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CALCULATED FUEL ELEMENT MODEL PARAMETERS KVNS AND KVES

INTRODUCTION

Various Physics and Engineering parameters are listed below for the natural (KVNS) and enriched (KVES) fuel element models to be used in the proposed ribless zirconium tube program at the K reactors. The numbers were generated by R. O. Gumprecht's computer program, MOFDA.

INPUT ASSUMPTIONS

Two reactor environments corresponding to summer and winter operating conditions were assumed:

1) Winter: 1840 KW/Tube, 0.1°C inlet water temperature
2) Summer: 1650 KW/Tube, 22°C inlet water temperature

Other reactor assumptions common to both of these cases are:

1) Goal Exposure; 700 MWD/Ton (natural and enriched)
2) Zirconium tube diameters; 1.807" O.D., 1.724" I.D.
3) Front to rear header ΔP = 385.8 psi
4) Charge length; a) 38 elements of nominal 8.865" length, natural uranium
   b) 46 elements of nominal 6.540" length, enriched uranium
5) Enrichment; a) 0.711 weight per cent uranium-235, natural metal
   b) 0.947 weight per cent uranium-235, enriched metal

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6) Self-supported rail height; a) 0.095" natural metal (KVNS)
b) 0.100" enriched metal (KVES)

7) Eight rails per element of 0.200" effective rail width

8) Fuel element external dimensions; a) KVNS 1.520" x 0.420" x 8.865"
b) KVES 1.509" x 0.432" x 6.540"

9) Fuel element core dimensions; a) KVNS 1.431" x 0.533" x 8.325"
b) KVES 1.420" x 0.545" x 6.000"

10) Graphite temperature; 600° C

DISCUSSION

The hydraulic demand of the self-supported elements is designed to be compatible with the current pump modification program at the K reactors. When fully loaded with KVNS and KVES elements, the K reactor flow should be 200,000 gpm bulk flow on a year-round average basis, with approximately 2,000 gpm higher flow in the summer and 2,000 gpm lower flow in the winter due to inlet temperature induced viscosity changes in the coolant.

No fuel or tube dimensional tolerances are considered. The calculated numbers give average values without consideration of possible extremes resulting from combinations of such tolerances. The input numbers should never be used for equipment design purposes, or other purposes where absolute maximums or minimum values are critical. To assume that these tolerances have only a small effect on the critical parameters is entirely inadmissable. As an example, decreasing the rail height by only 0.010", increases the annulus corrosion rate for the KVNS model by a factor of 3.8 (from 5.6 mils/month to 21.5 mils/month).

The numbers given should be used primarily for comparison purposes with other fuel element models, and should not be used as absolute magnitudes in themselves. This is especially true of the reactivity and conversion ratio values given. While it has been impossible to check most of the numbers given by direct laboratory measurement, measurements taken in the flow laboratory and in-pile experience on the KVNS(1) models and the KIVN models have shown good agreement with predicted flow and temperature distributions, and with the total flow.

RESULTS

Table I gives the values of interest for winter operating conditions. Table II is a repeat of these values for summer operating conditions. For comparison purposes, values for the present natural uranium ribbed tube fuel element model (KIVN) are given. The reactivity value given is for a complete reactor loading, with a variable exposure goal of 700 MWD/Ton.

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(1) HW-69964-C, "Pilot Test of Self-Supported Fuel Elements in K-size Smooth Zirconium Process Tubes", M.A. Clinton and D. H. Curtiss, June 19, 1961 (SECRET).

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TABLE I
(Winter Conditions)

		KVNS	KVES	KIVN
Maximum Specific Power (KW/FT)		86.7	89.8	86.7
Maximum Heat Flux (BTU/HR/SQFT)	Outer	5.0×10^5	5.18×10^5	5.30×10^5
	Inner	8.70×10^5	8.85×10^5	9.13×10^5
Heat to Coolant (BTU/HR)	Outer	2.16×10^5 (69.2%)	2.22×10^5 (68.9%)	2.19×10^5 (70.4%)
	Inner	0.96×10^5 (30.8%)	1.00×10^5 (31.1%)	0.92×10^5 (29.6%)
Flow (GPM)	Outer	43.2 (65.6%)	44.5 (64.9%)	51.1 (73.6%)
	Inner	22.7 (34.4%)	24.1 (35.1%)	18.3 (26.4%)
Uranium Temp. (°C)	average	266.0	268.0	264.0
	maximum	334.0	335.0	335.0
Uranium Surface Temp. (°C)	Outer	136	137	122
	Inner	139	138	154
Coolant Outlet Temp. (°F)	Outer	233.0	226.0	205.0
	Inner	203.0	194.0	235.0
Can Skin Temp. (°F)	Outer	256	256	228
	Inner	241	232	269
Corrosion Rate mils/month	Outer	5.6	5.9	2.8
	Inner	5.1	4.9	10.3
Reactivity (Milli K)		4.1	103.4	-0.7
Initial Conversion Ratio (GMS Pu/MWD)		1.080	0.890	1.064
Average Conversion Ratio to 700 MWD/Ton		0.939	0.809	0.926
%Pu 240 to 700 MWD/Ton		5.9	4.5	5.9
Maximum Elastic Core Stress (PSI)		69,711	69,831	74,323

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TABLE II
(Summer Conditions)

		KVNS	KVES	KIVN
Maximum Specific Power (KW/FT)		77.7	80.4	77.7
Maximum Heat Flux (BTU/HR/SQFT)	Outer	4.48x10	4.64x10	4.75×10^5
	Inner	7.82x10	7.95x10	8.18×10^5
Heat to Coolant (BTU/HR)	Outer	1.93×10^5 (69.1%)	1.99×10^5 (68.8%)	1.96×10^5 (70.4%)
	Inner	0.86×10^5 (30.9%)	0.90×10^5 (31.2%)	$.83 \times 10^5$ (29.6%)
Flow (GPM)	Outer	43.6 (65.5%)	44.9 (64.8%)	52.8 (73.9%)
	Inner	22.9 (34.5%)	24.4 (35.2%)	18.5 (26.1%)
Uranium Temp. (°C)	Average	256	258	254
	Maximum	317	319	319
Maximum Uranium Surface Temp. (°C)	Outer	141	141	156
	Inner	142	141	127
Coolant Outlet Temp. (°F)	Outer	250	244	223
	Inner	223	216	252
Can Skin Temp. (°F)	Outer	267	267	240
	Inner	252	248	278
Corrosion Rate (mils/month)	Outer	6.3	6.7	3.2
	Inner	5.9	5.6	11.3
Reactivity (Milli-K)		4.7	104.0	-0.1
Initial Conversion GMS Pu/MWD		1.081	0.891	1.064
Average Conversion Ratio to 700 MWD/Ton		0.938	0.808	0.924
% Pu 240 to 700 MWD/Ton		6.0	4.5	6.0
Maximum Elastic Core Stress (PSI)		62,272	62,354	66,625

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