PHYSICAL CHARACTERISTICS OF NON-FUEL
ASSEMBLY REACTOR COMPONENTS

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ABSTRACT

The primary objective of this report is to enhance the utility of the Characteristics Data Base (CDB), detailed in DOE report DOE/RW-0184-R1, Volume 1. This has been accomplished by providing a pictorial representation of the principal non-fuel assembly (NFA) components along with a tabular summary of key information about each type of component.

SCOPE

This report is intended for use as an adjunct to the CDB. Toward this end, the report may be used either as a complement to the detailed descriptions in the CDB, or as a stand-alone document that acts as an illustrated abstract of the CDB. Line drawings of major NFA components are included. Data not provided in the CDB are also included. Summary descriptions of each component are given in tabular format.

One complication arises from the manufacture of NFA components by vendors other than the original supplier of the Nuclear Steam Supply System (NSSS). Fuel vendors compete not only for fuel assembly reload contracts, but also to supply NFA components. The design differences between similar components made by different vendors have not been well-documented in public literature. However, the design of such components must satisfy the interface specifications of the original NSSS supplier. Therefore, the design differences are minor relative to the interface standards. Where detailed information is available on components fabricated by non-NSSS vendors, the design differences have been found to consist mainly of changes in the materials of construction. The descriptions provided in this document are representative of all components supplied for a specific reactor type.

ORGANIZATION OF DATA

In order to facilitate the use of this report with the CDB, the data are presented in the same sequence, and components are labeled according to the conventions used by the CDB. For ease of use, line drawings are interspersed throughout the document so that they are presented in close proximity to the

accompanying tabular description. When information about a component is publicly unavailable, the tabular entry is categorized as "To Be Determined," which is abbreviated in the tables as "TBD."

CONCLUSION

This information represents the publicly available data on NFA components. Some data on NFAs are not publicly available for a number of reasons. In some cases, the vendor considers the information proprietary. Often, with early, one-of-a-kind component designs, descriptive information was not documented as thoroughly as for later designs. There are also some instances in which the plant owner is not in possession of the design documentation, or in which the NSSS vendor is no longer in business. Additions to this report will depend largely on the extent to which NFA manufacturers can be persuaded to disclose further descriptive detail. The need for further information will depend on the level of detail required by designers and systems engineers to plan for the handling and disposition of these components.

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TABLE 1. Babcock and Wilcox Pressurized Water Reactor Control Rod Assembly Summary Description

Babcock & Wilcox Control Rod Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
15 x 15 Class Control Rod Assembly (CRA)	Spider 7	Rod Length 156	Spider: CF3M, SS 304 and SS 316 Clad: SS 304 Plugs, nuts, and spacers: SS 304 or 308 Poison: Ag-In-Cd
	Clad, end plugs, nuts and spring spacers 25.9	Rod Diameter 0.440	
	Poison (absorber) 95	Overall Length 160	
	Total 130		
Indian Point-1 13 x 14 Class Cruciform Regulating Rod	TBD	Effective Length 96.5	Hafnium
		Width 10.22	
Indian Point-1 13 x 14 Class Cruciform Shim Rod	TBD	Width 7	Stainless steel with 1% boron, of which 80% is Boron-10

Dimensions and design are typical for a B&W Control Rod Assembly

FIGURE 1. Babcock and Wilcox Control Rod Assembly

TABLE 2. Babcock and Wilcox Pressurized Water Reactor Axial Power Shaping Assembly
Summary Description

Babcock & Wilcox Axial Power Shaping Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
15 x 15 Class Axial Power Shaping Assembly (APSA)	Spider 7.8	Rod Length 156	Spider: CF3M, SS 304 and SS 316 Clad: SS 304 Plugs, nuts, and spacers: SS 304 or 308 Poison: Ag-In-Cd
	Clad, end plugs, nuts and spring spacers 24.7	Rod Diameter 0.440	
	Poison (absorber) 23.4	Overall Length 160	
	Total 57		
15 x 15 Class Gray Axial Power Shaping Assembly (GAPSA)	Spider 7.5	Rod Length 156	Spider: CF3M, SS 304 and SS 316 Clad: SS 304 Plugs, nuts, and spacers: SS 304 or 308 Poison: Inconel 600
	Clad, end plugs, nuts and spring spacers 29.8	Rod Diameter 0.444	
	Poison (absorber) 33.8	Overall Length 159.75	
	Total 71

Dimension and design are typical for a B&W Axial Power Shaping Assembly

FIGURE 2A. Babcock and Wilcox Axial Power Shaping Assembly

Dimensions and design are typical for a B&W Gray Axial Power Shaping Rod Assembly

FIGURE 2B. Babcock and Wilcox Gray Axial Power Shaping Rod Assembly

TABLE 3. Babcock and Wilcox Pressurized Water Reactor Neutron Source Assembly Summary Description

Babcock & Wilcox Neutron Source Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
15 x 15 Class Primary Neutron Source Assembly	Spider TBD Shroud tube, intermediate and lower end plug 1 Source Material 0.02	Rod Length 145.75 Rod Diameter 0.440	Spider: TBD Shroud: SS 304 Plugs: SS 304 Source: Am-Be-Cu
15 x 15 Class Regenerative (Secondary) Neutron Source Assembly	Spider 7.8 Shroud tube, intermediate and lower end plug 12 Source Material 26.4 Total 46.3	Rod Length 140 Rod Diameter 0.440	Spider: CF3M, SS 304 and SS 316 Clad: SS 304 Plugs: SS 304 Source: Sb-Be

TABLE 4. Babcock and Wilcox Pressurized Water Reactor Burnable Absorber Assembly Summary Description

Babcock & Wilcox Burnable Absorber Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
15 x 15 Class Burnable Absorber Assembly	Spider 7.8	Rod Length 150	Spider: CF3M, SS 304 and SS 316
	Clad, nuts, and end fittings 25.2	Rod Diameter 0.430	Clad, nuts, and end fittings: Zircaloy-4
	Hold-down springs 2.1		Hold-down spring: SS 302 or SS 304
	Absorber Material 20.8		Absorber: mix of B_4C and Al_2O_3
	Total: 57 ^(a)		
(a) Information for end plugs is not available, but the total mass of the assembly is given as 57 lb.			

FIGURE 3. Babcock and Wilcox Burnable Absorber Assembly

Dimensions and design are typical for a B&W Burnable Absorber Assembly

TABLE 5. Babcock and Wilcox Pressurized Water Reactor Orifice Rod Assembly Summary Description

Babcock & Wilcox Orifice Rod Assembly	Weight (lb)		Outer Envelope Dimensions (inches)	Materials of Construction
15 x 15 Class Orifice Rod Assembly	Spider	7.8	Rod Length 12	Spider: CF3M and SS 304
	Rods and nuts	7.7	Rod Diameter 0.480	Rods: SS 304
	Orifice Plugs	0.3		Nuts: SS 304 or SS 308
	Total	15.8		Orifice plugs: SS 304

Dimensions and design are typical for a B&W Orifice Rod Assembly

FIGURE 4. Babcock and Wilcox Orifice Rod Assembly

TABLE 6. Babcock and Wilcox Pressurized Water Reactor In-core Instrument Tube Summary Description

Babcock & Wilcox Instrument Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
15 x 15 Class In-core Instrument Tube	TBD	Diameter 0.29	Insulator: Al_2O_3 Emitters: rhodium

Dimensions and design are typical for a B&W In-Core Instrument Tube

FIGURE 5. Babcock and Wilcox In-Core Instrument Tube

TABLE 7. Babcock and Wilcox Pressurized Water Reactor Fuel Channel Summary Description

Babcock & Wilcox Fuel Channel	Weight (lb)	Outer Envelope Dimensions (inches)		Materials of Construction
Indian Point-1 13 x 14 Class Fuel Channel	112.2	Width	5.711	Zircaloy-2
		Depth	5.711	
		Length	117.3125	

TABLE 8. Combustion Engineering Pressurized Water Reactor Control Element Assembly Summary Description

Combustion Engineering Control Element Assembly	Weight (lb)		Outer Envelope Dimensions (inches)		Materials of Construction
14 x 14 Class Control Element Assembly (CEA) 5-element Full-length	Spider	7.5	Rod Length	161	Spider: SS 304
	Total	76.8	Rod Diameter	0.948	Clad: Inconel 625 Poison: Ag-In-Cd, B ₄ C
14 x 14 Class Control Element Assembly (CEA) 5-element Part-length Type I	Spider	7.5	Rod Length	161	Spider: SS 304
	Total	104.5	Rod Diameter	0.948	Clad: Inconel 625 Poison: B ₄ C, SS
14 x 14 Class Control Element Assembly (CEA) 5-element Part-length Type II	Spider	7.5	Rod Length	161	Spider: SS 304
	Total	82.4	Rod Diameter	0.948	Clad: Inconel 625 Poison: B ₄ C, Ag-In-Cd Spacer: Al ₂ O ₃
14 x 14 Class Control Element Assembly (CEA) 5-element Part-length Type III	Spider	7.5	Rod Length	161	Spider: SS 304
	Total	63.0	Rod Diameter	0.948	Clad: Inconel 625 Poison: B ₄ C, Ag-In-Cd Spacer: Al ₂ O ₃ , SS

TABLE 8. (continued)

Combustion Engineering Control Element Assembly	Weight (lb)		Outer Envelope Dimensions (inches)		Materials of Construction
16 x 16 Class Control Element Assembly (CEA) 5-element Full-length	Spider	8	Rod Length	181.3	Spider: SS 304
	Total	72	Rod Diameter	0.816	Plenum Springs: SS 302 Clad: Inconel 625 Poison: Ag-In-Cd, B ₄ C
16 x 16 Class Control Element Assembly (CEA) 5-element Part-length	Spider	8	Rod Length	181.3	Spider: SS 304
	Total	92	Rod Diameter	0.816	Plenum Springs: SS 302 Clad: Inconel 625 Poison: B ₄ C, Inconel 625
Arkansas Nuclear One-2 16 x 16 Class Control Element Assembly (CEA) 5-element Full-length	Spider	8	Rod Length	180.8	Spider: SS 304
	Total	71.3	Rod Diameter	0.816	Plenum Springs: SS 302 Clad: Inconel 625 Poison: B ₄ C, Inconel 625

TABLE 8. (continued)

Combustion Engineering Control Element Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
Arkansas Nuclear One-2 16 x 16 Class Control Element Assembly (CEA) 5-element Part-length	Spider 8 Total 91.1	Rod Length 180.8 Rod Diameter 0.816	Spider: SS 304 Plenum Springs: SS 302 Clad: Inconel 625 Poison: B ₄ C, Inconel 625
SYSTEM 80 Control Element Assembly (CEA) 12-element Full-length	Spider 19.5 Total 192.2	Rod Length 253 Rod Diameter 0.816	Spider: SS 304 Plenum Springs: SS 302 Clad: Inconel 625 Poison: B ₄ C
SYSTEM 80 Control Element Assembly (CEA) 4-element Full-length	Spider TBD Total 68	Rod Length 253 Rod Diameter 0.816	Spider: SS 304 Plenum Springs: SS 302 Clad: Inconel 625 Poison: B ₄ C
SYSTEM 80 Control Element Assembly (CEA) 4-element Part-length	Spider TBD Total 95.0	Rod Length 253 Rod Diameter 0.816	Spider: SS 304 Plenum Springs: SS 302 Clad: Inconel 625 Poison: B ₄ C, Inconel 625

TABLE 8. (continued)

Combustion Engineering Control Element Assembly	Weight (lb)		Outer Envelope Dimensions (inches)		Materials of Construction
Fort Calhoun 14 X 14 Class Control Element Assembly (CEA) 5-element Full-length	Spider	7.5	Rod Length	152	Spider: SS 304
	Total	66.5	Rod Diameter	0.948	Plenum Springs: SS 302 Clad: Inconel 625 Poison: B ₄ C
Fort Calhoun 14 X 14 Class Control Element Assembly (CEA) 5-element Part-length	Spider	7.5	Rod Length	152	Spider: SS 304
	Total	63	Rod Diameter	0.948	Plenum Springs: SS 302 Clad: Inconel 625 Poison: B ₄ C
St. Lucie-2 16 X 16 Class Control Element Assembly (CEA) 5-element Full-length	Spider	7.5	Rod Length	162.8	Spider: SS 304
	Total	65.8	Rod Diameter	0.816	Plenum Springs: SS 302 Clad: Inconel 625 Poison: B ₄ C, Ag-In-Cd
St. Lucie-2 16 X 16 Class Control Element Assembly (CEA) 5-element Part-length	Spider	7.5	Rod Length	162.8	Spider: SS 304
	Total	83.0	Rod Diameter	0.816	Plenum Springs: SS 302 Clad: Inconel 625 Poison: B ₄ C, Inconel 625

Dimensions and design are typical for a Combustion Engineering Control Element Assembly

FIGURE 6A. Combustion Engineering 16 x 16 Class 5-Element Part-Length Control Element Assembly

Dimensions and design are typical for a Combustion Engineering Control Element Assembly

FIGURE 6B. Combustion Engineering 16 x 16 Class 5-Element Full-Length Control Element Assembly

Dimensions and design are typical for a Combustion Engineering Control Element Assembly

FIGURE 6C. Combustion Engineering 16 x 16 Class 4-Element Full-Length Control Element Assembly

Dimensions and design are typical for a Combustion Engineering Control Element Assembly

FIGURE 6D. Combustion Engineering SYSTEM 80 4-Element Part-Length Control Element Assembly

Dimensions and design are typical for a Combustion Engineering Control Element Assembly

FIGURE 6E. Combustion Engineering SYSTEM 80 4-Element Full-Length Control Element Assembly

4-element CEA

Control Element

Design is typical for a Combustion Engineering Control Element Assembly

FIGURE 6F. Exploded View of Combustion Engineering SYSTEM 80 4-Element Control Element Assembly

Dimensions and design are typical for a Combustion Engineering Control Element Assembly

FIGURE 6G. Combustion Engineering SYSTEM 80 12-Element Full-Length Control Element Assembly

4-element CEA

8 Element CEA

12 Element CEA

Designs are typical for Combustion Engineering Control Element Assemblies

FIGURE 6H. Combustion Engineering SYSTEM 80 Control Element Assemblies

TABLE 9. Combustion Engineering Pressurized Water Reactor Control Blade Summary Description

Combustion Engineering Control Blade Assembly	Weight (lb)		Outer Envelope Dimensions (inches)	Materials of Construction
Palisades 15 x 15 Class Control Blade Assembly	Hanger	62.2	Blade Width 12.250	Hanger: SS 304 and 308
	Cruciform	151.8	Blade Depth 12.250	Clad: SS 304
	Total	214.0	Active Length 151	Absorber: Ag-In-Cd
			Handle Length TBD	
			Base Length TBD	

TABLE 10. Combustion Engineering Pressurized Water Reactor Neutron Source Assembly Summary Description

Combustion Engineering Neutron Source Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
14 x 14 Class Neutron Source Assembly (NSA)	Springs 0.4 SS 9.4 Beryllium 0.5 Plutonium 0.3 Antimony 0.3 Total 10.9	Lower Subassembly 42.5 Upper Subassembly 63.5 Overall Length 106 Rod Diameter 0.875	Plunger, clad, upper sub- assembly, lower spacer: SS 316 Springs: nickel-based alloy Sources: Sb-Be, Pu-Be
16 x 16 Class, SYSTEM 80, St. Lucie-2, and ANO-2 Neutron Source Assembly (NSA)	Springs 0.4 SS 9.1 Beryllium 0.5 Plutonium 0.3 Antimony 0.3 Total 10.6	Lower Subassembly 42.5 Upper Subassembly 70.5 Overall Length 113 Rod Diameter 0.812	Plunger, clad, upper sub- assembly, lower spacer: SS 304 Springs: nickel-based alloy Sources: Sb-Be, Pu-Be
Fort Calhoun 14 x 14 Class Neutron Source Assembly (NSA)	Springs 0.2 SS 7.2 Beryllium 0.4 Plutonium 0.2 Antimony 0.2 Total 10.6 ^(a)	Lower Subassembly 42.5 Upper Subassembly 57.5 Overall Length 100 Rod Diameter 0.875	Plunger, clad, upper sub- assembly, lower spacer: SS 316 Springs: nickel-based alloy Sources: Sb-Be, Pu-Be

TABLE 10. (continued)

Combustion Engineering Neutron Source Assembly	Weight (lb)		Outer Envelope Dimensions (inches)		Materials of Construction
Palisades 15 x 15 Class Startup (Primary) Neutron Source Assembly (NSA)	SS	4.1	Overall Length	115	Clad: SS 304
	Beryllium	0.2	Rod Diameter	0.34	Sources: Pu-Be, Sb-Be
	Plutonium	0.1			
	Antimony	0.2			
	Total	4.5			
Palisades 15 x 15 Class Sustaining (Secondary) Neutron Source Assembly (NSA)	SS	4.1	Overall Length	115	Clad: SS 304
	Beryllium	0.2	Rod Diameter	0.34	Sources: Sb-Be
	Antimony	0.2			
	Total	4.5			
(a) The masses listed for the constituent parts of this component do not add up to the total mass given. Either there is an error in one of the references, or there are additional components which have not been accounted for.					

TABLE 11. Combustion Engineering Pressurized Water Reactor In-core Instrument Assembly Summary Description

Combustion Engineering Instrument Assembly	Weight (lb)	Outer Envelope Dimensions	Materials of Construction
14 x 14 Class Instrument Assembly	11.7 - 12.8	Length 38-41 ft. Diameter 0.35 in.	Inner sheath, lead wires: Inconel 600 Outer sheath: Stainless Steel Insulator: Al_2O_3 Emitters: rhodium
16 x 16 Class Instrument Assembly	6.4 - 7.3	Length 37-38 ft. Diameter 0.35 in.	Inner sheath, lead wires, outer sheath: Inconel 600 Insulator: Al_2O_3 Emitters: rhodium
SYSTEM 80 Instrument Assembly	34.3	Length 116 ft. Diameter 0.45 in.	Inner sheath, lead wires, outer sheath: Inconel 600 Insulator: Al_2O_3 Emitters: rhodium
Fort Calhoun 14 x 14 Class Instrument Assembly	11.6	Length 39 ft. Diameter 0.35 in.	Inner sheath, lead wires: Inconel 600 Outer sheath: SS 304 Insulator: Al_2O_3 Emitters: rhodium

TABLE 11. (continued)

Combustion Engineering Instrument Assembly	Weight (lb)	Outer Envelope Dimensions	Materials of Construction
St. Lucie-2 16 x 16 Class Instrument Assembly	7.0	Length 35 ft. Diameter 0.35 in.	Inner sheath, lead wires, outer sheath: Inconel 600 Insulator: Al_2O_3 Emitters: rhodium
Palisades 15 x 15 Class Instrument Assembly	9.3	Length 37 ft. Diameter 0.35 in.	Inner sheath, lead wires: Inconel 600 Outer sheath: SS 304 Insulator: Al_2O_3 Emitters: rhodium

Dimensions and design are typical for a CE In-core Instrument Tube

FIGURE 7. Combustion Engineering In-Core Instrument Tube

TABLE 12. Westinghouse Pressurized Water Reactor Control Element Assembly Summary Description

Westinghouse Control Element Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
14 x 14 Class Control Rod Assembly (CRA) 16-rod, Standard	Spider: 7.86 SS 6.25 Inconel 1.61 Rodlet 7.59 Total 129.4	Width 5.43 Depth 5.43 Rod Length 152.7 Rod Diameter 0.435 Overall Length 158.5	Spider: SS 304, SS 308, Inconel-X-750 Clad: SS 304 End Plugs: SS 308 Poison: Ag-In-Cd
14 x 14 Class Control Rod Assembly (CRA) 16-rod, Part-length	Spider 7.86 SS 6.25 Inconel 1.61 Rodlet 6.33 Total 110	Width 5.43 Depth 5.43 Rod Length 128 Rod Diameter 0.435 Overall Length 140 ^(a)	Spider: SS 304, SS 308, Inconel-X-750 Clad: SS 304 End Plugs: SS 308 Poison: Ag-In-Cd
San Onofre 14 x 14 Class Control Rod Assembly (CRA) 16-rod, Full-length	Spider 7.86 SS 6.25 Inconel 1.61 Total TBD	Width 5.43 Depth 5.43 Rod Diameter 0.435 Overall Length 133.7	Spider: SS 304, SS 308, Inconel-X-750 Clad: SS 304 End Plugs: SS 308 Poison: Ag-In-Cd

TABLE 12. (continued)

Westinghouse Control Element Assembly	Weight (lb)		Outer Envelope Dimensions (inches)		Materials of Construction
15 x 15 Class Control Rod Assembly (CRA) 20-rod, Standard	Spider	7.86	Width	6.073	Spider: SS 304, SS 308, Inconel-X-750 Clad: SS 304 End Plugs: SS 308 Poison: Ag-In-Cd
	SS	6.25	Depth	6.073	
	Inconel	1.61	Rod Length	150.9 to 152.7	
	Rodlet	7.80	Rod Diameter	0.443	
	Total	165.0	Overall Length	156.6 to 158.5	
17 x 17 Class Control Rod Assembly (CRA) 24-rod, Full-length (Ag-In-Cd CR)	Spider	8.6 - 9.3	Width	6.34	Spider: SS 304, SS 308, Inconel-X-750 Clad: SS 304 End Plugs: SS 308 Poison: Ag-In-Cd
	SS	6.9 - 7.6	Depth	6.34	
	Inconel	1.65	Rod Diameter	0.385	
	Rodlet	5.87	Rod Length	151.9	
	Total	149.5 - 150.2	Overall Length	160.9	
17 x 17 Class Control Rod Assembly (CRA) 24-rod, Full-length (Hafnium CR)	Spider	9.33	Width	6.34	Spider: SS 304, SS 308, Inconel-X-750 Clad: SS 304 End Plugs: SS 308 Poison: Hafnium
	SS	6.90	Depth	6.34	
	Inconel	1.65	Rod Diameter	0.385	
	Rodlet	7.16	Rod Length	151.9	
	Total	181.2	Overall Length	160.9	

TABLE 12. (continued)

Westinghouse Control Element Assembly	Weight (lb)		Outer Envelope Dimensions (inches)		Materials of Construction
17 x 17 Class Control Rod Assembly (CRA) 24-rod, Full-length (Hybrid CR)	Spider	8.60	Width	6.34	Spider: SS 304, SS 308, Inconel-X-750 Clad: SS 304 End Plugs: SS 308 Poison: Ag-In-Cd, B ₄ C
	SS	6.90	Depth	6.34	
	Inconel	1.65	Rod Diameter	0.385	
	Rodlet	3.33	Rod Length	151.9	
	Total	92.7	Overall Length	160.9	
17 x 17 Class Control Rod Assembly (CRA) 24-rod, Part-length	Spider	6.50	Width	6.34	Spider: SS 304, SS 308, Inconel-X-750 Clad: SS 304 End Plugs: SS 308 Poison: Ag-In-Cd Spacer: Al ₂ O ₃
	SS	4.8	Depth	6.34	
	Inconel	1.65	Rod Diameter	0.385	
	Rodlet	3.81	Rod Length	151.9	
	Total	100	Overall Length	160.9	

TABLE 12. (continued)

Westinghouse Control Element Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
South Texas 17 x 17 Class Control Rod Assembly (CRA) 24-rod, Full-length	TBD	Width 6.34 Depth 6.34 Rod Diameter 0.381 Rod Length 171.85 Overall Length 180.92	Spider: SS 304, SS 308 Springs: Inconel 718 Retainer: 17-4 PH Clad: Stainless steel End Plugs: SS 308 Poison: Hafnium

Dimensions and design are typical for a Westinghouse Control Rod Assembly

FIGURE 8A. Westinghouse 14 x 14 Class Control Rod Assembly

Dimensions and design are typical for a Westinghouse Control Rod Assembly

FIGURE 8B. Westinghouse 15 x 15 Class Control Rod Assembly

Dimensions and design are typical for a Westinghouse Control Rod Assembly
FIGURE 8C. Westinghouse 17 x 17 Class Control Rod Assembly

TABLE 13. Westinghouse Pressurized Water Reactor Neutron Source Assembly Summary Description

Westinghouse Neutron Source Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
14 x 14 Class Primary Neutron Source Assembly (NSA)	Spider SS 304 7.8 Inconel 0.5 - 1.1	Overall Length 143 - 158 Rod Diameter 0.431 - 0.437	Spider: SS 304 with Inconel springs
	Rodlet 2.9 - 3.6 Clad 0.9 - 1.1 Plugs 0.07 - 0.12		Clad: SS 304
	Total 26 or 28		End Plugs: SS 308
			Thimble Plugs: see TPA table
			Secondary Source Rods: see table
			Spacer Material: Sb-Be, Al ₂ O ₃ , SS 304
			Primary Sources: Pu-Be, Californium (Cf)

TABLE 13. (continued)

Westinghouse Neutron Source Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
14 x 14 Class Primary Neutron Source Assembly (NSA)	Spider	Overall Length 143 - 158	Spider: SS 304 with Inconel springs
	SS 304 7.8	Rod Diameter 0.431 - 0.437	Clad: SS 304
	Inconel 0.5 - 1.1		End Plugs: SS 308
	Rodlet 2.8 - 3.6		Thimble Plugs: see TPA table
	Clad 0.9 - 1.1		Burnable Absorber Rods: see BAA table
	Plugs 0.07 - 0.12		Secondary Source Rods: see table
	Total 48 or 50		Spacer Material: Sb-Be, Al ₂ O ₃ , SS 304
			Primary Sources: Cf, Pu-Be, Po-Be

TABLE 13. (continued)

Westinghouse Neutron Source Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
14 x 14 Class Secondary Neutron Source Assembly (NSA)	Spider SS 304 7.8 Inconel 0.5-1.1 Rodlet 1.5 - 3.1 Clad 0.6 - 1.1 Plugs 0.18 Total 20.7 - 27.7	Overall Length 91 - 157 Rod Diameter 0.431 - 0.437	Spider: SS 304 with Inconel springs Clad: SS 304 End Plugs: SS 308 Thimble Plugs: see TPA table Spacer Material: SS 304 or none Sources: Sb-Be

TABLE 13. (continued)

Westinghouse Neutron Source Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
15 x 15 Class Primary Neutron Source Assembly (NSA)	Spider 7.8	Overall Length 143 - 158	Spider: SS 304
	Holddown Assembly	Rod Diameter 0.431 - 0.437	Holddown Assembly:
	SS 3.6 - 3.83		SS 304 or 308 with
	Springs 0.80		springs of Inconel
			718, SS 302, or
	Rodlet 2.8 - 3.6		Inconel-X-750
	Clad 0.9 - 1.1		Clad: SS 304
	Plugs 0.07 - 0.12		End Plugs: SS 308
	Total 20 - 52		Thimble Plugs: see TPA table
			Burnable Absorber Rods: see BAA table
			Secondary Source Rods: see table
			Spacer Material: Sb-Be, Al ₂ O ₃ , SS 304
			Primary Sources: Pu-Be, Po-Be, Cf

TABLE 13. (continued)

Westinghouse Neutron Source Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
15 x 15 Class Secondary Neutron Source Assembly (NSA)	Spider 7.8 Holddown Assy SS 3.6 - 3.83 Springs 0.80 Rodlet 1.5 - 3.1 Clad 0.6 - 1.1 Plugs 0.18 Total 19 - 52	Overall Length 116 - 157 Rod Diameter 0.431 - 0.437	Spider: SS 304 Holddown Assembly: SS 304 or 308 with springs of Inconel 718, SS 302, or Inconel-X-750 Clad: SS 304 End Plugs: SS 308 Thimble Plugs: see TPA table Burnable Absorber Rods: see BAA table Spacer Material: SS 304 or none Source: Sb-Be

TABLE 13. (continued)

Westinghouse Neutron Source Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
17 x 17 Class Primary Neutron Source Assembly (NSA)	Spider SS 304 Springs	Overall Length 156 Rod Length 153.7	Spider: SS 304 with springs of Inconel 718
	Rodlet Clad Plugs	Rod Diameter 0.385	Clad: SS 304
			End Plugs: SS 308
			Thimble Plugs: see TPA table
			Burnable Absorber Rods: see BAA table
	Total		Secondary Source Rods: see table
			Spacer Material: Alumina (Al_2O_3)
			Source: Californium

TABLE 13. (continued)

Westinghouse Neutron Source Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
17 x 17 Class Secondary Neutron Source Assembly (NSA)	Spider SS 304 5 Springs 0.6 - 1.4	Overall Length 156 Rod Diameter 0.385	Spider: SS 304 with springs of Inconel 718 Clad: SS 304 End Plugs: SS 308 Thimble Plugs: see TPA table Burnable Absorber Rods: see BAA table Spacer: none Source: Sb-Be
	Rodlet 2.0 - 2.15 Clad 0.9 - 1.1 Plugs 0.07 - 0.18		
	Total 17 - 51		

TABLE 13. (continued)

Westinghouse Neutron Source Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
South Texas 17 x 17 Class Primary Neutron Source Assembly (NSA)	TBD	Rod Diameter 0.381	Hold-down Assembly: SS 304 Springs: Inconel 718 Clad: SS 304 End Plugs: SS 308 Thimble Plugs: see TPA table Burnable Absorber Rods: see BAA table Secondary Source Rods: see table Spacer Material: Alumina (Al ₂ O ₃) Source Material: Pu-Be, Californium (Cf)

TABLE 13. (continued)

Westinghouse Neutron Source Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
South Texas 17 x 17 Class Secondary Neutron Source Assembly (NSA)	TBD	Overall Length 181.461 Rod Diameter 0.381	Spider: SS 304 Springs: Inconel 718 Clad: SS 304 End Plugs: SS 308 Thimble Plugs: see TPA table Burnable Absorber Rods: see BAA table Source: Sb-Be

Dimensions and design are typical for a Westinghouse Primary Neutron Source Assembly

FIGURE 9A. Westinghouse 15 x 15 Class Primary Neutron Source Assembly

- ① Secondary Source Rod
- ② Thimble Plug
- ③ Burnable Poison Rod

Dimensions and design are typical for a Westinghouse Secondary Neutron Source Assembly

FIGURE 9B. Westinghouse 15 x 15 Class Secondary Neutron Source Assembly

Dimensions and design are typical for a Westinghouse Primary Neutron Source Assembly

FIGURE 9C. Westinghouse 17 x 17 Class Primary Neutron Source Assembly

Dimensions and design are typical for a Westinghouse Secondary Neutron Source Assembly

FIGURE 9D. Westinghouse 17 x 17 Class Secondary Neutron Source Assembly

TABLE 14. Westinghouse Pressurized Water Reactor Burnable Absorber Assembly Summary Description

Westinghouse Burnable Absorber Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
14 x 14 Class Standard Burnable Absorber Assembly (BAA)	Rodlet 2.2 - 2.3 Clad 1.1 Absorber 0.83 Plugs 0.08 - 0.17 Assembly 11 - 40 ^(a)	Overall Length 156.1 Rod Length 150.4 - 152.2 Rod Diameter 0.437 or 0.445	Clad: SS 304 End Plugs: SS 308 Absorber: boro- silicate glass (pyrex tubing)
14 x 14 Class Wet Annular Burnable Absorber Assembly (WABA)	Rodlet 1.8 Clad 1.6 Absorber 0.23 Assembly 15.6 - 34.2 ^(a)	Overall Length 153.6 Rod Length 150.1 Rod Diameter 0.381	Clad: Zircaloy-4 Absorber: B ₄ C
15 x 15 Class Standard Burnable Absorber Assembly (BAA)	Rodlet 2.2 - 2.3 Clad 1.1 Absorber 0.83 Plugs 0.08 - 0.17 Assembly 17.0 - 53.7 ^(a)	Overall Length 156.1 - 156.9 Rod Length 150.4 - 152.2 Rod Diameter 0.437 or 0.445	Clad: SS 304 End Plugs: SS 308 Absorber: boro- silicate glass (pyrex tubing)

TABLE 14. (continued)

Westinghouse Burnable Absorber Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
15 x 15 Class Wet Annular Burnable Absorber Assembly (WABA)	Rodlet 1.8	Overall Length 146.6 or 153.7	Clad: Zircaloy-4
	Clad 1.6	Rod Length 150.1	Absorber: B ₄ C
	Absorber 0.23	Rod Diameter 0.381	
	Assembly 16 - 46.8 ^(a)		
17 x 17 Class Standard Burnable Absorber Assembly (BAA)	Rodlet 1.8	Overall Length 156.1 - 156.7	Clad: SS 304
	Clad 0.92	Rod Length 152.4	End Plugs: SS 308
	Absorber 0.70	Rod Diameter 0.385	Absorber: boro- silicate glass (pyrex tubing)
	Plugs 0.08		
17 x 17 Class Wet Annular Burnable Absorber Assembly (WABA)	Assembly 15.1 - 50.3 ^(a)		
	Rodlet 1.9	Overall Length 153.6	Clad: Zircaloy-4
	Clad 1.6	Rod Length 150.0	Absorber: B ₄ C
	Absorber 0.17 - 0.23	Rod Diameter 0.381	
	Assembly 15.2 - 51.7 ^(a)		

TABLE 14. (continued)

Westinghouse Burnable Absorber Assembly	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
South Texas 17 x 17 Class Burnable Absorber Assembly	TBD	Rod Length 177.047 Rod Diameter 0.381	Clad: SS 304 End Plugs: SS 308 Springs: Inconel 718 Absorber: boro- silicate glass (pyrex tubing)
<p>(a) Many different configurations of burnable absorber rods have been used for each type of assembly. Clearly, the greater the number of rods used, the greater the mass of the assembly. The ranges of weights given in the table above represent the following ranges of rods used in the assembly.</p> <p>14 x 14 Class BAA 1 - 16 rods 14 x 14 Class WABA 4 - 16 rods 15 x 15 Class BAA 4 - 20 rods 15 x 15 Class WABA 4 - 20 rods 17 x 17 Class BAA 3 - 24 rods 17 x 17 Class WABA 3 - 24 rods</p>

Top View

Dimensions and design are typical for a Westinghouse Burnable Absorber Assembly

FIGURE 10A. Westinghouse 15 x 15 Class Burnable Absorber Assembly

Dimensions and design are typical for a Westinghouse Burnable Absorber Assembly

FIGURE 10B. Westinghouse 17 x 17 Class Burnable Absorber Assembly

Westinghouse 17 x 17 Class Standard
Burnable Absorber Rod

Westinghouse 17 x 17 Class Wet
Annular Burnable Absorber Rod

Dimensions and designs are typical for a Westinghouse Burnable Absorber Rod

FIGURE 10C. Westinghouse 17 x 17 Class Burnable Absorber Rods

TABLE 15. Westinghouse Pressurized Water Reactor Thimble Plug Assembly Summary Description

Westinghouse Thimble Plug Assembly	Weight (lb)	Outer Envelope Dimensions (in)	Materials of Construction
14 x 14 Class Thimble Plug Assembly (TPA)	Pluglet 0.29 - 0.40	Overall Length 10.8 - 13.6	SS 304 or 308
	Assembly 9.5 - 13.2	Rod Length 6.56 - 8.02	
		Rod Diameter 0.434 - 0.502	
15 x 15 Class Thimble Plug Assembly (TPA)	Pluglet 0.29 - 0.40	Overall Length 10.8 - 13.6	SS 304 or 308
	Assembly 9.5 - 13.2	Rod Length 6.56 - 8.02	
		Rod Diameter 0.434 - 0.502	
17 x 17 Class Thimble Plug Assembly (TPA)	Pluglet 0.29 - 0.40	Overall Length 10.8 - 13.6	SS 304 or 308
	Assembly 9.5 - 13.2	Rod Length 6.56 - 8.02	
		Rod Diameter 0.434 - 0.502	
South Texas 17 x 17 Class Thimble Plug Assembly (TPA)	TBD	Rod Length 9.16	SS 304 with springs of Inconel 718
		Rod Diameter 0.426

Top View

Dimensions and design are typical for a Westinghouse Thimble Plug Assembly

FIGURE 11A. Westinghouse 14 x 14 Class Thimble Plug Assembly

Dimensions and design are typical for a Westinghouse Thimble Plug Assembly

FIGURE 11B. Westinghouse 15 x 15 Class Thimble Plug Assembly

Dimensions and design are typical for a Westinghouse Thimble Plug Assembly

FIGURE 11C. Westinghouse 17 x 17 Class Thimble Plug Assembly

TABLE 16. General Electric Boiling Water Reactor Control Blade Summary Description

General Electric Control Blade	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
GE Reference Design	218 - 225	Blade Width 9.75 - 9.81 Blade Depth 9.75 - 9.81 Active Length 143 - 144 Handle Length 6.0 Base Length 24 Total Length 173.75	Sheath: SS 304 Cladding: SS 304 Absorber rods: boron carbide (B_4C)
GE Hybrid I Control Rod (HICR)	218 - 225	Blade Width 9.75 - 9.81 Blade Depth 9.75 - 9.81 Active Length 143 - 144 Handle Length 6.0 Base Length 24 Total Length 173.75	Sheath: SS 304 Cladding: SS 304 Absorber rods: boron carbide (B_4C), unclad hafnium (Hf)
GE Advanced Long Life Control Rod (ALLCR)	218 - 225	Blade Width 9.75 - 9.81 Blade Depth 9.75 - 9.81 Active Length 143 - 144 Handle Length 6.0 Base Length 24 Total Length 173.75	Sheath: SS 304 Cladding: SS 304 Absorber rods: boron carbide (B_4C), unclad hafnium (Hf) Absorber plates: hafnium (Hf)
GE Dresden-1 Control Blade	TBD	Blade Width 6.5 Blade Depth 6.5 Active Length 102	Sheath: SS 304 Cladding: SS 304 Absorber rods: boron carbide (B_4C)

TABLE 16. (continued)

General Electric Control Blade	Weight (lb)	Outer Envelope Dimensions (inches)		Materials of Construction
GE Humboldt Bay Control Blade	TBD	Blade Width	8.75	Sheath: SS 304
		Blade Depth	8.75	Cladding: SS 304
		Active Length	75.5	Absorber rods: boron carbide (B_4C)
GE Big Rock Point Control Blade	TBD	Blade Width	11.5	Sheath: SS 304
		Blade Depth	11.5	Cladding: SS 304
		Active Length	66	Absorber rods: boron carbide (B_4C)
ASEA-Atom CR-70 Control Blade ^(a)	225	Blade Width	9.84	Sheath: SS 304
		Blade Depth	9.84	Cladding: none
		Active Length	142.9	Absorber:
		Handle Length	6.0	boron carbide (B_4C)
		Base Length	24	
		Total Length	174.2	
ASEA-Atom CR-82 and CR-85 Control Blade ^(a)	218 - 222	Blade Width	9.84	Sheath: SS 304
		Blade Depth	9.84	Cladding: none
		Active Length	142.9	Absorber:
		Handle Length	6.0	boron carbide (B_4C)
		Base Length	24	hafnium (Hf)
		Total Length	174.2	
(a) The ASEA-Atom Control Blades described here were made by ASEA-Atom for use in General Electric Boiling Water Reactors.

Dimensions and design are typical for a GE Control Rod Blade

FIGURE 12. General Electric Control Rod Blade

TABLE 17. General Electric Boiling Water Reactor Neutron Source Summary Description

General Electric Neutron Source	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
General Electric BWR/6 Neutron Source Rod	TBD	Diameter 0.7	Clad: Stainless Steel Source: Sb-Be

Dimensions and design are typical for a GE Neutron Source

FIGURE 13. General Electric BWR/6 Neutron Source

TABLE 18. General Electric Boiling Water Reactor Fuel Channel Summary Description

General Electric Fuel Channel	Weight (lb)	Outer Envelope Dimensions (inches)		Materials of Construction
General Electric BWR/2,3; 80 mil thick BWR channel	64	Width	5.438	Zircaloy-4
		Depth	5.438	
		Length	162.2	
GE BWR/2,3; 100 mil thick BWR channel	80	Width	5.478	Zircaloy-4
		Depth	5.478	
		Length	162.2	
GE BWR/4; 80 mil thick BWR channel	66	Width	5.438	Zircaloy-4
		Depth	5.438	
		Length	166.9	
GE BWR/4,5; 100 mil thick BWR channel	82	Width	5.478	Zircaloy-4
		Depth	5.478	
		Length	166.9	
GE BWR/6; 120 mil thick BWR channel	98	Width	5.438	Zircaloy-4
		Depth	5.438	
		Length	167.4	
GE BWR/2,3; Interactive Fuel Channel	TBD	TBD		TBD
GE BWR/4-6; Interactive Fuel Channel	TBD	TBD		TBD
Dresden-1 (60 mil thick BWR channel)	30	Width	4.410	Zircaloy-2
		Depth	4.410	
		Length	120	

TABLE 18. (continued)

General Electric Fuel Channel	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
Humboldt Bay (60 mil thick BWR channel)	23.4	Width 4.662 Depth 4.662 Length 88.6	Zircaloy-2
Big Rock Point	TBD	TBD	Zircaloy-2, SS ^(a)
(a) 24 to 28 stainless steel fuel channels were used in the initial core to help provide reactivity control for initial operation. Several experimental assemblies were used in early cores at Big Rock Point, most of which did not employ fuel channels.

Dimensions and design are typical for a GE Fuel Channel

FIGURE 14. General Electric BWR/4 Fuel Channel

TABLE 19. Allis-Chalmers Boiling Water Reactor Control Blade Summary Description

Allis-Chalmers Control Blade	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
LaCrosse 10 x 10 Class Control Blade	TBD	Blade Width 9.750	Sheath: SS 304
		Blade Depth 9.750	Clad: Inconel 600
		Active Length 83	Absorber: B ₄ C
		Handle Length 2.875	
		Base Length TBD	

TABLE 20. Allis-Chalmers Boiling Water Reactor Fuel Channel Summary Description

Allis-Chalmers Fuel Channel	Weight (lb)	Outer Envelope Dimensions (inches)	Materials of Construction
Lacrosse 10 x 10 Class Fuel Channel	TBD	Width 5.806	SS 304 or zirconium alloy
		Depth 5.806	
		Length 102.34 ^(a)	
(a) Estimate based on length of fuel assembly			

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