device, etc	175.87
Rod Pitch (inches)	
Total Assembly Weight (lbs)	681
Weight of Heavy Metal (lbs)	418
Metric Tons Initial Heavy Metal (metric tons)	0.1896
Enrichment Range (% U235)	
Average Design Burnup (MWd/MTIHM)	
Maximum Design Burnup (MWd/MTIHM)	
Linear Heat Rating (KW/foot)	

Comments:
Weight of the fuel assembly includes the weight of the fuel channel. This assembly type used at BWR/4 class reactors only. The width is the outside dimension of the 0.080" fuel channel.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 7 X 7 GE-3; VERS. 2b BWR

EIA Assembly Code..... 07G33
CDB Assembly Code..... G07G
CDB Assembly Class..... GE BWR/4,5,6

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	49	0.0000	TOP	Inconel X-750	1.00000
T. TIE PLATE	1	1.9150	TOP	St.Steel 304	1.00000
SPACERS	7	2.0290	IN CORE	Zircaloy-4	0.00000
				Inconel X-750	0.00000
B. TIE PLATE	1	4.4080	BOTTOM	St.Steel 304	1.00000

Drawing Numbers Associated With Assembly:

814E756 *SHARED
814E905

References Associated With Assembly:

Bauer 1973

Comments:

The weights of the SFD hardware for this assembly type are estimates based on the weights of the SFD hardware for similar assembly types.

The weight of the compression springs may be included in the weight of the top tie plate.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 7 X 7 GE-3; VERS. 2b BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 07G33
CDB Assembly Code..... G07G
CDB Assembly Class..... GE BWR/4,5,6

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 49

Typical Number of Fueled Rods per Assembly..... 49

Rod Diameter (inches)..... 0.563

Rod Length (inches)..... (164)*

Active Length (inches)..... 146.0

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.037

Clad Final Conditioning.....

Fuel-Clad Gap (inches).....

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 0

Nitrogen Content of Fill Gas (percent).....

Comments:

A proprietary hydrogen getter is used in the plenum region of fuel rods. Gadolinia poisons are used in some fuel rods.

* The tip-to-tip rod length is estimated from the fuel rod length for other CLASS 456 assembly types. The actual fuel rod length for other assemblies is 163.71 inches.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 7 X 7 GE-3; VERS. 2b BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code	07G33
CDB Assembly Code	G07G
CDB Assembly Class	GE BWR/4,5,6
Fuel Pellet Material	Uranium Oxide
Fuel Pellet Shape	Chamfered
Fuel Pellet Diameter (inches)	0.477
Fuel Pellet Length (inches)	0.5
Fuel Pellet Weight per Rod (lbs)	
Open Porosity (percent)	
Grain Size (microns)	
Fuel Density (% theoretical)	94
O/U Ratio	
Smear Density	
Spacer Pellet Material	
Spacer Pellet Length (inches)	
Plenum Spring Material	
Plenum Spring Weight per Assembly (lbs)	
Plenum Length (inches)	14
Plenum Volume (cubic inches)	

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 8 X 8 GE-4; VERS. 1 BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 08G41
CDB Assembly Code..... G08A
CDB Assembly Class..... GE BWR/2,3

Initial Year of Manufacture.....

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches)..... 5.438

Assembly Length (inches)..... 171.125
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches)..... 0.640

Total Assembly Weight (lbs).....

Weight of Heavy Metal (lbs)..... 403

Metric Tons Initial Heavy Metal (metric tons).... 0.183

Enrichment Range (% U235)..... 2.19-2.62

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM)..... 30000

Linear Heat Rating (KW/foot)..... 13.4

Comments:
This assembly used in BWR/2 and BWR/3 class reactors only. The width is the outside dimension of the 0.080" fuel channel.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 8 X 8 GE-4; VERS. 1 BWR

EIA Assembly Code..... 08G41
CDB Assembly Code..... G08A
CDB Assembly Class..... GE BWR/2,3

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	63	0.0000	TOP	Inconel X-750	1.00000
T. TIE PLATE	1	2.0000	TOP	St.Steel 304	1.00000
SPACERS	7	2.2750	IN CORE	Zircaloy-4	0.85700
				Inconel X-750	0.14300
WATER ROD*	1	0.8400	IN CORE	Zircaloy-2	1.00000
B. TIE PLATE	1	4.7700	BOTTOM	St.Steel 304	1.00000
FINGER SPRINGS	4	0.0480	BOTTOM	Inconel X-750	1.00000

Drawing Numbers Associated With Assembly:

814E988
829E249
829E343
829E390

References Associated With Assembly:

GE 1974
GE 1976a
Lee 1974
Mayer 1973b
Musolf 1983

Comments:

Finger springs are not part of all fuel assemblies.

* The weight of the water rod(s) is an estimate based on the diminsions of the water rod and the density of Zircaloy-2.

The weight of the compression springs may be included in the weight of the top tie plate.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 8 X 8 GE-4; VERS. 1 BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code	08G41
CDB Assembly Code	G08A
CDB Assembly Class	GE BWR/2,3
Type of Rod	
Fuel Rod Positions per Assembly	64
Typical Number of Fueled Rods per Assembly	63
Rod Diameter (inches)	0.493
Rod Length (inches)	(159)*
Active Length (inches)	144.0
Weight per Rod (lbs)	
Clad Material	Zircaloy-2
Clad Thickness (inches)	0.034
Clad Final Conditioning	
Fuel-Clad Gap (inches)	
Fill Gas Used	He
Initial Gas Pressure (psig)	0
Nitrogen Content of Fill Gas (percent)	

Comments:

A proprietary hydrogen getter is used in the plenum region of fuel rods. Up to 4 gadolinia-poisoned fuel rods are used per assembly.

* The tip-to-tip fuel rod length is estimated from the fuel rod length for other CLASS 23 assembly types. The actual fuel rod length for other assemblies is 158.95 inches for fuel rods, 159.33 for tie rods, and 159.81 inches for the gadolinia-doped rods.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 8 X 8 GE-4; VERS. 1 BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 08G41
CDB Assembly Code..... G08A
CDB Assembly Class..... GE BWR/2,3

Fuel Pellet Material..... Uranium Oxide

Fuel Pellet Shape..... Chamfered

Fuel Pellet Diameter (inches)..... 0.416

Fuel Pellet Length (inches).....

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical)..... 95.0

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

Plenum Length (inches)..... 11.24

Plenum Volume (cubic inches).....

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 8 X 8 GE-4; VERS. 2a BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code	08G42
CDB Assembly Code	G08B
CDB Assembly Class	GE BWR/4,5,6
Initial Year of Manufacture	
Final Year of Manufacture	
Total Number Fabricated to Date	
Assembly Width (inches)	5.478
Assembly Length (inches)	175.87
with Control Rod Inserted	
including Holddown Device, etc	
Rod Pitch (inches)	0.640
Total Assembly Weight (lbs)	
Weight of Heavy Metal (lbs)	404.5
Metric Tons Initial Heavy Metal (metric tons)	0.1835
Enrichment Range (% U235)	2.5-2.74
Average Design Burnup (MWd/MTIHM)	
Maximum Design Burnup (MWd/MTIHM)	30000
Linear Heat Rating (KW/foot)	13.4

Comments:
This assembly used at BWR/4 class reactorss only. The width is the outside dimension of the 0.100" fuel channel.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 8 X 8 GE-4; VERS. 2a BWR

EIA Assembly Code..... 08G42
CDB Assembly Code..... G08B
CDB Assembly Class..... GE BWR/4,5,6

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	63	0.0000	TOP	Inconel X-750	1.00000
T. TIE PLATE	1	2.0000	TOP	St.Steel 304	1.00000
SPACERS	7	2.2750	IN CORE	Zircaloy-4	0.85700
				Inconel X-750	0.14300
WATER ROD*	1	0.8700	IN CORE	Zircaloy-2	1.00000
B. TIE PLATE	1	4.8310	BOTTOM	St.Steel 304	1.00000
FINGER SPRINGS	4	0.0480	BOTTOM	Inconel X-750	1.00000

Drawing Numbers Associated With Assembly:

814E993
829E321
829E434

References Associated With Assembly:

GE 1974

Comments:

Finger springs are not part of all fuel assemblies.

* The weight of the water rod(s) is an estimate based on the dimensions of the water rod and the density of Zircaloy-2.

The weight of the compression springs may be included in the weight of the top tie plate.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 8 X 8 GE-4; VERS. 2a BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 08G42
CDB Assembly Code..... G08B
CDB Assembly Class..... GE BWR/4,5,6

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 64

Typical Number of Fueled Rods per Assembly..... 63

Rod Diameter (inches)..... 0.493

Rod Length (inches)..... (164)*

Active Length (inches)..... 144.0

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.034

Clad Final Conditioning.....

Fuel-Clad Gap (inches).....

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 0

Nitrogen Content of Fill Gas (percent).....

Comments:

A proprietary hydrogen getter used in the plenum region of fuel rods. Up to four gadolinia-poisoned fuel rods used per assembly.

* The tip-to-tip fuel rod length is estimated from the fuel rod length for other CLASS 456 assembly types. The actual fuel rod length for other assemblies is 163.71 inches.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 8 X 8 GE-4; VERS. 2a BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 08G42
CDB Assembly Code..... G08B
CDB Assembly Class..... GE BWR/4,5,6

Fuel Pellet Material..... Uranium Oxide

Fuel Pellet Shape..... Chamfered

Fuel Pellet Diameter (inches)..... 0.416

Fuel Pellet Length (inches)..... 0.420

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical)..... 95.0

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

Plenum Length (inches)..... 16

Plenum Volume (cubic inches).....

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 8 X 8 GE-4; VERS. 2b BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code	08G43
CDB Assembly Code	G08C
CDB Assembly Class	GE BWR/4,5,6
Initial Year of Manufacture	
Final Year of Manufacture	
Total Number Fabricated to Date	
Assembly Width (inches)	5.438
Assembly Length (inches) with Control Rod Inserted including Holddown Device, etc	175.87
Rod Pitch (inches)	0.640
Total Assembly Weight (lbs)	681
Weight of Heavy Metal (lbs)	410
Metric Tons Initial Heavy Metal (metric tons)	0.186
Enrichment Range (% U235)	2.74
Average Design Burnup (MWd/MTIHM)	
Maximum Design Burnup (MWd/MTIHM)	30000
Linear Heat Rating (KW/foot)	13.4

Comments:
The weight of the fuel assembly includes the weight of the fuel channel. This assembly used at BWR/4 class reactors only. The width is the outside dimension of the 0.080" fuel channel.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 8 X 8 GE-4; VERS. 2b BWR

EIA Assembly Code..... 08G43
CDB Assembly Code..... G08C
CDB Assembly Class..... GE BWR/4,5,6

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	63	0.0000	TOP	Inconel X-750	1.00000
T. TIE PLATE	1	2.0000	TOP	St.Steel 304	1.00000
SPACERS	7	2.2750	IN CORE	Zircaloy-4	0.00000
				Inconel X-750	0.00000
WATER ROD*	1	0.8700	IN CORE	Zircaloy-2	1.00000
B. TIE PLATE	1	4.8310	BOTTOM	St.Steel 304	1.00000

Drawing Numbers Associated With Assembly:

814E964
829E131
829E293

References Associated With Assembly:

Elkins 1978
GE 1974
Jones 1975
LILCO 1976

Comments:

The weights of the SFD hardware for this assembly type are estimates based on the weights of the SFD hardware for similar assembly types.

* The weight of the water rod(s) is an estimate based on the dimensions of the water rod and the density of Zircaloy-2.

The weight of the compression springs may be included in the weight of the top tie plate.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 8 X 8 GE-4; VERS. 2b BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 08G43
CDB Assembly Code..... G08C
CDB Assembly Class..... GE BWR/4,5,6

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 64

Typical Number of Fueled Rods per Assembly..... 63

Rod Diameter (inches)..... 0.493

Rod Length (inches)..... (164)*

Active Length (inches)..... 146.0

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.034

Clad Final Conditioning.....

Fuel-Clad Gap (inches)..... 0.009

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 0

Nitrogen Content of Fill Gas (percent).....

Comments:

A proprietary hydrogen getter is used in the plenum region of fuel rods. Up to four fuel rods contain gadolinia as a neutron absorber.

* The tip-to-tip fuel rod length is estimated from the fuel rod length for other CLASS 456 assembly types. The actual fuel rod length for other assemblies is 163.71 inches.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 8 X 8 GE-4; VERS. 2b BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code	08G43
CDB Assembly Code	G08C
CDB Assembly Class	GE BWR/4,5,6
Fuel Pellet Material	Uranium Oxide
Fuel Pellet Shape	Chamfered
Fuel Pellet Diameter (inches)	0.416
Fuel Pellet Length (inches)	0.42
Fuel Pellet Weight per Rod (lbs)	
Open Porosity (percent)	
Grain Size (microns)	
Fuel Density (% theoretical)	95
O/U Ratio	
Smear Density	
Spacer Pellet Material	
Spacer Pellet Length (inches)	
Plenum Spring Material	
Plenum Spring Weight per Assembly (lbs)	
Plenum Length (inches)	14
Plenum Volume (cubic inches)	

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 8 X 8 GE-5; VERS. 1 BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code	08G51
CDB Assembly Code	G08D
CDB Assembly Class	GE BWR/2,3
Initial Year of Manufacture	
Final Year of Manufacture	
Total Number Fabricated to Date	
Assembly Width (inches)	5.438
Assembly Length (inches) with Control Rod Inserted including Holddown Device, etc	171.125
Rod Pitch (inches)	0.640
Total Assembly Weight (lbs)	
Weight of Heavy Metal (lbs)	390
Metric Tons Initial Heavy Metal (metric tons)	0.1768
Enrichment Range (% U235)	2.65-2.84
Average Design Burnup (MWd/MTIHM)	
Maximum Design Burnup (MWd/MTIHM)	30000
Linear Heat Rating (KW/foot)	13.4

Comments:
This assembly used at BWR/2 and BWR/3 class reactors only. The width is the outside diammeter of the 0.080" fuel channel. The inside diameter is given as 5.278", with 0.080" or 0.100" channels.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 8 X 8 GE-5; VERS. 1 BWR

EIA Assembly Code..... 08G51
CDB Assembly Code..... G08D
CDB Assembly Class..... GE BWR/2,3

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	62	0.0000	TOP	Inconel X-750	1.00000
T. TIE PLATE	1	2.0980	TOP	St.Steel 304	1.00000
SPACERS	7	2.3050	IN CORE	Zircaloy-4	0.00000
				Inconel X-750	0.00000
WATER ROD*	2	1.8200	IN CORE	Zircaloy-2	1.00000
B. TIE PLATE	1	4.6700	BOTTOM	St.Steel 304	1.00000

Drawing Numbers Associated With Assembly:

192B457BMG1 ?
829E517 ?
829E518 ?
829E775 ?

References Associated With Assembly:

GE 1978b
Musolf 1983

Comments:

The weights of the SFD hardware for this assembly type are estimates based on the weights of the SFD hardware for similar assembly types.

* The weight of the water rod(s) is an estimate based on the dimensions of the water rod and the density of Zircaloy-2.

The weight of the compression springs may be included in the weight of the top tie plate.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 8 X 8 GE-5; VERS. 1 BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 08G51
CDB Assembly Code..... G08D
CDB Assembly Class..... GE BWR/2,3

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 64

Typical Number of Fueled Rods per Assembly..... 62

Rod Diameter (inches)..... 0.483

Rod Length (inches)..... (159)*

Active Length (inches)..... 145.24

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.032

Clad Final Conditioning.....

Fuel-Clad Gap (inches).....

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 0

Nitrogen Content of Fill Gas (percent).....

Comments:

A proprietary hydrogen getter is used in the plenum region of fuel rods. Some fuel rods contain gadolinia as a burnable neutron absorber.

* The tip-to-tip fuel rod length is estimated from the fuel rod length for other CLASS 456 assembly types. The actual fuel rod length for other assemblies is 163.71 inches.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 8 X 8 GE-5; VERS. 1 BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 08G51
CDB Assembly Code..... G08D
CDB Assembly Class..... GE BWR/2,3

Fuel Pellet Material..... Uranium Oxide

Fuel Pellet Shape..... Chamfered

Fuel Pellet Diameter (inches)..... 0.410

Fuel Pellet Length (inches)..... 0.410

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical)..... 95.0

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

Plenum Length (inches)..... 9.48

Plenum Volume (cubic inches).....

Comments:
The top and bottom six inches of the active fuel length are fueled with natural uranium.

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 8 X 8 GE-5; VERS. 2 BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 08G52
CDB Assembly Code..... G08G
CDB Assembly Class..... GE BWR/4,5,6

Initial Year of Manufacture.....

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches)..... 5.478

Assembly Length (inches)..... 175.87
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches)..... 0.640

Total Assembly Weight (lbs).....

Weight of Heavy Metal (lbs)..... 403

Metric Tons Initial Heavy Metal (metric tons).... 0.1826

Enrichment Range (% U235)..... 2.60-2.74

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM)..... 30000

Linear Heat Rating (KW/foot)..... 13.4

Comments:
This assembly used at BWR/4, BWR/5, and BWR/6 class reactors only. The width is the outside dimension of the 0.100" fuel channel.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 8 X 8 GE-5; VERS. 2 BWR

EIA Assembly Code..... 08G52
CDB Assembly Code..... G08G
CDB Assembly Class..... GE BWR/4,5,6

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	62	0.0000	TOP	Inconel X-750	1.00000
T. TIE PLATE	1	2.0980	TOP	St.Steel 304	1.00000
SPACERS	7	2.3050	IN CORE	Zircaloy-4	0.85700
				Inconel X-750	0.14300
WATER ROD*	2	1.8800	IN CORE	Zircaloy-2	1.00000
B. TIE PLATE	1	4.6700	BOTTOM	St.Steel 304	1.00000
FINGER SPRINGS	4	0.0480	BOTTOM	Inconel X-750	1.00000

Drawing Numbers Associated With Assembly:

829E375 ?
829E433 ?
829E434 ?
829E441 ?
829E443 ?
829E473 ?
829E490 ?
829E4905 ?
829E520 ?
829E774 ?
829E776 ?
829E7770 ?
829E998 ?

References Associated With Assembly:

Elkins 1978
GE 1976a
GE 1977
GE 1986b
Rogers 1975
Whitmer 1978

Comments:

* The weight of the water rod(s) is an estimate based on the dimensions of the water rod and the density of Zircaloy-2.

The weight of the compression springs may be included in the weight of the top tie plate.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 8 X 8 GE-5; VERS. 2 BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 08G52
CDB Assembly Code..... G08G
CDB Assembly Class..... GE BWR/4,5,6

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 64

Typical Number of Fueled Rods per Assembly..... 62

Rod Diameter (inches)..... 0.483

Rod Length (inches)..... 163.71*

Active Length (inches)..... 150.0

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.032

Clad Final Conditioning.....

Fuel-Clad Gap (inches).....

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 0

Nitrogen Content of Fill Gas (percent).....

Comments:

A proprietary hydrogen getter is used in the plenum region of the fuel rods. Gadolinia is used is some fuel rods as a burnable neutron absorber.

*The tip-to-tip length of a standard fuel rod is taken from EPRI-NP-4602.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 8 X 8 GE-5; VERS. 2 BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 08G52
CDB Assembly Code..... G08G
CDB Assembly Class..... GE BWR/4,5,6

Fuel Pellet Material..... Uranium Oxide

Fuel Pellet Shape..... Chamfered

Fuel Pellet Diameter (inches)..... 0.410

Fuel Pellet Length (inches)..... 0.410

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical)..... 95.0

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

Plenum Length (inches)..... 9.48

Plenum Volume (cubic inches).....

Comments:
The top and bottom six inches of the active fuel length are fueled with natural uranium.

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 8 X 8 Pres.; VERS. 1 BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 08G61
CDB Assembly Code..... G08E
CDB Assembly Class..... GE BWR/2,3

Initial Year of Manufacture.....

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches)..... 5.438

Assembly Length (inches)..... 171.125
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches)..... 0.640

Total Assembly Weight (lbs).....

Weight of Heavy Metal (lbs)..... 388-390

Metric Tons Initial Heavy Metal (metric tons).... 0.176-0.177

Enrichment Range (% U235)..... 2.65-2.84

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM).....

Linear Heat Rating (KW/foot)..... 13.4

Comments:
This assembly used at BWR/2 and BWR/3 class reactors only. The width is the outside dimension of the 0.080" fuel channel.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 8 X 8 Pres.; VERS. 1 BWR

EIA Assembly Code..... 08G61
CDB Assembly Code..... G08E
CDB Assembly Class..... GE BWR/2,3

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	62	0.0000	TOP	Inconel X-750	1.00000
T. TIE PLATE	1	2.0980	TOP	St.Steel 304	1.00000
SPACERS	7	2.3050	IN CORE	Zircaloy-4	0.00000
				Inconel X-750	0.00000
WATER ROD*	2	1.8200	IN CORE	Zircaloy-2	1.00000
B. TIE PLATE	1	4.6700	BOTTOM	St.Steel 304	1.00000

Drawing Numbers Associated With Assembly:

192B457BMG1 ?
829E517 ?
829E518 ?
829E775 ?

References Associated With Assembly:

GE 1978b
GE 1978b
Musolf 1983

Comments:

The weights of the SFD hardware for this assembly type are estimates based on the weights of the SFD hardware for similar assembly types.

* The weight of the water rod(s) is an estimated based on the dimensions of the water rod and the density of Zircaloy-2.

The weight of the compression springs may be included in the weight of the top tie plate.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 8 X 8 Pres.; VERS. 1 BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 08G61
CDB Assembly Code..... G08E
CDB Assembly Class..... GE BWR/2,3

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 64

Typical Number of Fueled Rods per Assembly..... 62

Rod Diameter (inches)..... 0.483

Rod Length (inches)..... (159)*

Active Length (inches)..... 145.24

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.032

Clad Final Conditioning.....

Fuel-Clad Gap (inches).....

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 30

Nitrogen Content of Fill Gas (percent).....

Comments:

A proprietary hydrogen getter is used in the plenum region of fuel rods. Some fuel rods contain gadolinia as a burnable neutron absorber.

* The tip-to-tip fuel rod lenght is estimated from the fuel rod length for other CLASS 23 assembly types. The actual fuel rod length for other assemblies is 158.95 inches for fuel rods, 159.33 inches for the tie rods, and 159.81 inches for the gadolinia-doped rods.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 8 X 8 Pres.; VERS. 1 BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 08G61
CDB Assembly Code..... G08E
CDB Assembly Class..... GE BWR/2,3

Fuel Pellet Material..... Uranium Oxide

Fuel Pellet Shape..... Chamfered

Fuel Pellet Diameter (inches)..... 0.410

Fuel Pellet Length (inches)..... 0.410

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical)..... 95.0

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

Plenum Length (inches)..... 9.48

Plenum Volume (cubic inches).....

Comments:
The top and bottom six inches of the active fuel length are fueled with natural uranium.

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 8 X 8 Pres.; VERS. 2 BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 08G62
CDB Assembly Code..... G08H
CDB Assembly Class..... GE BWR/4,5,6

Initial Year of Manufacture.....

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches)..... 5.438

Assembly Length (inches)..... 175.87
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches)..... 0.640

Total Assembly Weight (lbs).....

Weight of Heavy Metal (lbs)..... 403

Metric Tons Initial Heavy Metal (metric tons).... 0.1826

Enrichment Range (% U235)..... 2.60

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM).....

Linear Heat Rating (KW/foot)..... 13.4

Comments:
This assembly use at BWR/4, BWR/5, and BWR/6 class reactors only. The width is the outside dimension of the 0.080" fuel channel.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 8 X 8 Pres.; VERS. 2 BWR

EIA Assembly Code..... 08G62
CDB Assembly Code..... G08H
CDB Assembly Class..... GE BWR/4,5,6

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	62	0.0000	TOP	Inconel X-750	1.00000
T. TIE PLATE	1	2.0980	TOP	St.Steel 304	1.00000
SPACERS	7	2.3050	IN CORE	Zircaloy-4	0.00000
				Inconel X-750	0.00000
WATER ROD*	2	1.8800	IN CORE	Zircaloy-2	1.00000
B. TIE PLATE	1	4.6700	BOTTOM	St.Steel 304	1.00000

Drawing Numbers Associated With Assembly:

829E375	?
829E433	?
829E434	?
829E441	?
829E443	?
829E473	?
829E490	?
829E4905	?
829E520	?
829E774	?
829E776	?
829E7770	?
829E998	?

References Associated With Assembly:

Elkins 1978

Comments:

The weights of the SFD hardware for this assembly type are estimates based on the weights of the SFD hardware for similar asssembly types.

* The weight of the water rod(s) is an estimate based on the dimensions of the water rod and the density of Zircaloy-2.

The weight of the compression springs may be included in the weight of the top tie plate.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 8 X 8 Pres.; VERS. 2 BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 08G62
CDB Assembly Code..... G08H
CDB Assembly Class..... GE BWR/4,5,6

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 64

Typical Number of Fueled Rods per Assembly..... 62

Rod Diameter (inches)..... 0.483

Rod Length (inches)..... (164)*

Active Length (inches)..... 150.0

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.032

Clad Final Conditioning.....

Fuel-Clad Gap (inches).....

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 30

Nitrogen Content of Fill Gas (percent).....

Comments:

A proprietary hydrogen getter is used in the plenum region of the fuel rods. Gadolinia is used in some fuel rods as a burnable neutron absorber.

* The tip-to-tip fuel rod length is estimated from the fuel rod length for other CLASS 456 assembly types. The actual fuel rod length for other assemblies is 163.71 inches.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 8 X 8 Pres.; VERS. 2 BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 08G62
CDB Assembly Code..... G08H
CDB Assembly Class..... GE BWR/4,5,6

Fuel Pellet Material..... Uranium Oxide

Fuel Pellet Shape..... Chamfered

Fuel Pellet Diameter (inches)..... 0.410

Fuel Pellet Length (inches)..... 0.410

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical)..... 95.0

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

Plenum Length (inches)..... 9.48

Plenum Volume (cubic inches).....

Comments:
The top and bottom six inches of the active fuel length are fueled with natural uranium.

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 8 X 8 Barrier; VERS. 1 BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 08G71
CDB Assembly Code..... G08F
CDB Assembly Class..... GE BWR/2,3

Initial Year of Manufacture.....

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches)..... 5.438

Assembly Length (inches)..... 171.125
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches)..... 0.640

Total Assembly Weight (lbs).....

Weight of Heavy Metal (lbs)..... 388-390

Metric Tons Initial Heavy Metal (metric tons).... 0.176-0.177

Enrichment Range (% U235)..... 2.65-2.84

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM).....

Linear Heat Rating (KW/foot).....

Comments:
This assembly used at BWR/2 and BWR/3 class reactors only. The width is the outside dimension of the 0.080" fuel channel.

Pure zirconium barrier on the interior of fuel rod cladding to reduce pellet-clad interaction.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 8 X 8 Barrier; VERS. 1 BWR

EIA Assembly Code..... 08G71
CDB Assembly Code..... G08F
CDB Assembly Class..... GE BWR/2,3

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	62	0.0000	TOP	Inconel X-750	1.00000
T. TIE PLATE	1	2.0980	TOP	St.Steel 304	1.00000
SPACERS	7	2.3050	IN CORE	Zircaloy-4	0.00000
				Inconel X-750	0.00000
WATER ROD*	2	1.8200	IN CORE	Zircaloy-2	1.00000
B. TIE PLATE	1	4.6700	BOTTOM	St.Steel 304	1.00000

Drawing Numbers Associated With Assembly:

192B457BMG1 ?
829E517 ?
829E518 ?
829E775 ?

References Associated With Assembly:

Comments:

The weights of the SFD hardware for this assembly type are estimates based on the weights of the SFD hardware for similar assembly types.

* The weight of the water rod(s) is an estimate based on the dimensions of the water rod and the density of Zircaloy-2.

The weight of the compression springs may be included in the weight of the top tie plate.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 8 X 8 Barrier; VERS. 1 BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 08G71
CDB Assembly Code..... G08F
CDB Assembly Class..... GE BWR/2,3

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 64

Typical Number of Fueled Rods per Assembly..... 62

Rod Diameter (inches)..... 0.483

Rod Length (inches)..... 158.95*

Active Length (inches)..... 145.24

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.032

Clad Final Conditioning.....

Fuel-Clad Gap (inches).....

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 30

Nitrogen Content of Fill Gas (percent).....

Comments:

A proprietary hydrogen getter is used in the plenum region of the fuel rods. Gadolinia is used in some fuel rods as a burnable neutron absorber.

* The tip-to-tip length of a standard fuel rod. Tie rods are approximately 159.33 inches long, and gadolinia-doped fuel rods are approximately 159.81 inches long.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 8 X 8 Barrier; VERS. 1 BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 08G71
CDB Assembly Code..... G08F
CDB Assembly Class..... GE BWR/2,3

Fuel Pellet Material..... Uranium Oxide

Fuel Pellet Shape..... Chamfered

Fuel Pellet Diameter (inches)..... 0.410

Fuel Pellet Length (inches)..... 0.410

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical)..... 95.0

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

Plenum Length (inches)..... 9.48

Plenum Volume (cubic inches).....

Comments:
The top and bottom six inches of the active fuel length are fueled with natural uranium.

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 8 X 8 Barrier; VERS. 2 BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 08G72
CDB Assembly Code..... G08I
CDB Assembly Class..... GE BWR/4,5,6

Initial Year of Manufacture.....

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches)..... 5.438

Assembly Length (inches)..... 175.87
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches)..... 0.640

Total Assembly Weight (lbs).....

Weight of Heavy Metal (lbs)..... 403

Metric Tons Initial Heavy Metal (metric tons).... 0.1826

Enrichment Range (% U235)..... 2.60

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM).....

Linear Heat Rating (KW/foot).....

Comments:
This assembly use at BWR/4, BWR/5, and BWR/6 class reactors only. The width is the outside dimension of the 0.080" fuel channel.

Pure zirconium barrier on the interior of fuel rod cladding to reduce pellet-clad interaction.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 8 X 8 Barrier; VERS. 2 BWR

EIA Assembly Code..... 08G72
CDB Assembly Code..... G08I
CDB Assembly Class..... GE BWR/4,5,6

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	62	0.0000	TOP	Inconel X-750	1.00000
T. TIE PLATE	1	2.0980	TOP	St.Steel 304	1.00000
SPACERS	7	2.3050	IN CORE	Zircaloy-4	0.00000
				Inconel X-750	0.00000
WATER ROD*	2	1.8800	IN CORE	Zircaloy-2	1.00000
B. TIE PLATE	1	4.6700	BOTTOM	St.Steel 304	1.00000

Drawing Numbers Associated With Assembly:

829E375	?
829E433	?
829E434	?
829E441	?
829E443	?
829E473	?
829E490	?
829E4905	?
829E520	?
829E774	?
829E776	?
829E7770	?
829E998	?

References Associated With Assembly:

Comments:

The weights of the SFD hardware for this assembly type are estimates based on the weights of the SFD hardware for similar assembly types.

* The weight of the water rod(s) is an estimate based on the dimensions of the water rod and the density of Zircaloy-2.

The weight of the compression springs may be included in the weight of the top tie plate.

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 8 X 8 Barrier; VERS. 2 BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 08G72
CDB Assembly Code..... G08I
CDB Assembly Class..... GE BWR/4,5,6

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 64

Typical Number of Fueled Rods per Assembly..... 62

Rod Diameter (inches)..... 0.483

Rod Length (inches)..... (164)*

Active Length (inches)..... 150.0

Weight per Rod (lbs).....

Clad Material..... Zircaloy-2

Clad Thickness (inches)..... 0.032

Clad Final Conditioning.....

Fuel-Clad Gap (inches).....

Fill Gas Used..... He

Initial Gas Pressure (psig)..... 30

Nitrogen Content of Fill Gas (percent).....

Comments:

A proprietary hydrogen getter is used in the plenum region of fuel rods. Gadolinia is used in some fuel rods as a burnable neutron absorber.

* The tip-to-tip fuel rod length is estimated from the fuel rod length for other CLASS 456 assembly types. The actual fuel rod length for other assemblies is 163.71 inches.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 8 X 8 Barrier; VERS. 2 BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 08G72
CDB Assembly Code..... G08I
CDB Assembly Class..... GE BWR/4,5,6

Fuel Pellet Material..... Uranium Oxide

Fuel Pellet Shape..... Chamfered

Fuel Pellet Diameter (inches)..... 0.410

Fuel Pellet Length (inches)..... 0.410

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical)..... 95.0

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

Plenum Length (inches)..... 9.48

Plenum Volume (cubic inches).....

Comments:
The top and bottom six inches of the active fuel length are fueled with natural uranium.

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 8 X 8 GE-8; VERS. 1a BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 08G81
CDB Assembly Code..... G08J
CDB Assembly Class..... GE BWR/2,3

Initial Year of Manufacture.....

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches).....

Assembly Length (inches).....
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches).....

Total Assembly Weight (lbs).....

Weight of Heavy Metal (lbs).....

Metric Tons Initial Heavy Metal (metric tons)....

Enrichment Range (% U235).....

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM).....

Linear Heat Rating (KW/foot).....

Comments:
This assembly used in BWR/2 and BWR/3 class reactors only.

No quantative data for this assembly is available.
Qualatitively, this assembly type uses new several
mechanical and nuclear features. These include:

1) increased prepressurization (to 5 ATM),
2) increased pellet diameter,
3) variable number of water rods (up to 4),
4) single diameter upper end plug shafts,
5) a streamlined upper tie plate to reduce the two-phase pressure drop,
6) higher bundle enrichments for longer operating cycles and increased discharge burnup, and
7) axially zoned gadolinia.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 8 X 8 GE-8; VERS. 1a BWR

EIA Assembly Code..... 08G81
CDB Assembly Code..... G08J
CDB Assembly Class..... GE BWR/2,3

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	62	0.0000	TOP	Inconel X-750	1.00000
T. TIE PLATF	1	2.0980	TOP	St.Steel 304	1.00000
SPACERS	7	2.3050	IN CORE	Zircaloy-4	0.00000
				Inconel X-750	0.00000
WATER ROD	4	0.0000	IN CORE	Zircaloy-2	1.00000
B. TIE PLATE	1	4.6700	BOTTOM	St.Steel 304	1.00000

Drawing Numbers Associated With Assembly:

References Associated With Assembly:

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 8 X 8 GE-8; VERS. 1a BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 08G81
CDB Assembly Code..... G08J
CDB Assembly Class..... GE BWR/2,3

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 64

Typical Number of Fueled Rods per Assembly..... 60

Rod Diameter (inches).....

Rod Length (inches)..... (159)*

Active Length (inches)..... 145.24

Weight per Rod (lbs).....

Clad Material.....

Clad Thickness (inches).....

Clad Final Conditioning.....

Fuel-Clad Gap (inches).....

Fill Gas Used.....

Initial Gas Pressure (psig).....

Nitrogen Content of Fill Gas (percent).....

Comments:

* The tip-to-tip fuel rod length is estimated from the fuel rod length for other CLASS 23 assembly types. The actual fuel rod length for other assemblies is 158.95 inches for fuel rods, 159.33 inches for tie rods, and 159.81 inches for the gadolinia doped rods.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 8 X 8 GE-8; VERS. 1a BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 08G81
CDB Assembly Code..... G08J
CDB Assembly Class..... GE BWR/2,3

Fuel Pellet Material.....

Fuel Pellet Shape.....

Fuel Pellet Diameter (inches).....

Fuel Pellet Length (inches).....

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical).....

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

Plenum Length (inches).....

Plenum Volume (cubic inches).....

Comments:
The top and bottom six inches of the active fuel length are fueled with natural uranium.

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 8 X 8 GE-8; VERS. 1b BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 08G81
CDB Assembly Code..... G08N
CDB Assembly Class..... GE BWR/2,3

Initial Year of Manufacture.....

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches).....

Assembly Length (inches).....
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches).....

Total Assembly Weight (lbs).....

Weight of Heavy Metal (lbs).....

Metric Tons Initial Heavy Metal (metric tons)....

Enrichment Range (% U235).....

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM).....

Linear Heat Rating (KW/foot).....

Comments:
This assembly used in BWR/2 and BWR/3 class reactors only.

No quantative data for this assembly is available. Qualatitively, this assembly type uses new several mechanical and nuclear features. These include:

1) increased prepressurization (to 5 ATM),
2) increased pellet diameter,
3) variable number of water rods (up to 4),
4) single diameter upper end plug shafts,
5) a streamlined upper tie plate to reduce the two-phase pressure drop,
6) higher bundle enrichments for longer operating cycles and increased discharge burnup, and
7) axially zoned gadolinia.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 8 X 8 GE-8; VERS. 1b BWR

EIA Assembly Code..... 08G81
CDB Assembly Code..... G08N
CDB Assembly Class..... GE BWR/2,3

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction

Drawing Numbers Associated With Assembly:

References Associated With Assembly:

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 8 X 8 GE-8; VERS. 1b BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 08G81
CDB Assembly Code..... G08N
CDB Assembly Class..... GE BWR/2,3

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 64

Typical Number of Fueled Rods per Assembly..... 60

Rod Diameter (inches).....

Rod Length (inches)..... (159)*

Active Length (inches)..... 142.24

Weight per Rod (lbs).....

Clad Material.....

Clad Thickness (inches).....

Clad Final Conditioning.....

Fuel-Clad Gap (inches).....

Fill Gas Used.....

Initial Gas Pressure (psig).....

Nitrogen Content of Fill Gas (percent).....

Comments:

* The tip-to-tip fuel rod length is estimated from the fuel rod length for other CLASS 23 assembly types. The actual fuel rod length for other assemblies is 158.95 inches for fuel rods, 159.33 inches for tie rods, and 159.81 inches for the gadolinia doped rods.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 8 X 8 GE-8; VERS. 1b BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 08G81
CDB Assembly Code..... G08N
CDB Assembly Class..... GE BWR/2,3

Fuel Pellet Material.....

Fuel Pellet Shape.....

Fuel Pellet Diameter (inches).....

Fuel Pellet Length (inches).....

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical).....

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

Plenum Length (inches).....

Plenum Volume (cubic inches).....

Comments:
The top and bottom six inches of the active fuel length are fueled with natural uranium.

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 8 X 8 GE-8; VERS. 2a BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 08G82
CDB Assembly Code..... G08K
CDB Assembly Class..... GE BWR/4,5,6

Initial Year of Manufacture.....

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches).....

Assembly Length (inches).....
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches).....

Total Assembly Weight (lbs).....

Weight of Heavy Metal (lbs).....

Metric Tons Initial Heavy Metal (metric tons)....

Enrichment Range (% U235).....

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM).....

Linear Heat Rating (KW/foot).....

Comments:
This assembly used in BWR/4, BWR/5, and BWR/6 class reactors only.

No quantative data for this assembly is available. Qualatitively, this assembly type uses new several mechanical and nuclear features. These include:

1) increased prepressurization (to 5 ATM),
2) increased pellet diameter,
3) variable number of water rods (up to 4),
4) single diameter upper end plug shafts,
5) a streamlined upper tie plate to reduce the two-phase pressure drop,
6) higher bundle enrichments for longer operating cycles and increased discharge burnup, and
7) axially zoned gadolinia.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 8 X 8 GE-8; VERS. 2a BWR

EIA Assembly Code..... 08G82
CDB Assembly Code..... G08K
CDB Assembly Class..... GE BWR/4,5,6

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction
COMP. SPRINGS	62	0.0000	TOP	Inconel X-750	1.00000
T. TIE PLATE	1	2.0980	TOP	St.Steel 304	1.00000
SPACERS	7	2.3050	IN CORE	Zircaloy-4	0.00000
				Inconel X-750	0.00000
WATER ROD	4	0.0000	IN CORE	Zircaloy-2	1.00000
B. TIE PLATE	1	4.6700	BOTTOM	St.Steel 304	1.00000

Drawing Numbers Associated With Assembly:

References Associated With Assembly:

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 8 X 8 GE-8; VERS. 2a BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 08G82
CDB Assembly Code..... G08K
CDB Assembly Class..... GE BWR/4,5,6

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 64

Typical Number of Fueled Rods per Assembly..... 60

Rod Diameter (inches).....

Rod Length (inches)..... (164)*

Active Length (inches)..... 150.0

Weight per Rod (lbs).....

Clad Material.....

Clad Thickness (inches).....

Clad Final Conditioning.....

Fuel-Clad Gap (inches).....

Fill Gas Used.....

Initial Gas Pressure (psig).....

Nitrogen Content of Fill Gas (percent).....

Comments:

* The tip-to-tip fuel rod length is estimated from the fuel rod length for other CLASS 23 assembly types. The actual fuel rod length for other assemblies is 158.95 inches for fuel rods, 159.33 inches for tie rods, and 159.81 inches for the gadolinia doped rods.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 8 X 8 GE-8; VERS. 2a BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 08G82
CDB Assembly Code..... G08K
CDB Assembly Class..... GE BWR/4,5,6

Fuel Pellet Material.....

Fuel Pellet Shape.....

Fuel Pellet Diameter (inches).....

Fuel Pellet Length (inches).....

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical).....

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

Plenum Length (inches).....

Plenum Volume (cubic inches).....

Comments:
The top and bottom six inches of the active fuel length are fueled with natural uranium.

PHYSICAL DESCRIPTION REPORT PAGE: 1

General Electric 8 X 8 GE-8; VERS. 2b BWR

OVERALL ASSEMBLY CHARACTERISTICS

EIA Assembly Code..... 08G82
CDB Assembly Code..... G080
CDB Assembly Class..... GE BWR/4,5,6

Initial Year of Manufacture.....

Final Year of Manufacture.....

Total Number Fabricated to Date.....

Assembly Width (inches).....

Assembly Length (inches).....
with Control Rod Inserted.....
including Holddown Device, etc.....

Rod Pitch (inches).....

Total Assembly Weight (lbs).....

Weight of Heavy Metal (lbs).....

Metric Tons Initial Heavy Metal (metric tons)....

Enrichment Range (% U235).....

Average Design Burnup (MWd/MTIHM).....

Maximum Design Burnup (MWd/MTIHM).....

Linear Heat Rating (KW/foot).....

Comments:
This assembly used in BWR/4, BWR/5, and BWR/6 class reactors only.

No quantative data for this assembly is available. Qualatitively, this assembly type uses new several mechanical and nuclear features. These include:

1) increased prepressurization (to 5 ATM),
2) increased pellet diameter,
3) variable number of water rods (up to 4),
4) single diameter upper end plug shafts,
5) a streamlined upper tie plate to reduce the two-phase pressure drop,
6) higher bundle enrichments for longer operating cycles and increased discharge burnup, and
7) axially zoned gadolinia.

PHYSICAL DESCRIPTION REPORT PAGE: 2

General Electric 8 X 8 GE-8; VERS. 2b BWR

EIA Assembly Code..... 08G82
CDB Assembly Code..... G080
CDB Assembly Class..... GE BWR/4,5,6

FUEL ASSEMBLY HARDWARE PARTS AND MATERIALS

Part Name	Parts/ Assembly	Weight(kg)/ Assembly	Zone	Material Name	Material Fraction

Drawing Numbers Associated With Assembly:

References Associated With Assembly:

Comments:

PHYSICAL DESCRIPTION REPORT PAGE: 3

General Electric 8 X 8 GE-8; VERS. 2b BWR

FUEL ROD DESCRIPTION TABLE

EIA Assembly Code..... 08G82
CDB Assembly Code..... G080
CDB Assembly Class..... GE BWR/4,5,6

Type of Rod..... Fuel Rod

Fuel Rod Positions per Assembly..... 64

Typical Number of Fueled Rods per Assembly..... 60

Rod Diameter (inches).....

Rod Length (inches)..... (164)*

Active Length (inches)..... 147.0

Weight per Rod (lbs).....

Clad Material.....

Clad Thickness (inches).....

Clad Final Conditioning.....

Fuel-Clad Gap (inches).....

Fill Gas Used.....

Initial Gas Pressure (psig).....

Nitrogen Content of Fill Gas (percent).....

Comments:

* The tip-to-tip fuel rod length is estimated from the fuel rod length for other CLASS 23 assembly types. The actual fuel rod length for other assemblies is 158.95 inches for fuel rods, 159.33 inches for tie rods, and 159.81 inches for the gadolinia doped rods.

PHYSICAL DESCRIPTION REPORT PAGE: 4

General Electric 8 X 8 GE-8; VERS. 2b BWR

FUEL ROD DESCRIPTION TABLE continued

EIA Assembly Code..... 08G82
CDB Assembly Code..... G080
CDB Assembly Class..... GE BWR/4,5,6

Fuel Pellet Material.....

Fuel Pellet Shape.....

Fuel Pellet Diameter (inches).....

Fuel Pellet Length (inches).....

Fuel Pellet Weight per Rod (lbs).....

Open Porosity (percent).....

Grain Size (microns).....

Fuel Density (% theoretical).....

O/U Ratio.....

Smear Density .....

Spacer Pellet Material.....

Spacer Pellet Length (inches).....

Plenum Spring Material.....

Plenum Spring Weight per Assembly (lbs).....

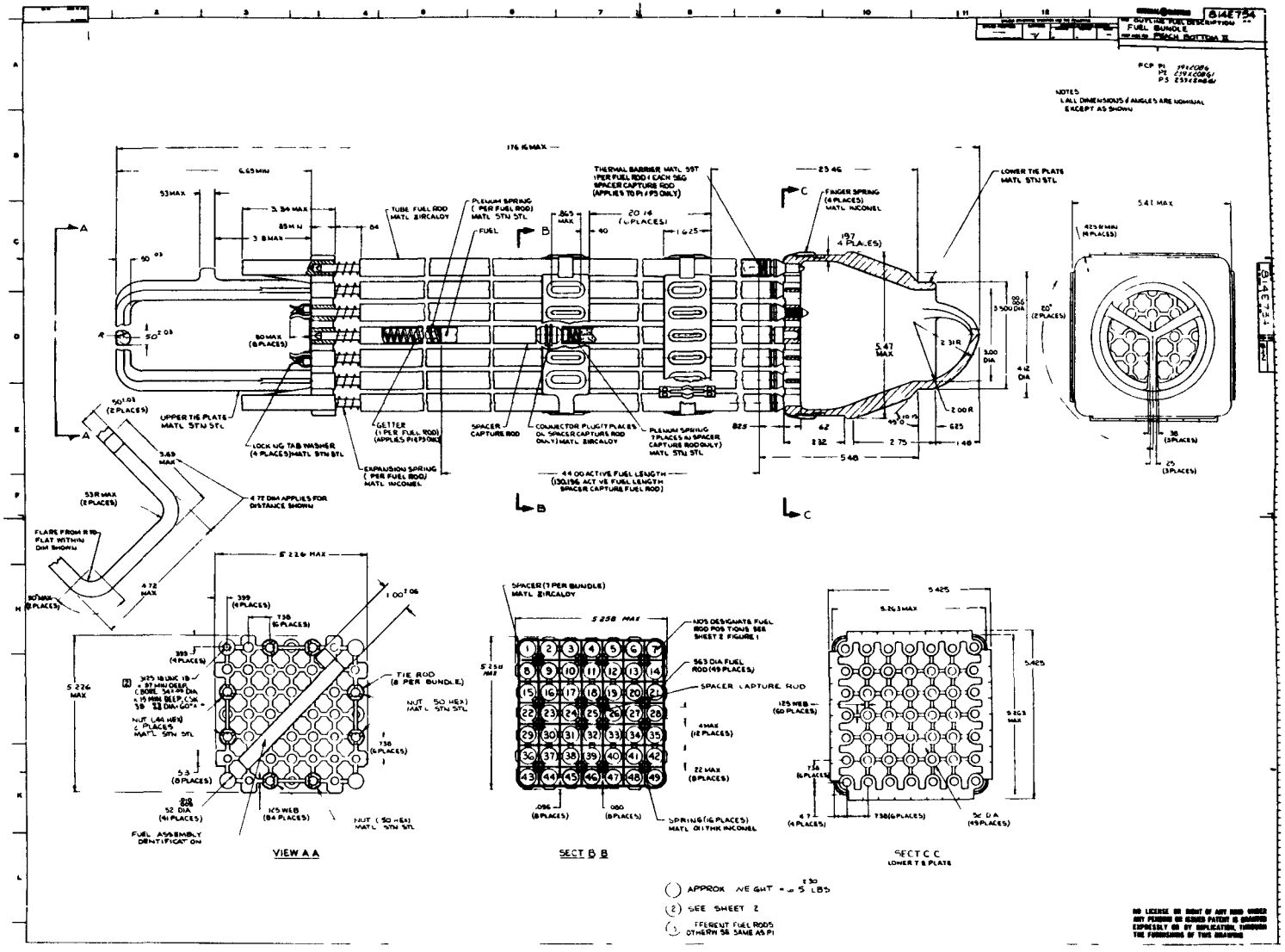
Plenum Length (inches).....

Plenum Volume (cubic inches).....

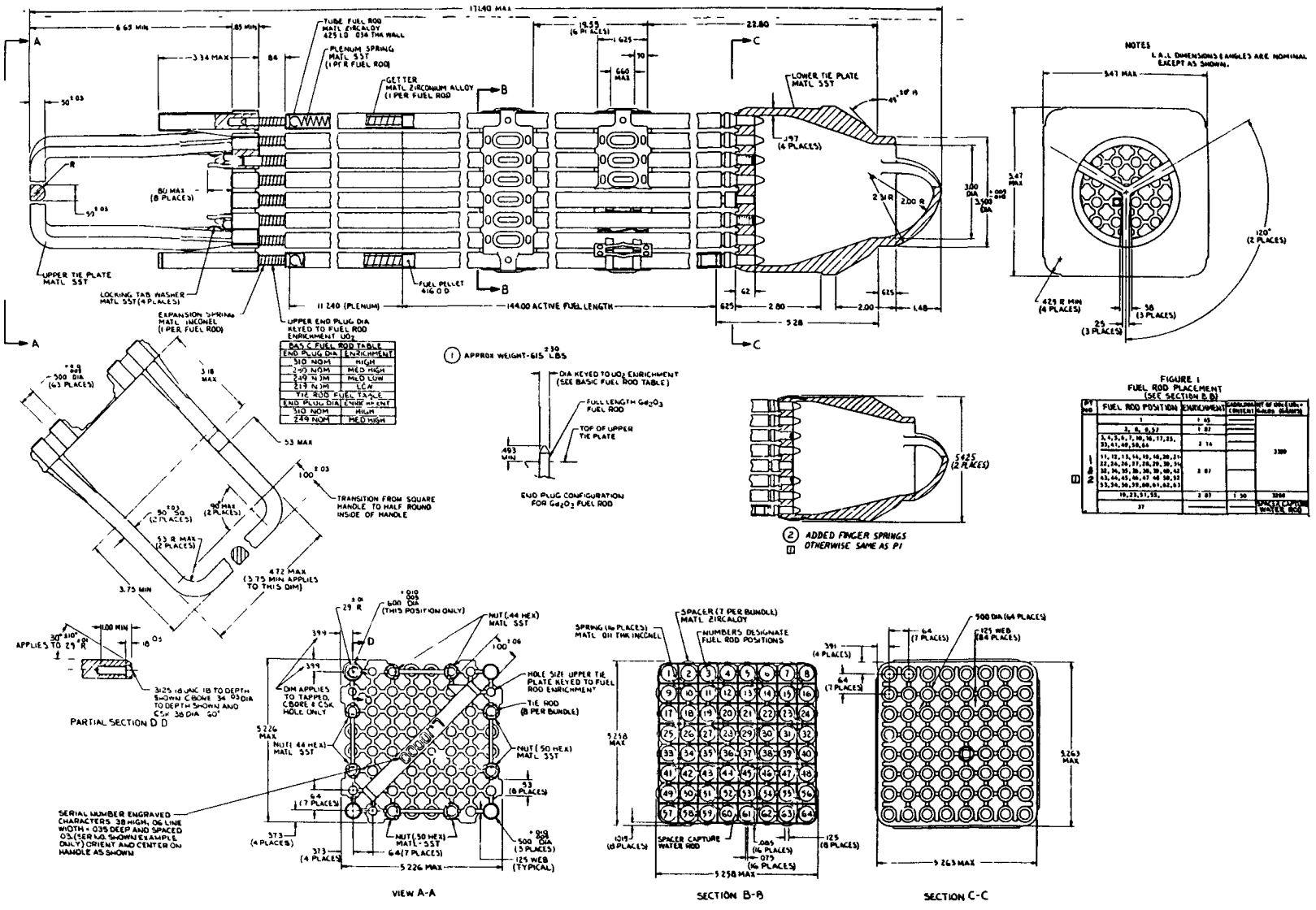
Comments:
The top and bottom six inches of the active fuel length are fueled with natural uranium.

APPENDIX B

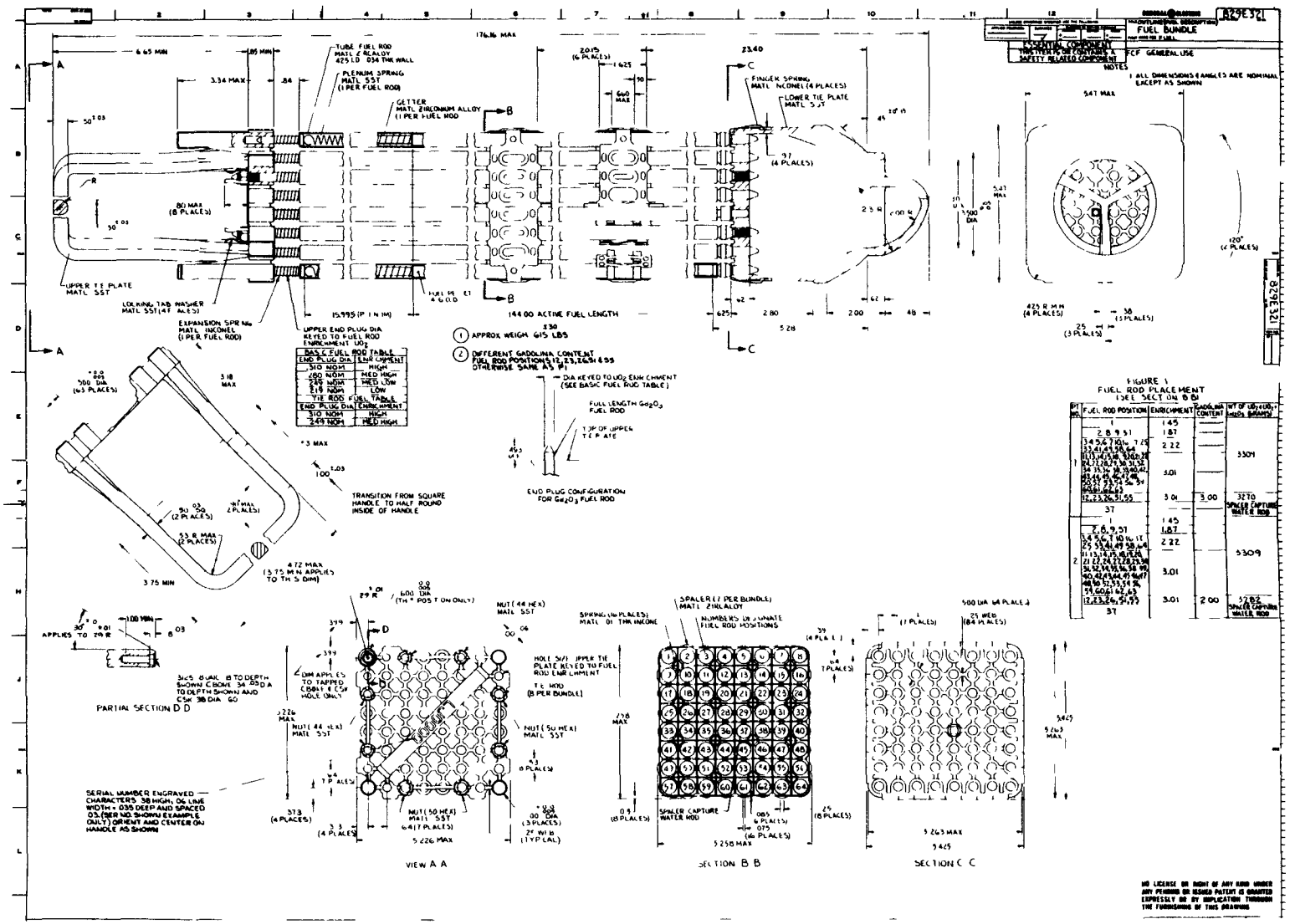
FUEL ASSEMBLY DRAWINGS



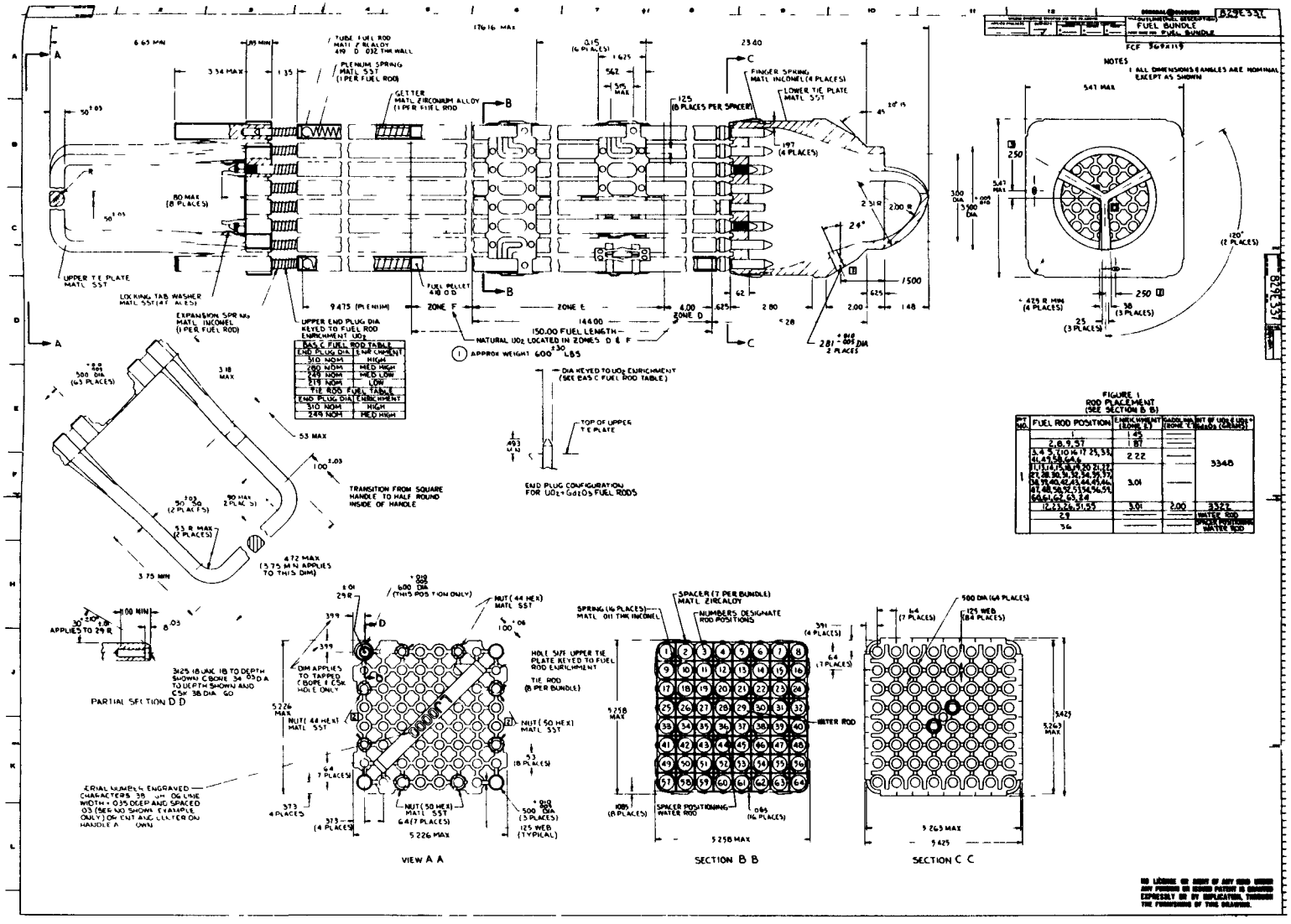
GE 7x7 GE-3, V2a fuel assembly (Source: GE 1979)



GE 8x8 GE-4, V1 fuel assembly (Source: GE 1983b)



GE 8x8 GE-4, V2a fuel assembly (Source: GE 1978a)



GE 8x8 GE-5, V2 fuel assembly (Source: GE 1978a)

APPENDIX C

FUEL ASSEMBLY DATA SHEETS REFERENCES

REFERENCES

Bauer 1973 — Bauer, E. G. Philadelphia Electric Company, letter to J. F. O'Leary, U.S. Nuclear Regulatory Commission, DOCKET 50-277-128, Oct. 1, 1973.

Bliss 1970 — Bliss, H. E., Commonwealth Edison Company, letter to P. A. Morris, U.S. Atomic Energy Commission, DOCKET 50-010-064, Feb. 2, 1970.

Bolger 1977 — Bolger, R. L., Commonwealth Edison Company, letter to B. C. Rusche, U.S. Nuclear Regulatory Commission, DOCKET 50-010-721, Apr. 11, 1977.

Bower 1966 — Bower, D. R., Commonwealth Edison Company, letter to P. A. Morris, U.S. Atomic Energy Commission, DOCKET 50-010-038, Oct. 6, 1966.

Brosnan 1971 — Brosnan, T. J., Niagara Mohawk Power Corporation, letter to P. A. Morris, U.S. Atomic Energy Commission, DOCKET 50-220-066, July 27, 1971.

CP&L 1972 — Carolina Power & Light Company, Final Safety Analysis Report, Brunswick Steam Electric Plant Units 1 & 2, DOCKET 50-324-046, April 1972.

Commonwealth Edison 1957 — Commonwealth Edison Company and General Electric Company, Preliminary Hazards Summary Report for the Dresden Nuclear Power Station, GEAP-1044, General Electric Company, San Jose, Calif., September 1957.

Crane 1976a — Crane, P. A,. Jr., Pacific Gas and Electric Company, letter to R. W. Reid, U.S. Nuclear Regulatory Commission, DOCKET 50-133-362, Apr. 15, 1976.

Crane 1976b — Crane, P. A., Jr., Pacific Gas and Electric Company, letter to R. W. Reid, U.S. Nuclear Regulatory Commission, DOCKET 50-133-414, Aug. 11, 1976.

Elkins 1977 — Elkins, R. B., Experience with BWR Fuel Through December 1976, NEDO-21660, General Electric Company, San Jose, Calif., July 1977.

Elkins 1978 — Elkins, R. B., Fuel Rod Prepressurization, NEDO-23786, General Electric Company, San Jose, Calif., March 1978.

GE 1961 — General Electric Company, Technical Information for Amendment to License for Dresden (First Reload Fuel), GEAP-3586, General Electric Company, San Jose, Calif., January 1, 1961 (DOCKET 50-010-088).

GE 1973 — General Electric Company, General Design Information for General Electric Boiling Water Reactor Reload Fuel Commencing in Spring, 1974, NEDO-20103, General Electric Company, San Jose, Calif., September 1973.

GE 1974 — General Electric Company, General Electric Boiling Water Reactor Generic Reload Application for 8X8 Fuel, NEDO-20360, General Electric Company, San Jose, Calif., December 1974.

GE 1976a — General Electric Company, Lead Test Assembly Supplemental Information for Reload 1 Licensing Submittal for Peach Bottom Atomic Power Station Unit 2, NEDO-21172, General Electric Company, San Jose, Calif., February 1976. (DOCKET 50-277-617).

GE 1976b — General Electric Company, BWR/4 and BWR/5 Fuel Design, NEDO-20944, General Electric Company, San Jose, Calif., October 1976.

GE 1976c — General Electric Company, Core Design and Operating Data for Cycles 1 and 2 of Quad Cities 1, EPRI-NP-240, Electric Power Research Institute, Palo Alto, Calif., November 1976.

GE 1977 — General Electric Company, General Electric Boiling Water Reactor Reload-2 Licensing Application for Edwin I. Hatch Nuclear Plant Unit 1, NEDO-24040, General Electric Company, San Jose, Calif., July 1977.

GE 1978a — General Electric Company, Core Design and Operating Data for Cycles 1 and 2 of Peach Bottom 2, EPRI-NP--563, Electric Power Research Institute, Palo Alto, Calif., June 1978.

GE 1978b — General Electric Company, Quad Cities Nuclear Power Station Unit 1 Reload 4 Supplemental Licensing Information for Barrier Lead Test Assemblies, NEDO-24147, General Electric Company, San Jose, Calif., September 1978.

GE 1979 — General Electric Company, Core Design and Operating Data for Cycle 1 of Hatch 1, EPRI-NP--562, Electric Power Research Institute, Palo Alto, Calif., January 1979.

GE 1981 — General Electric Company, Demonstration of Fuel Resistant to Pellet-Cladding Interaction Phase 2 -- Fourth Semiannual Report, July - December 1980, GEAP-25163-4, General Electric Company, San Jose, Calif., March 1981.

GE 1983a — General Electric Company, Core Design and Operating Data for Quad Cities 1 Cycle 3 of Peach Bottom 2, EPRI-NP-971, Electric Power Research Institute, Palo Alto, Calif., March 1983.

GE 1983b — General Electric Company, Core Design and Operating Data for Quad Cities 1 Cycle 3, EPRI-NP-552, Electric Power Research Institute, Palo Alto, Calif., March 1983.

GE 1984 — General Electric Company, Core Design and Operating Data for Cycles 2 and 3 of Hatch 1, EPRI-NP-2106, Electric Power Research Institute, Palo Alto, Calif., February 1984.

GE 1986a — General Electric Company, General Electric Standard Application for Reactor Fuel, NEDO-24011-A-8, General Electric Company, San Jose, Calif., May 1986.

GE 1986b — General Electric Company, BWR Fuel Rod Performance Evaluation Program, EPRI-NP-4602, Electric Power Research Institute, Palo Alto, Calif., May 1986.

Jones 1975 — Jones, J. A., Carolina Power & Light Company, letter to B. C. Rusche, U.S. Nuclear Regulatory Commission, DOCKET 50-324-461, Nov. 26, 1975.

Lee 1974 — Lee, B. Jr., Commonwealth Edison Company, letter to J. F. O'Leary, U.S. Atomic Energy Commission, DOCKET 50-254-318, Feb. 28, 1974.

LILCO 1976 — Long Island Lighting Company, Final Safety Analysis Report, Shoreham Nuclear Power Station Unit 1, DOCKET 50-322-110, 1976.

Mayer 1973a — Mayer, L. O., Northern States Power Company, letter to A. Giambusso, U.S. Atomic Energy Commission, DOCKET 50-263-187, Feb. 20, 1973.

Mayer 1973b — Mayer, L. O., Northern States Power Company, letter to J. F. O'Leary, U.S. Atomic Energy Commission, DOCKET 50-263-281, Nov. 19, 1973.

Mills 1981a — Mills, L. M., Tennessee Valley Authority, letter to H. R. Denton, U.S. Nuclear Regulatory Commission, DOCKET 50-296, Nov. 4, 1981, No. 8111100658.

Mills 1981b — Mills, L. M., Tennessee Valley Authority, letter to H. R. Denton, U.S. Nuclear Regulatory Commission, DOCKET 50-296, Dec. 8, 1981, No. 8112230431.

Musolf 1983 — Musolf, D., Northern States Power Company, letter to Director, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, DOCKET 50-263, Apr. 29, 1983, No. 8305030603.

PG&E 1961 — Pacific Gas and Electric Company, Final Hazards Summary Report Humboldt Bay Power Plant Unit No. 3, DOCKET 50-133-001, Sep. 1, 1961.

PG&E 1968 — Pacific Gas and Electric Company, Humboldt Bay Power Plant Unit No. 3 Technical Specifications, DOCKET 50-133-008, June 8, 1968.

Peterson 1969 — Peterson, R. H., Pacific Gas and Electric Company, letter to Director, Division of Reactor Licensing, U.S. Atomic Energy Commission, DOCKET 50-133-012, Mar. 24, 1969

Peterson 1970 — Peterson, R. H., Pacific Gas and Electric Company, letter to Director, Division of Reactor Licensing, U.S. Atomic Energy Commission, DOCKET 50-133-028, Mar. 13, 1970.

Phil. Elec. 1970 — Philadelphia Electric Company, Final Safety Analysis Report, Peach Bottom Atomic Power Station Units No. 2 & 3, Vol. 2, DOCKET 50-277-12, Aug. 31, 1970.

PSE&G 1970 — Public Service Electric and Gas Company, Newbold Island Nuclear Generating Station, Preliminary Safety Analysis Report, DOCKET 50-354-002, February 1970.

Raymond 1973 — Raymond, P. D., Niagara Mohawk Power Corporation, letter to A. Giambusso, U.S. Atomic Energy Commission, DOCKET 50-220-170, Sept. 14, 1973.

Reder 1971 — Reder, R. E., Nebraska Public Power District, letter to P. A. Morris, U.S. Atomic Energy Commission, DOCKET 50-298-013, Feb. 26, 1971.

Rogers 1975 — Rogers, B. N., et al., BWR/6 Fuel Design, NEDO-20948, General Electric Company, San Jose, Calif., December 1975.

Rowland 1985 — Rowland, T. C., et al., Large-Scale Demonstration of Barrier Fuel in the Quad Cities Unit 2 Nuclear Power Station, NEDO-30967, General Electric Company, San Jose, Calif., April 1985.

Stoller 1984 — S. M. Stoller Corporation, Comparison of Advanced BWR Fuel Designs with Current Standard Designs, EPRI-NP-3490, Electric Power Research Institute, Palo Alto, Ca, May 1984.

Sewell 1972 — Sewell, R. B., Consumers Power Company, letter to J. F. O'Leary, U.S. Atomic Energy Commission, DOCKET 50-155-120, July 24, 1972.

Skovholt 1971 — Skovholt, D. J., U.S. Atomic Energy Commission, letter to R. B. Sewell, Consumers Power Company, DOCKET 50-155-095, Dec. 9, 1971.

Thompson 1981 — Thompson, J. R., Barrier-Fuel Lead Test Assemblies: Pre-irradiation Characterization and First-Cycle Post-Irradiation Examination, GEAP-25447-1, General Electric Company, San Jose, Calif., November 1981.

Walke 1970a — Walke, G. J., Consumer Power Company, letter to P. A. Morris, U. S. Atomic Energy Commission, DOCKET 50-155-054, Dec. 15, 1970.

Walke 1970b — Walke, G. J., Consumers Power Company, letter to P. A. Morris, U.S. Atomic Energy Commission, DOCKET 50-155-55, Dec. 17, 1970.

Whitmer 1978 — Whitmer, C. F. Georgia Power Company, letter to Director of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, DOCKET 50-321-1069, Feb. 22, 1978.

ORNL/TM-10902
Dist. Category
UC-85

DISTRIBUTION

1-8. DOE - Office of Civilian Radioactive Waste Management, Washington, D. C. 20585

A. B. Brownstein
W. J. Danker
H. J. Hale
N. Moon
M. L. Payton
W. Stringfield
E. Svenson
J. Williams

9-12. DOE - Energy Information Administration, Washington, D. C. 20585

J. A. Disbrow
K. Gibbard
B. K. O'Brien
D. Troop

13-14. DOE - Albuquerque Operations Office, P.O. Box 5400, Albuquerque, NM 87115

K. Golliher
D. M. Lund

15-19. DOE - Idaho Operations Office, 785 DOE Place, Idaho Falls, ID 83402

M. Fisher
S. T. Hinschberger
J. L. Lyle
T. Rowland
M. W. Shupe

20-26. DOE - Nevada Operations Office, P.O. Box 14100, Las Vegas, NV 89114

C. Gertz
M. Kunich
J. Robson
E. Rodriquez
L. Skousen
E. L. Wilmot
T. Zvada

27-28. DOE - Oak Ridge Operations Office, P.O. Box E, Oak Ridge, TN 37831

Office of Assistant Manager for Energy Research
M. Heiskell

29-30. DOE - Richland Operations Office, P.O. Box 550, Richland, WA 99352

D. Kenyon
D. C. Langstaff

31-34. U. S. Nuclear Regulatory Commission, Division of Waste Management, Washington, D. C. 20555

R. M. Bernero, Division of Risk Analysis
J. T. Buckley, Division of Waste Management
M. R. Knapp, Division of Waste Management
F. C. Sturtz, Office of Nuclear Material Safety and Safeguards

35-37. Argonne National Laboratory, 9700 S. Cass Ave., Argonne, IL 60439

S. Y. Chen
M. J. Steindler
Y. C. Yuan

38-40. Lawrence Livermore National Laboratory, P.O. Box 808, Livermore, CA 94550

L. Ballou
W. R. Lloyd
H. Shaw

41-42. Los Alamos National Laboratory, P.O. Box 1663, Los Alamos, NM 87545

D. T. Oakley
J. L. Warren

43-70. Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN 37831

J. M. Begovich
A. G. Croff
R. K. Genung
R. M. Gove
D. S. Joy
W. C. McClain
K. J. Notz (10 copies)
Central Research Library
Laboratory Records Department
Laboratory Records, ORNL RC
ORNL Y-12 Technical Library, Doc. Ref. Sect.
ORNL Patent Section
W. J. Reich
R. Salmon
F. M. Scheitlin
S. N. Storch
M.G. Stewart
T. D. Welch
A. Zucker

71-76. Pacific Northwest Laboratory, P.O. Box 999, Richland, WA 99352

G. H. Beeman
B. M. Cole
A. T. Luksic
R. W. McKee
R. W. Walling
T. Wood

77-81. Sandia National Laboratory, P.O. Box 5800, Alburquerque, NM 87185

G. Allen
A. W. Dennis
E. Hertel
T. Hunter
J. Stiegler

82. Advanced Nuclear Fuels Corporation, P.O. Box 90777, Bellevue, WA 98009

M. Ungar

83-85. Advanced Nuclear Fuels Corporation, 2101 Horn Rapids Road, Richland, WA 99352

D. Adams
G. L. Ritter
M. K. Valentine

86-106. ASG, Inc., 800 Oak Ridge Turnpike, Oak Ridge, TN 37830

R. S. Moore (20 copies)
E. A. Lewis

107-110. Babcock & Wilcox, P.O. Box 10935, Lynchburg, VA 24506

P. Childress
L. Hassler
J. Matheson
L. Walton

111-113. Battelle - Columbus Laboratories, 505 King Ave., Columbus, OH 43201

R. J. Burian
W. Pardue
J. Taylor

114. Bechtel National, Inc. P.O. Box 3965, San Francisco, CA 94119

L. Jardine

115. Bechtel National, Inc., P.O. Box 350, Oak Ridge, TN 37830

P. Bradbury

116. Brown Boveri Nuclear Services, Inc., 9190 Red Branch Road, Columbia, MD 21045

B. Snyder

117-118. Combustion Engineering, 1000 Prospect Hill Road, Windsor, CT 06095

W. Burns
D. Hayduk

119-122. Commonwealth Edison, 72 West Adams St., Chicago, IL 60690

H. E. Bliss
J. M. Dolter
K. Peterson
B. F. Momsen

123. DataPhile, Inc., 9121 Garrison Rd., Knoxville, TN 379

K. E. Jones

124. David Andress Associates, Inc., 11008 Harriett Lane, Kensington, MD 20895

D. Andress

125. Edison Electric Institute, 1111 19th Street NW, Washington, D.C. 20036

S. Kraft, UNWMG

126-132. EG&G Idaho, Inc., P.O. Box 1625, Idaho Falls, ID 83415

L. W. Ball
W. A. Franz
I.K. Hall
M. A. Knecht
R. Piscitella
K. L. Williams
H. Worle

133-134. EPRI - Electronic Power Research Institute, P.O. Box 10412, Palo Alto, CA 94303

R. W. Lambert
O. Ozer

135-137. E. R. Johnson Associates, Inc. 10461 White Granite Dr., Suite 204, Oakton, VA 22124

B. M. Cole
E. R. Johnson
N. B. McLeod

138-139. Fluor Technologies, Inc., 3333 Nicholsen Drive, Irvine, CA 92730

J. K. Clark
V. Pierce

140-141. General Atomics, P.O. Box 85608, San Diego, CA 92138

R. M. Burgoyne S. D. Su

142-144. General Electric Nuclear Energy, 175 Curtner Ave., San Jose, CA 95125

J. S. Charnley R. E. Spicka
G. Plotycia

145. Golder Associates, 4104 148th Avenue, NW, Redmond, WA 98052

I. Miller

146. H & R Technical Associates, 575 Oak Ridge Turnpike, Oak Ridge, TN 37830

W. R. Rhyne

147. Northeast Technologies Corp., UPO Box 4178, Kingston, NY 12477

K. Lindquist

148-149. Northern States Power Co., 414 Nicollet Mall 104, Minneapolis, MN 55401

J. Kapitz L. McCarten

150-151. Nuclear Assurance Corp., 6251 Cooked Creek Road, Norcross, GA 30092

J. Houston N. Mote

152. Nuclear Packaging, Inc., 1010 South 336th Federal Way, WA 98003

J. R. Schornhorst

153. NUS Corporation, 910 Clopper Road, Gaithersberg, MD 20878

C. Heath

154. PAI Corporation, P.O. Box 1135, Oak Ridge, TN 37830

D. L. Phung

155. Energy Resources International Inc., Suite 500, 1015 18th Street, NW, Washington, DC 20036

M. H. Schwartz

156. Rochester Gas & Electric Corp., 89 East Ave., Rochester, NY 14649

A. A. Fuierer

157. Science Applications International Corp., 3015 Hopyard Road, Suite M, Pleasanton, CA 94556

C. Smith

158-159. Science Applications International Corp., 800 Oak Ridge Turnpike, Oak Ridge, TN 37830

R. Best R. W. Peterson

160. Science Applications International Corp., 20030 Century Blvd., Suite 201, Germantown, MD 20874

R. E. Yoder

161-162. Science Applications Int. Corp., 101 Convention Center Drive, Las Vegas, NV 89109

R. Morrisette J. Waddell

163. Transnuclear, Inc., Two Skyline Drive, Hawthorne, NY 10532-2120

W. R. Teer

164. University of Florida, Department of Nuclear Engineering Sciences, Gainesville, FL 32611

D. A. Williamson

165. Virginia Power, 5000 Dominion Blvd., Glen Allen, VA 23060

M. L. Smith

166-167. Westinghouse Hanford Operations, P. O. Box 800, Richland, WA 99352

R. A. Watrous D. D. Wodrich

168-169. Westinghouse Electric Corp., Nuclear Waste Department, P.O. Box 3912, Pittsburgh, PA 15230

B. R. Nair
A. L. Shah

170-172. R. F. Weston, 955 L'Enfant Plaza, SW, Eighth Floor, Washington, D. C. 20024

M. Conroy
J. Lilly
J. DiNunno

173. R. F. Weston, 1 Weston Way, West Chester, PA 19380

R. R. MacDonald

174-251. Given distribution as shown in document DOE/TIC-4500 (Rev. 74) under these categories:

UC-812 Spent Fuel Storage (RW) (78 copies)

☆U S GOVERNMENT PRINTING OFFICE 1989-648-119/ 00034