

分置

本資料は 年 月 日付けで登録区分、
変更する。

01.11.30

[技術情報室]

INSPECTION RECORDS TO ACCOMPANY ABSORBER PINS FOR DFR 464/2 IRRADIATION PROGRAM

November 1973

Fast Breeder Reactor Project
Power Reactor and Nuclear Fuel
Development Corporation

本資料の全部または一部を複写・複製・転載する場合は、下記にお問い合わせください。

〒319-1184 茨城県那珂郡東海村大字村松4番地49
核燃料サイクル開発機構
技術展開部 技術協力課

Inquiries about copyright and reproduction should be addressed to:
Technical Cooperation Section,
Technology Management Division,
Japan Nuclear Cycle Development Institute
4-49 Muramatsu, Tokai-mura, Naka-gun, Ibaraki, 319-1184
Japan

© 核燃料サイクル開発機構 (Japan Nuclear Cycle Development Institute)

© 核燃料サイクル開発機構 (Japan Nuclear Cycle Development Institute)

CERTIFICATE

As shown in the following Articles I, II, III, IV, V, and VI, all absorber pins for DFR 464/2 irradiation experiment are made according to the specifications and drawings.

Hereby, I approve this certificate.

Kunihiko UEMATSU

Senior Engineer

Fast Breeder Reactor Project

Power Reactor & Nuclear Fuel
Development Corporation

———— CONTENTS ————

Certificate

I. Mensuration and Weight of Each Absorber Pin 3

II. Mensuration, Weight and Composition of Specimens in Each Absorber
Pin 6

III. Specifications and Test Results of Capsule Components 13

IV. Certificate on Degree of Leak Tightness of the Absorber Pins 20

V. X-ray Inspections of Welds and Pins 21

VI. Certificate on Degree of Cleanliness of the Absorber Pins 22

Appendix

- (1) Photos of the Complete Absorber Pins and Their Components
- (2) Shipping List of the Absorber Pins and Reference Specimens
- (3) Capsule Drawings

Drawing No. DFR-B-01-01

Drawing No. DFR-B-02-01

I. MENSURATION AND WEIGHT OF EACH ABSORBER PIN

Mensurations of each absorber pin was performed using a micrometer and a caliper. All results are summarized in Tables I-1 and I-2.

Full weights of the absorber pins and their components are shown in Table I-3.

All results satisfy the Preliminary Design and Pin Drawings.

Table I-1 Mensuration Records of Absorber Pins

Items	Max. or Min.	Pin Identification		
		No. 1	No. 2	No. 3
Total Pin Length (mm)		179.76	179.86	174.48
Clad Outer Diameter* (mm)	Max.	15,139	15,144	15,137
	Min.	15,126	15,126	15,124
Outer Dia. of Upper Weld Bead (mm)	Max.	15,354	15,364	15,357
Outer Dia. of Lower Weld Bead (mm)	Max.	15,349	15,381	15,485

* Detailed mensuration results are shown in Table A-2

Table I-2 Mensuration Records of Pin Diameter

Pin No. Orientation Distance from Bottom (cm)	1		2		3	
	X	Y	X	Y	X	Y
(Lower Weld Bead)	15,340	15,349	15,381	15,340	15,485	15,463
1	15,123	15,137	15,129	15,131	15,132	15,130
2	15,128	15,133	15,126	15,130	15,124	15,128
3	15,127	15,134	15,123	15,134	15,129	15,132
4	15,128	15,131	15,126	15,133	15,125	15,136
5	15,132	15,134	15,127	15,143	15,124	15,134
6	15,126	15,133	15,124	15,133	15,129	15,131
7	15,130	15,132	15,124	15,134	15,131	15,127
8	15,126	15,131	15,123	15,138	15,129	15,137
9	15,130	15,132	15,130	15,136	15,130	15,126
10	15,129	15,131	15,134	15,138	15,131	15,125
11	15,128	15,134	15,136	15,136	15,128	15,124
12	15,131	15,132	15,131	15,133	15,132	15,123
13	15,129	15,139	15,130	15,137	15,132	15,124
14	15,128	15,135	15,130	15,144	15,133	15,132
15	15,127	15,137	15,127	15,134	15,136	15,127
16	15,131	15,135	15,129	15,137	15,125	15,128
17	15,132	15,130	15,129	15,127	-	-
(Upper Weld Bead)	15,344	15,354	15,356	15,364	15,357	15,342

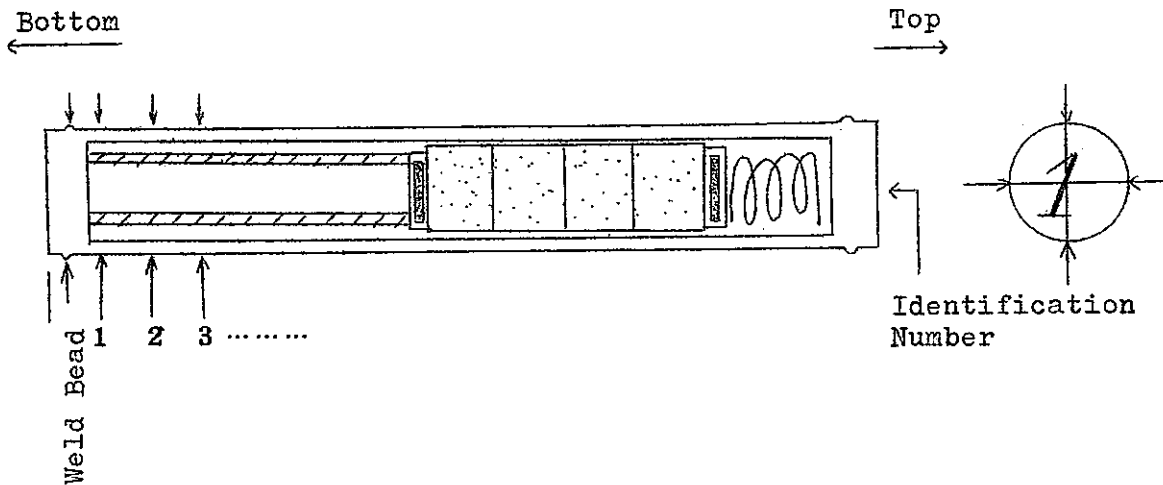


Table I-3 Full Weights of Absorber Pins and Their Components

Pin Identification	No. 1	No. 2	No. 3
a. Total Weight of Complete Pin (g)	141,900	141,940	136,647
b. Total Weight of B ₄ C Specimens (g)	16,155	16,846	11,745
c. Total Weight of Temp. Monitors (SiC) (g)	0.498	0.491	0.494
d. Total Weight of * Stainless Steel (g)	125,247	124,603	124,409

* Calculated from following formula;

$$d = a - (b + c)$$

II. MENSURATION, WEIGHT AND COMPOSITION OF SPECIMENS IN EACH ABSORBER PIN

Three different ^{10}B enriched boron carbides were pelletized for this irradiation. Both natural B_4C pellets and 22.5 % enriched B_4C pellets were prepared by sintering, while 85 % enriched B_4C pellets were fabricated by hot pressing. All these pellets having the same relative densities of 75 % T.D. were ground to right circular cylinders prior to the encapsulation.

Mensurations and weights of these pellets are summarized in Tables II-1 to II-3. Chemical compositions for raw powder and fabricated pellets are shown in Tables II-4 and II-5.

The results of metallographic examination are shown in Figure II-1 to II-6.

Table II-1 Dimensions & Weights of 22.5 % Enriched B₄C Pellets

Specimen No.	Dia. (mm)	Height (mm)	Weight (gr)	Density (g/cc)	R. D. * (% T.D.)	Remarks
1-1	11.71	20.05	4,051	1,876	74.92	for irradiation (Pin No. 1)
1-2	11.70	20.05	4,045	1,877	74.94	
1-3	11.70	20.05	4,067	1,887	75.35	
1-4	11.70	20.05	3,992	1,852	73.96	
1-5	11.70	20.10	4,073	1,885	75.27	reference specimen

* Theoretical density for 22.5 % enriched B₄C = 2,504 gr/cc

Table II-2 Dimensions & Weights of Natural B₄C Pellets

Specimen No.	Dia. (mm)	Height (mm)	Weight (gr)	Density (g/cc)	R. D. * (% T.D.)	Remarks
2-1	11.70	20.10	4,030	1,865	74.30	for irradiation (Pin No. 2)
2-2	11.70	20.10	4,031	1,865	74.31	
2-3	11.70	20.10	4,029	1,864	74.28	
2-4	11.70	20.10	4,056	1,877	74.78	
2-5	11.70	20.10	4,047	1,873	74.61	reference specimen

* Theoretical density for natural B₄C = 2.51 g/cc

Table II-3 Dimensions & Weights of 85 % Enriched Pellets

Specimen No.	Dia. (mm)	Height (mm)	Weight (gr)	Density (g/cc)	R. D. * (% T.D.)	Remarks
3-1	11.71	20.05	3,888	1,801	75.26	for irradiation (Pin No. 3)
3-2	11.70	20.10	3,916	1,812	75.76	
3-3	11.71	20.05	3,941	1,825	76.30	
3-4	11.71	20.10	3,886	1,795	75.06	reference specimen

* Theoretical density for 85 % enriched B₄C = 2,392 g/cc

Table II-4 Chemical Analysis of Raw Powder

Element	22.5% enriched B ₄ C powder	Natural B ₄ C powder	85% enriched B ₄ C powder
total B (wt%) ^{*1}	75.84	76.91	78.83
total C (wt%)	22.28	22.39	21.21
total (B+C) (wt%)	98.12	99.30	100.04
*2			
Other impurities			
Al	-	VW	m
Ca	-	W	-
Cu	-	VW	-
Fe	W	m	W
Mg	VVW	W	VVW
Mn	-	VVW	-
Pb	-	VVW	-
Si	m	m	m
Co	VW	-	VW
¹⁰ B (wt%) ^{*3}	22.73 ± 0.2	18.53 ± 0.1	85.17 ± 0.3
¹¹ B (wt%)	77.27 ± 0.3	81.47 ± 0.3	14.83 ± 0.1

* 1) Boron and carbon were analysed chemically

The procedures of boron and carbon analysis are as follows.

Total B:

Sampling → Alkaline fusion → Dissolution → Acidity Adjustment
 (Na₂CO₃ + K₂CO₃) (HCl)
 → Boiling → Neutralization of free acid → Titration
 (0.1N NaOH) (0.1N NaOH)

Total C:

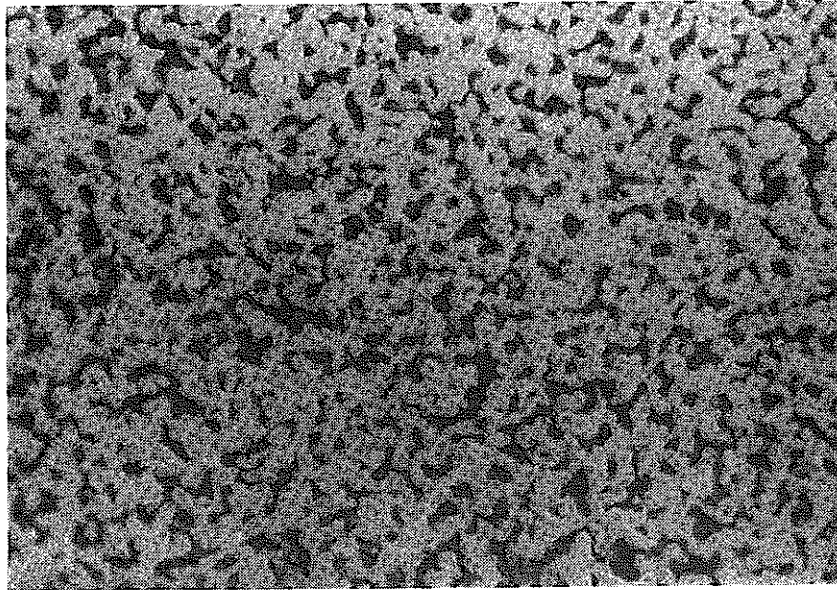
Sampling → Addition of Sn powder → Combustion in O₂ gas stream
 (1300°C)
 → Coulometric carbon analyser

* 2) Impurities were qualitatively determined by emission spectroscopic analysis. Relative contents of elements are listed in intensity. Where m, w and v represent medium, weak and very respectively.

* 3) B₄C powder is converted to boric acid at 800^o C under the existence of vapour in order to analyze isotopic composition by mass spectrometer.

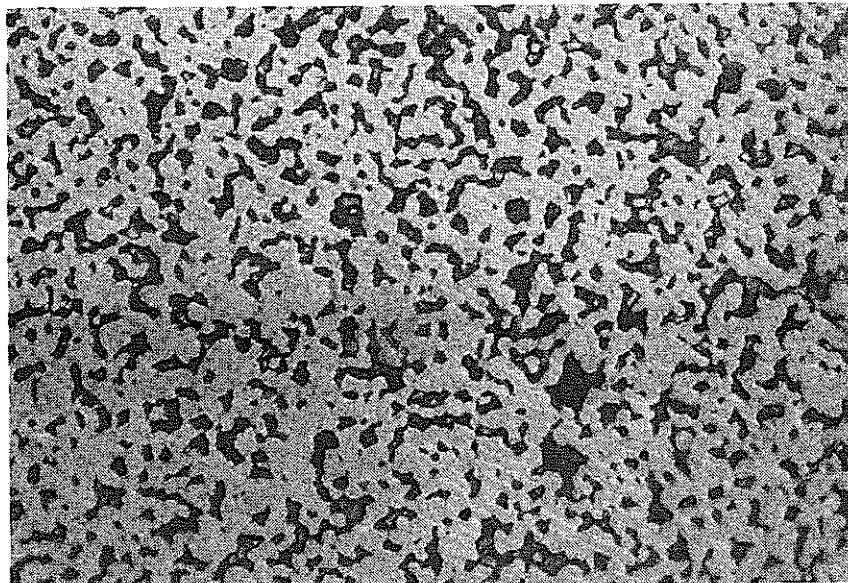
Table II-5 Chemical Analysis of the Fabricated B₄C Pellets

element	22.5% enriched	natural	85% enriched
total B	78.58 (wt%)	75.50 (wt%)	78.12 (wt%)
total C	22.28 (wt%)	21.92 (wt%)	21.71 (wt%)
total (B+C)	100.86 (wt%)	99.42 (wt%)	99.83 (wt%)
other impurities			
Al	-	-	VVW
Fe	VW	VW	VW
Mg	VVW	VVW	VVW
Si	m	s	w



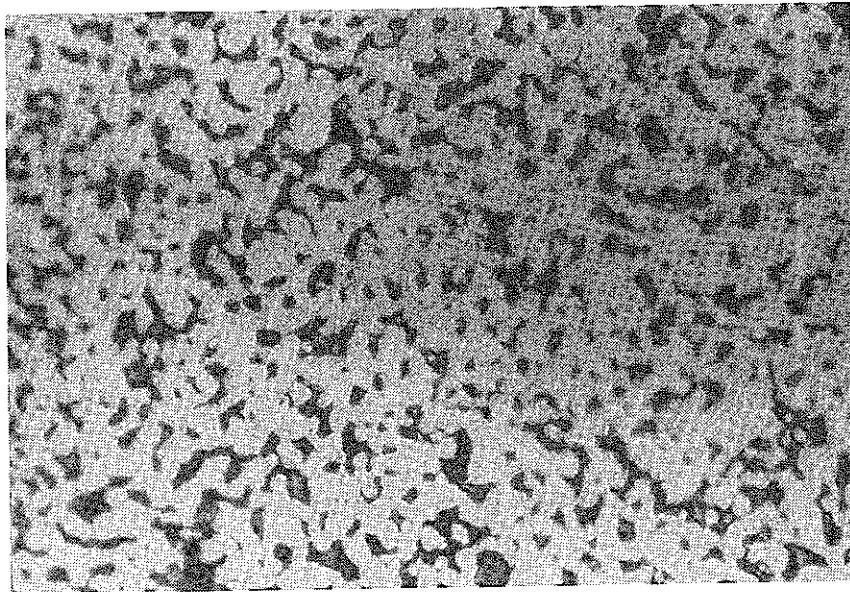
60μ

Figure II-1 As polished enriched (22.5%) B₄C pellet (x500)



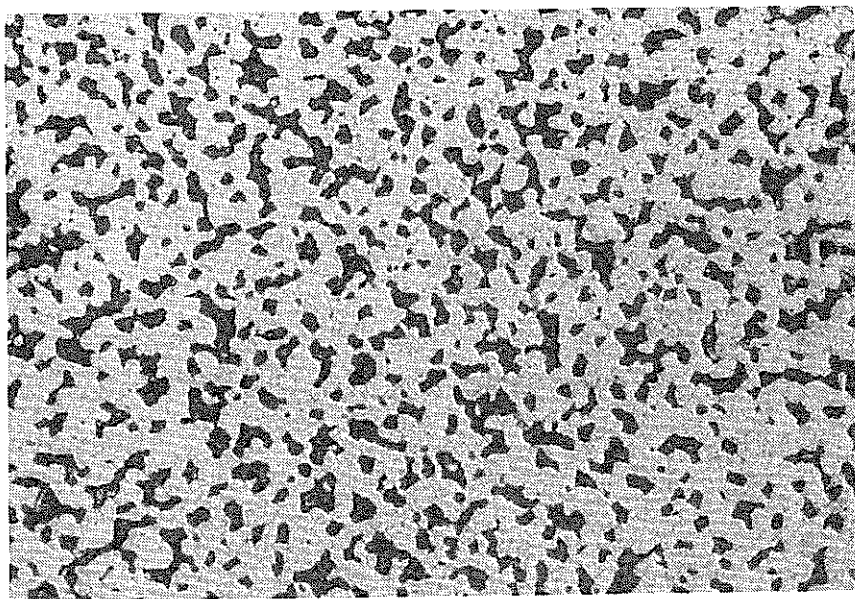
60μ

Figure II-2 Etched enriched (22.5%) B₄C pellet (x500)



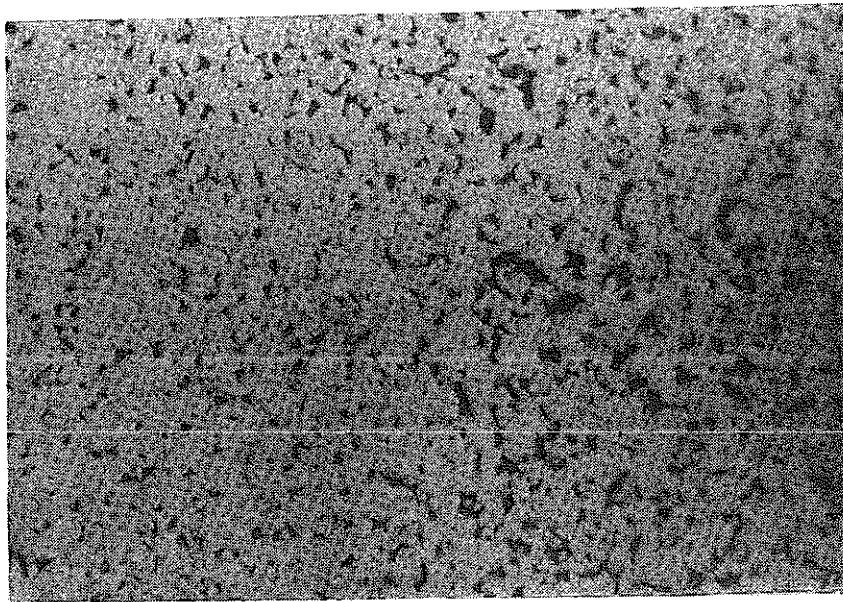
60μ

Figure II-3 As polished natural B₄C pellet (x500)



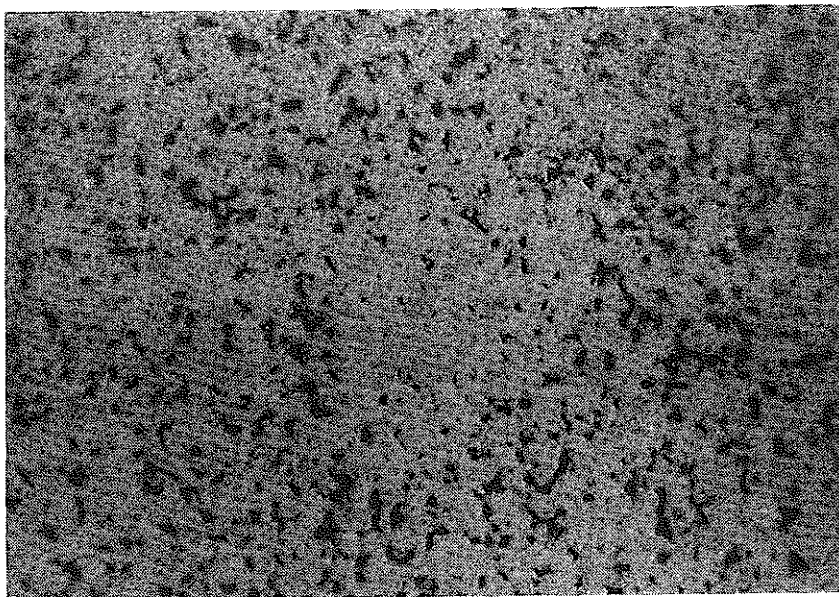
60μ

Figure II-4 Etched natural B₄C pellet (x500)



60μ

Figure II-5 As polished enriched (85%) B₄C pellet (x500)



60μ

Figure II-6 Etched enriched (85%) B₄C pellet (x500)

III. SPECIFICATIONS AND TEST RESULTS OF CAPSULE COMPONENTS

Dimensions of all capsule components were measured using a micrometer and a caliper. The results are tabulated in Article III-1. Chemical compositions and mechanical properties are summarized in Article III-2.

All results satisfy the Preliminary Design and Pin Drawings.

III-1 MENSURATION RECORDS OF CAPSULE COMPONENTS

Table III-1 Mensuration Records of Cladding Tubes

Item	Specification	Capsule No. 1	Capsule No. 2	Capsule No. 3
Outer diameter (mm)	15.1 ± 0.05	max. 15,133 min. 15,118	max. 15,130 min. 15,120	max. 15,130 min. 15,120
Inner diameter (mm)	(12.0)	max. 11,982 min. 11,953	max. 11,985 min. 11,952	max. 11,992 min. 11,956
Wall thickness (mm)	1.55 ± 0.05	max. 1,600 min. 1,556	max. 1,598 min. 1,563	max. 1,599 min. 1,550

Table III-2 Mensuration Records of Spacer Tubes

Item	Specification	Capsule No. 1	Capsule No. 2	Capsule No. 3
Outer diameter (mm)	11.6 ± 0.04	max. 11,623 min. 11,618	max. 11,624 min. 11,620	max. 11,625 min. 11,620
Inner diameter (mm)	(10.6)	max. 10,618 min. 10,612	max. 10,608 min. 10,601	max. 10,613 min. 10,604
Wall thickness (mm)	0.50 ± 0.04	max. 0.519 min. 0.506	max. 0.517 min. 0.502	max. 0.515 min. 0.506
Length (mm)	No.1 } No.2 } 58.5 ± 0.1 No.3 } 73.5 ± 0.1	58.50	58.51	73.54

Table III-3 Mensuration Records of End Plugs

Pin Identification		D_x (mm)	D_y (mm)	t (mm)	L (mm)
No. 1	Top	15,124	15,124	3,998	8,043
	Bottom	15,105	15,102	4,029	8,021
No. 2	Top	15,112	15,115	4,059	8,064
	Bottom	15,098	15,098	4,057	8,071
No. 3	Top	15,119	15,116	4,000	8,023
	Bottom	15,114	15,112	4,010	8,040

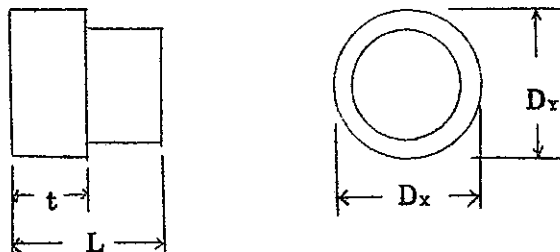


Table III-4 Mensuration Records of Disks

Pin Identification		D_x (mm)	D_y (mm)	t (mm)
No. 1	Top	11,640	11,640	1,056
	Bottom	11,638	11,638	1,009
No. 2	Top	11,640	11,641	1,040
	Bottom	11,659	11,660	0.994
No. 3	Top	11,697	11,694	1,008
	Bottom	11,680	11,683	0.979

(Hole diameter = 1.8 mm ϕ)

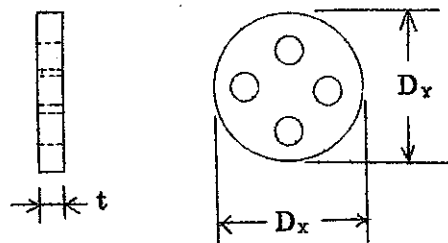


Table III-5 Mensuration Records of Temperature Monitor Holders

Pin Identification		D_{OX} (mm)	D_{OY} (mm)	D_{IX} (mm)	D_{IY} (mm)	t (mm)	h (mm)
No. 1	Top	11,695	11,697	10,150	10,150	1,055	2,554
	Bottom	11,692	11,692	10,142	10,142	1,070	2,536
No. 2	Top	11,708	11,708	10,119	10,121	0.998	2,508
	Bottom	11,697	11,698	10,137	10,139	1,048	2,544
No. 3	Top	11,707	11,706	10,122	10,126	1,038	2,525
	Bottom	11,703	11,702	10,136	10,135	1,020	2,528

(Hole diameter = 1.8 mm ϕ)

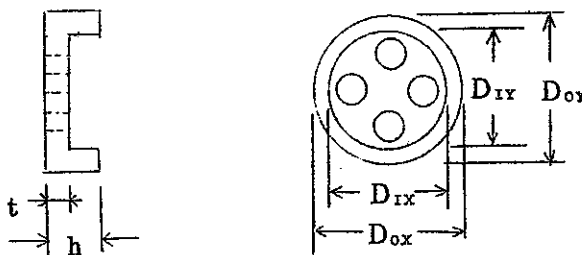


Table III-6 Dimensions and Weights of Silicon Carbides for
Temperature Monitors

Capsule No.	SiC No.	Dia. (mm)	Thickness (mm)	Weight g	Density (g/cc)	Apparent Porosity (%)
1	9	10.0	1,250	0.2514	2,583	19,054
	10	10.0	1,255	0.2461	2,509	21,700
2	11	10.0	1,242	0.2420	2,518	21,244
	12	10.0	1,252	0.2487	2,549	20,281
3	13	10.0	1,258	0.2473	2,518	21,166
	14	10.0	1,245	0.2462	2,546	20,463

III-2 MATERIAL SPECIFICATION AND TEST RESULT OF CAPSULE COMPONENTS

1. Cladding Tube

Item	Specification	Test Results
Grade	AISI 316 Solution treatment & 10% cold worked	
Chemical Composition		
C (%)	0.04 ~ 0.08	0.058
Si	Max. 0.75	0.52
Mn	1.50 ~ 2.00	1.74
P	Max. 0.030	0.003
S	Max. 0.030	0.007
Ni	11.00 ~ 14.00	12.92
Cr	16.00 ~ 18.00	17.20
Mo	2.00 ~ 3.00	2.50
Co	Max. 0.10	0.02
B	Max. 0.001	0.0002
N	Max. 0.035	0.0062
Tensile Test at Room Temp.		
Yield Strength (kg/mm ²)	Min. 40	54, 52
Rupture Strength (kg/mm ²)	Min. 60	70, 73
Elongation (GL 50mm) (%)	Min. 25	34, 36
Tensile Test at 600°C		
Yield Strength (kg/mm ²)	Min. 20	-, 36.1
Rupture Strength (kg/mm ²)	Min. 30	44.2, 43.2
Elongation (%)	Min. 15	25.5, 21.4
Hydraulic Pressure Test (P _{max} = 1400 kg/cm ²)		No deformation at maximum pressure
Vicker's Hardness	Max. Hv 290	Max. 253
Flare Test		Good
Grain Size (ASTM No.)	No. 6 finer	7.4, 7.3
Surface Roughness	Max. 3S	Good
Colour Check		Good

2. Sleeve Tube

Item	Specification	Test Result
Grade	AISI 316 Solution treatment & 20 % Cold Worked	
Chemical Composition		
C (%)	0.04 ~ 0.08	0.054
Si	Max. 0.75	0.53
Mn	1.50 ~ 2.00	1.76
P	Max. 0.03	0.003
S	Max. 0.03	0.008
Ni	11.00 ~ 14.00	12.92
Cr	16.00 ~ 18.00	17.20
Mo	2.00 ~ 3.00	2.50
Co	Max. 0.10	0.06
B	Max. 0.001	0.0002
N	Max. 0.035	0.0056
Tensile Test at Room Temp.		
Yield Strength (kg/mm ²)	Min. 58	72.1, 71.8
Rupture Strength (kg/mm ²)	Min. 70	84.0, 83.1
Elongation (%)	Min. 10	22, 20
Tensile Test at 650°C		
Yield Strength (kg/mm ²)	Min. 30	40.2
Rupture Strength (kg/mm ²)	Min. 40	45.4
Elongation (%)	Min. 7	21
Grain Size (ASTM No.)	No. 6 finer	8

3. End plugs, Disks and Monitor Holders

Item	Specification	Test Result
Grade	AISI 316	
Chemical Composition		
C (%)	0.04 ~ 0.08	0.068
Si	Max. 0.75	0.56
Mn	1.50 ~ 2.00	1.57
P	Max. 0.030	0.001
S	Max. 0.030	0.012
Ni	11.00 ~ 14.00	12.90
Cr	16.00 ~ 18.00	16.68
Mo	2.00 ~ 3.00	2.43
Co	Max. 0.10	-
B	Max. 0.001	-
N	Max. 0.035	0.020
Tensile Test at Room Temp.		
Yield Strength (kg/mm ²)	-	-
Rupture Strength (kg/mm ²)	-	62.4, 62.6
Elongation (%)	-	52, 52
Grain Size	-	ASTM No. 7

IV. CERTIFICATE ON DEGREE OF LEAK TIGHTNESS OF ABSORBER PINS

Leak tightness of all absorber pins was checked by a helium mass spectrometer

Result ; Good
Apparatus ; 24-120B Leak Detector
(DUPONT DE NEMOURS & Co.)
Sensitivity ;

V. X-RAY INSPECTION ON WELDS AND PINS

All welds and pins were inspected by X-ray radiography. X-ray films were attached with this certificate.

Result ; No detectable defect in welds and pins

Apparatus ; EXS-300, TOSHIBA ELECTRIC Co.

Film ; KODAK Type M

Penetrameter; JIS Z3106 FO2 Wire Type (0.10 - 0.40 mm^φ)

Test Condition for Weld Inspection;

X-ray energy & current; 190 KV, 6 mA

Exposure time ; 5 min.

Test Condition for Pin Structure Inspection;

X-ray energy & current ; 130 KV, 4 mA

Exposure time ; 50 sec

Contents of Attached X-ray Films

1. Exposure on the upper end plugs
2. Exposure on the lower end plugs
3. Exposure on the whole absorber pins from
X direction
4. Exposure on the whole absorber pins from Y
direction

VI. CERTIFICATE ON DEGREE OF CLEANLINESS OF THE ABSORBER PINS

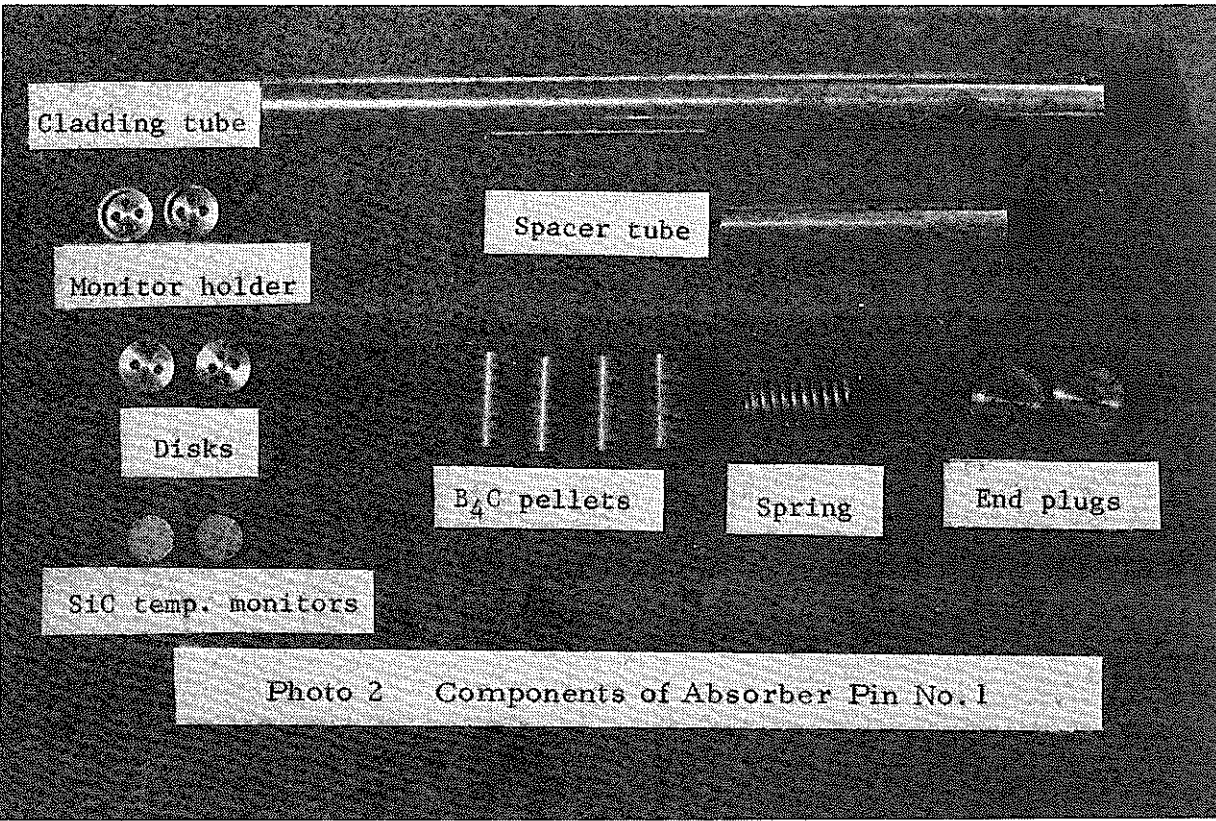
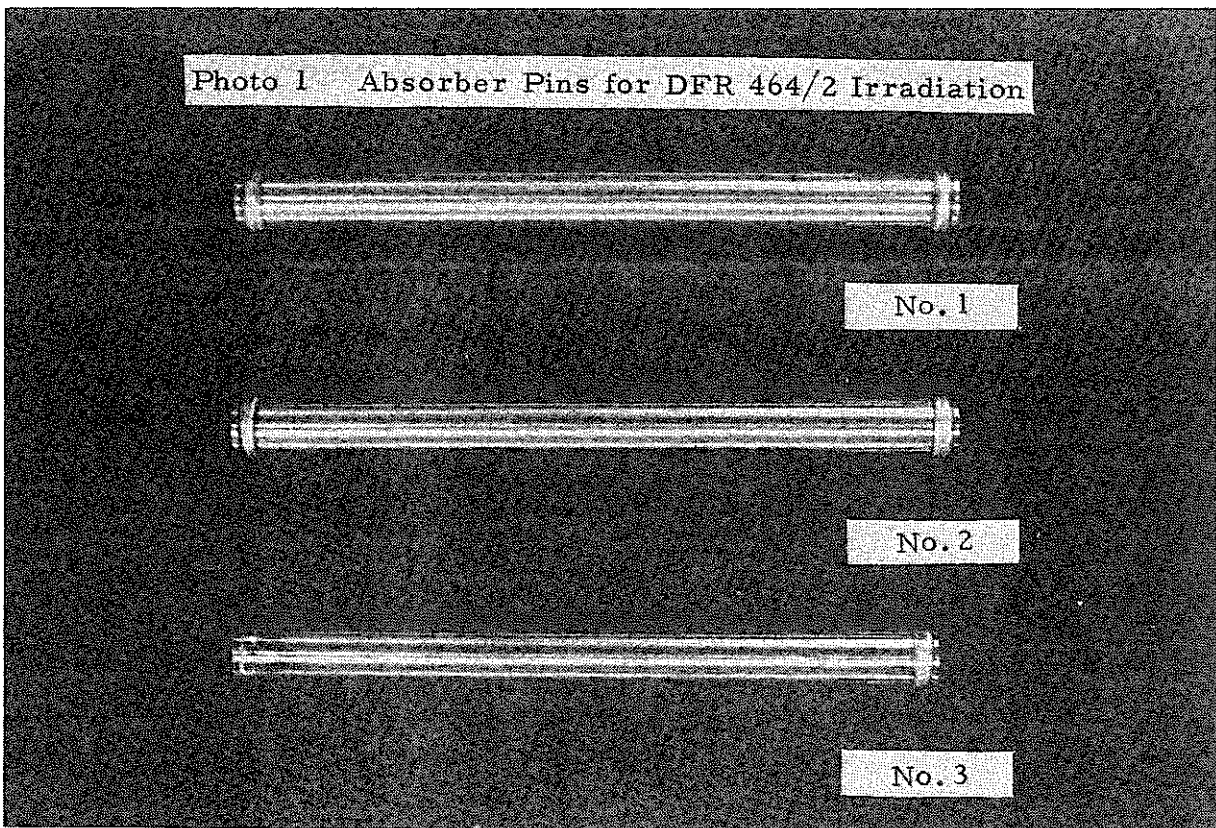
Following all necessary inspections, absorber pins were cleaned by tissue swabbing with acetone. Therefore, the surfaces of those absorber pins are considered to be clean for use in irradiation.

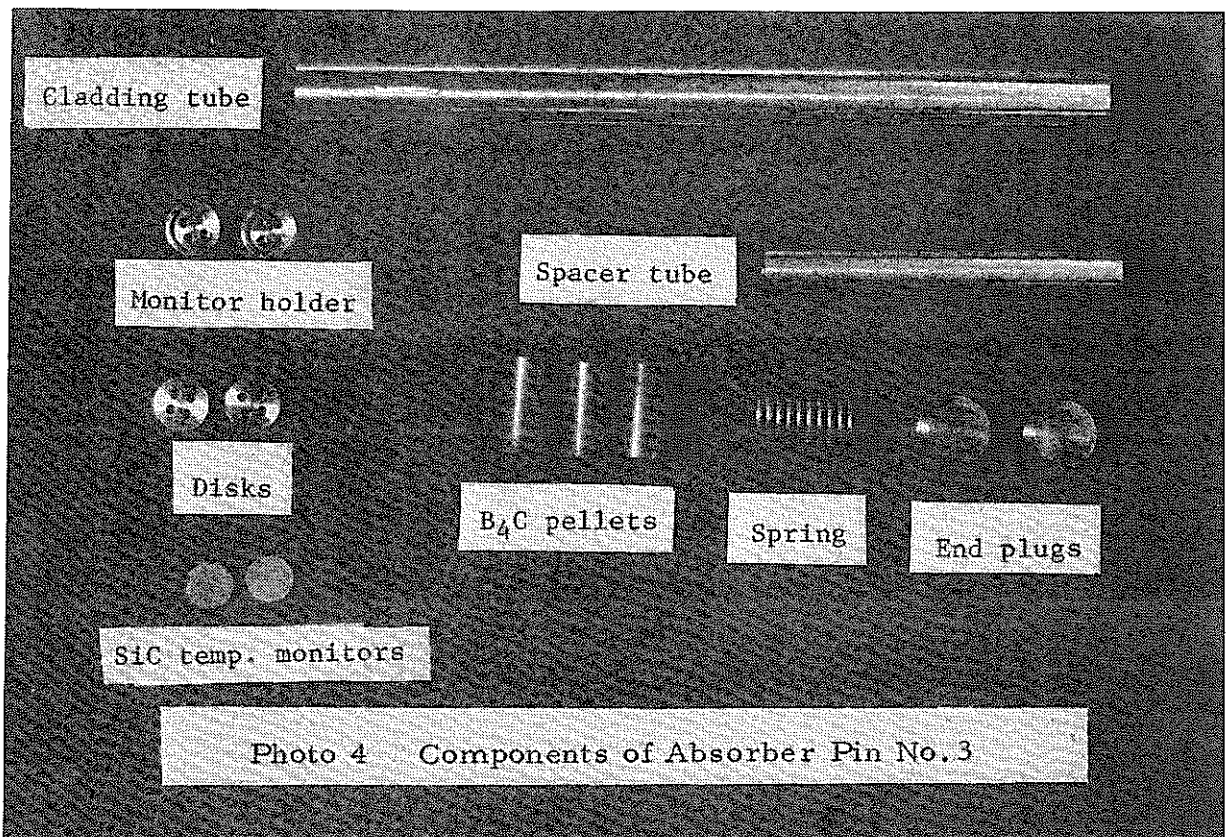
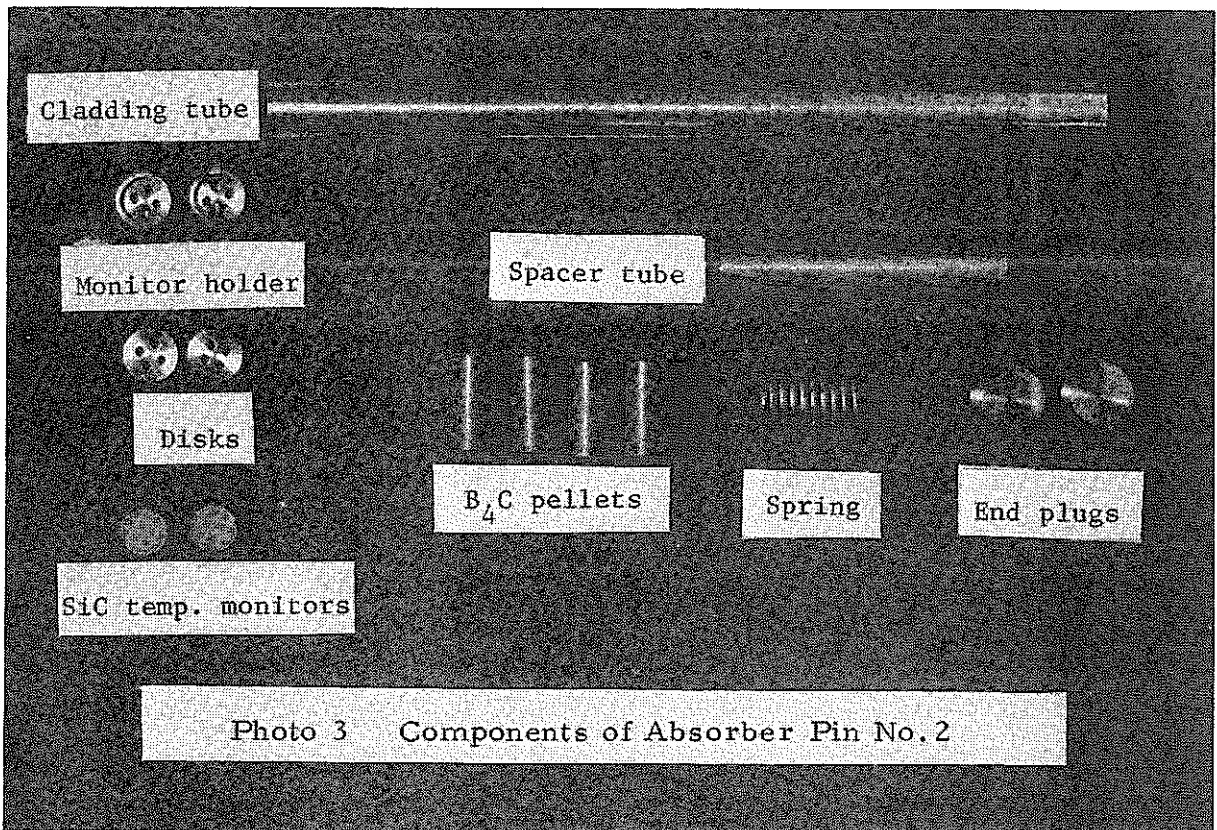
These pins are being supplied in a clean condition:

Appendix-1

Photos of Complete Absorber Pins and their Components

Photo 1 Absorber Pins for DFR 464/2 Irradiation





SHIPPING LIST

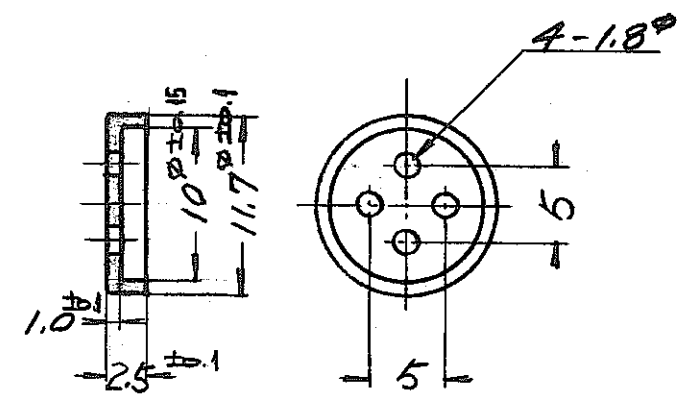
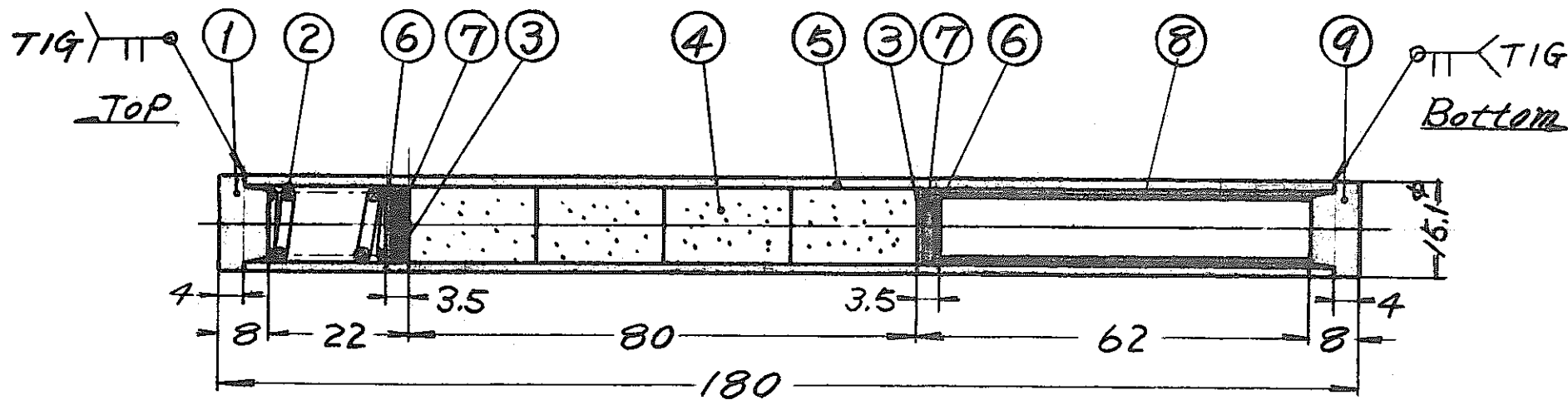
1. Absorber pin No. 1
2. Absorber pin No. 2
3. Absorber pin No. 3
4. One 22.5 % Enriched $B_{14}C$ Pellet No. 1-5
5. One Natural $B_{14}C$ Pellet No. 2-5
6. One 85 % Enriched $B_{14}C$ Pellet No. 3-4
7. One set of X-ray films (separate mail)

Appendix-3

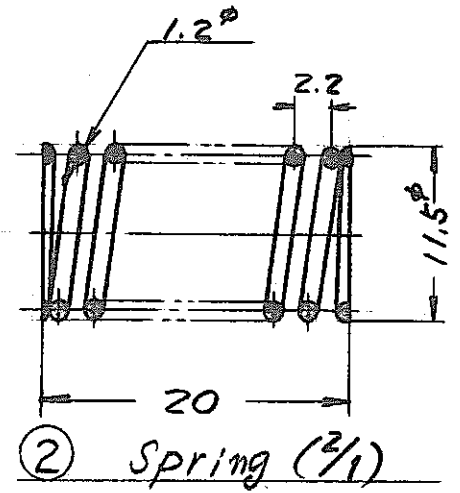
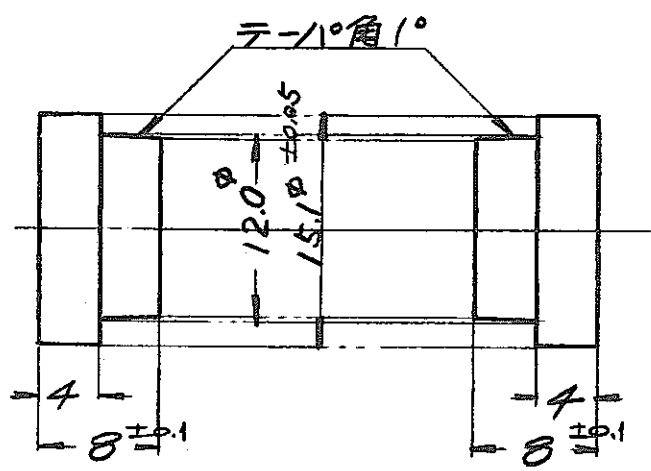
Capsule Drawings

Drawing No. DFR-B-01-01

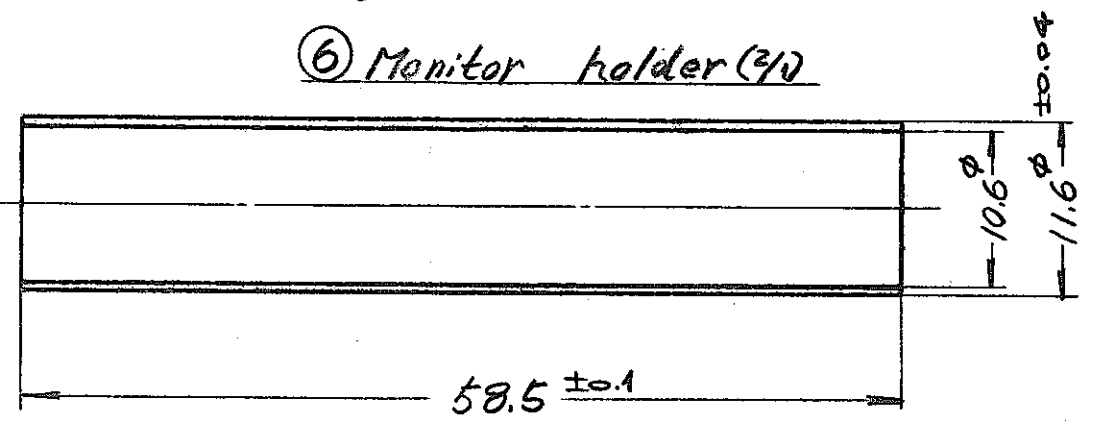
Drawing No. DFR-B-02-01



⑥ Monitor holder (2/1)

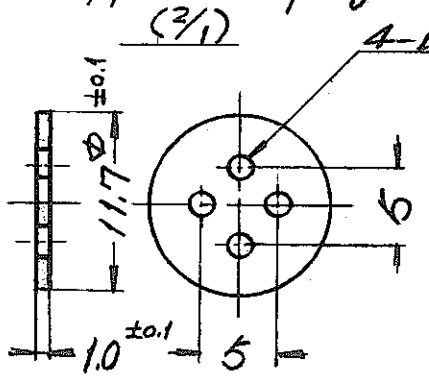


② Spring (2/1)

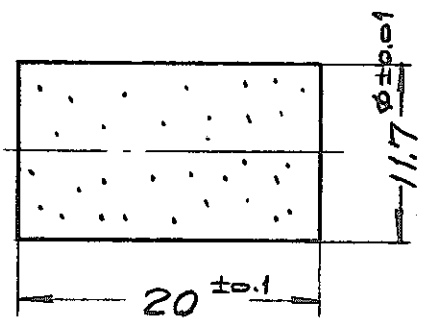


⑧ Spacer tube (2/1)

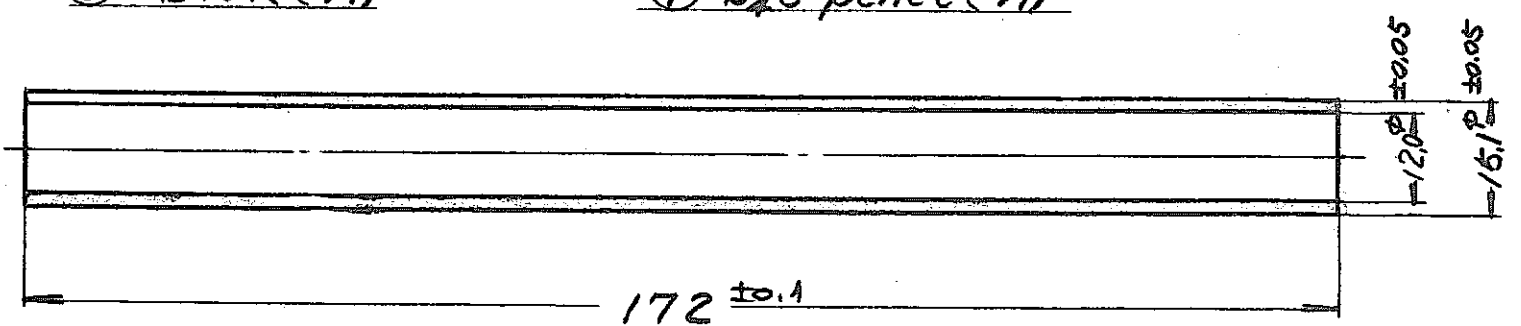
① Upper end plug ⑨ Lower end plug (2/1)



③ Disk (2/1)



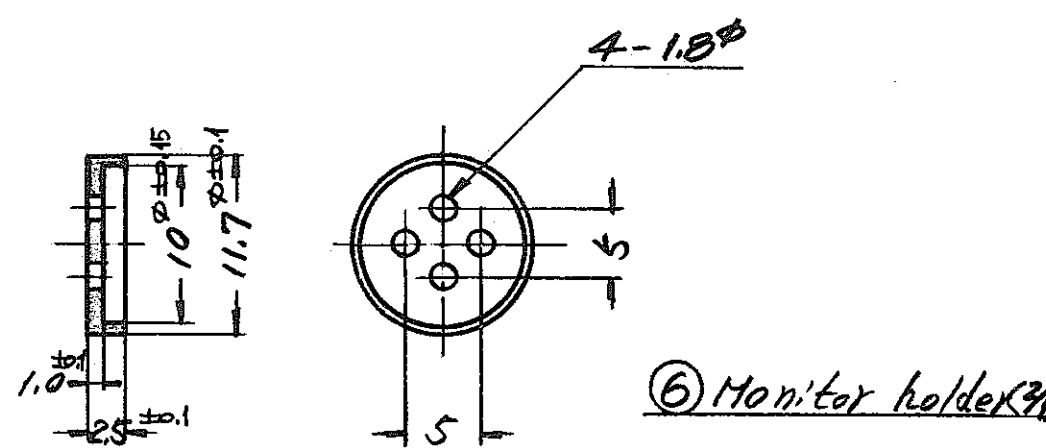
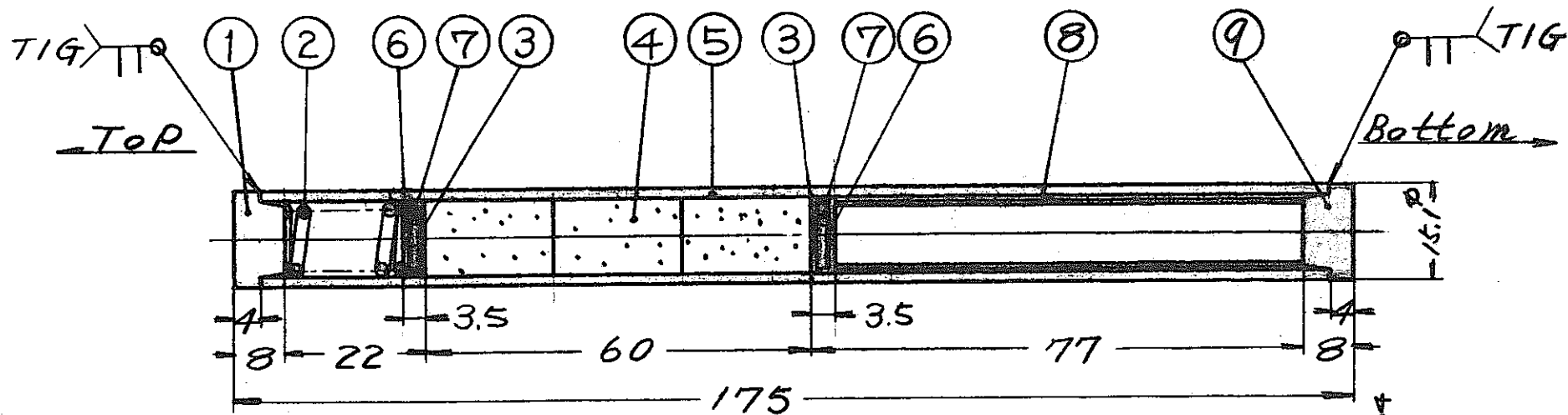
④ B₄C pellet (2/1)



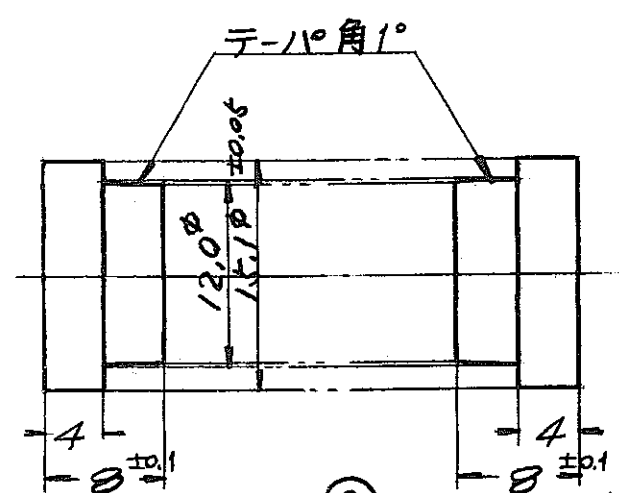
⑤ Cladding tube (1/1)

ITEM	NAME	MATERIAL	SUPL. NO	REMARKS
9	Lower end plug	AISI-316	1	
8	Spacer tube	AISI-316	1	
7	Temp. monitor	B-SiC	2	9.0 ϕ x 1.0 t
6	Monitor holder	AISI-316	2	
5	Cladding tube	AISI-316	1	
4	B ₄ C Pellet	B ₄ C	4	
3	Disk	AISI-316	2	
2	Spring	AISI-316	1	
1	Upper end plug	AISI-316	1	

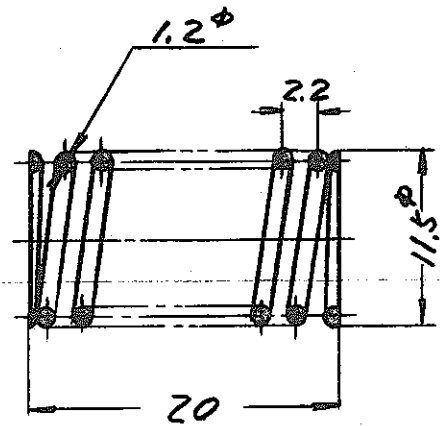
TITLE		SCALE	DATE.	
DFR464/2 B ₄ C Irradiation Pin No.1 and No.2			DESIGN	--
		ANGLE.	DWG. ④	--
			CHECK Y.F	48-8-10
			APPR.	--
POWER REACTOR AND NUCLEAR FUEL DEVELOPMENT CORPORATION TOKAI - JAPAN			DWG. NO DFR-B-01-01	



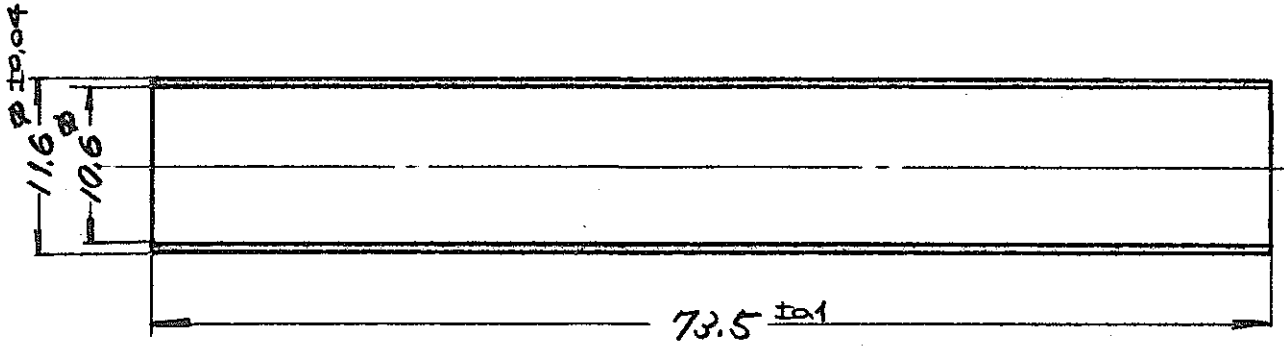
⑥ Monitor holder (2/1)



① Upper end plug (2/1)

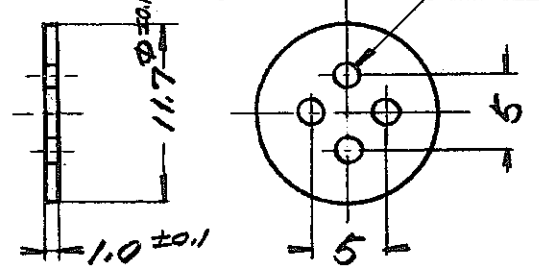


② Spring (2/1)

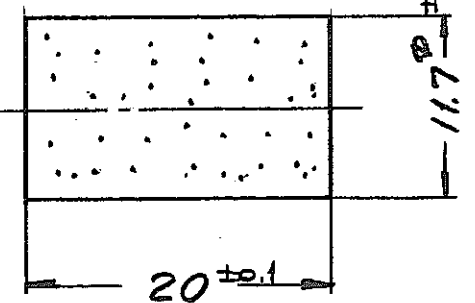


⑧ Spacer tube (2/1)

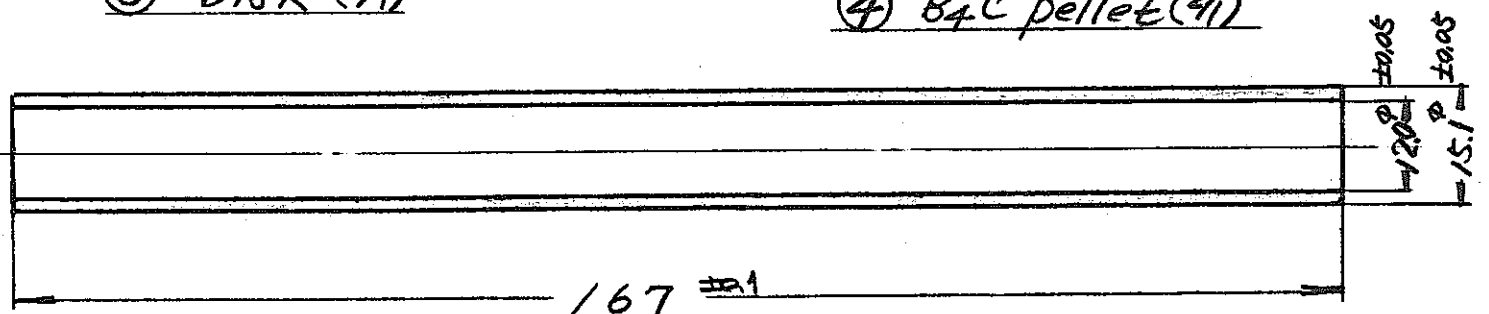
⑨ Lower end plug (2/1)



③ Disk (2/1)



④ B4C pellet (2/1)



⑤ Cladding tube (1/1)

ITEM	NAME	MATERIAL	SUPL. NO	REMARKS
9	Lower end plug	AISI-316	1	
8	Spacer tube	AISI-316	1	
7	Temp. monitor	B-SiC	2	9.0φ x 1.0 [±]
6	Monitor holder	AISI-316	2	
5	Cladding tube	AISI-316	1	
4	B ₄ C pellet	B ₄ C	3	
3	Disk	AISI-316	2	
2	Spring	AISI-316	1	
1	Upper end plug	AISI-316	1	

TITLE		SCALE	DATE.
DFR 464/2 B ₄ C Irradiation			
Pin No. 3		ANGLE.	
		DESIGN	--
		DWG. ④	--
		CHECK y-j	98-8-10
		APPR.	--
POWER REACTOR AND NUCLEAR FUEL DEVELOPMENT CORPORATION TOKAI - JAPAN		DWG. NO DFR-B-02-01	