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Office of Civilian Radioactive Waste Management

CHARACTERISTICS OF SPENT FUEL, HIGH-LEVEL WASTE, AND OTHER RADIOACTIVE WASTES WHICH MAY REQUIRE LONG-TERM ISOLATION

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JUNE 1988

U.S. Department of Energy
Office of Civilian Radioactive Waste Management
Washington, D.C. 20585

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Appendix 4A. **Nuclear Reactors at Educational Institutions in the United States**

Appendix 4B. **Data Sheets for Nuclear Reactors at Educational Institutions**

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APPENDIX 4A. NUCLEAR REACTORS AT EDUCATIONAL INSTITUTIONS IN THE UNITED STATES

4A.1 INTRODUCTION

There are fifty reactors at educational institutions in the U.S. These reactors may be categorized into six general types, as follows: (1) open pool type with plate fuel assemblies, (2) open pool TRIGA type with cylindrical fuel pins (often used in 4-pin "clusters"), (3) open pool AGN-201 type with fuel elements consisting of UO_2-polyethylene discs (about 10" diameter), (4) open pool PULSTAR type (5 x 5 fuel pin arrays), (5) Atomics International liquid fuel type, and (6) miscellaneous types. Table 4A.1 shows the number of educational reactors in each of the categories.

Table 4A.2 is a complete list of the reactors summarized in the previous table and gives data on locations, thermal power, fuel type category, and other details. This list was compiled principally from information in Burn and Bilof (1983), supplemented by conversations with individuals at the various institutions.

4A.2 FUEL SUPPLY ARRANGEMENTS

Under DOE's university assistance program, DOE supplies the fuel for university and educational reactors and retains ownership of the fuel; thus DOE is responsible for disposal of the fuel when it is removed from a reactor. Figure 4A.1 is a schematic representation of the fuel supply arrangements for reactors under this program. The fuel procurement contractor is EG&G, Idaho Falls, Idaho, and procurement arrangements are made by EG&G with the fuel manufacturers. When an order for fuel is received from EG&G, the fuel manufacturer ships the desired number of fuel elements directly to the university reactor. Each university contacts EG&G when it needs to order fuel, and describes the type and number of fuel elements needed. Figure 4A.1 shows only those university reactors that regularly order fuel in appreciable quantities. Many university reactors require fueling only infrequently; for others, no refueling is planned in the foreseeable future. Table 4A.3 shows the approximate refueling rates for some of the major university reactors. This information was supplied by EG&G (Brown, 1986a).

4A.3 FUEL ELEMENT SERIAL NUMBERS

Tables 4A.4 - 4A.8 list fuel element serial numbers for reactors that use plate-type elements manufactured by Babcock and Wilcox and supplied to the reactors under the EG&G subcontract with DOE. The list indicates which elements have already been shipped to the reactors and which ones have not yet been shipped but are being stored at the B&W plant.

4A.4 REACTOR DATA SHEETS

Appendix 4B consists of detailed data sheets on the fifty university/educational reactors listed in Table 4A.2. Supplemental information is included in these data sheets to amplify on the data contained in Burn and Bilof 1983.

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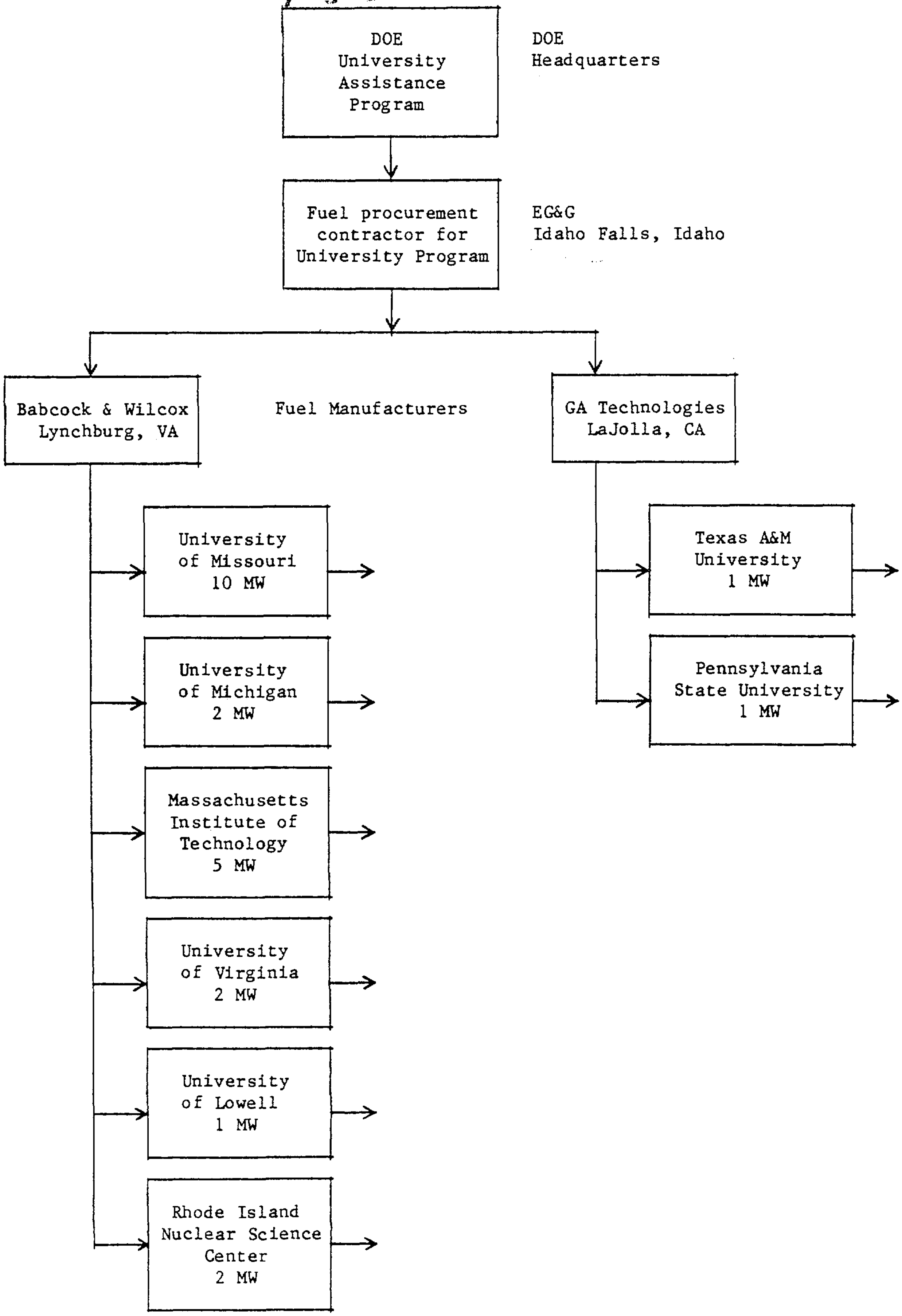

Fig. 4A.1. Fuel supply arrangements for DOE University Assistance Program.

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Table 4A.1. Reactor fuel types used at educational institutions

Fuel category	Description	Numbers of reactors listed
1	Open pool, plate fuel elements (includes ARGONAUT, MTR type, and other plate fuel reactors)	20
2	Open pool, TRIGA type, cylindrical fuel elements	18
3	Open pool, AGN-201 type, UO_2-polyethylene disc fuel elements	6
4	Open pool PULSTAR; fuel element is 5 x 5 array of pins	2
5	Atomics International liquid fuel type	2
6	AGN-211 UO_2-polyethylene block fuel elements	1
7	Open pool, pin-type fuel assembly	1
	Total	50

Table 4A.2. Reactors at universities and other educational institutions in the U.S.

Ref. no.	Institution	Location	Type	Power	Fuel type category
1	Brigham Young University	Provo, UT 84602	Atomics Intl Model L-77	10 W	5
2	Catholic University	Washington, DC 20064	Aerojet General Nucleonics AGN-201 CU	0.1 W	3
3	Columbia University	New York, NY 10027	TRIGA Mk II General Atomics	250 kW	2
4	Cornell University	Ithaca, NY 14853	TRIGA Mk II General Atomics	100 kW	2
5	Cornell University	Ithaca, NY 14853	Open tank pin fuel critical facility "zero power reactor"	100 W	6
6	Georgia Institute of Technology	Atlanta, GA 30332	General Nuclear Engineering Co. (tank type) plate fuel heavy water cooled and moderated	5 MW	1
7	Idaho State University	Pocatello, ID 83209	Aerojet General AGN-201M	5 W	3
8	Iowa State University	Ames, Iowa 50011	Argonaut	10 kW	1
9	Kansas State University	Manhattan, KA 66506	Open pool TRIGA	250 kW	2
10	Manhattan College	Riverdale, NY 10471	Open pool plate fuel	0.1 W	1

Table 4A.2. (continued)

Ref. no.	Institution	Location	Type	Power	Fuel type category
11	Massachusetts Institute of Technology	Cambridge, MA 02139	Tank type plate fuel (constructed by ACF Industries)	4.9 MW	1
12	Memphis State University	Memphis, TN 38152	AGN-201	0.1 W	3
13	Michigan State University	E. Lansing, MI 48824	TRIGA Mk I open pool type	250 kW	2
14	North Carolina State University	Raleigh, NC 27650	PULSTAR pool type	1 MW	4
15	Ohio State University	Columbus, OH 43212	Open pool plate type	10 kW	1
16	Oregon State University	Corvallis, OR 97331	Open pool TRIGA	1 MW	2
17	Pennsylvania State University	University Park, PA 16802	Open pool TRIGA Mk III	1 MW	2
18	Purdue University	W. Lafayette, IN 47907	Open pool plate type	10 kW	1
19	Reed College	Portland, OR 97202	Open pool TRIGA Mk I	250 kW	2
20	Rensselaer Polytechnic Institute	Troy, NY 12181	Tank type plate fuel	Critical assembly (100 W)	1

Table 4A.2. (continued)

Ref. no.	Institution	Location	Type	Power	Fuel type category
21	State University of New York	Buffalo, NY 14214	Open tank type PULSTAR	2 MW	4
22	Texas A&M University	College Station, TX 77843	AGN-201	5 W	3
23	Texas A&M University	College Station, TX 77843	Open pool TRIGA	1 MW	2
24	University of Arizona	Tucson, AR 85721	Open pool TRIGA	100 kW	2
25	University of California, Berkeley	Berkeley, CA 97420	Open pool TRIGA	1 MW	2
26	University of California, Irvine	Irvine, CA 92717	Open pool TRIGA Mk I	250 kW	2
27	University of California, Los Angeles	Los Angeles, CA 90024	Argonaut plate type	100 kW	1
28	University of California, Santa Barbara[a]	Santa Barbara, CA 93106	Liquid fuel[a]	10 W	5
29	University of Florida	Gainesville, FL 32611	Argonaut plate type	100 kW	1
30	University of Illinois	Urbana, IL 61801	Open pool TRIGA	1 W	2

Table 4A.2. (continued)

Ref. no.	Institution	Location	Type	Power	Fuel type category
31	University of Illinois	Urbana, IL 61801	Open pool TRIGA	1.5 MW	2
32	University of Kansas	Lawrence, KA 66045	Open pool plate type	10 kW	1
33	University of Lowell	Lowell, MA 01854	Open pool plate type	1 MW	1
34	University of Maryland	College Park, MD 20740	Open pool TRIGA	250 kW	2
35	University of Michigan	Ann Arbor, MI 48109	Open pool plate type	2 MW	1
36	University of Missouri, Columbia	Columbia, MO 65211	Open pool plate type	10 MW	1
37	University of Missouri, Rolla	Rolla, MO 65401	Open pool plate type	200 kW	1
38	University of New Mexico	Albuquerque, NM 87131	AGN-201	5 W	3
39	University of Oklahoma	Norman, OK 73019	AGN-211P Open pool, poly-ethylene block fuel	15 W	3
40	University of Texas	Austin, TX 78712	Open pool TRIGA Mk I modified	250 kW	2

Table 4A.2. (continued)

Ref. no.	Institution	Location	Type	Power	Fuel type category
41	University of Utah	Salt Lake City, UT 84112	AGN type (refer to Catholic University for details)	5 W	3
42	University of Utah	Salt Lake City, UT 84112	TRIGA Open pool	100 kW	2
43	University of Virginia	Charlottesville, VA 22901	Open pool plate type	100 W	1
44	University of Virginia	Charlottesville, VA 22901	Open pool plate type	2 MW	1
45	University of Washington	Seattle, WA 98195	Argonaut	100 kW	1
46	University of Wisconsin	Madison, WI 53706	Open pool TRIGA FLIP	1 MW	2
47	Virginia Polytechnic Institute	Blacksburg, VA 24060	Argonaut	100 kW	1
48	Washington State University	Pullman, WA 99164	Open pool TRIGA	1 MW	2
49	Worcester Polytechnic Institute	Worcester, MA 01609	Open pool (plate fuel)	10 kW	1
50	Rhode Island Nuclear Science Center	Narragansett, RI 02882	Open pool plate type	2 MW	1

[a]Reactor has been decommissioned and fuel has been shipped to DOE.

Table 4A.3. Shipments of fresh fuel to large university reactors[a]

Reactor location	Power	Type of fuel element	Average number of new fuel elements shipped per year	U-235 content per element (grams)
University of Missouri Columbia, Missouri	10 MW	plate	24	750
University of Michigan Ann Arbor, Michigan	2 MW	plate	18	167
University of Virginia Charlottesville, Virginia	2 MW	plate	6	195
Rhode Island Nuclear Science Center Narragansett, Rhode Island	2 MW	plate	18	126
University of Lowell Lowell, Massachusetts	1 MW	plate	4–5	126
Texas A & M University College Station, Texas	2 MW	TRIGA		
Pennsylvania State University University Park, Pennsylvania	1 MW	TRIGA	3–4	

[a]Data provided by EG&G, Idaho Falls, Idaho.

Table 4A.4. University of Michigan fuel element numbers[a]

Reactor location: University of Michigan, Ann Arbor, Michigan
2 MW (see Appendix A, Reactor No. 35)

Total number of elements listed: 103

Element numbers:

MI-01	MI-20	MI- 39	MI-202	MI-219	MI-236*
02	21	40	203	220	237*
03	22	41	204	221	238*
04	23	42	205	222	239*
05	24	43	206	223	240*
06	25	44	207	224	241*
07	28	45	208	225	242*
09	29	46	209	226	243*
10	30	47	210	227	244*
11	31	48	211	228	245*
12	32	49	212	229*	246*
13	33	50	213	230*	247*
15	34	51	214	231*	248*
16	35	53	215	232*	249*
17	36	54	216	233*	250*
18	37	200	217	234*	251*
19	38	201	218	235*	252*
					253*

[a]Source: EG&G, Idaho Falls, Idaho. Date: January 13, 1986.

*Elements marked with an asterisk are currently stored at Babcock and Wilcox, Lynchburg, VA.

Table 4A.5. University of Missouri fuel element numbers[a]

Reactor location: University of Missouri, Columbia, Missouri
10 MW (see Appendix A, Reactor No. 36)

Total number of elements listed: 174

Element numbers:

MO-01	MO-32	MO-67	MO- 99	MO-131	MO-164
02	33	68	100	132	165
03	34	69	101	133	200
04	35	70	102	134	201
05	36	71	103	135	202
06	37	72	104	136	203
07	38	73	105	138	205
08	39	74	106	138	205
09	40	75	107	140	206
10	41	76	108	141	207
11	42	77	109	142	208
12	43	78	111	143	209
13	44	79	112	144	210
14	45	80	113	145	211
15	46	81	114	146	212
16	47	82	115	147	213
17	48	83	116	148	214
18	53	84	117	149	215*
19	54	85	118	150	216*
20	55	87	119	151	
21	56	88	120	152	
22	57	89	121	153	
23	58	90	122	154	
24	59	91	123	155	
25	60	92	124	156	
26	61	93	125	157	
27	62	94	126	158	
28	63	95	127	159	
29	64	96	128	160	
30	65	97	129	161	
31	66	98	130	162	

[a]Source: EG&G, Idaho Falls, Idaho. Date: January 13, 1986.

*Elements marked with an asterisk are currently stored at Babcock and Wilcox, Lynchburg, VA.

Table 4A.6. Rhode Island Nuclear Science Center and University of Lowell fuel element numbers[a]

Reactor locations: Rhode Island Nuclear Science Center, Narragansett, RI
2 MW (see Appendix A, Reactor No. 50)

University of Lowell, Lowell, Mssachusetts
1 MW (see Appendix A, Reactor No. 33)

Total number of elements listed: 64

Element numbers:

RI-127	RI-142	RI-158	RI-174	RI-189
128	144	159	175	190
129	145	160	176	191
130	146	161	177	192
131	147	162	178	
132	148	163	179	
133	149	164	180	
135	150	166	181	
136	151	167	182	
137	153	169	184	
138	154	170	185	
139	155	171	186	
140	156	172	187	
141	157	173	188	

[a]Source: EG&G, Idaho Falls, Idaho. These fuel elements are usable in both of the reactors listed here.

Table 4A.7. University of Virginia fuel element numbers[a]

Reactor location: University of Virginia, Charlottesville, Va.
2 M (see Appendix A, Reactor No. 44)

Total number of elements listed: 26

Element numbers:

VI-001	VI-014*
002	015*
003	016*
004	017*
005	018
006	019
007	020
008	021
009	023
010	024
011	025*
012	026*
013	027*

[a]Source: EG&G, Idaho Falls, Idaho. Date: January 13, 1986.

*Elements marked with an asterisk are currently stored at Babcock and Wilcox, Lynchburg, VA.

Table 4A.8. Massachusetts Institute of Technology fuel element numbers[a]

Reactor location: Massachusetts Institute of Technology, Cambridge, Mass.
4.9 MW (see Appendix A, Reactor No. 11)

Total number of elements listed: 41

Element numbers:

MIT-01	MIT-22
02	23
03	24
04	25
05	32
06	33
07	34
08	35
09	36
10	37
11	38
12	39
13	40*
14	41
15	42
16	43
17	44*
18	45*
19	46*
20	47*
21	

[a]Source: EG&G, Idaho Falls, Idaho. Date: January 13, 1986.

*Elements marked with an asterisk are currently stored at Babcock and Wilcox, Lynchburg, VA.

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APPENDIX 4B. DATA SHEETS FOR NUCLEAR REACTORS AT EDUCATIONAL INSTITUTIONS IN THE UNITED STATES

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REACTOR NO. 1

REACTOR NAME Brigham Young University Reactor L-77

LOCATION Brigham Young University, Provo, UT 84602

POWER 10 W

LICENSE NO. NRC DOCKET NO. R-109 50-262

TYPE Atomics International Model L-77

STATUS Operational

FUEL ELEMENT

DESCRIPTION Liquid fuel

OVERALL DIMENSIONS

kg U-235 PER ELEMENT

ELEMENTS PER REACTOR

ENRICHMENT (% U-235) 20

DRAWING NO.

SUPPLIER Atomics International

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR		1.45
OUT OF REACTOR, FRESH FUEL		0.055
OUT OF REACTOR, SPENT FUEL		
TOTAL		1.505
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE None

SPENT FUEL SHIPMENTS None

NAMES OF PERSONS TO CONTACT: J. Rex Goates, Administrator, 801-378-2093

Dwight R. Dixon, Facility Chief, 801-378-2093

Gary Lee Jensen, Sr. Operator, 801-378-2093

7 0 0 0 8 2 6 8 1

REACTOR NO. 2

REACTOR NAME Catholic University AGN-201 CU

LOCATION The Catholic University of America, Washington, DC 20064

POWER 0.1 W

LICENSE NO. NRC DOCKET NO. R-31 50-77

TYPE Aerojet General Nucleonics AGN-201

STATUS Operational

FUEL ELEMENT

DESCRIPTION UO_2-polyethylene discs

OVERALL DIMENSIONS 25.75 cm diam, thickness 3.9, 2.3, and 1.0 cm

kg U-235 PER ELEMENT

ELEMENTS PER REACTOR 9 discs per reactor

ENRICHMENT (% U-235) 19.9

DRAWING NO.

SUPPLIER Aerojet General Nucleonics

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	9	0.69
OUT OF REACTOR, FRESH FUEL	0	0
OUT OF REACTOR, SPENT FUEL	0	0
TOTAL	9	0.69
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE None anticipated

SPENT FUEL SHIPMENTS None

NAMES OF PERSONS TO CONTACT: Edward Jordan, Reactor Administrator 202-635-5170

Y. C. Whang, Chairperson, Mech. Eng. Dept.

D. D. Ebert, Reactor Supervisor

REACTOR NO. 3

REACTOR NAME Columbia University TRIGA Mk II

LOCATION Columbia University, 520 W. 120 St., New York, NY 10027

POWER 250 kW

LICENSE NO. NRC DOCKET NO. R-128 50-208

TYPE Open pool, TRIGA Mk II

STATUS Built but never operated

FUEL ELEMENT

DESCRIPTION Cylindrical pins, 3.74 cm diam x 72.05 cm long

OVERALL DIMENSIONS

kg U-235 PER ELEMENT

ELEMENTS PER REACTOR 65-80

ENRICHMENT (% U-235) 20

DRAWING NO.

SUPPLIER General Atomic

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR		
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL		
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE None anticipated

SPENT FUEL SHIPMENTS None

NAMES OF PERSONS TO CONTACT: Prof. Charles F. Bonilla, 212-280-4441

Prof. Edward Melkonian, 212-280-4442

REACTOR NO. 4

REACTOR NAME Cornell University TRIGA Mk II

LOCATION Cornell University, Ward Laboratory, Ithaca, NY 14853

POWER 100 kW

LICENSE NO. NRC DOCKET NO. R-80 50-157

TYPE TRIGA Mk II

STATUS Operational

FUEL ELEMENT

DESCRIPTION Cylindrical pin

OVERALL DIMENSIONS

kg U-235 PER ELEMENT

ELEMENTS PER REACTOR

ENRICHMENT (% U-235)

DRAWING NO.

SUPPLIER General Atomic

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR		
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL		
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: David Clark, 607-256-3480

Howard Aderhold

70003 2634

REACTOR NO. 5

REACTOR NAME Cornell University Zero Power Reactor

LOCATION Cornell University, Ward Laboratory, Ithaca, NY 14850

POWER 100 W

LICENSE NO. NRC DOCKET NO. R-89 50-97

TYPE Open tank critical facility

STATUS Operational

FUEL ELEMENT

DESCRIPTION Cylindrical pin

OVERALL DIMENSIONS 1.52 cm diam x 121.92 cm long

kg U-235 PER ELEMENT

ELEMENTS PER REACTOR

ENRICHMENT (% U-235) 2.1

DRAWING NO.

SUPPLIER

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR		
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL		
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: David Clark, 607-256-3480

Howard Aderhold

7 0 0 0 8 2 6 8 5

REACTOR NO. 6

REACTOR NAME Georgia Tech Research Reactor

LOCATION Georgia Institute of Technology, Nuclear Research Center, 900 Atlantic Dr., NW, Atlantic, GA 30332

POWER 5 MW

LICENSE NO. NRC DOCKET NO. R-97 50-160

TYPE Tank type, heavy water moderated and cooled

STATUS Operational

FUEL ELEMENT

DESCRIPTION 18 curved plates per element, (16 fueled, 2 unfueled)

OVERALL DIMENSIONS 7.52 cm x 7.04 cm x 219.41 cm

kg U-235 PER ELEMENT 0.19

ELEMENTS PER REACTOR 17

ENRICHMENT (% U-235) 93

DRAWING NO.

SUPPLIER

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	17	3.01
OUT OF REACTOR, FRESH FUEL	0	0
OUT OF REACTOR, SPENT FUEL	0	0
TOTAL	17	3.01
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE 2 elements per 90 MW-days

SPENT FUEL SHIPMENTS spent fuel has been shipped to SRP in BMI-1 cask

NAMES OF PERSONS TO CONTACT: Dr. John L. Russel, 404-894-3606

Robert S. Kirkland

7 0 0 0 8 2 6 3 6

REACTOR NO. 7

REACTOR NAME Idaho State University AGN-201 M

LOCATION Idaho State University, Lillibridge Engineering Laboratory, Pocatello, Idaho 83209

POWER 5W

LICENSE NO. NRC DOCKET NO. R-110 50-284

TYPE Aerojet General Nucleonics AGN-201 M

STATUS Operational

FUEL ELEMENT

DESCRIPTION Discs of dispersed UO_2 in polyethylene

OVERALL DIMENSIONS 25.0 cm diam; thickness 5.0, 2.5, or 1.0 cm

kg U-235 PER ELEMENT

ELEMENTS PER REACTOR 9 discs per reactor

ENRICHMENT (% U-235) 19.88

DRAWING NO.

SUPPLIER

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	9	0.67
OUT OF REACTOR, FRESH FUEL		0
OUT OF REACTOR, SPENT FUEL		0
TOTAL	9	0.67
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE None anticipated

SPENT FUEL SHIPMENTS None

NAMES OF PERSONS TO CONTACT: Albert E. Wilson, Reactor Administrator, 208-236-2417

Terry W. Smith, Reactor Supervisor, 208-236-2311

7 0 0 0 3 2 6 3 7

REACTOR NO. 8

REACTOR NAME Iowa State University Research Reactor

LOCATION Iowa State University, Ames, Iowa

POWER 10 kW

LICENSE NO. NRC DOCKET NO.

TYPE ARGONAUT

STATUS operational

FUEL ELEMENT

DESCRIPTION rectangular fuel plates, 12 plates per element

OVERALL DIMENSIONS 7.62 cm x 15.24 cm x 66.04 cm

kg U-235 PER ELEMENT approximately 0.266

ELEMENTS PER REACTOR 12

ENRICHMENT (% U-235) 90

DRAWING NO.

SUPPLIER American Standard

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	12	3.19
OUT OF REACTOR, FRESH FUEL	2 plates	
OUT OF REACTOR, SPENT FUEL		
TOTAL	12	
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE approximately every 2 years

SPENT FUEL SHIPMENTS fuel has been shipped to Oak Ridge

NAMES OF PERSONS TO CONTACT: Dr. C. Hendrickson 515-294-6422

REACTOR NO. 9

REACTOR NAME Kansas State University Nuclear Reactor Facility

LOCATION Kansas State University, Manhattan, KA 66506

POWER 250 kW

LICENSE NO. NRC DOCKET NO. R-88 50-188

TYPE TRIGA

STATUS Operational

FUEL ELEMENT

DESCRIPTION cylindrical pin, 3.74 cm diam x 72.05 cm long

OVERALL DIMENSIONS 3.74 cm x 72.05 cm

kg U-235 PER ELEMENT 0.034

ELEMENTS PER REACTOR 80

ENRICHMENT (% U-235) <20%

DRAWING NO.

SUPPLIER General Atomic

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	80	2.70
OUT OF REACTOR, FRESH FUEL	0	0
OUT OF REACTOR, SPENT FUEL	8	0.27
TOTAL	88	2.97
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE None stated

SPENT FUEL SHIPMENTS None stated

NAMES OF PERSONS TO CONTACT: Richard E. Faw, Director, 913-532-5624

Timothy M. DeBey, Reactor Supervisor

7 0 0 0 8 2 5 3 9

REACTOR NO. 10

REACTOR NAME Manhattan College Zero Power Reactor

LOCATION Manhattan College, Leo Engineering Building, Riverdale, NY 10471

POWER 0.1 W

LICENSE NO. NRC DOCKET NO. R-94 50-199

TYPE Open pool

STATUS Operational

FUEL ELEMENT

DESCRIPTION 6 concentric cylinders of 3 plates each

OVERALL DIMENSIONS 8.89 cm diam x 93.98 cm long

kg U-235 PER ELEMENT

ELEMENTS PER REACTOR 16

ENRICHMENT (% U-235) 92%

DRAWING NO.

SUPPLIER Sylcor, Hicksville, NY

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	16	3.02
OUT OF REACTOR, FRESH FUEL	0	0
OUT OF REACTOR, SPENT FUEL	0	0
TOTAL	16	3.02
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE None anticipated

SPENT FUEL SHIPMENTS None

NAMES OF PERSONS TO CONTACT: Dr. Ronald S. Kane, 212-920-0145

Dr. Joseph Augustus

7 0 0 0 8 2 6 9 0

REACTOR NO. 11

REACTOR NAME MIT Research Reactor (MITR-II)

LOCATION Massachusetts Institute of Technology Nuclear, Reactor Laboratory, 138 Albany St., Cambridge, MA 02139

POWER 4.9 MW

LICENSE NO. NRC DOCKET NO. R-37 50-20

TYPE Tank type, plate fuel

STATUS Operational

FUEL ELEMENT

DESCRIPTION Flat plates, 15 per element

OVERALL DIMENSIONS 6.11 cm x 66.68 cm

kg U-235 PER ELEMENT 0.51

ELEMENTS PER REACTOR 24

ENRICHMENT (% U-235) 93

DRAWING NO.

SUPPLIER Babcock and Wilcox

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	24	12.2
OUT OF REACTOR, FRESH FUEL	0	0
OUT OF REACTOR, SPENT FUEL	0	0
TOTAL	24	12.2
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE 1 element every 17 operating days

SPENT FUEL SHIPMENTS SRP, Aiken, SC, or INEL, Idaho

NAMES OF PERSONS TO CONTACT: O. K. Harling, 617-253-4202

L. Clark, Jr.

J. Bernard

7 0 0 0 8   2 6 9 1

REACTOR NO. 12

REACTOR NAME Memphis State University AGN-201-108

LOCATION Memphis State University, Center for Nuclear Studies, Memphis, TN 38152

POWER 0.1 W

LICENSE NO. NRC DOCKET NO. R-127 50-538

TYPE Aerojet General Nucleonics AGN-201

STATUS Operational

FUEL ELEMENT

DESCRIPTION UO_2-polyethylene discs

OVERALL DIMENSIONS 25.4 cm diam, thickness 4.0, 2.0, and 1.0 cm

kg U-235 PER ELEMENT

ELEMENTS PER REACTOR 9 discs per reactor

ENRICHMENT (% U-235) 19.9

DRAWING NO.

SUPPLIER Fuel available from decommissioned reactors

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	9	0.66
OUT OF REACTOR, FRESH FUEL	0	0
OUT OF REACTOR, SPENT FUEL	0	0
TOTAL	9	0.66
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE None anticipated

SPENT FUEL SHIPMENTS to Oak Ridge National Laboratory, Oak Ridge, TN in DOT type 6J drums

NAMES OF PERSONS TO CONTACT: Dr. D. W. Jones, 901-454-2687

R. L. Dietz

7 0 0 0 8 2 6 9 2

REACTOR NO. 13

REACTOR NAME Michigan State University TRIGA Mk I

LOCATION Michigan State University, Nuclear Reactor Laboratory, East Lansing, MI 48824

POWER 250 kW

LICENSE NO. NRC DOCKET NO. R-114 50-294

TYPE pool type, TRIGA Mk I

STATUS Operational

FUEL ELEMENT

DESCRIPTION cylindrical pin

OVERALL DIMENSIONS 3.76 cm diam x 72.39 cm long

kg U-235 PER ELEMENT

ELEMENTS PER REACTOR

ENRICHMENT (% U-235) 20

DRAWING NO.

SUPPLIER General Atomic

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR		
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL		
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE Not stated

SPENT FUEL SHIPMENTS Not stated

NAMES OF PERSONS TO CONTACT: Mr. Bruce Wilkinson, 517-353-9097

517-355-3444

7 0 0 0 8 2 6 9 3

REACTOR NO. 14

REACTOR NAME North Carolina State University PULSTAR

LOCATION North Carolina State University, Department of Nuclear Engineering, Raleigh, NC 27650

POWER 1 MW

LICENSE NO. NRC DOCKET NO. R-120 50-297

TYPE PULSTAR, pool type

STATUS Operational

FUEL ELEMENT

DESCRIPTION element consists of 25 pins in 5 x 5 array

OVERALL DIMENSIONS 8.0 cm x 6.96 cm x 96.47 cm

kg U-235 PER ELEMENT 0.57

ELEMENTS PER REACTOR 25

ENRICHMENT (% U-235) 4

DRAWING NO.

SUPPLIER Westinghouse Canada

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR		14.36
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL		
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE Not stated

SPENT FUEL SHIPMENTS None

NAMES OF PERSONS TO CONTACT: Dr. Robert G. Cockrell, 919-737-2322 and 2323

Thomas C. Bray

David P. Coccamo

7 0 0 0 8 2 6 9 4

REACTOR NO. 15

REACTOR NAME Ohio State University Research Reactor

LOCATION Ohio State University, 1298 Kinnear Road, Columbus, Ohio 43212

POWER 10 kW

LICENSE NO. NRC DOCKET NO. R-75 50-150

TYPE open pool type, plate fuel

STATUS operational

FUEL ELEMENT

DESCRIPTION 10 plates per element

OVERALL DIMENSIONS 7.62 cm x 7.62 cm x 88.9 cm

kg U-235 PER ELEMENT 0.14

ELEMENTS PER REACTOR 20

ENRICHMENT (% U-235) 93

DRAWING NO.

SUPPLIER Texas Instruments, Dallas, TX

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	20	3.18
OUT OF REACTOR, FRESH FUEL	0	0
OUT OF REACTOR, SPENT FUEL	0	0
TOTAL	20	3.18
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE None anticipated

SPENT FUEL SHIPMENTS None

NAMES OF PERSONS TO CONTACT: Don W. Miller, Director 614-422-6755

Brian K. Hajek

Richard D. Myser

7 9 0 0 8   2 6 9 5

REACTOR NO. 16

REACTOR NAME Oregon State TRIGA Reactor

LOCATION Oregon State University, Radiation Center, Corvallis, Oregon 97331

POWER 1 MW

LICENSE NO. NRC DOCKET NO. R-106 50-243

TYPE open pool, TRIGA type

STATUS operational

FUEL ELEMENT

DESCRIPTION cylindrical pin

OVERALL DIMENSIONS 3.73 cm diam x 72.06 cm

kg U-235 PER ELEMENT approx. 0.13

ELEMENTS PER REACTOR 85

ENRICHMENT (% U-235)

DRAWING NO.

SUPPLIER General Atomic

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	85	11.17
OUT OF REACTOR, FRESH FUEL	0	0
OUT OF REACTOR, SPENT FUEL	0	0
TOTAL	85	
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE About 1 element/year

SPENT FUEL SHIPMENTS One shipment made to HEDL in BMI-1 cask

NAMES OF PERSONS TO CONTACT: Dr. C. H. Wang, Director 503-754-2341

A. G. Johnson

Dr. B. Dodd

REACTOR NO. 17

REACTOR NAME Penn State Brazeale Reactor

LOCATION Brazeale Nuclear Reactor, Pennsylvania State University,
University Park, PA 16802

POWER 1 MW

LICENSE NO. NRC DOCKET NO. R-2 50-5

TYPE Open pool, TRIGA Mk III

STATUS Operational

FUEL ELEMENT

DESCRIPTION Cylindrical pin

OVERALL DIMENSIONS 3.73 cm diam x 72.14 cm long

kg U-235 PER ELEMENT 0.056

ELEMENTS PER REACTOR 95

ENRICHMENT (% U-235) 20

DRAWING NO.

SUPPLIER General Atomic

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	95	3.42
OUT OF REACTOR, FRESH FUEL	0	0
OUT OF REACTOR, SPENT FUEL	0	0
TOTAL	95	3.42
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE About 6 elements every 2 years

SPENT FUEL SHIPMENTS Spent fuel stored on site

NAMES OF PERSONS TO CONTACT: Samuel H. Levine, Director, 814-865-6351
Ira B. McMaster, Deputy Director

REACTOR NO. 18

REACTOR NAME Purdue University Reactor

LOCATION School of Nuclear Engineering, Purdue University,
West Lafayette, Indiana 47907

POWER 10 kW

LICENSE NO. NRC DOCKET NO. R-87 50-182

TYPE Open pool, plate fuel

STATUS Operational

FUEL ELEMENT

DESCRIPTION 10 plates per fuel element

OVERALL DIMENSIONS 7.52 cm x 7.52 cm x 81.92 cm

kg U-235 PER ELEMENT 0.17

ELEMENTS PER REACTOR

ENRICHMENT (% U-235) 93

DRAWING NO.

SUPPLIER

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR		
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL		
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE Not stated

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Paul S. Lyroudis, 317-494-5764
Frank M. Clikeman
Eldon R. Stansberry

7 0 0 0 8   2 6 9 8

REACTOR NO. 19

REACTOR NAME Reed Reactor Facility

LOCATION Reed College, Portland, Oregon 97202

POWER 250 kW

LICENSE NO. NRC DOCKET NO. R-112 50-288

TYPE Open pool, TRIGA Mk I

STATUS Operational

FUEL ELEMENT

DESCRIPTION Cylindrical pin

OVERALL DIMENSIONS 3.73 cm diam x 72.14 cm long

kg U-235 PER ELEMENT approx. 0.038

ELEMENTS PER REACTOR 60

ENRICHMENT (% U-235) 20

DRAWING NO.

SUPPLIER General Atomic

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	60	2.3
OUT OF REACTOR, FRESH FUEL	0	0
OUT OF REACTOR, SPENT FUEL	0	0
TOTAL	60	2.3
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE About 1 element every 5 years

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: M. A. Kay, Director, 503-771-1112

C. A. Grant

Ross Mercer

7 0 9 0 8 2 6 9 9

REACTOR NO. 20

REACTOR NAME Rensselaer Critical Experiment Facility

LOCATION Nuclear Engineering Department, Rensselaer Polytechnic Institute, Troy, New York 12181

POWER 100 W

LICENSE NO. NRC DOCKET NO. CX-22 50-225

TYPE Tank type critical facility

STATUS Operational

FUEL ELEMENT

DESCRIPTION MTR-type plate fuel, 9 plates per element

OVERALL DIMENSIONS 7.54 cm x 7.54 cm x 68.58 cm

kg U-235 PER ELEMENT

ELEMENTS PER REACTOR

ENRICHMENT (% U-235) 93.07

DRAWING NO.

SUPPLIER

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR		
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL		
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Dr. Donald R. Harris, Director, 518-393-4281

Dr. Frank Wicks, Supervisor, 518-270-6403

REACTOR NO. 50

REACTOR NAME Rhode Island Nuclear Science Center

LOCATION Rhode Island Nuclear Science Center, Narragansett, Rhode Island 02882

POWER 2 MW

LICENSE NO. NRC DOCKET NO. R-95 50-193

TYPE open pool, plate fuel

STATUS operational

FUEL ELEMENT

DESCRIPTION 18 flat plates per element

OVERALL DIMENSIONS 7.62 cm x 7.62 cm x 100.33 cm

kg U-235 PER ELEMENT 0.12

ELEMENTS PER REACTOR 35

ENRICHMENT (% U-235) 93

DRAWING NO.

SUPPLIER Babcock and Wilcox, Lynchburg, VA

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	35	3.47
OUT OF REACTOR, FRESH FUEL	15	
OUT OF REACTOR, SPENT FUEL		
TOTAL		
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE about 18 elements/yr

SPENT FUEL SHIPMENTS shipped to SRP in BMI-1 cask

NAMES OF PERSONS TO CONTACT: A. Francis DiMeglio, Director RIAEC 401-789-9391

M. P. Doyle

7 0 0 0 8 2 7 2 8

REACTOR NO. 49

REACTOR NAME Worcester Polytechnic Institute Reactor

LOCATION Worcester Polytechnic Institute, Worcester, Massachusetts 01609

POWER 10 KW

LICENSE NO. NRC DOCKET NO. R-61 50-134

TYPE open pool, plate fuel

STATUS operational

FUEL ELEMENT

DESCRIPTION 10 flat plates per element

OVERALL DIMENSIONS 7.75 cm x 7.75 cm x 101.6 cm

kg U-235 PER ELEMENT 0.14

ELEMENTS PER REACTOR 24

ENRICHMENT (% U-235) 93

DRAWING NO.

SUPPLIER General Electric

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	24	3.26
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL	24	3.26
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE none anticipated

SPENT FUEL SHIPMENTS none shipped

NAMES OF PERSONS TO CONTACT: Prof. Leslie C. Wilbur, 617-793-5276

617-793-5688

7 0 0 0 8   2 7 2 7

REACTOR NO. 48

REACTOR NAME Washington State University Reactor

LOCATION Washington State University, Pullman, Washington 99164

POWER 1 MW

LICENSE NO. NRC DOCKET NO. R-76 50-27

TYPE open pool, TRIGA

STATUS operational

FUEL ELEMENT

DESCRIPTION cylindrical pin, one pin per element

OVERALL DIMENSIONS (cluster of 4) 7.92 cm x 7.92 cm x 93.9 cm

kg U-235 PER ELEMENT approximately 0.061

ELEMENTS PER REACTOR 110

ENRICHMENT (% U-235) 20 and 70

DRAWING NO.

SUPPLIER GA Technologies

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	110	6.7
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL	110	6.7
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE

SPENT FUEL SHIPMENTS none

NAMES OF PERSONS TO CONTACT: Dr. R. Filby, 509-335-8317

W. E. Wilson

J. Neidiger

7 0 0 0 3 2 7 2 6

REACTOR NO. 47

REACTOR NAME Virginia Polytechnic Institute and State University Research Reactor

LOCATION Virginia Polytechnic Institute and State University, Blacksburg, VA 24060

POWER 100 KW

LICENSE NO. NRC DOCKET NO. R-62 50-124

TYPE ARGONAUT

STATUS operational

FUEL ELEMENT

DESCRIPTION rectangular fuel plates, 12 plates per element

OVERALL DIMENSIONS 7.62 cm x 15.24 cm x 66.04 cm

kg U-235 PER ELEMENT approximately 0.266

ELEMENTS PER REACTOR 12

ENRICHMENT (% U-235) 90

DRAWING NO.

SUPPLIER American Standard

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	12	3.19
OUT OF REACTOR, FRESH FUEL	2 plates	
OUT OF REACTOR, SPENT FUEL		
TOTAL	12	
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE approximately every 2 years

SPENT FUEL SHIPMENTS none

NAMES OF PERSONS TO CONTACT: T. F. Parkinson, 703-961-6510

P. D. Holian

REACTOR NO. 46

REACTOR NAME University of Wisconsin Nuclear Reactor

LOCATION University of Wisconsin, Mechanical Engineering Building, Madison, Wisconsin 53706

POWER 1 MW

LICENSE NO. NRC DOCKET NO. R-74 50-156

TYPE open pool, TRIGA FLIP

STATUS operational

FUEL ELEMENT

DESCRIPTION cylindrical pin (one pin per element)

OVERALL DIMENSIONS 3.58 cm diam x 68.3 cm

kg U-235 PER ELEMENT ~0.348 (8.5% total U)

ELEMENTS PER REACTOR 91

ENRICHMENT (% U-235) 70

DRAWING NO.

SUPPLIER GA Technologies

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	91	8.0
OUT OF REACTOR, FRESH FUEL	18	
OUT OF REACTOR, SPENT FUEL	116	
TOTAL	225	
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE 10 years

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: R. J. Cashwell, Director, 608-262-3392

S. M. Matusewic

7 0 0 0 3   2 7 2 4

REACTOR NO. 45

REACTOR NAME University of Washington Nuclear Reactor

LOCATION University of Washington Nuclear Reactor Bldg., Seattle, Washington 98195

POWER 100 KW

LICENSE NO. NRC DOCKET NO. R-73 50-139

TYPE Argonaut

STATUS operational

FUEL ELEMENT

DESCRIPTION flat plates, 11 plates per element

OVERALL DIMENSIONS 7.11 cm x 6.1 cm x 65.09 cm

kg U-235 PER ELEMENT ~0.143

ELEMENTS PER REACTOR 24

ENRICHMENT (% U-235) 93

DRAWING NO.

SUPPLIER Babcock & Wilcox

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	24	3.43
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL	24	3.43
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE no refueling anticipated

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: William S. Chalk, Director, 206-543-4170

William P. Miller

7 0 0 0 3   2 7 2 3

REACTOR NO. 44

REACTOR NAME University of Virginia Reactor

LOCATION University of Virginia Reactor Facility, Charlottesville, VA 22901

POWER 2 MW

LICENSE NO. NRC DOCKET NO. R-66 50-62

TYPE open pool, plate fuel

STATUS operational

FUEL ELEMENT

DESCRIPTION either 18 curved plates or 12 flat plates

OVERALL DIMENSIONS 7.61 cm x 8.26 cm x 93.66 cm

kg U-235 PER ELEMENT 0.19 (curved) or 0.17 (flat)

ELEMENTS PER REACTOR 20

ENRICHMENT (% U-235) 93

DRAWING NO.

SUPPLIER Atomics International

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	20	3.3
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL	20	3.3
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE

SPENT FUEL SHIPMENTS shipped to SRP in BMI-1 Cask

NAMES OF PERSONS TO CONTACT: Dr. J. S. Brenizer, 804-924-7136

J. P. Farrar

7 0 0 0 8 3 2 7 2 2

REACTOR NO. 43

REACTOR NAME University of Virginia CAVALIER

LOCATION University of Virginia Reactor Facility, Charlottesville, VA 22901

POWER 100 W

LICENSE NO. NRC DOCKET NO. R-123 50-396

TYPE open pool, plate type fuel

STATUS operational

FUEL ELEMENT

DESCRIPTION flat plates, 12 plates per element

OVERALL DIMENSIONS 7.61 cm x 8.26 cm x 93.66 cm

kg U-235 PER ELEMENT 0.165

ELEMENTS PER REACTOR

ENRICHMENT (% U-235) 93

DRAWING NO.

SUPPLIER

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR		
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL		
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Dr. J. S. Brenizer, 804-924-7136

J. P. Farrar

7 0 0 0 8   2 7 2 1

REACTOR NO. 42

REACTOR NAME University of Utah TRIGA Reactor

LOCATION University of Utah, Salt Lake City, Utah 84112

POWER 100 KW

LICENSE NO. NRC DOCKET NO. R-126   50-407

TYPE open pool, TRIGA

STATUS operational

FUEL ELEMENT

DESCRIPTION cylindrical pin, one pin per element

OVERALL DIMENSIONS 3.75 cm diam x 72.2 cm long

kg U-235 PER ELEMENT 0.037

ELEMENTS PER REACTOR 87

ENRICHMENT (% U-235) <20%

DRAWING NO.

SUPPLIER GA Technologies

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	84	2.90
OUT OF REACTOR, FRESH FUEL	2	0.074
OUT OF REACTOR, SPENT FUEL		
TOTAL	86	2.974
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE none anticipated

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: H. R. Jacobs, 801-581-7109

Gary M. Sandquist

Craig M. Jensen

REACTOR NO. 41

REACTOR NAME University of Utah AGN-201-107

LOCATION University of Utah, Merrill Engineering Bldg., Salt Lake City, UT 84112

POWER 5 W

LICENSE NO. NRC DOCKET NO. R-25 50-72

TYPE AGN-201 homogeneous disc fuel

STATUS operational

FUEL ELEMENT

DESCRIPTION UO_2-polyethylene discs

OVERALL DIMENSIONS 25.6 cm diam x 4.0, 2.0, and 1.0 cm thick

kg U-235 PER ELEMENT

ELEMENTS PER REACTOR 9

ENRICHMENT (% U-235) 19.5

DRAWING NO.

SUPPLIER Aerojet General Nucleonics

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	9	0.69
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL		
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE none anticipated

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Dr. Gray M. Sandquist, 801-581-7109

Dr. H. R. Jacobs, 801-581-7372

7 0 0 0 8   2 7 1 9

REACTOR NO. 40

REACTOR NAME University of Texas TRIGA Mk I

LOCATION University of Texas, Nuclear Engineering Teaching Laboratory, Austin, Texas 78712

POWER 250 KW

LICENSE NO. NRC DOCKET NO. R-92 50-192

TYPE open pool, TRIGA

STATUS operational

FUEL ELEMENT

DESCRIPTION cylindrical pin, one pin per element

OVERALL DIMENSIONS 3.76 cm diam x 72.06 cm long

kg U-235 PER ELEMENT (8.5 wt % U)

ELEMENTS PER REACTOR

ENRICHMENT (% U-235) 20

DRAWING NO.

SUPPLIER GA Technologies

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR		
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL		
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Dr. Dale Klein, 512-471-5136

Dr. T. L. Bauer

REACTOR NO. 39

REACTOR NAME University of Oklahoma AGN-211P

LOCATION University of Oklahoma, Nuclear Reactor Laboratory, Norman, OK 73019

POWER 15 W

LICENSE NO. NRC DOCKET NO. R-53 50-112

TYPE open pool, AGN-211

STATUS operational

FUEL ELEMENT

DESCRIPTION uranium oxide-polyethylene blocks (two blocks per element)

OVERALL DIMENSIONS 7.32 cm x 7.77 cm x 70.17 cm

kg U-235 PER ELEMENT

ELEMENTS PER REACTOR 12

ENRICHMENT (% U-235) 19.84

DRAWING NO.

SUPPLIER Aerojet General Nucleonic

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	12	0.81
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL	12	0.81
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE none anticipated

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Dr. C. W. Terrell, 405-325-5084

Johnny James

Dr. Duaine Lindstrom

7 0 0 0 8 2 7 1 7

REACTOR NO. 38

REACTOR NAME University of New Mexico AGN-201

LOCATION University of New Mexico, Nuclear Engineering Laboratory, Albuquerque, New Mexico 87131

POWER 5 W

LICENSE NO. NRC DOCKET NO. R-102 50-252

TYPE open pool, AGN-201

STATUS operational

FUEL ELEMENT

DESCRIPTION uranium oxide-polyethylene disc

OVERALL DIMENSIONS 25.6 cm diam, height 4.0, 2.0, and 1.0 cm,

kg U-235 PER ELEMENT

ELEMENTS PER REACTOR 9

ENRICHMENT (% U-235) 20

DRAWING NO.

SUPPLIER Aerojet General Nucleonics

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR		
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL		
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE none anticipated

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Dr. Craig Robertson, 505-277-5431

Dr. David Woodall

7 9 0 0 8 2 7 1 6

REACTOR NO. 37

REACTOR NAME University of Missouri-Rolla Reactor

LOCATION University of Missouri, Rolla, Missouri 65401

POWER 200 KW

LICENSE NO. NRC DOCKET NO. R-79 50-123

TYPE open pool, plate type fuel

STATUS operational

FUEL ELEMENT

DESCRIPTION 10 curved plates per element

OVERALL DIMENSIONS 7.57 cm x 8.74 cm x 87.0 cm

kg U-235 PER ELEMENT 0.17

ELEMENTS PER REACTOR 28

ENRICHMENT (% U-235) 89-93

DRAWING NO.

SUPPLIER W. R. Grace & Co., Erwin, Tennessee

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	28	2.85
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL		2.85
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE none anticipated

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Albert E. Bolon, Director, 314-341-4236

7 0 0 0 8 2 7 1 5

REACTOR NO. 36

REACTOR NAME University of Missouri Research Reactor

LOCATION University of Missouri, Research Park, Columbia, Missouri 65211

POWER 10 MW

LICENSE NO. NRC DOCKET NO. R-103 50-186

TYPE open pool, plate fuel

STATUS operational

FUEL ELEMENT

DESCRIPTION 24 curved plates per element

OVERALL DIMENSIONS 7.04 cm x 14.63 cm x 82.55 cm

kg U-235 PER ELEMENT 0.78

ELEMENTS PER REACTOR 8

ENRICHMENT (% U-235) 93.15

DRAWING NO.

SUPPLIER Atomic International/EG&G

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	8	6.2
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL	27	
TOTAL	35	
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE 8 elements every 2 weeks

SPENT FUEL SHIPMENTS shipped to SRP in GE-700 cask

NAMES OF PERSONS TO CONTACT: Don Alger, 314-882-4211

Charles McKibben

R. Brugger

7 0 0 0 8 2 7 1 4

REACTOR NO. 35

REACTOR NAME University of Michigan Ford Nuclear Reactor

LOCATION University of Michigan, North Campus, Ann Arbor, Michigan 48109

POWER 2 MW

LICENSE NO. NRC DOCKET NO. R-28 50-2

TYPE open pool, plate type fuel

STATUS operational

FUEL ELEMENT

DESCRIPTION curved plates, 18 plates per element

OVERALL DIMENSIONS 7.47 cm x 8.25 cm x 87.38 cm

kg U-235 PER ELEMENT 0.167

ELEMENTS PER REACTOR 39

ENRICHMENT (% U-235) 93 and 19.5

DRAWING NO.

SUPPLIER Babcock and Wilcox, Lynchburg, WV

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	35	6.35
OUT OF REACTOR, FRESH FUEL	43	
OUT OF REACTOR, SPENT FUEL	66	
TOTAL	144	
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE 1 element per 17 days

SPENT FUEL SHIPMENTS shipped to SRP in BMI-1 or GE USA-5942 cask

NAMES OF PERSONS TO CONTACT: William Kerr, 313-764-6223

Reed R. Burn

Gary M. Cook

7000327 13

REACTOR NO. 34

REACTOR NAME Maryland University Training Reactor

LOCATION University of Maryland, College Park, Maryland 20740

POWER 250 KW

LICENSE NO. NRC DOCKET NO. R-70 50-166

TYPE open pool, TRIGA

STATUS operational

FUEL ELEMENT

DESCRIPTION cylindrical pin

OVERALL DIMENSIONS 3.58 cm diam x 68.58 cm

kg U-235 PER ELEMENT approx. 0.0354

ELEMENTS PER REACTOR 96

ENRICHMENT (% U-235) 20

DRAWING NO.

SUPPLIER GA Technologies

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	96	3.4
OUT OF REACTOR, FRESH FUEL	0	0
OUT OF REACTOR, SPENT FUEL	0	0
TOTAL	96	3.4
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Ralph L. Belcher, Director, 301-454-2436

7900081 2712

REACTOR NO. 33

REACTOR NAME University of Lowell Nuclear Reactor

LOCATION University of Lowell, North Campus, Lowell, Mass. 01854

POWER 1 MW

LICENSE NO. NRC DOCKET NO. R-125 50-233

TYPE open pool, plate fuel

STATUS operational

FUEL ELEMENT

DESCRIPTION 18 flat plates per element

OVERALL DIMENSIONS 7.62 cm x 7.62 cm x 101.6 cm

kg U-235 PER ELEMENT 0.14

ELEMENTS PER REACTOR 26

ENRICHMENT (% U-235) 93

DRAWING NO.

SUPPLIER Atomics International

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	26	3.5
OUT OF REACTOR, FRESH FUEL	0	0
OUT OF REACTOR, SPENT FUEL	0	0
TOTAL	26	3.5
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Leon Beghian, 617-45205000, ext. 2232 and 2245

Thomas Wallace

George Chabot

7 0 0 0 3 2 7 1 1

REACTOR NO. 32

REACTOR NAME University of Kansas, Bendix Research and Training Reactor

LOCATION Nuclear Reactor Center, University of Kansas, Lawrence, Kansas 66045

POWER 10 KW

LICENSE NO. NRC DOCKET NO. R-78 50-148

TYPE open pool, plate type fuel

STATUS operational

FUEL ELEMENT

DESCRIPTION flat plate type, 10 plates/element

OVERALL DIMENSIONS 7.62 cm x 7.62 cm x 86.31 cm

kg U-235 PER ELEMENT 0.17

ELEMENTS PER REACTOR 16

ENRICHMENT (% U-235) 90

DRAWING NO.

SUPPLIER

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	16	2.50
OUT OF REACTOR, FRESH FUEL	2	0.34
OUT OF REACTOR, SPENT FUEL	0	0
TOTAL	18	2.84
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Russell Mesler, 913-864-3938

Harold Rosson

Benjamin Friesen

REACTOR NO. 31

REACTOR NAME University of Illinois TRIGA

LOCATION University of Illinois, Nuclear Reactor Laboratory, Urbana, IL 61801

POWER 1.5 MW

LICENSE NO. NRC DOCKET NO. R-115 50-151

TYPE open pool, TRIGA

STATUS operational

FUEL ELEMENT

DESCRIPTION cylindrical pin

OVERALL DIMENSIONS 3.73 cm diam x 71.12 cm long

kg U-235 PER ELEMENT about 0.038 (7.0 g/cc U235)

ELEMENTS PER REACTOR 100

ENRICHMENT (% U-235) 20

DRAWING NO.

SUPPLIER GA Technologies

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	100	3.8
OUT OF REACTOR, FRESH FUEL	8	0.30
OUT OF REACTOR, SPENT FUEL		0
TOTAL	108	4.10
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE about 2 elements/yr

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Gerald P. Beck, 217-333-0866

Craig Pohlod, 217-333-7755

Jerome J. Steerman

7 0 0 0 8   2 7 0 9

REACTOR NO. 30

REACTOR NAME University of Illinois Low Power Reactor

LOCATION University of Illinois, Nuclear Reactor Laboratory, Urbana, IL 61801

POWER 10 kW

LICENSE NO. NRC DOCKET NO. R-117 50-356

TYPE open pool, TRIGA

STATUS operational

FUEL ELEMENT

DESCRIPTION cylindrical pin

OVERALL DIMENSIONS 3.73 cm diam x 71.12 cm long

kg U-235 PER ELEMENT approx 0.038 (7.0 g/cc U235)

ELEMENTS PER REACTOR 55

ENRICHMENT (% U-235) 20

DRAWING NO.

SUPPLIER GA Technologies

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	55	2.09
OUT OF REACTOR, FRESH FUEL	0	0
OUT OF REACTOR, SPENT FUEL	0	0
TOTAL	55	2.09
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE none

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Gerald P. Beck, 217-333-0866

Craig Pohlod, 217-333-7755

Jerome J. Steerman

7 0 0 0 3 2 7 0 8

REACTOR NO. 29

REACTOR NAME University of Florida Training Reactor

LOCATION University of Florida, Nuclear Sciences Center, Gainesville, FL 32611

POWER 100 KW

LICENSE NO. NRC DOCKET NO. R-56 50-83

TYPE Argonaut (modified)

STATUS operational

FUEL ELEMENT

DESCRIPTION 11 flat plates per element

OVERALL DIMENSIONS 7.23 cm x 5.44 cm x 65.09 cm

kg U-235 PER ELEMENT

ELEMENTS PER REACTOR 24

ENRICHMENT (% U-235) 93

DRAWING NO.

SUPPLIER Babcock and Wilcox

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	24	3.35
OUT OF REACTOR, FRESH FUEL		0.17
OUT OF REACTOR, SPENT FUEL		0.00
TOTAL		3.52
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE refueled once to change from 20% to 93% enrichment

SPENT FUEL SHIPMENTS shipment made to SRP in National Lead Cask

NAMES OF PERSONS TO CONTACT: W. H. Chen, 904-392-1429

J. A. Wethington

W. G. Vernetson

N. J. Diaz

7 0 0 0 8 2 7 0 7

REACTOR NO. 28

REACTOR NAME University of California Santa Barbara L-77

LOCATION University of Santa California, Santa Barbara, CA 93106

POWER 10 W

LICENSE NO. NRC DOCKET NO. R-124 50-433

TYPE liquid fuel

STATUS shut down

FUEL ELEMENT

- **DESCRIPTION** spherical core, liquid fuel
- **OVERALL DIMENSIONS** 30.3 cm diameter
- **kg U-235 PER ELEMENT**
- **ELEMENTS PER REACTOR**
- **ENRICHMENT (% U-235)** 89
- **DRAWING NO.**
- **SUPPLIER** Atomics International

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR		1.23
OUT OF REACTOR, FRESH FUEL		0
OUT OF REACTOR, SPENT FUEL		0
TOTAL		1.23
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE Reactor has been disassembled and fuel has been shipped to a DOE site

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Prof. A. E. Profio, 805-961-4146

805-961-3412

7 0 0 0 3 2 7 0 6

REACTOR NO. 27

REACTOR NAME University of California Los Angeles Training Reactor

LOCATION University of California Los Angeles, Boelter Hall,
Los Angeles, California 90024

POWER 100 kW

LICENSE NO. NRC DOCKET NO. R-71 50-142

TYPE Argonaut

STATUS Operational

FUEL ELEMENT

DESCRIPTION MTR plate-type fuel, 11 plates/element

OVERALL DIMENSIONS 6.03 cm x 7.23 cm x 68.56 cm

kg U-235 PER ELEMENT 0.14

ELEMENTS PER REACTOR 24

ENRICHMENT (% U-235) 93

DRAWING NO.

SUPPLIER Atomics International

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	24	3.56
OUT OF REACTOR, FRESH FUEL	20	
OUT OF REACTOR, SPENT FUEL	0	
TOTAL	44	
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE 1 element per refueling

SPENT FUEL SHIPMENTS Shipped to INEL in GE-700 cask

NAMES OF PERSONS TO CONTACT: Ivan Catton, Director, 213-825-2040
Neill Ostrander, 213-825-2825
Tony Zane

7 0 0 0 8 2 7 0 5

REACTOR NO. 26

REACTOR NAME University of California Irvine TRIGA Mk I

LOCATION University of California Irvine, Irvine, California 92717

POWER 250 kW

LICENSE NO. NRC DOCKET NO. R-116 50-326

TYPE Open pool, TRIGA Mk I

STATUS Operational

FUEL ELEMENT

DESCRIPTION Cylindrical pin

OVERALL DIMENSIONS 3.81 cm diam x 71.12 cm

kg U-235 PER ELEMENT (8.5 wt% U)

ELEMENTS PER REACTOR 81

ENRICHMENT (% U-235) 19.9

DRAWING NO.

SUPPLIER GA Technologies

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	81	2.9
OUT OF REACTOR, FRESH FUEL	1	0.038
OUT OF REACTOR, SPENT FUEL		0.99
TOTAL		3.928
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE not stated

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: F. S. Rowland, 714-833-6015

G. E. Miller

7 0 0 0 3 2 7 ? 4

REACTOR NO. 25

REACTOR NAME University of California Berkeley Research Reactor

LOCATION Department of Nuclear Engineering, University of California, Berkeley, California 94720

POWER 1 MW

LICENSE NO. NRC DOCKET NO. R-101 50-224

TYPE Open pool TRIGA

STATUS Operational

FUEL ELEMENT

- **DESCRIPTION** Cylindrical pin
- **OVERALL DIMENSIONS** 3.63 cm diam
- **kg U-235 PER ELEMENT** approx. 0.034 (8.5 wt% U)
- **ELEMENTS PER REACTOR** 106
- **ENRICHMENT (% U-235)** 20
- **DRAWING NO.**
- **SUPPLIER** GA Technologies

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	106	3.6
OUT OF REACTOR, FRESH FUEL	12	0.41
OUT OF REACTOR, SPENT FUEL	0	0
TOTAL	118	4.01
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Selig N. Kaplan, 415-642-5213

Tek H. Lim, 415-642-5224

Harry G. Braun

7 0 0 0 3 2 7 ? 3

REACTOR NO. 24

REACTOR NAME University of Arizona TRIGA Reactor

LOCATION University of Arizona, Dept. of Nuclear and Energy Engineering, Tucson, Arizona 85721

POWER

LICENSE NO. NRC DOCKET NO. R-52 50-113

TYPE Open pool TRIGA

STATUS Operational

FUEL ELEMENT

DESCRIPTION Cylindrical pin

OVERALL DIMENSIONS 3.73 cm diam x 72.31 cm long

kg U-235 PER ELEMENT approx. 0.038

ELEMENTS PER REACTOR 87

ENRICHMENT (% U-235) 20

DRAWING NO.

SUPPLIER GA Technologies

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	87	3.31
OUT OF REACTOR, FRESH FUEL	0	0
OUT OF REACTOR, SPENT FUEL	0	0
TOTAL	87	3.31
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE None anticipated

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: R. L. Seale, 602-626-3903

G. W. Nelson

H. J. Doane

REACTOR NO. 23

REACTOR NAME Texas A&M Nuclear Science Center Reactor

LOCATION Texas A&M University, Nuclear Science Center,
College Station, Texas 77843

POWER 1 MW

LICENSE NO. NRC DOCKET NO. R-83 50-128

TYPE Open pool, TRIGA

STATUS Operational

FUEL ELEMENT

- DESCRIPTION Cylindrical pin
- OVERALL DIMENSIONS 3.58 cm diam x 76.2 cm
- kg U-235 PER ELEMENT approx. 0.12
- ELEMENTS PER REACTOR 90
- ENRICHMENT (% U-235) 20% standard, 70% FLIP
- DRAWING NO.
- SUPPLIER GA Technologies

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	90	10.48
OUT OF REACTOR, FRESH FUEL	1	0.122
OUT OF REACTOR, SPENT FUEL	84	
TOTAL	175	
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Donald E. Feltz, Director, 713-845-7551
Gary Waldrep
Dan Rodgers

7 0 0 0 8 2 7 0 1

REACTOR NO. 22

REACTOR NAME Texas A&M AGN-201 Training Reactor Facility

LOCATION Texas A&M University, Department of Nuclear Engineering,
College Station, Texas 77843

POWER 5 W

LICENSE NO. NRC DOCKET NO. R-23 50-59

TYPE AGN-201 homogeneous disc-type fuel, critical facility

STATUS Operational

FUEL ELEMENT

DESCRIPTION Homogeneous disc, UO_2 - polyethylene

OVERALL DIMENSIONS 25 cm diam x 3.9, 2.3, or 1.0 cm thick

kg U-235 PER ELEMENT

ELEMENTS PER REACTOR 9

ENRICHMENT (% U-235) 20

DRAWING NO.

SUPPLIER

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	9	0.69
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL		
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE

SPENT FUEL SHIPMENTS

NAMES OF PERSONS TO CONTACT: Dr. Carl A. Erdman, 713-845-4161

7 0 0 0 8 2 7 0 0

REACTOR NO. 21

REACTOR NAME State University of New York NSTF

LOCATION State University of New York, Rotary Road, Buffalo, New York 14214

POWER 2 MW

LICENSE NO. NRC DOCKET NO. R-77 50-57

TYPE Open pool, tank type PULSTAR

STATUS Operational

FUEL ELEMENT

DESCRIPTION 25 cylindrical pins in 5 x 5 array

OVERALL DIMENSIONS 6.96 cm x 8.0 cm x 96.52 cm

kg U-235 PER ELEMENT 0.76

ELEMENTS PER REACTOR 24

ENRICHMENT (% U-235) 6

DRAWING NO.

SUPPLIER

INVENTORY OF U-235	FUEL ELEMENTS	kg U-235
IN REACTOR	24	18.2
OUT OF REACTOR, FRESH FUEL		
OUT OF REACTOR, SPENT FUEL		
TOTAL		
TOTAL PER NMMSS RECORDS		

REFUELING SCHEDULE >10 years

SPENT FUEL SHIPMENTS Shipment made to INEL in BMI-1 cask

NAMES OF PERSONS TO CONTACT: Lewis G. Henry, 716-831-2826

Philip Orlosky

APPENDIX 4C. SUPPLEMENTAL DATA FOR FORT ST. VRAIN SPENT FUEL

4C. SUPPLEMENTAL DATA FOR FORT ST. VRAIN SPENT FUEL

This appendix contains additional data on inventory, fuel element description, fuel types and markings, and postirradiation condition.

4C.1 INVENTORY OF FORT ST. VRAIN FUEL

Three reactor segments have been discharged from the FSV Reactor as of September 1987.

The discharge dates and number of elements were

Discharge 1	February 1, 1979	245 elements
Discharge 2	May 13, 1981	240 elements
Discharge 3	January 2, 1984	240 elements

The serial numbers for the above 725 fuel elements are provided in Tables 4C.1, 4C.2, and 4C.3. The remains of one element which was destructively examined are at General Atomics, San Diego. The remaining 724 are located at INEL.

The future discharge rate is obviously uncertain, but if the reactor average power level is 50% of rating, and if the average burnup of discharged fuel is 100,000 MWD/MTIHM, the discharge rate will be 1.54 MTIHM per year, which is roughly equivalent to 136 fuel elements.

The present contract between General Atomics and Public Service of Colorado calls for 10 fuel reloads, of which three have been supplied. If this contract runs to completion, another seven reloads will be discharged. Should there be no further reloads, the total discharge would then be 1 2/3 full cores (since each reload is 1/6 core) plus the final full core discharge, for a total of 2 2/3 cores, or about 3900 elements. At four elements per canister, this is just under 1000 canisters.

Burnups are available on the floppy discs as cited in Section 4.2.4 (FSV Radiological Characteristics) of the report.

4C.2 FSV REACTOR FUEL ELEMENT

The following general fuel description was taken from (Bingham and Evans 1976):

"A Fort St. Vrain fuel element consists of a 300 lb hexagonal, needle-coke graphite block, 14.2 in. across the flats and 31.2-in.-high. Each graphite fuel block (see Fig. 4.2.1) contains 108 coolant channels and 210 fuel holes, all drilled from the top face of the element. The coolant holes extend through the element; the fuel holes extend to within about 0.3 in. of the bottom face. The fuel holes occupy alternating positions with the coolant channels in a triangular array within the element structure and contain the active fuel. After the fuel is inserted in a fuel hole, the hole is sealed with a graphite plug cemented into place.

The fresh fuel itself is in the form of carbide particles coated with layers of pyrolytic carbon and silicon carbide, loosely bonded by a carbonaceous matrix material into fuel sticks. The fuel bed contains a homogeneous mixture of two types of particles, called fissile and fertile. Fresh fissile particles contain thorium and 93.5% enriched uranium; fresh fertile particles contain only thorium. The important parameters of fresh particles are:

Parameter	Fissile	Fertile
Th/U (atomic ratio)	4.25	All Th
Particle composition	$(Th/U)C_2$	$Th\ C_2$
Average fuel particle diameter, μm	200	450
Average total coating thickness, μm	130	140

Besides fission products, the irradiated fuel contains thorium, U-233, U-235, other uranium isotopes, and a small quantity of plutonium. In the fertile particles, the fissile material is essentially U-233, while the fissile particles contain the residual U-235 and bred U-233."

4C.3 FUEL TYPES AND IDENTITY MARKINGS

This information is from Bingham 1976, GA 1985, and Kowal 1984. The initial core loading consisted 84 different types of fuel elements. The large number of different types was due to variations in design of the blocks, different fuel loadings in blocks of the same design, variations in positioning of the burnable poison rods, and the neutron sources. Each fuel element has a permanent three digit type number engraved on the side of the hexagonal block. This type number identifies the specific contents of the element. In addition, each element has a permanent serial number engraved on the side of the hexagonal block. The serial number is unique for each element and can be used to trace the entire fabrication history of the components within an element. Table 4C.4 shows a listing of the various types of fuel elements along with their corresponding drawing numbers.

The fuel element assembly type number, as illustrated in Fig. 4C.1 is painted on the top surface of each initial core fuel element. The assembly type number and serial number are engraved on the side of each element for all segments.

The format of the serial number is as follows:

Y - XXXX for H-327 graphite

and

Y - XXXXX for H-451 graphite.

The "X's" represents a 4-digit or 5-digit manufacturer's serial number for fuel elements made from H-327 or H-451 graphite, respectively. The "Y" denotes the style of fuel block, as follows:

Y = 1 denotes standard fuel block

2 denotes control fuel block

3 denotes bottom control fuel block

4 denotes neutron source block

5 denotes standard block with enlarged handling hole

6 denotes control block with enlarged handling hole

7 denotes bottom control with enlarged handling hole

8 denotes fuel test elements

11 denotes Cf neutron source block

Certain selected elements within the core are designated as surveillance elements and as fuel test elements. The element identification includes the core location number and identification as shown in Fig. 4C.1.

4C.3.1 Standard Fuel Element

Figures 4C.2 through 4C.8 depict variations of the standard fuel element design. This design has been used not only for conventional fuel element service, but also for surveillance elements, neutron source elements, and test elements. Considering differences in fuel loadings, there are 64 types of standard fuel elements as listed in Table 4C.4.

All standard fuel elements have 210 fuel holes containing a total of 3132 fuel rods, and 108 coolant passages. All the graphite blocks for the regular elements have a 0.500-in. diameter hole in each of their six corners. Some of these elements contain burnable poison rods in selected corner holes (see Figs. 4C.4 through 4C.7) and some elements have an enlarged fuel pickup hole as shown in Fig. 4C.3.

Surveillance elements were extensively characterized prior to loading into the reactor core, including a detailed characterization of the fuel rods, burnable poison rods, and the graphite blocks. In addition, these fuel elements include small temperature and fluence monitors in selected fuel rod stacks. The purpose of the preirradiation characterization of fuel and reflector elements was to provide a means for future evaluation of the in-core element performance, as a part of the overall development program for future FSV and other HTGR fuel.

The test elements are designed to operate within the limits of peak fuel temperature, neutron fluence, and burn-up specified for the initial core and reload fuel elements. Instrumentation is included in the test elements to measure each of these parameters. The purpose of these fuel test elements is to test new graphites and fuel forms for commerical HTGRs and to test improved fuel contemplated for use in future FSV reload segments.

The bottom of the fuel handling hole has been extended in some of the regular fuel elements to accommodate a neutron source. Sources are placed in neutron source elements as shown in Fig. 4C.6.

Two startup neutron sources consisting of Californium-252 encapsulated in platinum and stainless steel were originally installed in the core. A third source consisting of Californium-252 doubly encapsulated in stainless steel was added during the second refueling outage, and a fourth source was added during the third refueling outage. The Californium neutron source element is shown in Fig. 4C.8.

4C.3.2 Control Fuel Elements

The center control rod fuel element in each region is similar to the surrounding fuel elements, but contains enlarged channels for the two control rods and the reserve shutdown absorber material. The control rod channels have a 9.72 in. centerline spacing and a diameter of 4.00 in. The reserve shutdown channel has a diameter of 3.75 in. Each control rod fuel element contains 120 fuel holes loaded with a total of 1782 fuel rods, and 57 coolant channels.

All control fuel elements have a 0.500-in. diameter hole in four corners of the hexagonal block for burnable poison rods. None of the control elements in the initial core contain burnable poison rods.

Figure 4C.9 depicts a control fuel element with an enlarged fuel pickup hole. Some of the control fuel elements are surveillance elements as described above. Considering differences in fuel loadings, there are 13 types of control fuel elements as listed in Table 4C.4.

4C.3.3 Bottom Control Fuel Elements

The bottom element in the control rod column extends below the core about 7.5 in. The fuel holes in the bottom control rod element are 22.3 in. deep so the bottom of the fuel holes of all elements at the bottom of the core are at the same elevation. The reserve shutdown absorber channel hole is also 22.3 in. deep. Each bottom control fuel element contains 120 fuel holes loaded with a total of 1302 fuel rods. All bottom control elements have a 0.500-in. diameter hole in four corners of the hexagonal block for burnable poison rod loading. None of the bottom control fuel elements in the initial core contain burnable poison rods.

Figure 4C.10 depicts a bottom control fuel element with an enlarged fuel pickup hole. Considering differences in fuel loadings, there are seven types of bottom control fuel elements as listed in Table 4C.4.

4C.4 POSTIRRADIATION CONDITION OF FUEL

A nondestructive examination of various fuel elements was performed once the elements were removed from the core. Nearly all of the exa mined elements shrank slightly in both axial and radial dimensions. The inspected elements were in good condition.

4C.4.1 Segment 1 Discharge

Common Fuel Elements (Miller 1980). No cracks were observed on any of the element surfaces. With the exception of two large chips on chamfers (both noted during preirradiation visual inspection), all observed abnormalities were surface markings only. These markings had not etched the graphite to any harmful extent. Most blemishes observed on the elements were stains, rub marks, interface marks, soot deposits, scratches, and fingerprints.

The average axial and radial shrinkages measured for fuel elements which attained maximum burnup were 0.073 and 0.031 in., respectively. A few of the elements expanded slightly in the radial direction. The maximum expansion was 0.004 in. The maximum observed bow was 0.012 in.

Surveillance Element (Saurwein 1981). A postirradiation examination and evaluation was performed on surveillance element 1-0743. All observed abnormalities were surface markings only and had not etched the graphite to any harmful extent. Observed abnormalities included rub marks, soot deposits, scrapes, and scratches.

No evidence of mechanical interaction between the fuel rods and fuel body was found. Although minor cracking in the matrix end caps and some surface debonding were observed, the fuel rods were in good condition. About 3% of the rods were broken, but the majority were broken during unloading, and the evidence indicates that the remainder were broken prior to (or during) assembly of the element.

4C.4.2 Segment 2 Discharge (Saurwein 1982).

Little evidence was observed of graphite oxidation or erosion. Most blemishes observed on the elements were stains, scratches, scrapes, rub marks, and flow marks. The maximum average shrinkages observed for the elements were 0.115 in. in the length and 0.037 in. between opposing side faces. The maximum observed bow was 0.017 in.

Two fuel elements each had a single localized crack. The more prominent crack, observed in element 1-2415, was located in the center of the face adjacent to the single large dowel and extended the length of the element. The second crack was observed in fuel element 1-0172, which was located directly beneath element 1-2415 in the core. This crack was also located in the center of the face adjacent to the large dowel and ran vertically down the element.

The preirradiation inspection reports indicate that neither element was cracked prior to insertion into the core, there is no record of any damage having been done during handling. Therefore, these cracks are assumed to have developed during irradiation.

4C.4.3 Segment 3 Discharge (McCord 1985)

Little evidence was observed of graphite oxidation or erosion. Most blemishes observed on the elements were typical scratches, scrapes, rub marks, interface marks, and flow marks. The core Segment 3 maximum element average shrinkages in length and between-flats dimensions were 0.23 and 0.08 in, respectively. The maximum observed bow was 0.027 in. One H-327 graphite fuel element expanded slightly (0.001 in.) between flats.

There were a few small nicks and chips on the elements. Most of these were very minor and insignificant. However, element 1-1228 had minor damage to all three of its dowel pins. Element 2-1707 had damage to one dowel socket. A small chip of the graphite web between that socket and the central coolant hole on the nearest face edge was missing.

4C.5 REFERENCES

References for this appendix may be found in Section 4.2 of the body of this report.

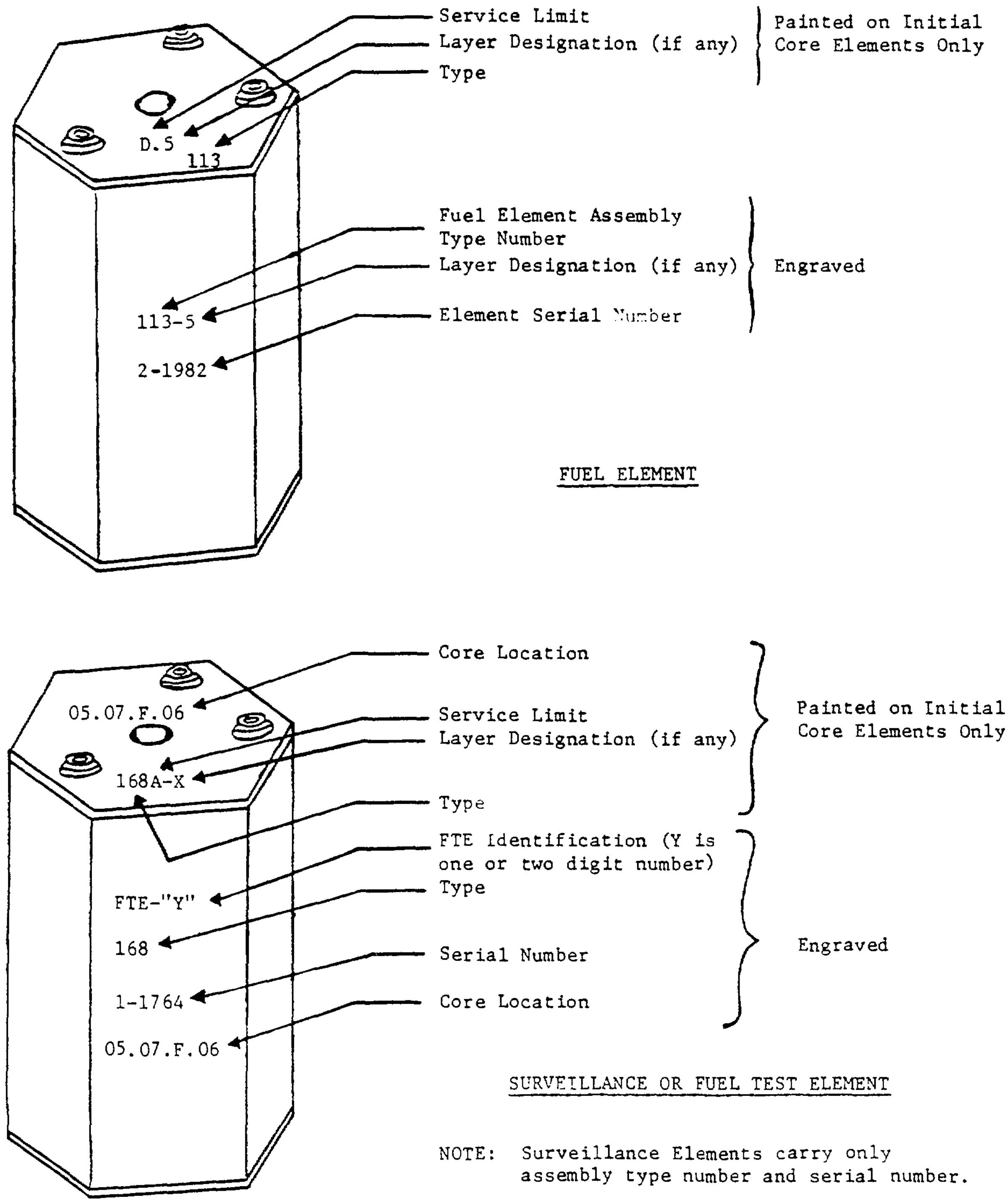
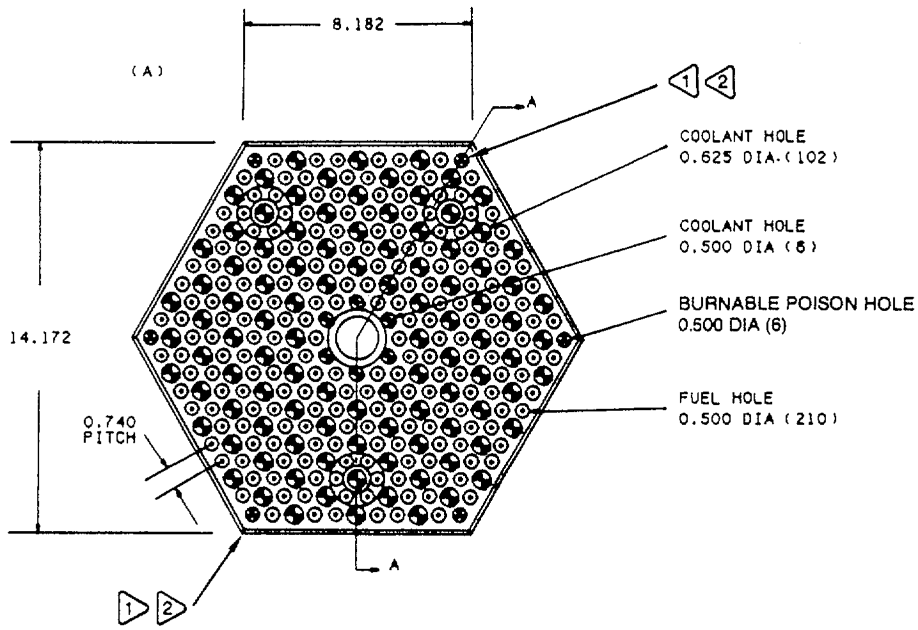


Fig. 4C.1. FSV fuel element identification system.



		FUEL TYPES
1	UNLOADED. THIS APPLIES TO DRAWING NUMBERS:	
	90-R1801-110-101 & 102	101, 102
	90-R1801-810-168 & 169	168, 169
	90-R1802-140-205	205
	90-R1802-160-206	206
	90-R1802-570-207	207
2	LOADED WITH BURNABLE POISON RODS. THIS APPLIES TO DRAWING NUMBERS:	
	90-R1801-110-103 THRU 112	103 THRU 112
	90-R1801-810-170 & 175	170, 175

Fig. 4C.2. Standard fuel element with Type I burnable poison loading.

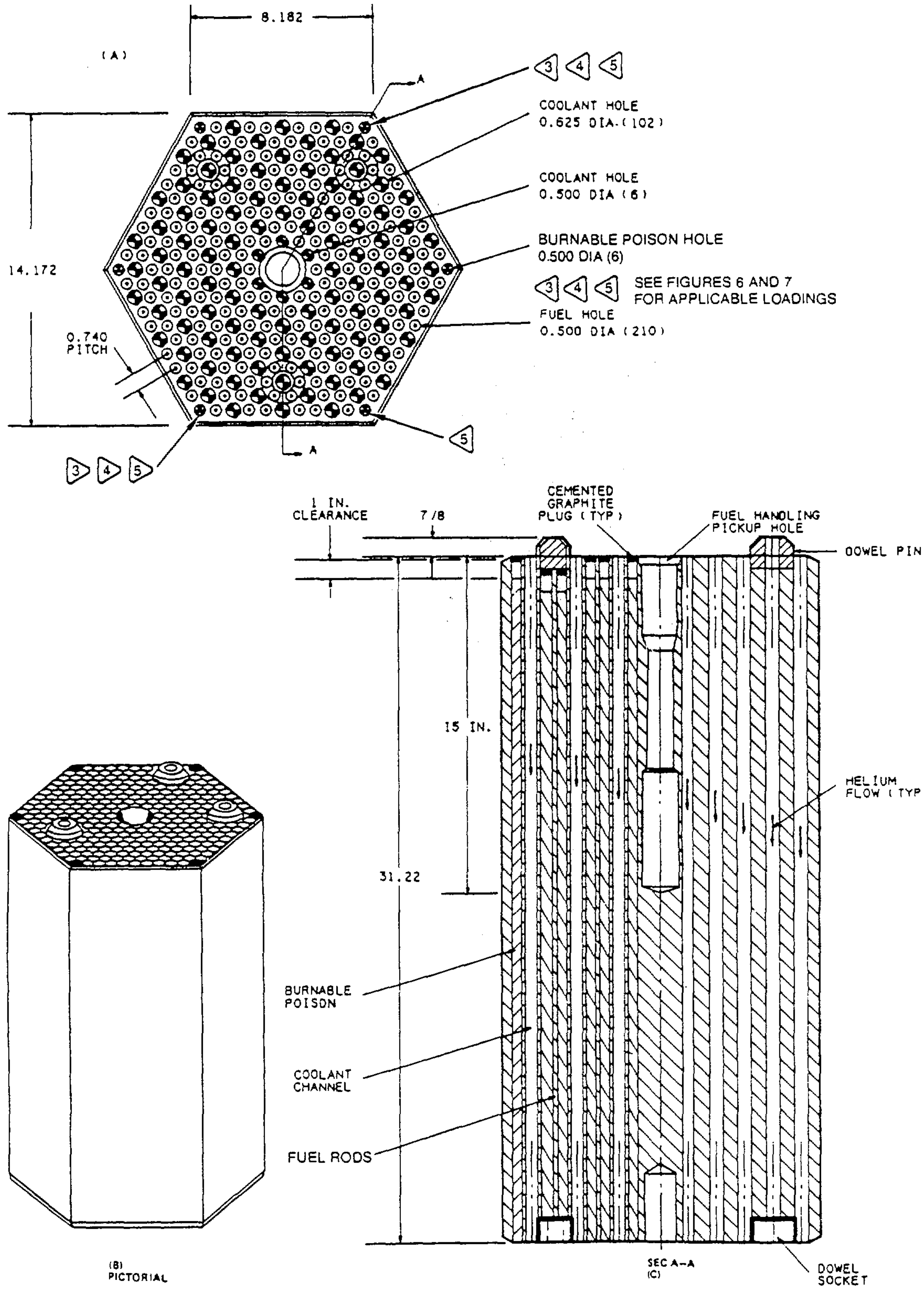
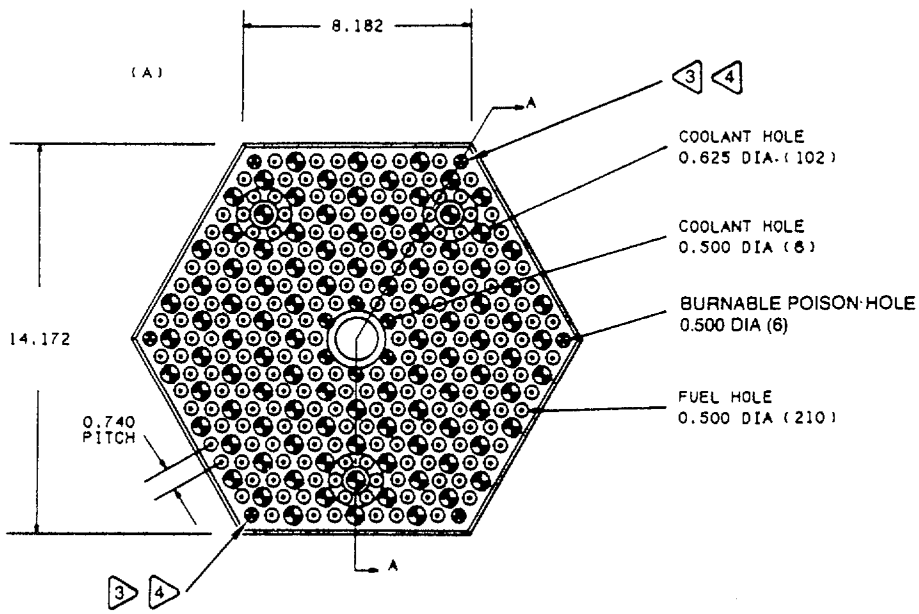
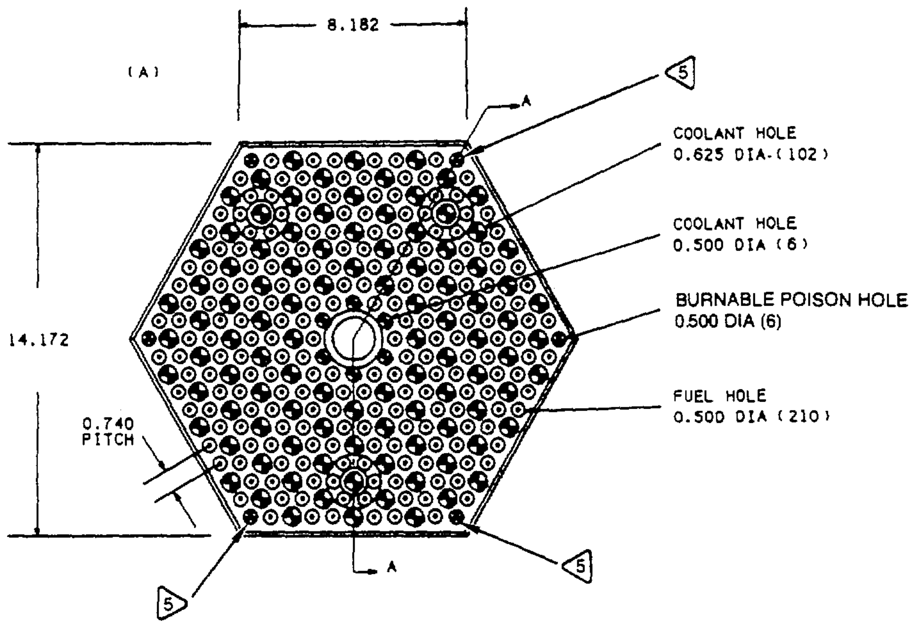


Fig. 4C.3. Standard fuel element with enlarged pickup hole.



		FUEL TYPES
3	UNLOADED. THIS APPLIES TO DRAWING NUMBERS:	
	90-R1801-510-136 & 137	136, 137
	520-142 & 143	142, 143
	530-148 & 149	148, 149
	540-154 & 155	154, 155
	90-R1801-550-160 & 161	160, 161
4	LOADED WITH BURNABLE POISON RODS. THIS APPLIES TO DRAWING NUMBERS:	
	90-R1801-510-140 & 141	140, 141
	520-146 & 147	146, 147
	530-152 & 153	152, 153
	540-158 & 159	158, 159
	550-164 & 165	164, 165
	90-R1801-830-180	180

Fig. 4C.4. Standard fuel element with Type II burnable poison loading.



5 LOADED WITH BURNABLE POISON RODS
THIS APPLIES TO DRAWING NUMBERS:

	FUEL TYPES
90-R1801-510-138 & 139	138, 139
520-144 & 145	144, 145
530-150 & 151	150, 151
540-156 & 157	156, 157
550-162 & 163	162, 163
90-R1801-830-179	179

Fig. 4C.5. Standard fuel element with Type III burnable poison loading.

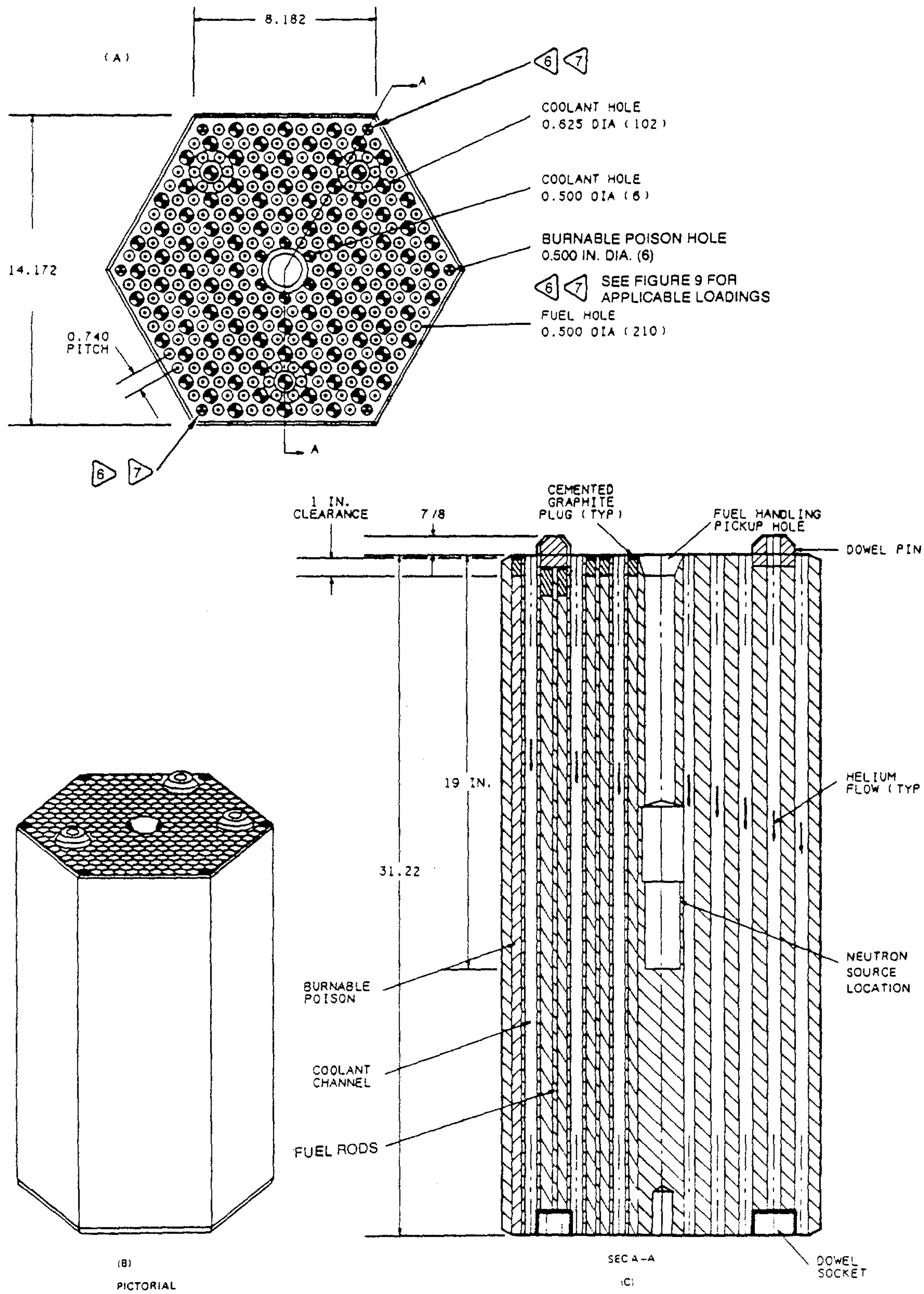
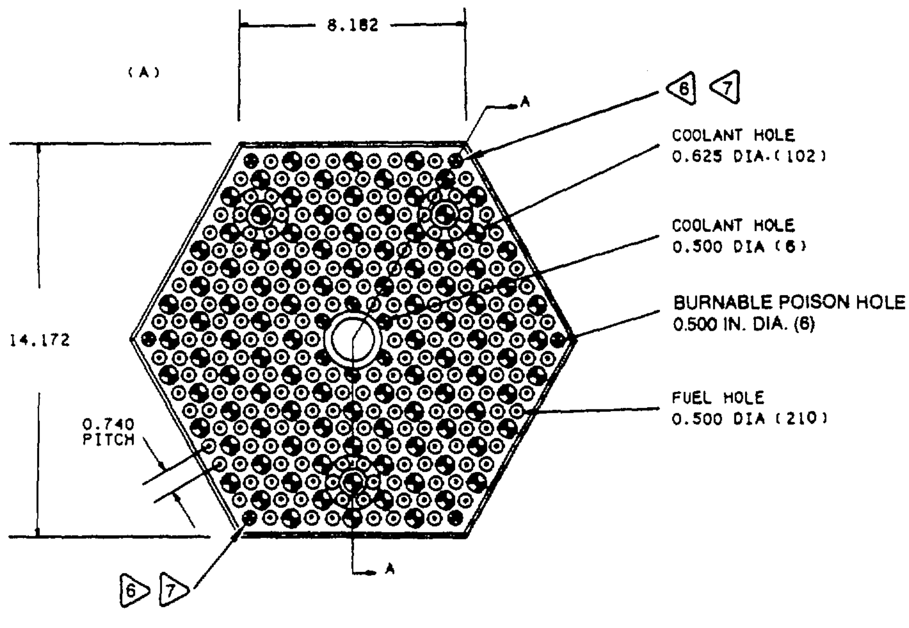


Fig. 4C.6. Standard fuel element modified for neutron source.



		FUEL TYPES
6	UNLOADED. THIS APPLIES TO DRAWING NUMBER: 90-R1801-410-131	131
7	LOADED WITH BURNABLE POISON RODS. THIS APPLIES TO DRAWING NUMBERS: 90-R1801-410-132 THRU 135	132 THRU 135

Fig. 4C.7. Standard fuel element with Type IV burnable poison loading.

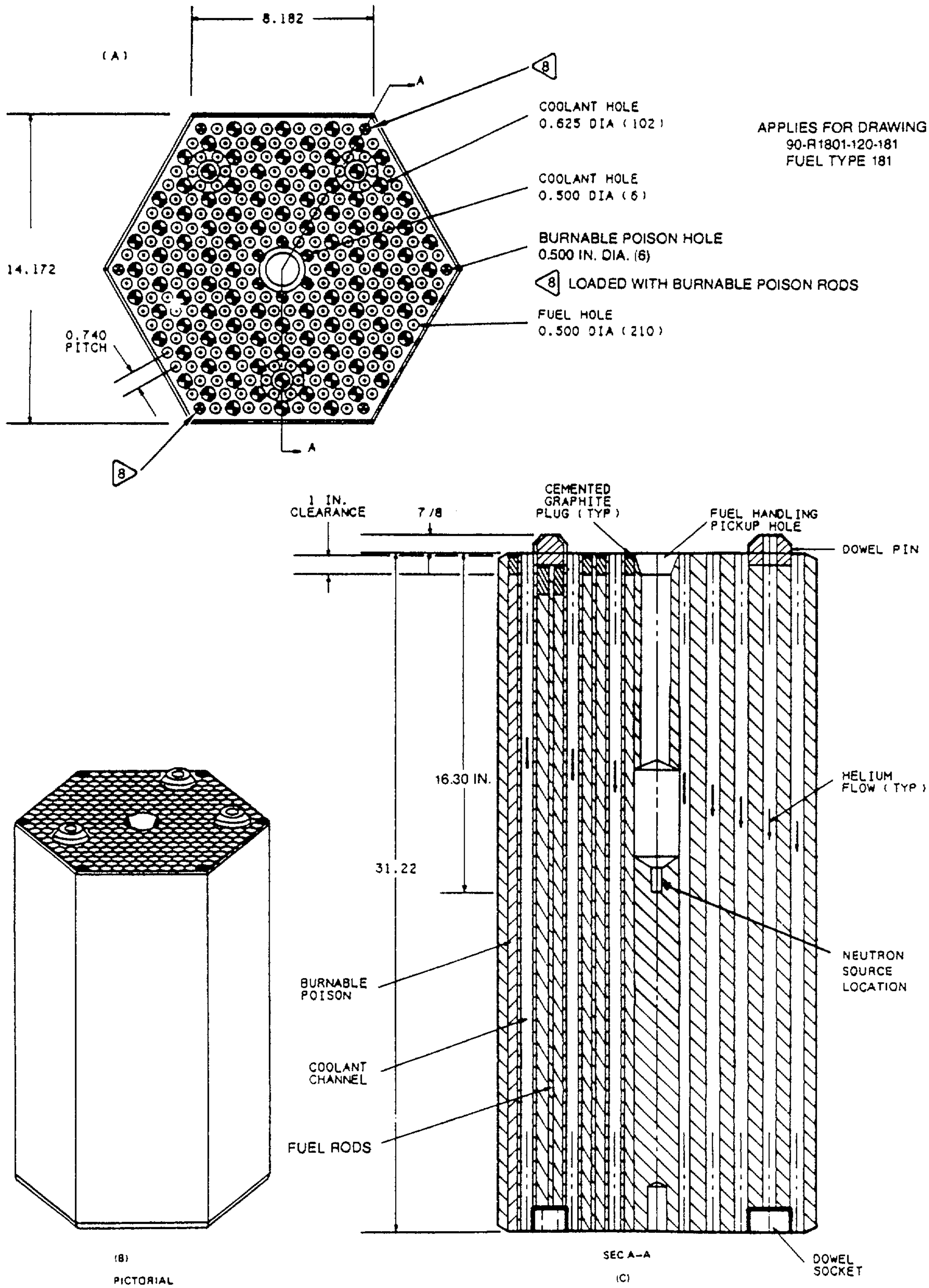


Fig. 4C.8. Standard fuel element modified for Californium neutron source.

7 0 0 0 8 2 7 4 7

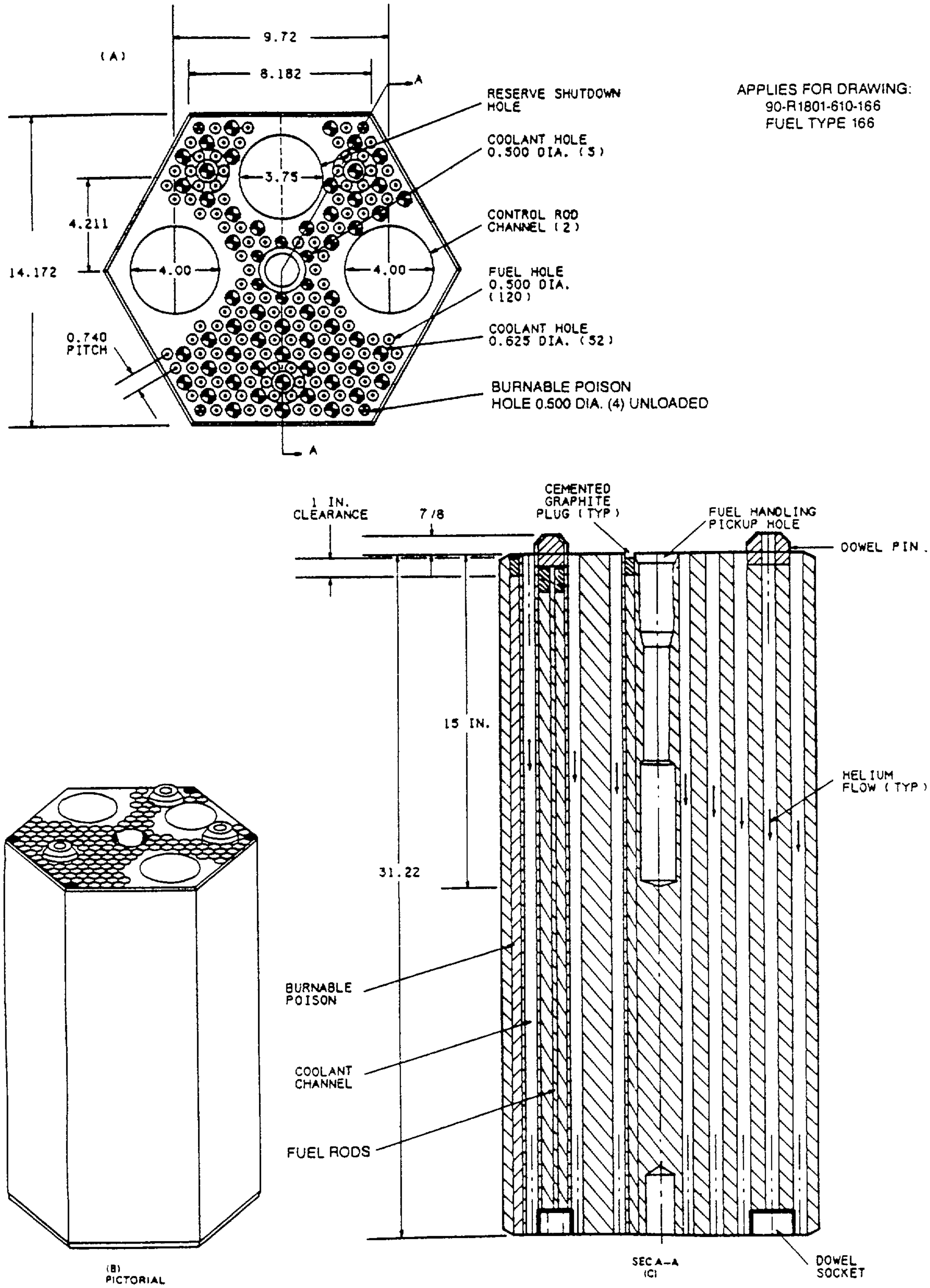


Fig. 4C.9. Control fuel element with enlarged pickup hole.

7 0 0 0 8 2 7 4 8

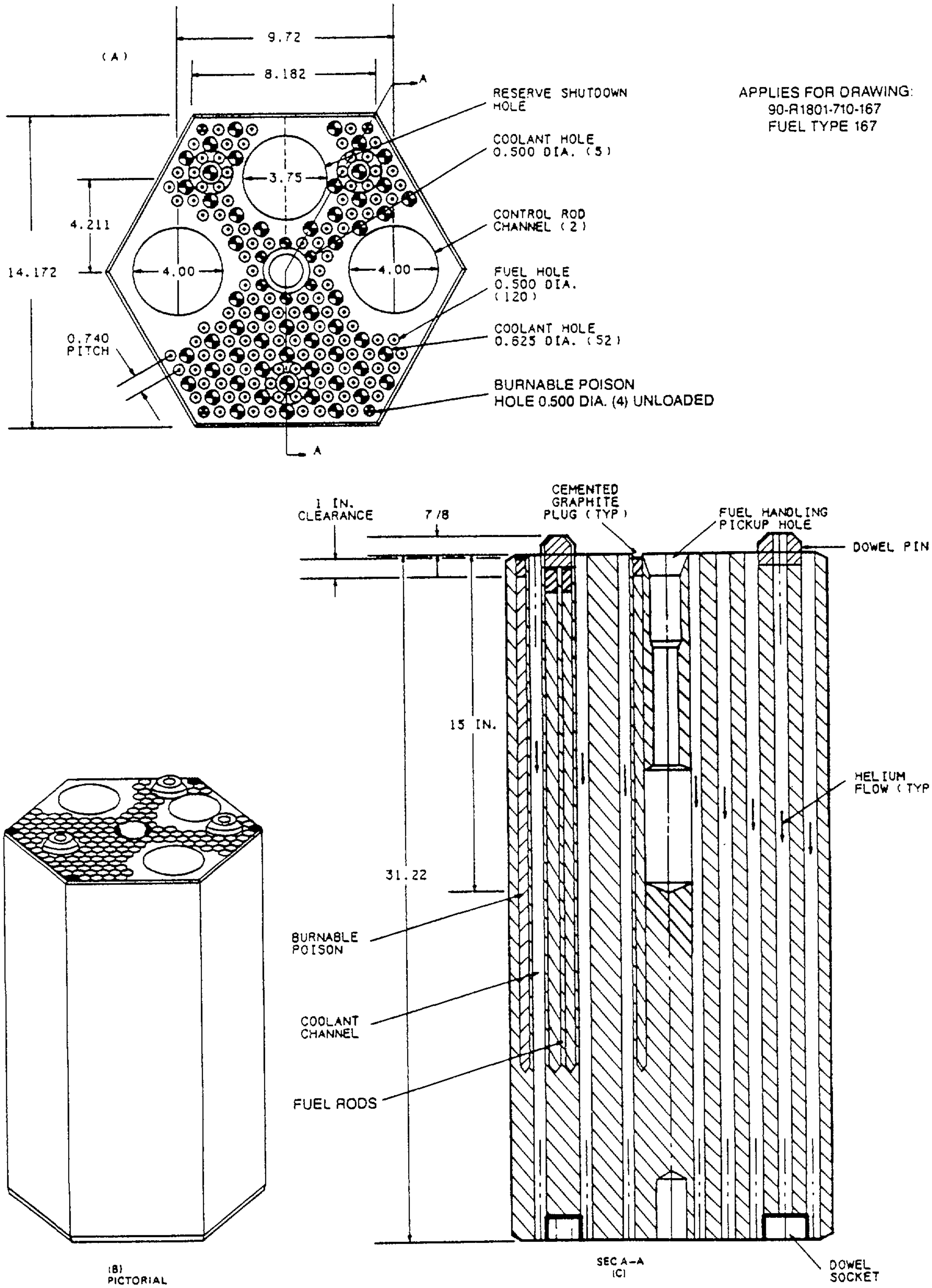


Fig. 4C.10. Bottom control fuel element with enlarged pickup hole.

Table 4C.1. FSV fuel discharge No. 1

Serial No.	Fuel type	Location
1-0003	101	ICPP
1-0022	102	ICPP
1-0030	102	ICPP
1-0052	101	ICPP
1-0089	102	ICPP
1-0094	101	ICPP
1-0099	102	ICPP
1-0126	102	ICPP
1-0148	101	ICPP
1-0204	101	ICPP
1-0205	102	ICPP
1-0215	102	ICPP
1-0239	102	ICPP
1-0242	102	ICPP
1-0323	101	ICPP
1-0326	102	ICPP
1-0343	102	ICPP
1-0344	101	ICPP
1-0411	102	ICPP
1-0424	101	ICPP
1-0449	101	ICPP
1-0457	101	ICPP
1-0467	101	ICPP
1-0469	102	ICPP
1-0478	101	ICPP
1-0494	101	ICPP
1-0529	102	ICPP
1-0537	101	ICPP
1-0551	102	ICPP
1-0552	101	ICPP
1-0599	101	ICPP
1-0641	101	ICPP
1-0666	101	ICPP
1-0681	101	ICPP
1-0733	101	ICPP
1-0768	101	ICPP
1-0771	101	ICPP
1-0791	101	ICPP
1-0794	101	ICPP
1-0867	169	ICPP
1-0890	101	ICPP
1-0891	102	ICPP
1-0904	102	ICPP
1-0938	101	ICPP

Table 4C.1. (continued)

Serial No.	Fuel type	Location
1-0963	102	ICPP
1-0990	111	ICPP
1-0993	101	ICPP
1-1006	101	ICPP
1-1021	101	ICPP
1-1032	102	ICPP
1-1035	101	ICPP
1-1043	102	ICPP
1-1054	102	ICPP
1-1062	102	ICPP
1-1066	102	ICPP
1-1069	101	ICPP
1-1075	102	ICPP
1-1099	101	ICPP
1-1108	102	ICPP
1-1116	101	ICPP
1-1135	101	ICPP
1-1136	102	ICPP
1-1147	101	ICPP
1-1161	102	ICPP
1-1178	101	ICPP
1-1183	101	ICPP
1-1186	102	ICPP
1-1215	101	ICPP
1-1223	102	ICPP
1-1253	168	ICPP
1-1262	107	ICPP
1-1264	101	ICPP
1-1271	101	ICPP
1-1278	102	ICPP
1-1301	101	ICPP
1-1311	101	ICPP
1-1331	101	ICPP
1-1345	101	ICPP
1-1346	101	ICPP
1-1349	101	ICPP
1-1440	101	ICPP
1-1446	102	ICPP
1-1450	102	ICPP
1-1459	101	ICPP
1-1544	102	ICPP
1-1574	102	ICPP
1-1585	101	ICPP
1-1589	101	ICPP
1-1593	102	ICPP
1-1614	102	ICPP

Table 4C.1. (continued)

Serial No.	Fuel type	Location
1-1624	101	ICPP
1-1625	102	ICPP
1-1649	102	ICPP
1-1658	101	ICPP
1-1669	101	ICPP
1-1676	101	ICPP
1-1677	102	ICPP
1-1678	102	ICPP
1-1690	102	ICPP
1-1714	102	ICPP
1-1741	102	ICPP
1-1782	101	ICPP
1-1822	101	ICPP
1-1861	102	ICPP
1-1894	101	ICPP
1-1903	102	ICPP
1-1908	102	ICPP
1-1923	102	ICPP
1-1949	102	ICPP
1-1977	102	ICPP
1-1985	102	ICPP
1-1989	169	ICPP
1-2008	102	ICPP
1-2035	102	ICPP
1-2068	102	ICPP
1-2080	102	ICPP
1-2086	102	ICPP
1-2119	102	ICPP
1-2120	101	ICPP
1-2140	168	ICPP
1-2143	102	ICPP
1-2175	102	ICPP
1-2179	102	ICPP
1-2230	101	ICPP
1-2243	102	ICPP
1-2255	101	ICPP
1-2309	102	ICPP
1-2336	102	ICPP
1-2337	101	ICPP
1-2352	102	ICPP
1-2368	101	ICPP
1-2407	102	ICPP
1-2427	102	ICPP
1-2485	101	ICPP
1-2543	102	ICPP
1-2551	101	ICPP

Table 4C.1. (continued)

Serial No.	Fuel type	Location
1-2642	102	ICPP
1-2665	102	ICPP
1-2674	101	ICPP
1-2682	101	ICPP
1-2718	102	ICPP
1-2735	101	ICPP
1-2755	101	ICPP
1-2758	102	ICPP
1-2767	101	ICPP
1-2773	102	ICPP
1-2798	102	ICPP
1-2865	102	ICPP
1-2873	102	ICPP
1-2928	107	ICPP
1-2935	101	ICPP
1-2942	101	ICPP
1-2952	102	ICPP
1-4381	101	ICPP
1-5198	102	ICPP
2-0047	113	ICPP
2-0095	113	ICPP
2-0211	113	ICPP
2-0286	113	ICPP
2-0455	113	ICPP
2-0688	113	ICPP
2-0732	113	ICPP
2-0827	114	ICPP
2-0980	114	ICPP
2-1324	114	ICPP
2-1468	114	ICPP
2-1520	114	ICPP
2-2102	113	ICPP
2-2138	114	ICPP
2-2158	113	ICPP
2-2169	114	ICPP
2-2187	176	ICPP
2-2209	114	ICPP
2-2260	113	ICPP
2-2385	113	ICPP
2-2548	113	ICPP
2-2683	113	ICPP
2-2722	114	ICPP
2-2733	114	ICPP
2-2880	113	ICPP
3-0574	125	ICPP
3-0919	125	ICPP

Table 4C.1. (continued)

Serial No.	Fuel type	Location
3-1282	125	ICPP
3-1711	125	ICPP
3-2422	125	ICPP
4-0101	131	ICPP
4-0716	131	ICPP
4-1050	131	ICPP
4-1055	131	ICPP
4-2464	131	ICPP
5-0068	148	ICPP
5-0279	155	ICPP
5-0365	155	ICPP
5-0375	137	ICPP
5-0430	148	ICPP
5-0541	154	ICPP
5-0610	137	ICPP
5-0683	154	ICPP
5-0704	155	ICPP
5-0766	142	ICPP
5-0773	143	ICPP
5-0785	142	ICPP
5-0799	155	ICPP
5-0819	149	ICPP
5-0825	149	ICPP
5-0965	143	ICPP
5-1014	155	ICPP
5-1024	149	ICPP
5-1269	148	ICPP
5-1486	160	ICPP
5-1515	148	ICPP
5-1818	155	ICPP
5-1887	143	ICPP
5-1979	160	ICPP
5-1987	137	ICPP
5-2020	143	ICPP
5-2039	160	ICPP
5-2089	156	ICPP
5-2110	161	ICPP
5-2154	136	ICPP
5-2165	142	ICPP
5-2238	142	ICPP
5-2353	161	ICPP
5-2417	148	ICPP
5-2436	154	ICPP
5-2456	149	ICPP
5-2481	154	ICPP
5-2528	136	ICPP

Table 4C.1. (continued)

Serial No.	Fuel type	Location
5-2579	154	ICPP
5-2608	149	ICPP
5-2670	143	ICPP
5-2685	154	ICPP
5-2703	148	ICPP
5-2728	136	ICPP
5-2736	142	ICPP
5-2802	149	ICPP
5-2813	142	ICPP
5-2826	161	ICPP
5-2838	143	ICPP
6-0111	166	ICPP
6-0488	166	ICPP
6-0820	166	ICPP
6-0844	166	ICPP
6-2792	166	ICPP
7-1451	167	ICPP

Table 4C.2. FSV fuel discharge No. 2.

Serial No.	Fuel type	Location
1-0023	101	ICPP
1-0033	102	ICPP
1-0048	102	ICPP
1-0108	101	ICPP
1-0140	102	ICPP
1-0143	102	ICPP
1-0161	101	ICPP
1-0166	102	ICPP
1-0169	102	ICPP
1-0172	102	ICPP
1-0175	101	ICPP
1-0199	101	ICPP
1-0212	102	ICPP
1-0238	102	ICPP
1-0250	102	ICPP
1-0272	102	ICPP
1-0276	101	ICPP
1-0284	102	ICPP
1-0294	101	ICPP
1-0304	101	ICPP
1-0308	101	ICPP
1-0342	102	ICPP
1-0347	101	ICPP
1-0351	102	ICPP
1-0368	101	ICPP
1-0380	101	ICPP
1-0393	102	ICPP
1-0396	101	ICPP
1-0419	101	ICPP
1-0456	102	ICPP
1-0471	101	ICPP
1-0510	102	ICPP
1-0515	101	ICPP
1-0538	101	ICPP
1-0542	102	ICPP
1-0553	169	ICPP
1-0589	101	ICPP
1-0612	102	ICPP
1-0613	102	ICPP
1-0623	102	ICPP
1-0649	102	ICPP
1-0658	101	ICPP
1-0702	102	ICPP
1-0711	102	ICPP

Table 4C.2. (continued)

Serial No.	Fuel type	Location
1-0727	101	ICPP
1-0736	101	ICPP
1-0778	102	ICPP
1-0792	101	ICPP
1-0798	101	ICPP
1-0811	102	ICPP
1-0812	101	ICPP
1-0839	102	ICPP
1-0858	101	ICPP
1-0874	101	ICPP
1-0882	102	ICPP
1-0901	101	ICPP
1-0910	102	ICPP
1-0931	102	ICPP
1-0951	102	ICPP
1-0989	101	ICPP
1-1011	102	ICPP
1-1015	102	ICPP
1-1030	102	ICPP
1-1033	102	ICPP
1-1057	102	ICPP
1-1142	101	ICPP
1-1177	102	ICPP
1-1184	101	ICPP
1-1210	101	ICPP
1-1212	102	ICPP
1-1243	102	ICPP
1-1251	102	ICPP
1-1268	101	ICPP
1-1296	101	ICPP
1-1305	102	ICPP
1-1315	102	ICPP
1-1321	101	ICPP
1-1329	101	ICPP
1-1357	102	ICPP
1-1361	102	ICPP
1-1367	102	ICPP
1-1374	101	ICPP
1-1421	102	ICPP
1-1497	101	ICPP
1-1516	101	ICPP
1-1535	101	ICPP
1-1571	101	ICPP
1-1694	102	ICPP
1-1706	102	ICPP

Table 4C.2. (continued)

Serial No.	Fuel type	Location
1-1717	102	ICPP
1-1720	101	ICPP
1-1727	101	ICPP
1-1742	102	ICPP
1-1764	168	ICPP
1-1767	101	ICPP
1-1780	101	ICPP
1-1787	169	ICPP
1-1797	101	ICPP
1-1825	102	ICPP
1-1829	102	ICPP
1-1832	102	ICPP
1-1869	102	ICPP
1-1913	101	ICPP
1-1914	102	ICPP
1-1931	102	ICPP
1-1952	102	ICPP
1-1961	101	ICPP
1-1969	102	ICPP
1-2000	102	ICPP
1-2017	101	ICPP
1-2038	101	ICPP
1-2087	102	ICPP
1-2155	101	ICPP
1-2156	101	ICPP
1-2157	102	ICPP
1-2199	101	ICPP
1-2223	101	ICPP
1-2256	101	ICPP
1-2281	101	ICPP
1-2284	102	ICPP
1-2306	101	ICPP
1-2364	101	ICPP
1-2371	101	ICPP
1-2373	101	ICPP
1-2377	101	ICPP
1-2392	102	ICPP
1-2423	101	ICPP
1-2445	102	ICPP
1-2458	102	ICPP
1-2515	101	ICPP
1-2535	101	ICPP
1-2561	101	ICPP
1-2650	101	ICPP
1-2676	102	ICPP

Table 4C.2. (continued)

Serial No.	Fuel type	Location
1-2719	102	ICPP
1-2731	102	ICPP
1-2738	101	ICPP
1-2759	101	ICPP
1-2777	101	ICPP
1-2783	102	ICPP
1-2820	168	ICPP
1-2832	102	ICPP
1-2842	102	ICPP
1-2857	101	ICPP
1-2869	102	ICPP
1-2929	102	ICPP
1-2931	102	ICPP
1-2936	101	ICPP
1-4361	102	ICPP
1-4716	101	ICPP
1-4834	102	ICPP
1-4987	101	ICPP
2-0228	114	ICPP
2-0298	113	ICPP
2-0400	114	ICPP
2-0415	113	ICPP
2-0518	113	ICPP
2-0532	113	ICPP
2-0655	114	ICPP
2-0806	113	ICPP
2-0962	113	ICPP
2-1131	113	ICPP
2-1133	114	ICPP
2-1299	113	ICPP
2-1529	114	ICPP
2-1532	114	ICPP
2-1570	114	ICPP
2-1590	114	ICPP
2-1835	113	ICPP
2-2084	113	ICPP
2-2350	113	ICPP
2-2501	114	ICPP
2-2531	113	ICPP
2-2693	113	ICPP
2-2769	176	ICPP
2-2851	113	ICPP
2-2893	114	ICPP
3-1171	125	ICPP
3-1412	125	ICPP

Table 4C.2. (continued)

Serial No.	Fuel type	Location
3-1814	125	ICPP
3-1965	125	ICPP
3-2852	128	ICPP
4-0930	131	ICPP
4-2646	131	ICPP
5-0100	148	ICPP
5-0255	154	ICPP
5-0268	148	ICPP
5-0333	149	ICPP
5-0373	143	ICPP
5-0401	161	ICPP
5-0517	161	ICPP
5-0654	137	ICPP
5-0700	155	ICPP
5-0782	160	ICPP
5-0801	155	ICPP
5-0836	149	ICPP
5-0850	155	ICPP
5-0903	154	ICPP
5-0928	137	ICPP
5-0957	148	ICPP
5-1008	148	ICPP
5-1039	155	ICPP
5-1086	154	ICPP
5-1144	161	ICPP
5-1192	160	ICPP
5-1225	154	ICPP
5-1307	143	ICPP
5-1388	142	ICPP
5-1417	142	ICPP
5-1628	136	ICPP
5-1682	136	ICPP
5-1722	148	ICPP
5-1837	154	ICPP
5-1844	148	ICPP
5-1912	142	ICPP
5-1954	155	ICPP
5-1963	143	ICPP
5-2037	142	ICPP
5-2151	143	ICPP
5-2181	155	ICPP
5-2360	143	ICPP
5-2478	148	ICPP
5-2549	149	ICPP
5-2692	142	ICPP
5-2713	149	ICPP

Table 4C.2. (continued)

Serial No.	Fuel type	Location
5-2839	137	ICPP
5-2841	154	ICPP
5-2846	143	ICPP
5-2879	160	ICPP
5-2907	149	ICPP
5-4764	149	ICPP
5-4837	136	ICPP
6-0675	166	ICPP
6-0735	166	ICPP
6-1715	166	ICPP
6-2222	166	ICPP
6-2285	166	ICPP
7-1670	167	ICPP
8-0085	205	ICPP
8-0139	101	ICPP

Table 4C.3. FSV fuel discharge No. 3.

Serial No.	Fuel type	Location
1-0024	110	ICPP
1-0034	109	ICPP
1-0043	109	ICPP
1-0057	109	ICPP
1-0065	109	ICPP
1-0088	110	ICPP
1-0091	110	ICPP
1-0137	109	ICPP
1-0152	111	ICPP
1-0157	111	ICPP
1-0162	109	ICPP
1-0191	110	ICPP
1-0192	109	ICPP
1-0195	112	ICPP
1-0251	110	ICPP
1-0285	109	ICPP
1-0292	110	ICPP
1-0305	109	ICPP
1-0324	110	ICPP
1-0335	175	ICPP
1-0337	109	ICPP
1-0367	109	ICPP
1-0409	112	ICPP
1-0420	111	ICPP
1-0428	110	ICPP
1-0443	110	ICPP
1-0459	112	ICPP
1-0462	109	ICPP
1-0504	112	ICPP
1-0530	110	ICPP
1-0536	110	ICPP
1-0556	111	ICPP
1-0580	109	ICPP
1-0581	110	ICPP
1-0587	110	ICPP
1-0614	110	ICPP
1-0647	109	ICPP
1-0661	111	ICPP
1-0667	110	ICPP
1-0670	109	ICPP
1-0684	109	ICPP
1-0715	110	ICPP
1-0720	112	ICPP
1-0725	110	ICPP
1-0824	112	ICPP

Table 4C.3 (continued)

Serial No.	Fuel type	Location
1-0834	110	ICPP
1-0843	111	ICPP
1-0873	109	ICPP
1-0877	111	ICPP
1-0912	112	ICPP
1-0921	112	ICPP
1-0932	112	ICPP
1-0940	109	ICPP
1-0948	109	ICPP
1-0974	109	ICPP
1-0975	112	ICPP
1-0994	110	ICPP
1-1004	111	ICPP
1-1018	109	ICPP
1-1023	112	ICPP
1-1049	110	ICPP
1-1053	109	ICPP
1-1101	109	ICPP
1-1111	112	ICPP
1-1117	111	ICPP
1-1121	111	ICPP
1-1153	109	ICPP
1-1163	111	ICPP
1-1204	109	ICPP
1-1224	112	ICPP
1-1235	111	ICPP
1-1273	110	ICPP
1-1288	109	ICPP
1-1336	109	ICPP
1-1337	110	ICPP
1-1353	112	ICPP
1-1378	111	ICPP
1-1397	109	ICPP
1-1403	111	ICPP
1-1410	109	ICPP
1-1458	111	ICPP
1-1555	109	ICPP
1-1584	111	ICPP
1-1612	109	ICPP
1-1621	110	ICPP
1-1673	110	ICPP
1-1692	111	ICPP
1-1701	110	ICPP
1-1737	110	ICPP
1-1750	112	ICPP

Table 4C.3. (continued)

Serial No.	Fuel type	Location
1-1771	109	ICPP
1-1773	110	ICPP
1-1796	110	ICPP
1-1805	110	ICPP
1-1806	112	ICPP
1-1817	110	ICPP
1-1850	109	ICPP
1-1872	112	ICPP
1-1876	109	ICPP
1-1890	110	ICPP
1-1904	110	ICPP
1-1918	109	ICPP
1-1940	112	ICPP
1-1988	109	ICPP
1-1990	109	ICPP
1-1998	109	ICPP
1-2019	112	ICPP
1-2021	110	ICPP
1-2044	109	ICPP
1-2106	110	ICPP
1-2134	112	ICPP
1-2142	109	ICPP
1-2174	112	ICPP
1-2206	109	ICPP
1-2228	109	ICPP
1-2282	109	ICPP
1-2351	109	ICPP
1-2396	110	ICPP
1-2400	111	ICPP
1-2403	112	ICPP
1-2440	109	ICPP
1-2447	109	ICPP
1-2455	111	ICPP
1-2474	110	ICPP
1-2519	110	ICPP
1-2521	109	ICPP
1-2529	112	ICPP
1-2560	109	ICPP
1-2563	110	ICPP
1-2570	109	ICPP
1-2606	174	ICPP
1-2640	110	ICPP
1-2715	111	ICPP
1-2720	110	ICPP
1-2760	110	ICPP
1-2795	110	ICPP

Table 4C.3. (continued)

Serial No.	Fuel type	Location
1-2919	109	ICPP
1-2920	111	ICPP
1-2923	112	ICPP
1-2939	110	ICPP
1-2940	110	ICPP
1-2943	175	ICPP
1-2944	110	ICPP
1-2946	110	ICPP
1-4304	110	ICPP
1-4318	110	ICPP
1-4430	110	ICPP
1-4715	110	ICPP
1-5152	110	ICPP
1-5217	110	ICPP
2-0265	122	ICPP
2-0577	122	ICPP
2-0642	124	ICPP
2-0673	121	ICPP
2-1028	124	ICPP
2-1044	122	ICPP
2-1120	121	ICPP
2-1182	123	ICPP
2-1471	123	ICPP
2-1489	122	ICPP
2-1519	121	ICPP
2-1606	122	ICPP
2-1707	121	ICPP
2-1726	124	ICPP
2-1792	123	ICPP
2-1950	122	ICPP
2-2088	123	ICPP
2-2263	121	ICPP
2-2424	121	ICPP
2-2781	178	ICPP
2-2815	121	ICPP
2-2836	124	ICPP
2-2882	123	ICPP
2-2891	123	ICPP
2-5178	121	ICPP
3-0787	129	ICPP
3-0898	130	ICPP
3-1719	129	ICPP
3-1766	129	ICPP
3-2850	130	ICPP
4-0463	134	ICPP
4-0765	135	ICPP

Table 4C.3. (continued)

Serial No.	Fuel type	Location
4-0981	134	ICPP
4-1994	135	ICPP
4-2339	134	ICPP
5-0026	146	ICPP
5-0027	164	ICPP
5-0036	153	ICPP
5-0127	159	ICPP
5-0129	165	ICPP
5-0190	159	ICPP
5-0427	152	ICPP
5-0723	146	ICPP
5-0731	152	ICPP
5-0746	158	ICPP
5-0749	140	ICPP
5-0751	158	ICPP
5-0805	146	ICPP
5-0831	159	ICPP
5-0854	152	ICPP
5-0862	152	ICPP
5-0892	164	ICPP
5-1058	158	ICPP
5-1095	147	ICPP
5-1148	147	ICPP
5-1176	140	ICPP
5-1249	147	ICPP
5-1460	159	ICPP
5-1563	141	ICPP
5-1739	147	ICPP
5-1799	158	ICPP
5-1801	159	ICPP
5-1865	153	ICPP
5-1974	153	ICPP
5-2001	153	ICPP
5-2022	158	ICPP
5-2031	153	ICPP
5-2104	146	ICPP
5-2159	147	ICPP
5-2191	180	ICPP
5-2213	140	ICPP
5-2235	112	ICPP
5-2275	146	ICPP
5-2349	153	ICPP
5-2416	165	ICPP
5-2430	158	ICPP
5-2460	152	ICPP
5-2530	165	ICPP

Table 4C.3. (continued)

Serial No.	Fuel type	Location
5-2556	141	ICPP
5-2688	141	ICPP
5-2908	164	ICPP
5-2933	147	ICPP
5-4278	146	ICPP
6-0067	166	ICPP
6-0209	166	ICPP
6-0961	166	ICPP
6-1984	166	ICPP
6-2288	166	ICPP
7-2499	167	ICPP
8-0206	206	GA

Table 4C.4. FSV fuel types and drawings (Ref. GA Technologies 1985)

Element Description and Assembly Drawing No.	Assembly Type No.	Element Description and Assembly Drawing No.	Assembly Type No.
Fuel elements	101	Fuel elements with	136
90-R1801-110	102	enlarged pickup hole	137
	103	90-R1801-510	138
	104		139
	105		140
	106		141
	107		
	108	90-R1801-520	142
	109		143
	110		144
	111		145
	112		146
			147
Control rod elements	113		
90-R1801-210	114	90-R1801-530	148
	115		149
	116		150
	117		151
	118		152
	119		153
	120		
	121	90-R1801-540	154
	122		155
	123		156
	124		157
			158
Bottom control rod	125		159
elements	126		
90-R1801-310	127	90-R1801-550	160
	128		161
	129		162
	130		163
			164
Neutron source fuel	131		165
element	132		
90-R1801-410	133	Control rod elements	166
	134	with enlarged pickup	
	135	hole	
		90-R1801-610	

Table 4C.4 (continued)

Element Description and Assembly Drawing No.	Assembly Type No.	Element Description and Assembly Drawing No.	Assembly Type No.
Bottom control rod elements with enlarged pickup hole 90-R1801-710	167	Surveillance fuel elements with enlarged pickup hole 90-R1801-830	179 180
Surveillance fuel elements 90-R1801-810	168 169 170 171 172 173 174 175	Californium neutron source fuel element 90-R1801-120 Fuel test elements 90-R1802-130 90-R1802-150	181 205 206
Surveillance control elements 90-R1801-820	176 177 178	90-R1802-560	207

APPENDIX 4D. SUPPLEMENTAL DATA FOR PEACH BOTTOM 1 SPENT FUEL

4D.1 INSTRUMENTED FUEL ELEMENT - CORE 1

Thirty-six fuel elements were instrumented for temperature measurement in various locations of the core. Each of these elements was instrumented with two thermocouples, and eight also contained acoustic thermometers. An acoustic thermometer is an instrument which utilizes the proportionality between resonance frequency of a transmitted sound wave and the temperature of helium gas in a cavity within the fuel element to determine the temperature. Table 4D.1 lists the number of instrumented fuel elements in each of the fuel loading types 1 through 4. Figure 4D.1 is a schematic of a typical core 1 instrumented fuel element (without the canister) as stored at INEL.

The instrumented fuel elements are very similar to the standard fuel elements. The differences involve the bottom connector and certain internal components which are slightly modified to allow passage of the thermocouple leads. These leads extend to different axial locations in the element as listed in Table 4D.1.

4D.2 STANDARD FUEL ELEMENT - CORE 2

Figure 4D.2 shows the Core 2 standard element as currently stored at INEL. The elements are stored in canisters located in the Irradiated Fuels Storage Facility at INEL.

The Core 2 standard fuel elements are essentially the same as the Core 1 elements. The only design difference is in the coated particles and the external appearance of fuel compacts. The coated particles in Core 1 used monolithic laminar pyrolytic coatings whereas the Core 2 coated particles consisted of an inner, low density, pyrolytic carbon coating surrounded by an outer isotropic pyrolytic carbon coating. The coated particles are between 340 and 630 microns in diameter with a total coating thickness of 90 to 130 microns. The Core 2 compacts do not have the axial grooves included in the Core 1 compacts (see Fig. 4D.3) and have slots on the ends which were not included in the Core 1 compacts.

In the as-stored configuration, the Core 2 element differs from the Core 1 element in that the top 18 in. of the upper reflector was cut off at INEL prior to storage in the facility. This is shown as Fig. 4D.2. Note that the bottom connector for the element placed in the B1610 position (within the core), is somewhat different from a standard fuel element.

4D.3 INSTRUMENTED FUEL ELEMENT - CORE 2

Core 2 shared its instrumented core locations with instrumented fuel elements and instrumented test elements. The instrumented fuel elements for Core 2 are of the same design as the Core 1 with the exceptions noted in the previous sections concerning fuel compact design and the cut off upper reflector. Figure 4D.4 shows a typical Core 2 instrumented fuel element as stored at INEL.

4D.4 TEST FUEL ELEMENTS

Since the PB Unit 1 reactor offered unique capabilities as a test facility for HTGR type fuel, test assemblies were tested in the core to evaluate interactions of fuel particles, fuel beds, and graphite structures. Test elements were included in both Core 1 and Core 2. Figure 4D.5 shows two configurations currently in storage at INEL and ORNL.

Two test elements of the proof test element (PTE) type were irradiated in Core 1. The first, PTE-1, did not perform correctly, and was removed, and shipped to INEL for storage. The second, PTE-2, remained in the core for further irradiation with Core 2.

An additional 32 test elements were constructed and irradiated in Core 2. These were manufactured in three classes of test elements - fuel test elements (FTEs)/fuel bed test elements (FBTEs), PTEs, and fuel pin test elements (FPTEs). Of the total 33 elements, 30 were of the FTE/FBTE design, one was of the PTE design, and two of the FPTE design.

The FPTEs were irradiated for UKAEA and were returned to the United Kingdom following their irradiation in the PB core and subsequent postirradiation examination (PIE) in the United States.

Table 4D.2 lists the 33 test elements, along with important parameters of each one of these elements.

The PTE test elements are hexagonal in shape as shown in Fig. 4D.5 and do not utilize graphite sleeves. The element is made up of four separate fuel sections containing fuel holes and coolant holes. These four sections along with a top reflector, bottom reflector, and bottom connector were threaded together to form an assembly approximately 3.5 in. across flats and 140 in. long. The top and bottom reflectors were specially designed to allow a special handling tool and coolant flow inlets and exits. The element was instrumented with two thermocouples. A description of the PTEs is given in Ref. 1.

The remaining test elements in storage are similar in external appearance to the standard and instrumented fuel elements. The fueled portion of some elements contain six fuel bodies as shown in Figs. 4D.6 and 4D.7, while others contain only three. Each fuel bodies has eight fuel holes surrounding a central hole. The fuel holes contain either fuel rods or loose fuel particles. Descriptions of the test elements are included in Scheffel 1972c, Sheffel 1972a, Sheffel 1972b, Sanders 1973, Wallroth 1980, Christie 1976, Wallroth 1974, Wallroth 1977, Walroth 1976, Fitzgerald 1976, Morrissette 1971, and Long 1974.

4D.5 CORE 1 STORAGE CANISTERS

Figures 4D.8 and 4D.9 are sketches of two fuel element storage canister types not described in Section 4.3.

4D.6 CORE 1 PACKAGE TYPES

Removal and canning of the failed Core 1 fuel resulted in a number of package types. These are given in Table 4D.3 (Agreement etc.).

4D.7 INVENTORY RELATED DATA

The data received from INEL (Denney 1986) on the PB1 spent fuel does not allow a detail inventory of each element by serial number or tyep. The elements are stored in groups of 18 or less. Table 4D.4 is the listing received from INEL on Core 1 which includes 814 elements (813 regular elements and one test element). Table 4D.5 is the listing on Core 2 which accounts for 785 elements. Additional information was provided to INEL by Philadelphia Electric for Core 1 (Denney 1986).

4D.8 ADDITIONAL ACCOUNTABILITY DATA

Tables 4D.6, 4D.7, and 4D.8 provide data on heavy metal loadings of the various Core 1 package types and the many types of test elements.

4D.9 References for Section 4D

Christie 1976. G. E. Christie, "The Irradiation of MK3 HTR Fuel in Peach Bottom HTGR Reactor, Irradiation History of Main Experiment - IE-486/3," UKAEA Report TRG 2748(S), February 1976.

Denney 1986. Letter No. RRDD-71-86 from R. D. Denney, Westinghouse, Idaho Nuclear Company, Inc., to N. Tomsio, GA Technologies, Inc., April 30, 1986.

Fitzgerald 1975. C. L. Fitzgerald, "Head-End Reprocessing Studies with Irradiated HTGR-Type Fuels: III. Studies with RTE-7: TRISO UC_2 - TRISO ThC_2," ERDA Report ORNL-5090, Oak Ridge National Laboratory, November 1975.

Long 1974. E. L. Long, et al., "Fabrication of ORNL Fuel Irradiated in the Peach Bottom Reactor and Post irradiation Examinations of Recycle Test Elements 7 and 4," USAEC Report ORNL/TM-4477, Oak Ridge National Laboratory, September 1974.

Morissette 1971. R. P. Morissette and K. P. Stewart, "Recycle Test Element Program Design, Fabrication, and Assembly," Gulf General Atomic Report GA-10109, September 1971.

Scheffel 1972c. W. J. Scheffel, "Design and Operational Evaluation for Fuel Test Elements No. 14 and 15," USAEC Informal Report Gulf-GA-B12344, Gulf General Atomic, November 3, 1972.

Scheffel, 1972a. W. J. Scheffel, "Phase III - Final Progress Report, Part I of Two Parts, Design and Operational Evaluation for the Plutonium Test Element (FTE-13)," Gulf General Atomic Report Gulf-GA-B12271, August 18, 1972.

Scheffel 1972b. W. J. Scheffel, "Phase III - Final Progress Report, Part II of Two Parts, Design and Fabrication of the Plutonium Fuels for the Plutonium Fuel Test Element (FTE-13)," Gulf General Atomic Report the Gulf-GA-B12288, August 22, 1972.

Sanders 1973. C. F. Sanders and J. D. Sease, "Fabrication and Characteristics of Plutonium Test FTE-13: An HTGR Test Element Containing PuO_{2-x}, $Th_{0.25}$, $Pu_{0.25}O_{2-x}$, and ThO_2," USAEC Report ORNL/TM-4207, Oak Ridge National Laboratory, August 1973.

Wallroth 1980. C. F. Wallroth, et al., "Thermal, Nuclear, and Fission Product Evaluation of Fuel Pin Test Element FPTE-1 and FPTE-3," General Atomic Report GA-A13849, December 1980.

Wallroth 1974. C. F. Wallroth, "Postirradiation Examination of Peach Bottom Fuel Test Element FTE-3," USAEC Report GA-A13004, General Atomic, August 15, 1974.

Wallroth 1977. C. F. Wallroth, "Postirradiation Examination of Peach Bottom Fuel Test Element FTE-4," General Atomic Report GA-A13452, July 1977.

Wallroth 1976. C. F. Wallroth, "Postirradiation Examination of Peach Bottom Fuel Test Element FTE-18," General Atomic Report GA-A13699, July 1977.

Agreement between USAEC and Philadelphia Electric Company for Master Terms and Conditions for Financial Settlement for Spent Fuels Appendix A to Contract No. AT(10-1)-1314, March 1971.

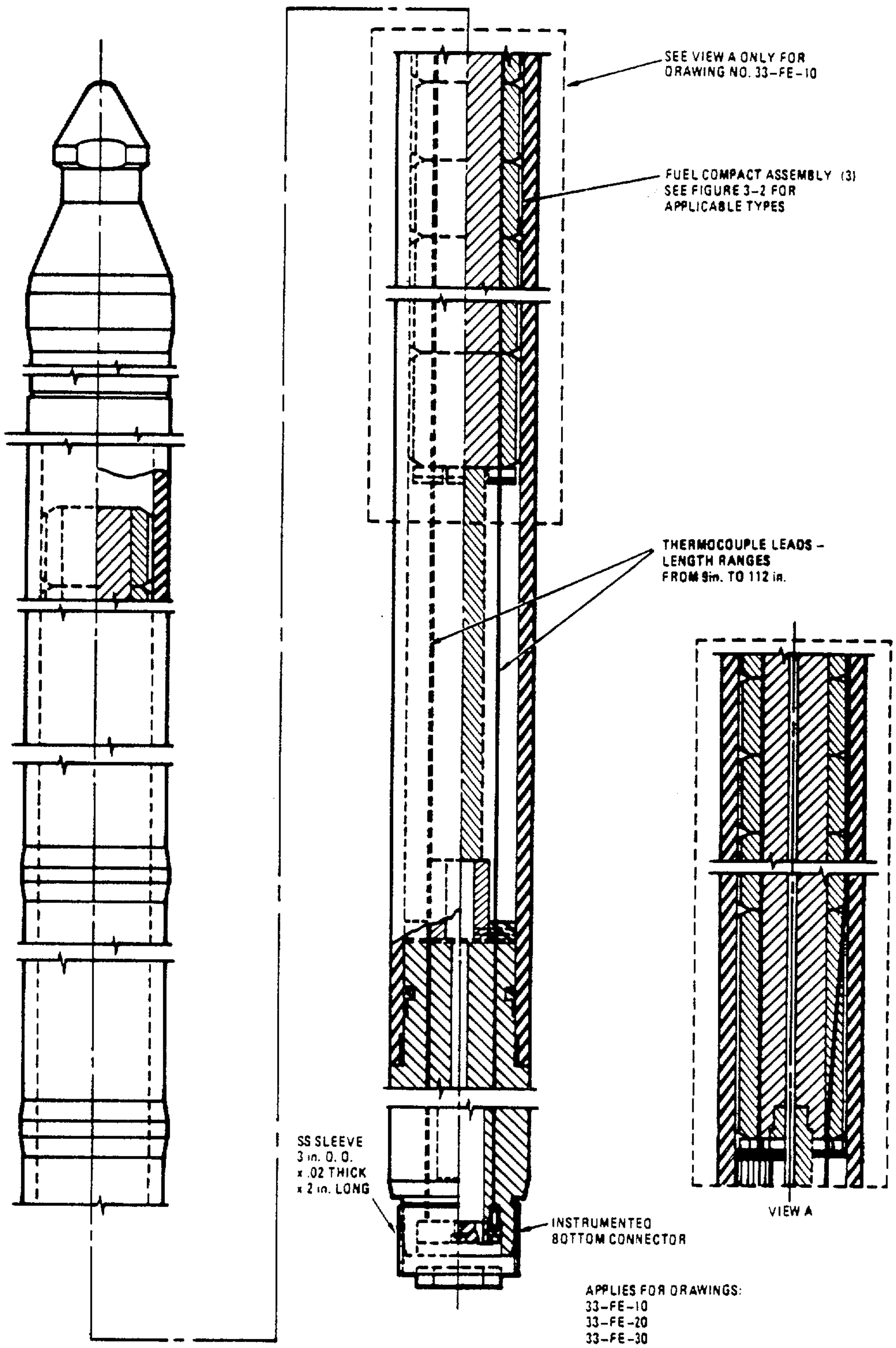


Fig. 4D.1. PB1/1 instrumented fuel element.

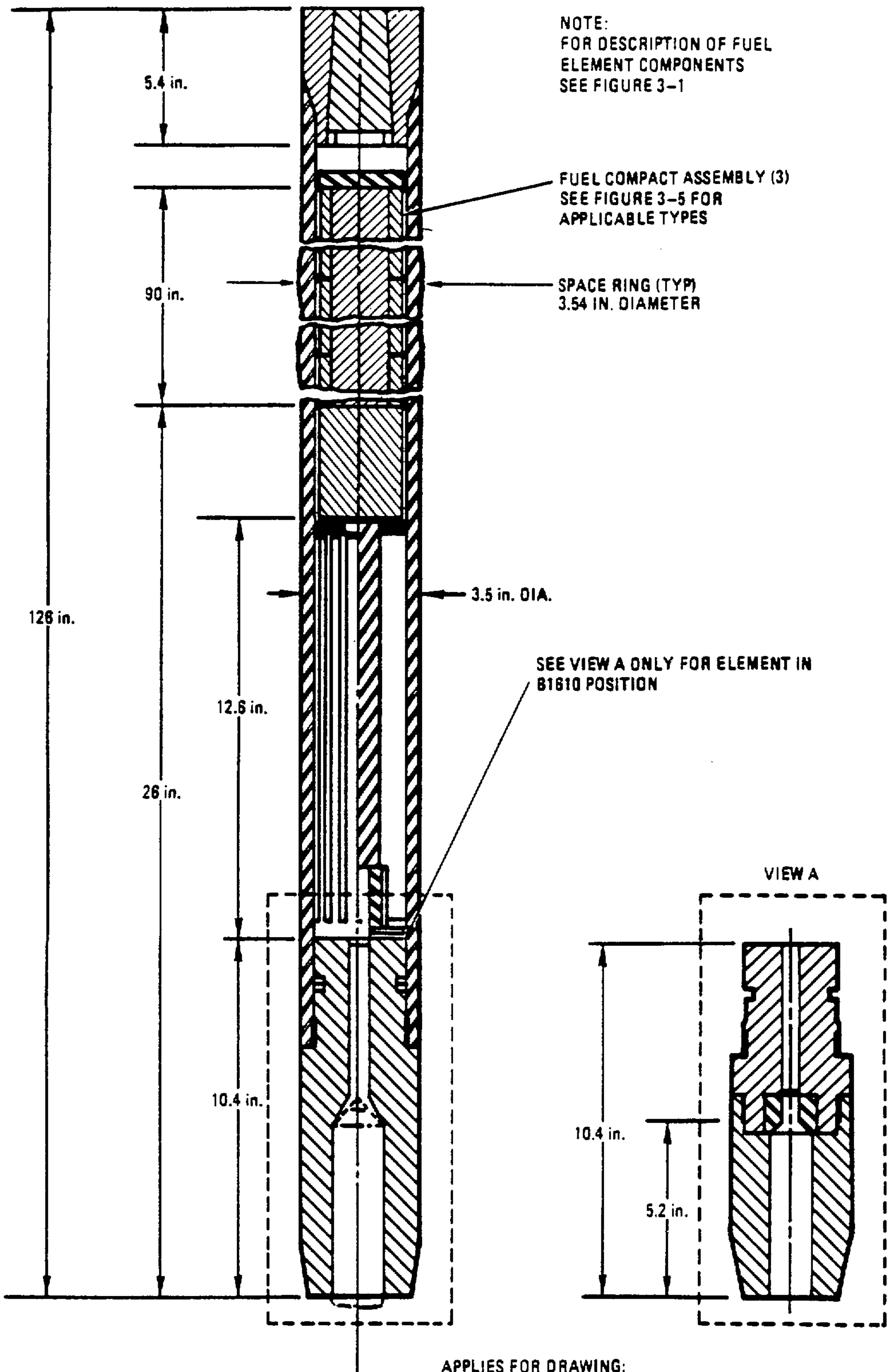


Fig. 4D.2. PB1/2 fuel element.

FUEL TYPE	NUMBER OF ELEMENTS REQUIRED
1	53
2	556
3	76
4	102
	787

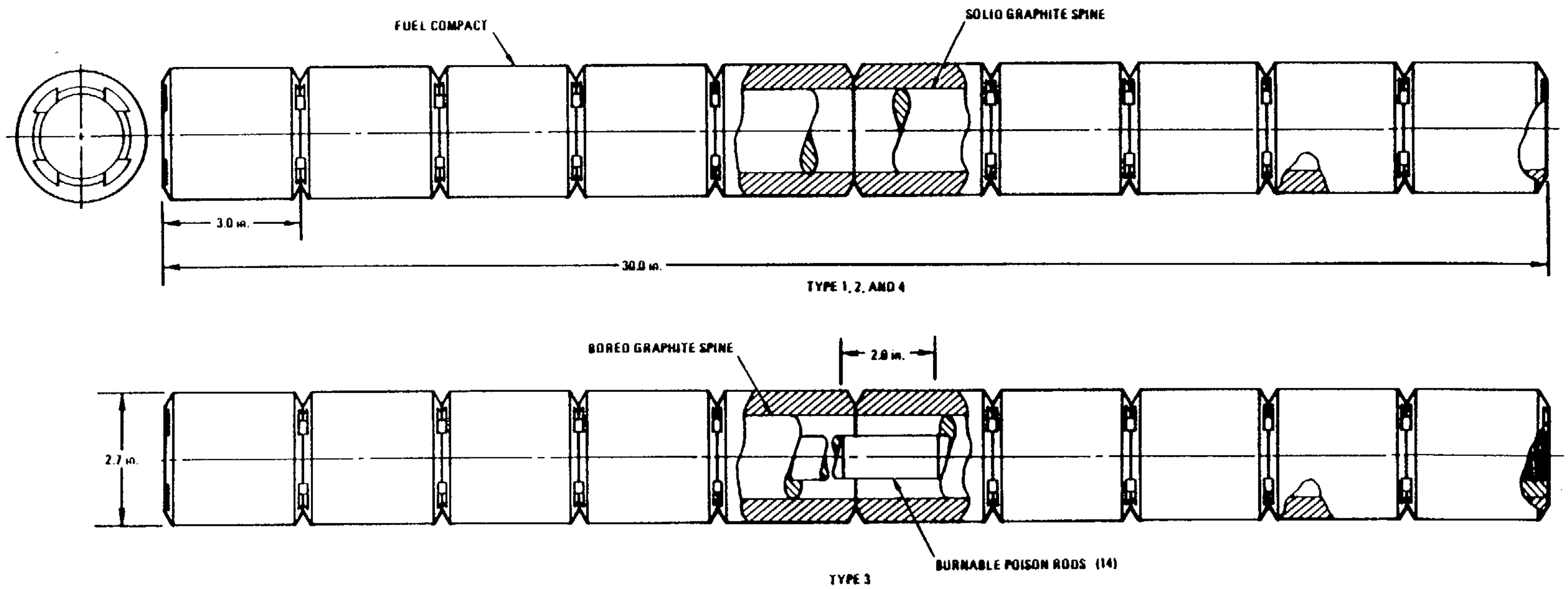


Fig. 4D.3. PB1/2 fuel compact assembly.

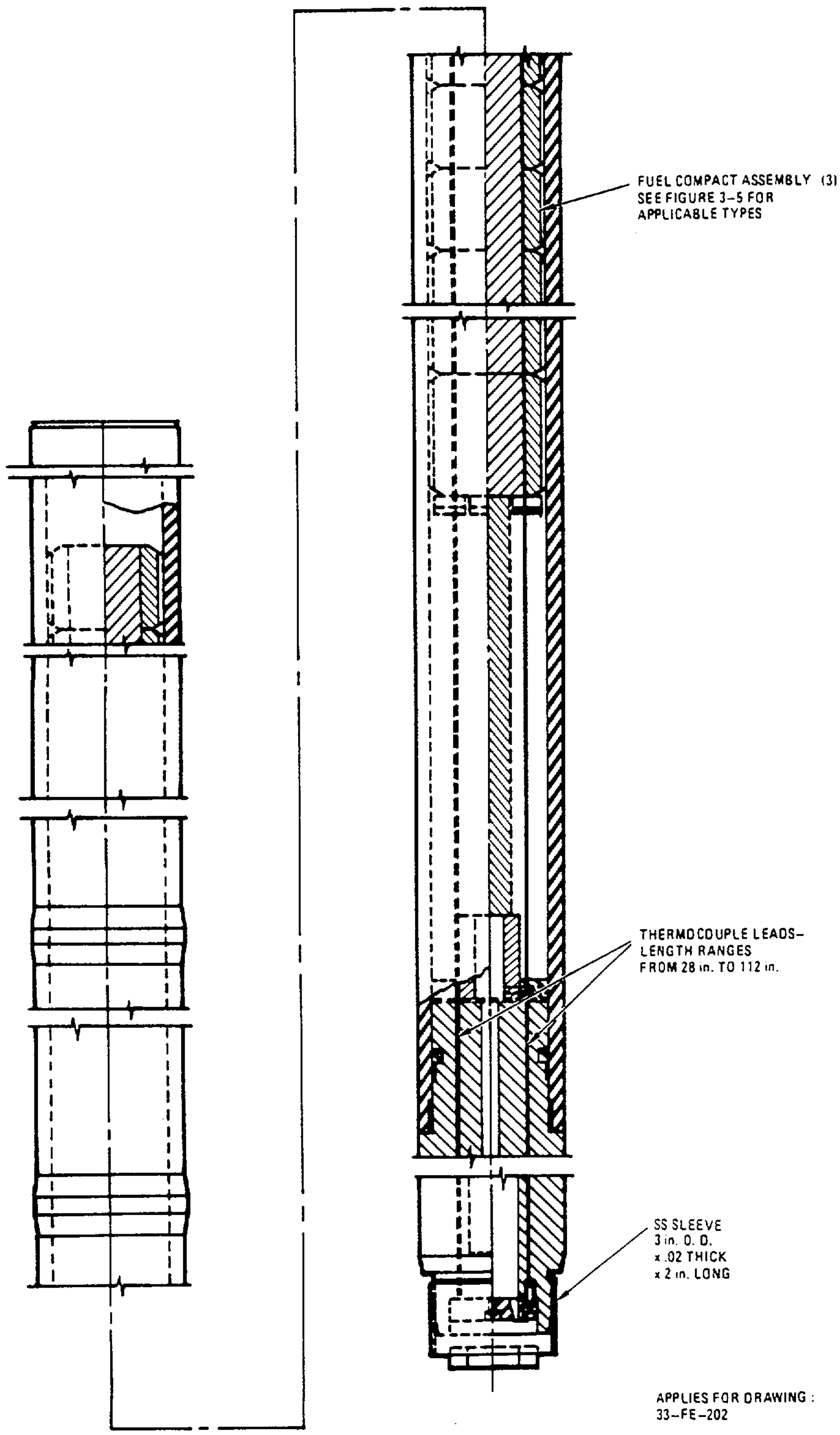


Fig. 4D.4. PB1/2 instrumented fuel element

7 0 0 0 3 2 7 7 9

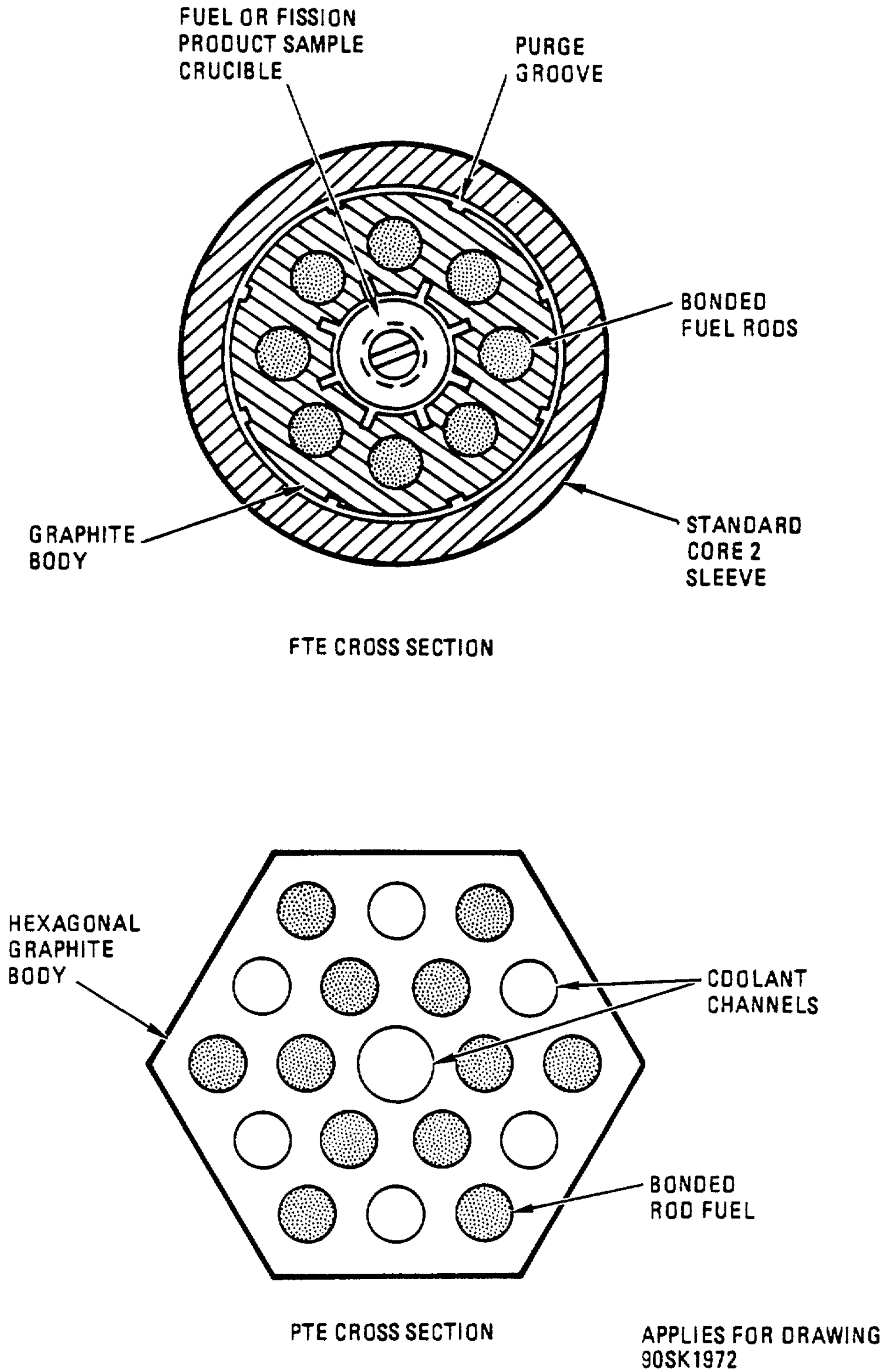


Fig. 4D.5. Cross sections of PB1 test element classes

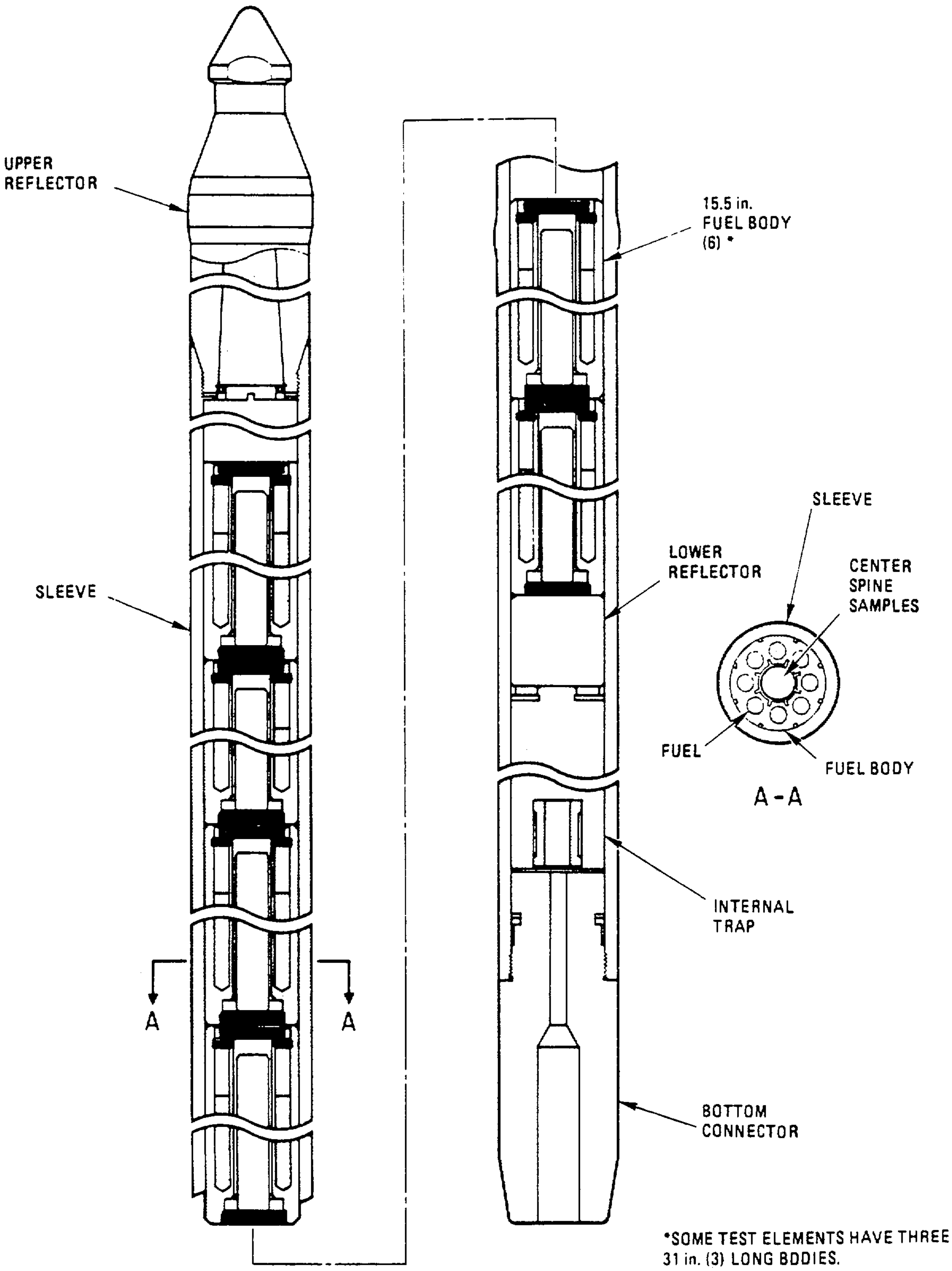
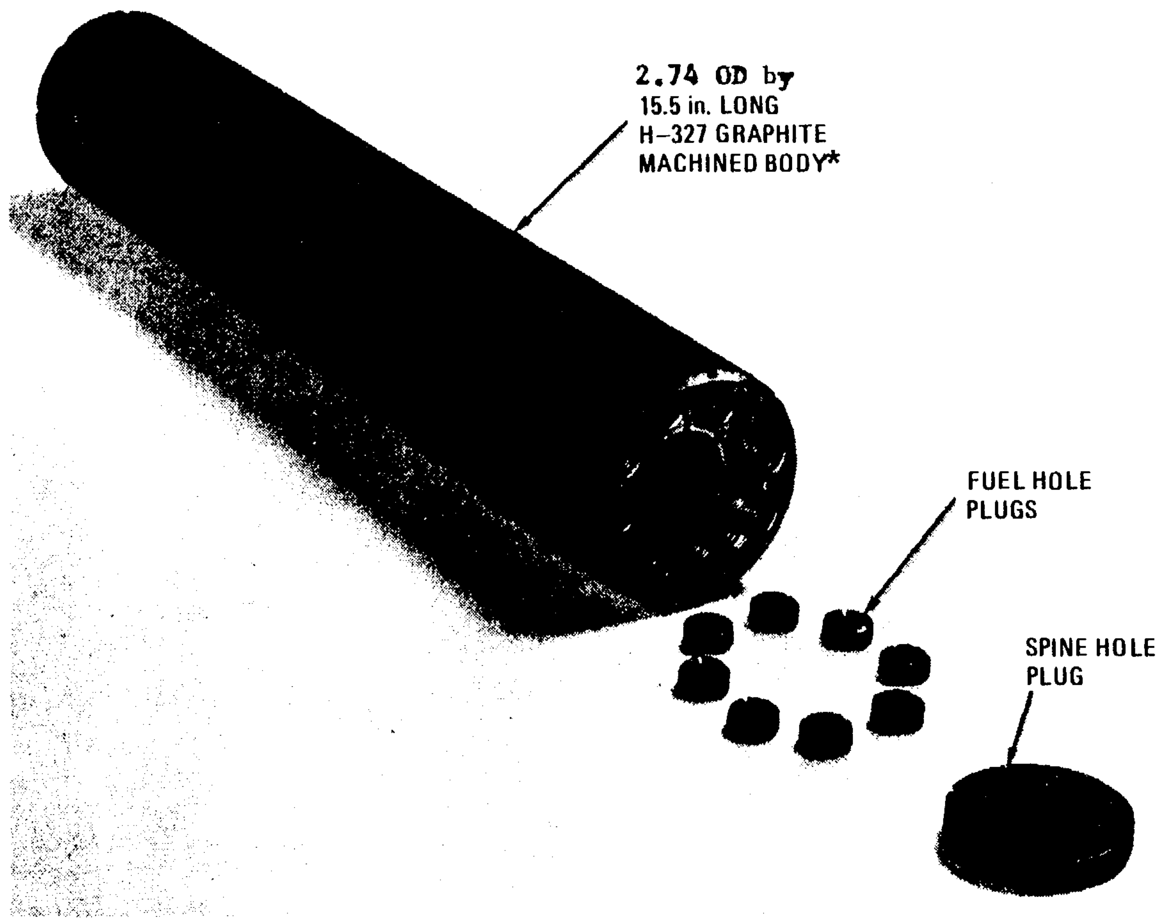
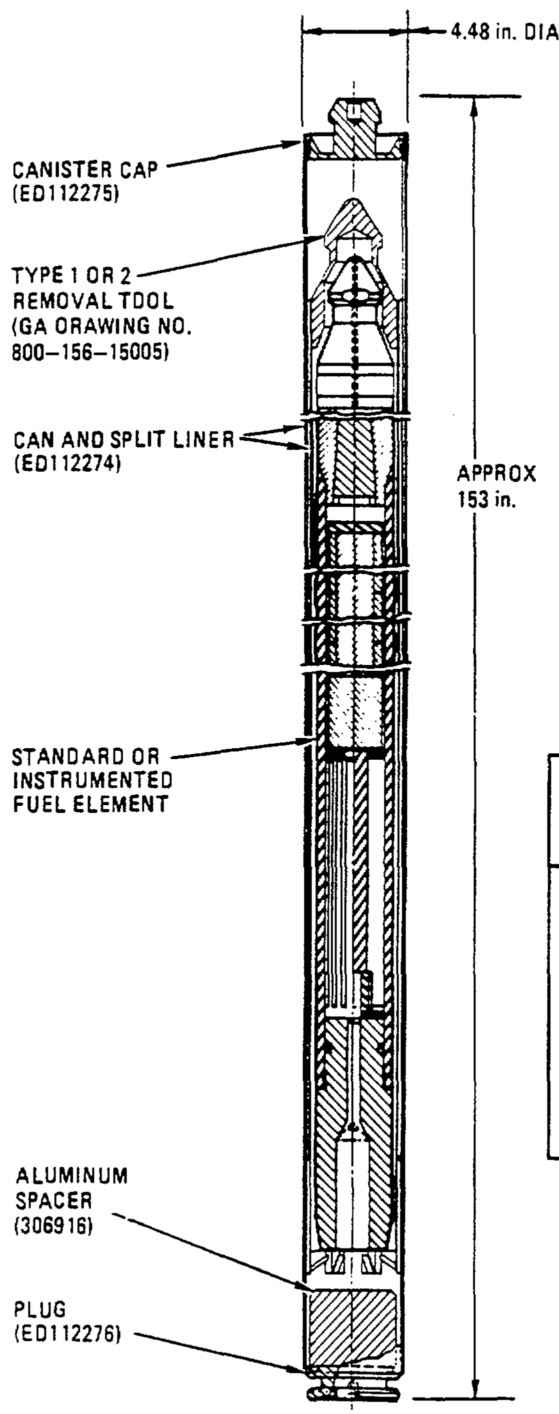


Fig. 4D.6. PB1 typical fuel test element assembly



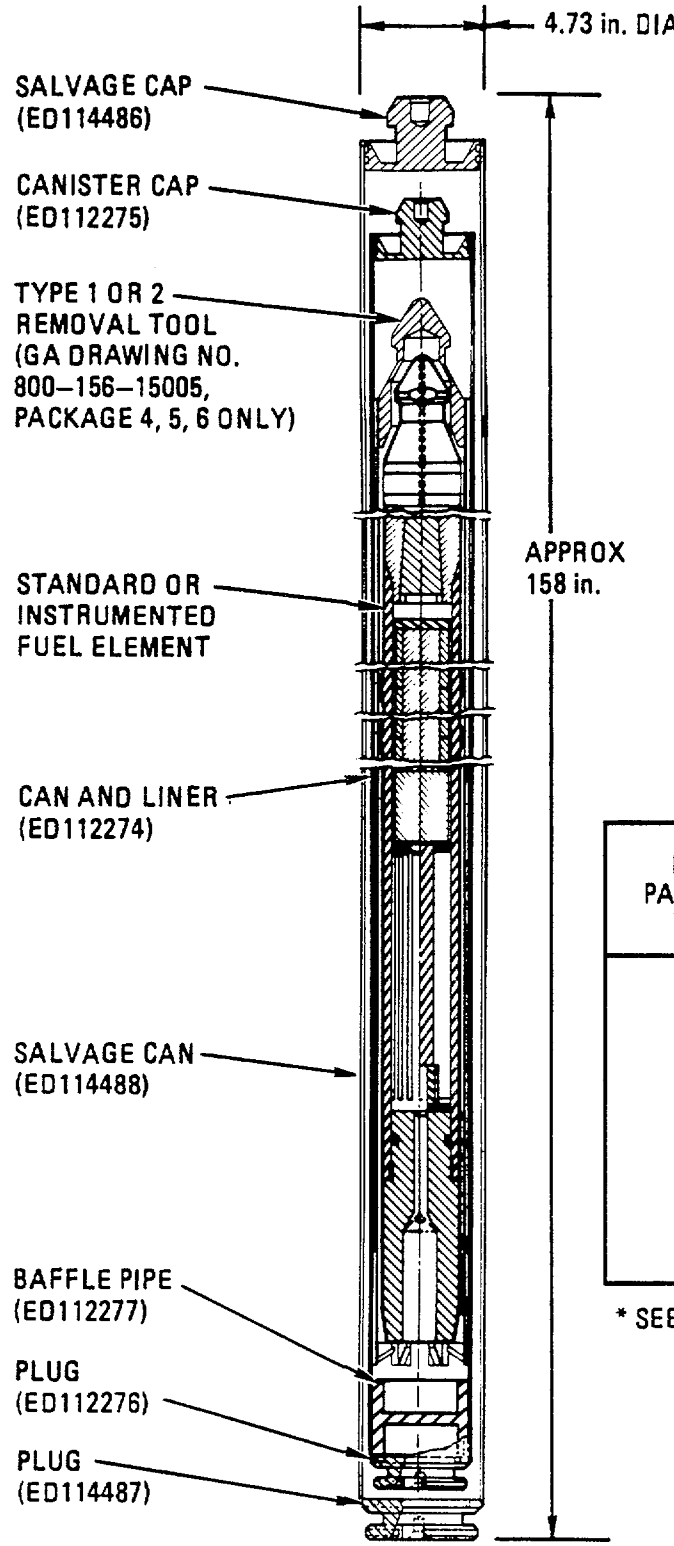
*Some Test Elements have three 31 in. long bodies.

Fig. 4.D.7. PB1 typical fuel test element fuel body



FUEL PACKAGE TYPE	NUMBER OF PACKAGES
2	58
3	7
10	8
11	1
13	1
15	5
16	1
19	3
	84

Fig. 4D.8. PB1/1 fuel element in storage canister with removal tool



FUEL PACKAGE TYPE *	NUMBER OF PACKAGES
4	1
5	1
6	1
7	1
8	1
12	1
	6

* SEE TABLE 3–3

Fig. 4D.9. PB1/1 failed fuel element in storage canister with removal tool in salvage canister

Table 4D.1. Uses of thermocouples in instrumented fuel elements

No. of Instrumented Fuel Elements	Fuel Loading Type	Use of Thermocouples	Reference Drawing No.
8	1 and 2	Spine and sleeve temperature. Also acoustic thermometer at center, hot spot height	33-FE-10
3	1	Axial profile of center of core - spine temperature	33-FE-20
5	1, 2, 3, and 4	Radial profile - spine plus internal trap inlet temperature	33-FE-20
7	1, 2, and 3	Radial profile - both thermocouples for spine temperature	33-FE-20
3	2	Both thermocouples for spine temperature	33-FE-20
2	4	Low U loading - both thermocouples for spine temperature	33-FE-20
2	1 and 2	Internal trap inlet and outlet temperature	33-FE-40
2	2 and 4	Standoff and bottom reflector temperature	33-FE-30
3	2	Axial profile at edge of core - spine temperature	33-FE-20
1	3	Boron loaded - both thermocouples for spine temperature	33-FE-20

Table 4D.2.

PEACH BOTTOM TEST ELEMENTS IRRADIATED IN CORE 2

Element	Phase[a]	Thermocouples	Fuel Bed	Description/Fuel Type
PTE-2[b]	1	Yes	Rods[c]	Proof test element for FSV - rods
FBTE-1	1	Yes	Rods	Fuel bed test element for LHTGRs - bonded rods
FBTE-2	1	Yes	Rods	Fuel bed test element for LHTGRs - bonded rods
FBTE-3	1	Yes	Rods	Fuel bed test element for LHTGRs - bonded rods
FBTE-4	1	Yes	Rods	Fuel bed test element for LHTGRs - bonded rods
FBTE-5	1	No	Blended[d]	Fuel bed test element for LHTGRs - blended bed
FBTE-6	1	Yes	Blended	Fuel bed test element for LHTGRs - blended bed
FTE-1	1	Yes	Blended	Fuel tets element for LHTGRs - blended bed
FTE-2	1	Yes	Blended	Fuel test element for LHTGRs - blended bed
FTE-5	1	Yes	Rods	Fuel test element for LHTGRs - bonded rods
RTE-2	1	No	Mixed	Recycle test element for ORNL - 1/2 beds, 1/2 rods
RTE-4	1	No	Mixed	Recycle test element for ORNL - 1/2 beds, 1/2 rods
RTE-5	1	No	Rods	Recycle test element for ORNL - bonded rods
RTE-6	1	No	Rods	Recycle test element for ORNL - bonded rods
RTE-7	1	No	Rods	Recycle test element for ORNL - bonded rods
RTE-8	1	NO	Rods	Recycle test element for ORNL - 1/6 beds, 5/6 rods
FPTE-1	1	Yes	Compacts	Fuel pin test element for UKAEA - fuel pins
FTE-3	2	Yes	Rods	Fuel test element for LHTGRs
FTE-4	2	?	Rods	Fuel test element for LHTGRs
FTE-6	2	Yes	Rods	Fuel test element for LHTGRs

Table 4D.2. (continued)

Element	Phase[a]	Thermocouples	Fuel Bed	Description/Fuel Type
FTE-7	2	Yes	Rods	Fuel test element for LHTGRs
FTE-8	2	Yes	Rods	Fuel test element for LHTGRs
FTE-9	2	Yes	Rods	Fuel test element for LHTGRs
FTE-10	2	Yes	Rods	Proof test element for FSV
FTE-11	2	No	Rods	Recycle test element for ORNL
FTE-12	2	Yes	Rods	Fuel test element for LHTGRs
FPTE-3	2	Yes	Compacts	Fuel pin test element for UKAEA
FTE-13	3	Yes	Rods	Plutonium fuel test
FTE-14	3	Yes	Rods	Large HTGR fuel test
FTE-15	3	Yes	Rods	Large HTGR fuel test
FTE-16	3	Yes	Rods	FSV fuel proof test
FTE-17	3	Yes	Rods	FSV fuel proof test
FTE-18	3	Yes	Monolithic	HOBEG/KFA molded fuel body test

(a) Phase 1 loaded at 0 EFPD of Core 2, Phase 2 loaded at 252 EFPD of Core 2, and Phase 3 loaded at 385 of Core 2.

(b) PTE-2 was irradiated 152 EFPD in Core 1, prior to irradiation in Core 2.

(c) A fuel rod, as used here, is a close-packed assembly of coated fuel particles bonded together with a carbonaceous matrix.

(d) A blended bed, as used here, is a close-packed assembly of unbonded, coated fuel particles.

Table 4D.3.

PEACH BOTTOM UNIT 1 - CORE 1 SPENT FUEL PACKAGE TYPES

Fuel Package Type	No. of Elements	Description
1	528	Type I or II fuel element, regular can and liner.
2	58	Type I or II fuel element, failed sleeve, normal can, split liner, spacer, type 2 removal tool.
3	7	Fuel assembly type 2 with a type 1 removal tool.
4	1	Type II fuel element (No. 263) broken and stored in 2 containers. Upper portion of element with 21 compacts is in a salvage can with unmarked salvage cap with partial type 2 removal tool, special spacer, component canister, 4.25 in. spacer and 50 lb of steel shot. Lower portion of element with 9 compacts is in a regular canister (cap No. 120) with a 3.25 in. spacer and a special GGA pulling tool.
5	1	Type II fuel element (No. 451), failed sleeve, normal can, split liner, spacer, type 1 removal tool. Due to leaking canister, recanned in salvage canister with special vented cap, unmarked.
6	1	Type II fuel element (No. 576), failed sleeve, type 2 removal tool, component canister and spacer in salvage canister, cap No. 8.
7	1	Type 2 fuel assembly in a salvage canister (cap No. 851, fuel element No. 731).
8	1	Type 2 fuel element (No. 848) less upper reflector canned in salvage canister (component canister and 4 in. spacer inside). Salvage cap is unmarked.
9	71	Type 3 fuel element, regular can and liner.
10	8	Fuel assembly type 2 with a type 3 fuel element.
11	1	Fuel assembly type 10 with a hollowed out cap (No. 90) due to a removal tool positioned too high (element No. 126).

Table 4D.3. (continued)

Fuel Package Type	No. of Elements	Description
12	1	Fuel assembly type 10 recanned in salvage canister with cap C5 (element No. 306).
13	1	Type 10 fuel assembly (element No. 870) in can No. 14 (cap unmarked) with type 1 removal tool.
14	98	Type 4 fuel element, regular can and liner.
15	5	Type 2 fuel assembly with acoustic thermometer installed.
16	1	Type 15 fuel assembly (fuel element No. 807) in can 01, cap unmarked, with a type 1 removal tool.
17	1	Type 1 fuel assembly (fuel element No. 808 and cap No. 252R) with acoustic thermometer installed.
18	18	Type 1 fuel assembly with thermocouple installed.
19	3	Type 2 fuel assembly (element No. 848) with thermocouple installed.
20	3	Type 9 fuel assembly with thermocouple installed.
21	4	Type 14 fuel assembly with thermocouple installed.

Table 4D.4.

PEACH BOTTOM UNIT 1 - CORE 1 INVENTORY AT INEL

Uranium (gm)	U-235 (gm)	Quantity	Type
4853	3847	18 elements	Peach Bottom
4662	3516	18 elements	Peach Bottom
4761	3621	18 elements	Peach Bottom
4857	3718	18 elements	Peach Bottom
4960	3884	18 elements	Peach Bottom
4719	3574	18 elements	Peach Bottom
4972	3890	18 elements	Peach Bottom
4919	3804	18 elements	Peach Bottom
4823	3667	18 elements	Peach Bottom
4705	3623	18 elements	Peach Bottom
4804	3643	18 elements	Peach Bottom
4777	3593	18 elements	Peach Bottom
4822	3687	18 elements	Peach Bottom
4939	3854	18 elements	Peach Bottom
4814	3679	18 elements	Peach Bottom
4794	3685	18 elements	Peach Bottom
4749	3672	18 elements	Peach Bottom
4835	3751	18 elements	Peach Bottom
4957	3869	18 elements	Peach Bottom
4884	3755	18 elements	Peach Bottom
4840	3681	18 elements	Peach Bottom
4865	3721	18 elements	Peach Bottom
4519	3414	18 elements	Peach Bottom
4776	3599	18 elements	Peach Bottom
4309	3176	18 elements	Peach Bottom
4335	3216	18 elements	Peach Bottom
4823	3709	18 elements	Peach Bottom
4919	3871	18 elements	Peach Bottom
4780	3712	18 elements	Peach Bottom
4253	3185	18 elements	Peach Bottom
3442	2352	18 elements	Peach Bottom
3480	2425	18 elements	Peach Bottom
3482	2444	18 elements	Peach Bottom
2805	1754	18 elements	Peach Bottom
3785	2721	18 elements	Peach Bottom
4874	3738	18 elements	Peach Bottom
4836	3680	18 elements	Peach Bottom
4099	2950	18 elements	Peach Bottom
2932	1869	18 elements	Peach Bottom
4687	3546	18 elements	Peach Bottom
4744	3624	18 elements	Peach Bottom
4702	3612	18 elements	Peach Bottom
4923	3848	18 elements	Peach Bottom
4879	3760	18 elements	Peach Bottom
4815	3738	18 elements	Peach Bottom
1084	842	4 elements	Peach Bottom
		814	

Table 4D.5.

PEACH BOTTOM UNIT 1 - CORE 2 INVENTORY AT INEL

Uranium (gm)	U-235 (gm)	Quantity	Type
3053	618	18 elements	Peach Bottom
2355	657	18 elements	Peach Bottom
1854	678	18 elements	Peach Bottom
1855	680	18 elements	Peach Bottom
2470	623	18 elements	Peach Bottom
3184	468	18 elements	Peach Bottom
2446	570	18 elements	Peach Bottom
2508	562	18 elements	Peach Bottom
2449	570	18 elements	Peach Bottom
2657	565	18 elements	Peach Bottom
2441	548	17 elements	Peach Bottom
2722	562	18 elements	Peach Bottom
2833	539	18 elements	Peach Bottom
2790	567	18 elements	Peach Bottom
2919	551	18 elements	Peach Bottom
2995	594	18 elements	Peach Bottom
2997	610	18 elements	Peach Bottom
3004	610	18 elements	Peach Bottom
3001	609	18 elements	Peach Bottom
3027	605	18 elements	Peach Bottom
3038	610	18 elements	Peach Bottom
3017	614	18 elements	Peach Bottom
3033	617	18 elements	Peach Bottom
3091	617	18 elements	Peach Bottom
3009	611	18 elements	Peach Bottom
3034	615	18 elements	Peach Bottom
3099	620	18 elements	Peach Bottom
3136	624	18 elements	Peach Bottom
3037	604	18 elements	Peach Bottom
3046	584	18 elements	Peach Bottom
2977	580	18 elements	Peach Bottom
2983	540	18 elements	Peach Bottom
2978	548	18 elements	Peach Bottom
2975	580	18 elements	Peach Bottom
2958	582	18 elements	Peach Bottom
2972	607	18 elements	Peach Bottom
2948	607	18 elements	Peach Bottom
2975	595	18 elements	Peach Bottom
2971	594	18 elements	Peach Bottom
2971	594	18 elements	Peach Bottom
2976	578	18 elements	Peach Bottom
2978	578	18 elements	Peach Bottom
2152	373	13 elements	Peach Bottom
2787	496	17 elements	Peach Bottom
		785	

Table 4D.6.

PEACH BOTTOM UNIT 1 - CORE 1 SUMMARY OF POSTIRRADIATION URANIUM LOADINGS BY FUEL ASSEMBLY PACKAGE TYPE

Package Type	No. of Elements	Total U Average (g) Maximum (g)	U-232 Average (μg) Maximum (μg)	U-233 Average (g) Maximum (g)	U-234 Average (g) Maximum (g)	U-235 Average (g) Maximum (g)	U-236 Average (g) Maximum (g)	U-238 Average (g) Maximum (g)
1	528	268.68 303.81	1645 2081	23.99 27.10	3.71 3.89	206.46 268.84	18.46 20.76	16.06 17.10
2	58	267.46 283.83	1697 2081	24.39 27.10	3.73 3.89	204.46 226.93	18.84 20.76	16.04 16.27
3	7	279.24 282.79	883 960	17.94 19.04	3.47 3.49	227.35 230.81	14.08 14.52	16.39 16.50
4	1	256.77 256.77	1584 1584	20.42 20.42	3.71 3.71	197.31 197.31	19.06 19.06	16.27 16.27
5	1	280.85 280.85	820 820	18.24 18.24	3.44 3.44	229.11 229.11	13.75 13.75	16.31 16.31
6	1	255.80 255.80	1699 1699	21.36 21.36	3.75 3.75	194.85 194.85	19.62 19.62	16.21 16.21
7	1	278.49 278.49	1191 1191	22.71 22.71	3.53 3.53	219.86 219.86	16.25 16.25	16.14 16.14
8	1	297.20 297.20	285 285	11.00 11.00	3.36 3.36	257.31 257.31	8.60 8.60	16.93 16.93
9	71	269.79 295.62	1594 2050	23.67 27.04	3.68 3.86	208.20 258.37	18.15 20.33	16.08 16.71
10	8	268.25 274.76	1836 2050	25.70 27.04	3.77 3.86	203.54 213.19	19.27 20.33	15.96 16.05
11	1	272.57 272.57	1646 1646	25.21 25.21	3.69 3.69	209.35 209.35	18.31 18.31	16.00 16.00
12	1	274.64 274.64	1498 1498	24.36 24.36	3.63 3.63	212.99 212.99	17.61 17.61	16.05 16.05
13	1	285.85 285.85	749 749	17.82 17.82	3.42 3.42	235.34 235.34	12.87 12.87	16.40 16.40
14	98	150.41 155.48	3009 3262	34.81 36.28	3.19 3.34	91.69 96.02	11.90 12.33	8.81 8.86
15	5	268.15 277.75	1715 2013	24.53 25.57	3.73 3.84	205.07 218.51	18.79 20.25	16.03 16.13
16	1	288.17 288.17	651 651	16.82 16.82	3.40 3.40	239.07 239.07	12.35 12.35	16.53 16.53
17	1	277.75 277.75	1279 1279	23.04 23.04	3.55 3.55	218.51 218.51	16.51 16.51	16.13 16.13
18	18	270.69 283.63	1550 2013	23.62 25.61	3.66 3.84	209.37 226.63	17.95 20.25	16.09 16.24
19	3	277.57 278.54	1228 1297	22.79 23.00	3.54 3.57	218.63 219.94	16.46 16.90	16.14 16.14
20	3	268.61 284.63	1378 1559	21.33 22.54	3.61 3.68	210.09 227.42	17.35 18.55	16.23 16.26
21	4	150.60 155.48	2933 3240	34.56 36.17	3.16 3.18	92.24 96.02	11.81 11.96	8.82 8.83

Table 4D.8.

PEACH BOTTOM UNIT 1 - CORE 2 TEST ELEMENT POSTIRRADIATION HEAVY METAL LOADINGS[(a)]

	Th-232	Pa-231	U-232	U-233[(b)]	U-234	U-235	U-236	U-238	Pu-239[(c)]	Pu-240	Pu-241	Pu-242	Np-237
PTE-2	2120.76	0.010	0.003	26.34	5.14	316.77	24.34	23.65	0.80	0.17	0.10	0.009	0.93
FBTE-1	1211.22	0.007	0.008	30.03	4.96	83.11	23.83	8.93	0.26	0.09	0.14	0.060	2.03
FBTE-2	526.21	0.003	0.004	16.88	4.00	87.36	26.26	9.76	0.25	0.09	0.14	0.069	2.14
FBTE-3	727.09	0.004	0.005	19.00	3.93	67.71	22.03	8.12	0.19	0.06	0.11	0.058	1.73
FBTE-4	932.78	0.003	(d)	9.64	3.44	179.16	9.78	10.97	0.28	0.05	0.02	0.001	0.26
FBTE-5	1457.91	0.008	0.011	32.04	5.39	65.95	22.64	7.98	0.20	0.07	0.12	0.066	1.99
FBTE-6	1650.59	0.005	0.001	14.67	2.92	131.30	8.53	8.41	0.20	0.04	0.02	0.002	0.23
FTE-1	1522.48	0.005	0.001	13.40	3.21	150.84	9.49	9.58	0.23	0.05	0.02	0.002	0.26
FTE-2	1614.40	0.007	0.003	20.36	3.24	120.73	11.44	8.37	0.25	0.06	0.04	0.005	0.46
FTE-5	1039.43	0.005	0.007	23.36	4.47	72.43	22.85	8.52	0.20	0.07	0.11	0.059	1.77
RTE-2	773.80	0.004	0.004	19.43	3.75	98.30	20.55	9.07	0.27	0.09	0.12	0.036	1.43
RTE-4	1072.56	0.005	0.002	16.10	2.95	110.60	11.97	8.00	0.23	0.06	0.05	0.007	0.52
RTE-5	1022.46	0.006	0.008	25.16	4.61	61.57	21.90	7.65	0.19	0.07	0.11	0.065	1.94
RTE-6	882.06	0.005	0.007	23.66	4.57	60.31	22.70	7.78	0.19	0.07	0.12	0.069	2.05
RTE-7	1235.16	0.004	0.001	12.78	2.89	135.34	8.71	8.60	0.22	0.04	0.02	0.002	0.25
RTE-8	837.34	0.005	0.007	22.51	4.38	58.99	22.09	7.58	0.19	0.06	0.11	0.067	1.99
FPTE-1	0	0	0	0	0	107.64	5.65	1330.60	6.65	1.18	0.58	0.041	1.13
FTE-3	990.41	0.002	(d)	6.00	1.54	170.22	5.13	11.75	0.20	0.02	0.005	(d)	0.08
FTE-4	1006.65	0.004	0.003	15.51	2.00	107.05	13.84	10.21	0.25	0.07	0.08	0.015	0.60
FTE-6	825.61	0.004	0.004	18.93	2.70	99.77	21.47	11.53	0.32	0.10	0.15	0.049	1.43
FTE-7	1359.43	0.006	0.006	23.34	3.07	100.27	21.05	11.74	0.27	0.09	0.13	0.044	1.23
FTE-8	499.05	0.002	0.002	12.67	2.02	80.83	17.31	9.58	0.22	0.07	0.10	0.037	1.01
FTE-9	1080.01	0.006	0.005	22.36	2.67	83.79	16.80	9.34	0.26	0.08	0.12	0.036	1.08
FTE-10	658.36	0.003	0.003	16.89	2.29	76.55	16.58	8.89	0.24	0.08	0.11	0.038	1.10
FTE-11	858.50	0.004	0.005	19.79	2.93	93.23	22.56	11.55	0.29	0.10	0.15	0.057	1.54
FTE-12	1301.92	0.007	0.006	23.94	2.83	90.26	17.75	9.96	0.28	0.09	0.12	0.037	1.13
FPTE-3	0	0	0	0	0	112.59	21.18	1337.45	7.15	2.26	3.05	0.933	1.19
FTE-13	1317.24	0.006	0.005	23.69	2.16	50.05	8.81	4.36	1.08	2.03	1.92	1.002	0.47
FTE-14	1889.32	0.007	0.002	27.83	3.51	132.15	10.45	8.69	0.23	0.05	0.03	0.003	0.35
FTE-15	1834.43	0.008	0.005	34.63	4.46	104.64	15.51	8.45	0.20	0.06	0.08	0.017	0.73
FTE-16	1018.51	0.005	0.003	18.45	2.88	75.85	12.35	6.31	0.17	0.05	0.06	0.015	0.67
FTE-17	881.11	0.004	0.003	17.70	2.41	50.00	9.01	4.37	0.11	0.04	0.05	0.012	0.51
FTE-18	712.83	0.003	0.003	15.54	4.91	75.75	15.12	14.48	0.37	0.12	0.16	0.046	0.91

(a) Assuming all test elements stay in Core 2 until Core-2 end-of-life (EOL).

(b) Includes Pa-233.

(c) Includes Np-239.

(d) Less than 0.001.

Table 4D.7.

PEACH BOTTOM UNIT 1 - CORE 2 TEST ELEMENT INITIAL HEAVY METAL LOADINGS

Test Element Number	Thorium	Uranium[a]
PTE-2	2152.62	450.0
FBTE-1	1263.6	215.9
FBTE-2	566.6	235.0
FBTE-3	762.2	194.2
FBTE-4	943.7	235.7
FBTE-5	1518.1	194.4
FBTE-6	1667.7	181.0
FTE-1	1537.8	206.1
FTE-2	1639.5	184.4
FTE-5	1082.4	203.3
RTE-2	804.0	211.9
RTE-4	1093.2	177.4
RTE-5	1083.5	186.6
RTE-6	928.2	190.6
RTE-7	1250.0	185.5
RTE-8	881.1	185.7
FPTE-1	0	1477.5 (9.15% enriched)
FTE-3	996.80	205.9
FTE-4	1027.63	188.42
FTE-6	855.43	222.94
FTE-7	1396.08	223.44
FTE-8	519.15	182.44
FTE-9	1114.5	179.76
FTE-10	685.1	171.81
FTE-11	891.02	224.14
FTE-12	1338.6	191.52
FPTE-3	0	1592.39 (14.08% enriched)
FTE-13	1352.03	99.94
	Pu-total	Pu-239
	18.77	16.65
FTE-14	1922.6	191.5
FTE-15	1883.7	191.85
FTE-16	1045.0	144.93
FTE-17	907.2	100.8
FTE-18	736.2	168.0 (86.46% enriched)

[a] 93.15% enriched except as noted.