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THERMAL CYCLING OF A FUEL ASSEMBLY

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TECHNICAL DIVISION
Engineering Development Section

September 29, 1949

THERMAL CYCLING OF A FUEL ASSEMBLY

H. C. Savage
F. Drosten

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A "thermal cycling" experiment was conducted on an active fuel assembly to determine its dimensional stability after repeated heating and cooling. The assembly was subjected to a total of 3925 cycles from $\sim 17^{\circ}$ C to $\sim 100^{\circ}$ C with no appreciable change in dimensions or other damage such as warping or blistering.

An eighteen (18) plate assembly in which the plates were aluminum clad with 30% natural uranium aluminum alloy core was used in the test. Heating was accomplished by passing steam thru the inside of the assembly; water sprays directed on the side plates of the assembly provided the cooling. Figure I is a photograph of the test set-up.

The steam and water were controlled automatically with two solenoid valves connected to a Flexopulse timer. The valves were operated alternately so that steam was passed thru the assembly for a set period of time then the cooling water sprays operated for a set period after the steam valve closed.

The first 1425 cycles were 4 minutes cycles (steam on 2 minutes, cooling water on 2 minutes). The next 500 cycles were 6 minute cycles (steam on 4 minutes, cooling water on 2 minutes). The last 2000 cycles were 12 minute cycles (steam on 10 minutes, cooling water on 2 minutes). Four dimensional checks were made at the end of 275, 1425, 1925, and 3925 cycles respectively. Tables 1 - 4 show the measured change in dimensions. Figure II illustrates the points of measurement used in Tables 1 - 4.

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The maximum deviations obtained were 0.006" in the sagitta dimension and 0.005" in the VCH dimension. These values are quite small since the method of obtaining these measurements involved the use of anvils and a micrometer so that an additional probability for error is introduced in properly locating the anvil which provided the reference line for the micrometer. The error involved in the sagitta and VCH readings is approximately ± 0.003" while the other dimensions were referenced from a surface plate with a probable error of ± 0.001".

The overall length of the assembly active plates and side plates was checked to the nearest 1/64 in. with no appreciable change after 3925 cycles.

It should be pointed out that the test method of thermal cycling used is much more severe than that expected in pile operation since the method of heating and cooling produced a severe temperature gradient across the width of the assembly.

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TABLE I

DIMENSIONAL CHANGES (INCHES)
AFTER 275 CYCLES

Distance from "A" End	Width A	Width B	Width C	VCH	Sagitta	Uppitta
2 1/2"	.000	-.001	+.001	+.004	-.002	+.003
7"	-.001	-.002	.000	+.003	-.004	-.001
12"	+.001	-.004	.000	+.001	-.004	.000
16"	-.001	-.002	.000	+.002	-.004	-.001
21"	.000	-.001	+.002	+.001	-.004	-.001
26 1/8"	.000	-.001	.000	+.002	-.005	+.001

Plate Spacing				
Plate No.	Distance from "A" End 2 1/2"	12"	16"	26 1/8"
1	+.003	(dent)	-.001	+.002
2	.000	-.001	-.001	.000
3	-.002	-.001	.000	+.002
4	+.001	-.002	-.001	-.001
5	.000	-.002	-.001	.000
6	+.002	-.003	-.002	-.002
7	-.002	-.002	.000	+.001
8	+.001	-.001	-.003	-.004
9	.000	+.001	+.001	+.002
10	+.002	.000	+.002	+.002
11	.000	+.001	.000	-.001
12	+.002	+.002	.000	.000
13	-.002	+.001	+.002	-.002
14	.000	.000	.000	.000
15	-.001	.000	.000	+.001
16	-.004	+.001	+.001	-.002
17	+.003	+.002	+.001	.000
	+3	-4	-2	-2

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TABLE 2

DIMENSIONAL CHANGES (INCHES)
AFTER 1425 CYCLES

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Distance from "A" End	Width A	Width B	Width C	VCH	Sagitta	Uppitta
2 1/2"	-.001	.000	-.001	+.005	-.003	+.001
7"	-.002	-.004	-.001	+.002	-.004	-.004
12"	-.001	-.003	-.001	+.001	-.005	-.004
16"	-.002	.000	.000	.000	-.005	-.003
21"	.000	+.003	+.001	+.001	-.005	-.002
26 1/8"	-.002	-.002	+.002	+.002	-.006	.000

Plate No.	Plate Spacing: Distance from "A" End 2 1/2"	12"	16"	26 1/8"
1	+.003	(dent)	-.001	+.002
2	.000	.000	.000	.000
3	-.001	-.002	.000	+.002
4	.000	-.001	-.001	.000
5	.000	-.003	-.003	+.003
6	+.001	-.002	-.002	.000
7	-.001	-.002	.000	+.001
8	+.001	-.002	-.003	-.002
9	+.001	+.001	+.001	+.003
10	+.004	+.002	+.003	.000
11	+.001	.000	-.001	-.001
12	+.004	+.002	+.002	+.001
13	-.001	+.002	+.003	.000
14	.000	.000	.000	+.001
15	-.001	+.002	+.002	+.002
16	-.004	.000	+.001	-.001
17	+.003	+.003	+.001	+.001
	+10	0	+2	+ 12

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TABLE 3

DIMENSIONAL CHANGES (INCHES)
AFTER 1925 CYCLES

Distance from "A" End	Width A	Width B	Width C	VCH	Sagitta	Uppitta
2 1/2"	-.002	-.001	.000	+.004	-.002	+.001
7"	-.001	-.003	-.001	+.001	-.005	-.002
12"	+.001	-.005	.000	+.001	-.006	-.002
16"	-.001	-.002	.000	+.001	-.005	-.001
21"	-.001	-.002	+.001	+.002	-.004	-.001
26 1/8"	-.001	-.001	.000	+.001	-.005	+.001

Plate Spacing				
Plate No.	Distance from "A" End 2 1/2"	12"	16"	26 1/8"
1	.000	(dent)	-.002	+.002
2	+.001	-.001	-.001	+.001
3	-.001	-.001	.000	+.002
4	+.002	-.002	-.001	.000
5	.000	-.003	-.003	+.003
6	+.003	-.002	-.003	.000
7	-.002	-.002	-.001	+.002
8	+.001	-.002	-.003	-.002
9	+.002	+.001	+.001	+.005
10	+.003	+.003	+.003	+.002
11	+.002	+.002	+.001	-.001
12	+.005	+.002	+.004	+.001
13	-.001	+.002	+.004	.000
14	+.001	.000	+.002	+.001
15	-.001	+.002	+.002	+.002
16	-.002	+.001	+.002	-.002
17	+.002	+.003	+.004	-.001
	+ 15	+ 3	+ 9	+ 15

[redacted]

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TABLE 4

DIMENSIONAL CHANGES (INCHES)
AFTER 3925 CYCLES

Distance from "A" End	Width A	Width B	Width C	VCH	Sagitta	Uppitta
2 1/2"	+.001	-.002	.000	+.001	-.003	+.001
7"	+.001	-.003	.000	+.001	-.005	-.002
12"	.000	-.004	+.001	+.001	-.006	-.003
16"	-.002	-.004	.000	.000	-.006	-.002
21"	-.001	-.003	+.002	-.001	-.005	-.001
26 1/8"	-.001	-.001	+.001	+.002	-.006	+.003

Plate Spacing				
Plate No.	Distance from "A" End			
	2 1/2"	12"	16"	26 1/8"
1	+.003	(dent)	-.002	+.002
2	.000	-.001	.000	.000
3	-.001	-.002	.000	-.001
4	+.002	-.002	-.001	.000
5	.000	-.003	-.003	+.001
6	+.002	-.003	-.003	.000
7	-.001	-.002	-.001	+.001
8	+.001	-.003	-.005	-.002
9	+.002	+.002	+.002	+.005
10	+.003	+.003	+.004	+.001
11	+.001	+.001	-.001	-.001
12	+.004	+.002	+.005	+.002
13	-.001	+.003	+.004	.000
14	+.001	+.001	.000	.000
15	.000	+.001	+.002	+.002
16	.000	+.001	+.001	-.003
17	+.001	+.004	+.002	+.001

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[redacted]

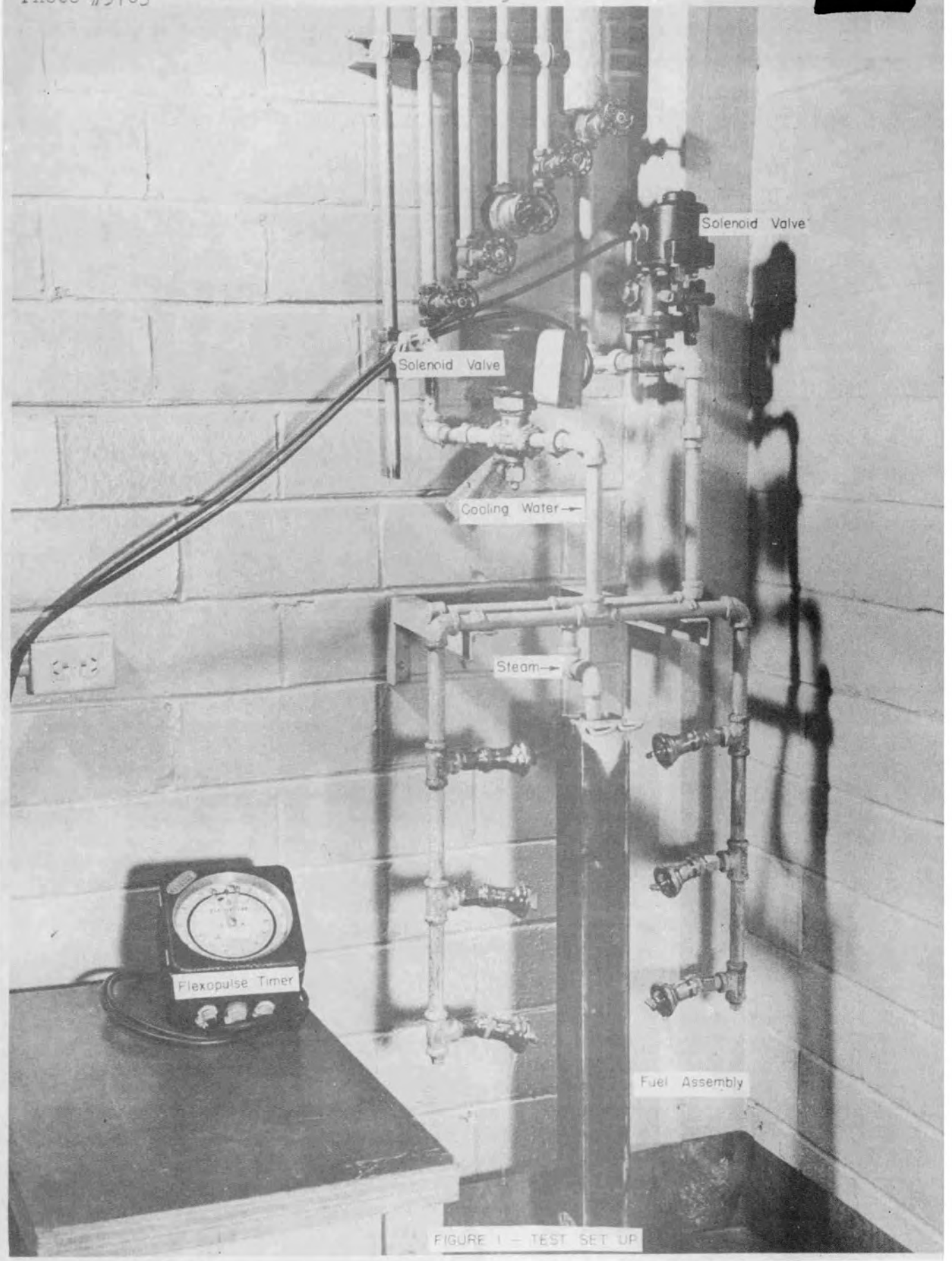

FIGURE 1 — TEST SET UP

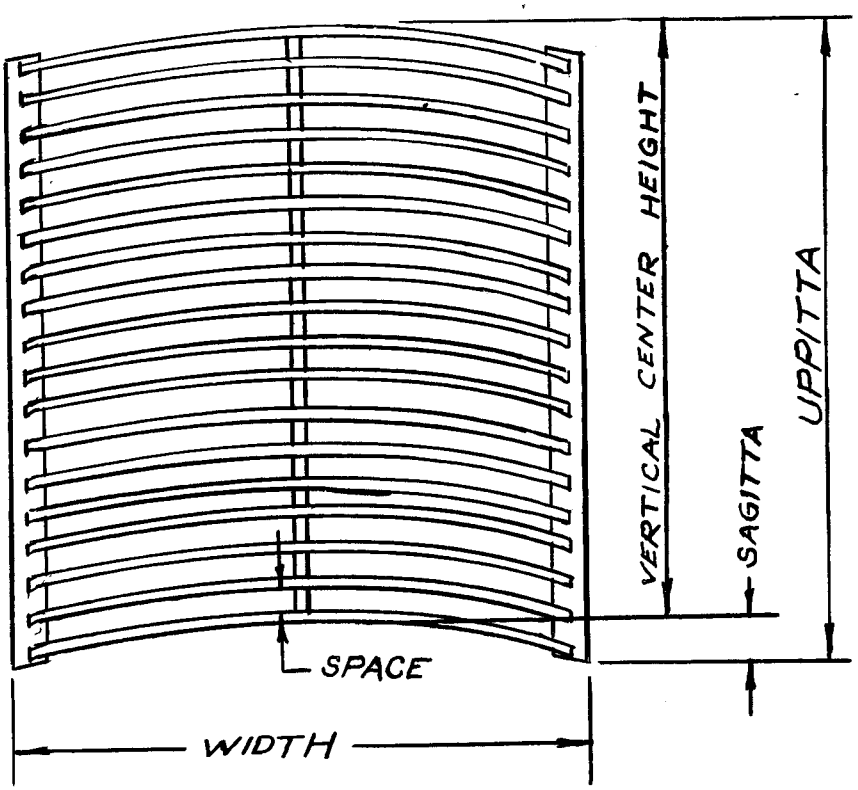

FIGURE II - DIMENSIONAL CHECK OF
FUEL ASSEMBLY