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HYDRAULIC DEMAND CHARACTERISTICS OF SELF-SUPPORTED C-IV-N AND K-I-N I&E FUEL ELEMENTS IN A ZIRCONIUM C-REACTOR TUBE

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HYDRAULIC DEMAND CHARACTERISTICS
OF SELF-SUPPORTED C-IV-N AND K-I-N IAN FUEL ELEMENTS
IN A ZIRCONIUM C-REACTOR TUBE

by

E. D. Waters

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HYDRAULIC DEMAND CHARACTERISTICS
OF SELF-SUPPORTED C-IV-N AND K-I-N I&M FUEL ELEMENTS
IN A ZIRCONIUM C-REACTOR TUBE

by

E. D. Waters

SUMMARY

The isothermal hydraulic demand characteristics were determined by laboratory experiment for full charges of self-supported I&M fuel elements in a zirconium process tube. Pressure drop and flow rate data are presented on Figure I and the calculations of annulus-to-hole flow ratio are presented in the discussion. For self-supported fuel elements, pressure drop does not vary with temperature as much as it does for non-self-supported fuel elements.

DISCUSSION

Experiments were performed with a full length ribless zirconium process tube with a 1.68 inch inside diameter. (The tube was identical to the two zirconium tubes installed in C reactor in mid-December 1959.) Pressure taps were located on the front nozzle barrel and the rear nozzle barrel rather than on the tube itself since the tube used in the laboratory could be used in the reactor, if need be.

Self-supported fuel elements were used in these experiments. The C-IV-N I&M fuel elements had nominal dimensions of 1.500 inch OD by 0.380 inch ID not including the "suitcase handle" support rails. Actual dimensions for some of the elements used are shown in Table I. Pressure drop versus flow rate data are shown for these fuel elements on Figure I. By plugging the hole of each fuel element for one experiment, the data allow determination of the annulus-to-hole flow ratio. For the C-IV fuel elements at 225 psi ΔP , the flow ratio is:

$$\frac{\text{Annulus flow rate}}{\text{Hole flow rate}} = \frac{31.1}{15.8} = \frac{1}{0.508} = 1.97$$

This flow ratio was the same for 10°C and for 50°C isothermal flow.

It is interesting to note that the pressure drop does not vary with temperature as much as it does for non-self-supported fuel elements. The variation of pressure drop with temperature for non-self-supported fuel elements was discussed in HW-54590 and a curve was presented to show this effect as caused by viscosity, density and friction factor changes. Experimental data with solid and I&M fuel elements in a ribbed tube have shown good agreement with this relation. However, the present data as well as data in HW-60566 for C-II self-supported fuel elements do not show as large a temperature effect as non-self-supported fuels. This is undoubtedly due to the support rails and the fact that the energy loss associated with them is of a contraction-expansion nature. Thus, the turbulence losses resulting from the supports would not be nearly as sensitive to viscosity and density changes as would the skin friction losses over the remainder of the fuel element or over the surface of a non-self-supported fuel element. It appears from available data that the temperature effect for self-supported fuel could be estimated as two-thirds of the effect for solid I&M non-self-supported fuel. If the pressure drop decreases 15 per cent for regular fuel elements, then it would only decrease 10 per cent for self-supported fuel for a given temperature change. This may be advantageous from a reactor startup operation standpoint.

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A charge of K-I-N self-supported fuel elements was available for comparison purposes. The actual dimensions of some of these fuel elements are shown in Table II. Data were taken for the non-plugged condition with these elements and plotted on Figure I. Considering the closeness of actual dimensions and the fact that the non-plugged data were identical for the two different fuel charges, data were not taken for the case of holes plugged with the K-I fuel elements. It is assumed that the flow split ratio would not be significantly different than 1.97 for this charge.

Since it was not desired to put pressure taps on the zirconium tube, the data on Figure I necessarily include the pressure drop across the downstream support charge. The support charge used in these experiments consisted of 15 eight inch thick-wall perfs which were extruded from aluminum with four integral support rails. Although specific data are not available for the pressure drop across only the support charge, it can be estimated to be quite low - approximately 6 psi at 50 gpm and 2.5 psi at 30 gpm.

The "suitcase handle" support rails on the fuel elements were stamped from aluminum sheet and spot welded to the fuel jacket. There were eight support rails attached to each fuel element. The rails were 3/16 inch wide at the raised portion but about 3/8 inch wide at the ends where they were welded. That is, the excess tab was not removed as it has been removed for some experimental self-supported fuel elements. Flow tests conducted in 1957 in the Hydraulics Laboratory indicated that removal of excess weld tab could reduce the pressure drop of the annulus by 8 per cent. These tests were for an 80 mil annulus with only six support rails attached to each fuel element. It seems reasonable to assume the excess tab removal would result in similar annulus pressure drop reduction for the C-IV fuel elements if it would be advantageous to adjust the flow split.

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TABLE I

MEASUREMENTS FROM C-IV-N I&E FUEL ELEMENTS
WITH "SUIT-CASE HANDLE" SUPPORT RAILS

Nominal Size: 1.500" OD x 0.380" ID
(Random selection of 6 from 68 of Lot No. KTOO4D-X272)

Outside Diameter of Fuel Jacket - Inches*

	<u>Male End</u>	<u>Center</u>	<u>Female End</u>
1	1.499 - 1.500	1.498 - 1.501	1.498 - 1.498
2	1.496 - 1.499	1.495 - 1.501	1.499 - 1.501
3	1.498 - 1.499	1.499 - 1.499	1.498 - 1.501
4	1.499 - 1.500	1.496 - 1.502	1.499 - 1.500
5	1.498 - 1.499	1.497 - 1.499	1.495 - 1.502
6	1.496 - 1.499	1.498 - 1.501	1.498 - 1.503

Outside Diameter Including Support Rails - Inches*

	<u>Male End</u>	<u>Female End</u>
1	1.636 - 1.637	1.634 - 1.641
2	1.652 - 1.655	1.636 - 1.638
3	1.635 - 1.639	1.639 - 1.641
4	1.654 - 1.654	1.636 - 1.654
5	1.661 - 1.673	1.664 - 1.672
6	1.664 - 1.670	1.664 - 1.664

Inside Diameter - Inches

	<u>Male End</u>	<u>Female End</u>
1	0.370	0.378
2	0.375	0.378
3	0.373	0.379
4	0.369	0.376
5	0.371	0.377
6	0.374	0.379

* Two measurements taken 90° apart.

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TABLE II

MEASUREMENTS FROM K-I-N I&S FUEL ELEMENTS
WITH "SUIT-CASE HANDLE" SUPPORT RAILS

Nominal Size: 1.496" x 0.375"
(Random Selection of 6 from 64 of Lot No. KK 163V-XA81)

Outside Diameter of Fuel Jacket - Inches*

	<u>Male End</u>	<u>Center</u>	<u>Female End</u>
1	1.498 - 1.498	1.499 - 1.499	1.500 - 1.502
2	1.499 - 1.500	1.499 - 1.499	1.502 - 1.503
3	1.493 - 1.504	1.498 - 1.500	1.500 - 1.501
4	1.491 - 1.494	1.498 - 1.499	1.501 - 1.502
5	1.498 - 1.500	1.498 - 1.500	1.498 - 1.503
6	1.500 - 1.502	1.497 - 1.503	1.502 - 1.504

Outside Diameter Including Support Rails - Inches*

	<u>Male End</u>	<u>Female End</u>
1	1.654 - 1.655	1.638 - 1.654
2	1.634 - 1.641	1.647 - 1.649
3	1.648 - 1.658	1.645 - 1.658
4	1.656 - 1.656	1.639 - 1.649
5	1.652 - 1.655	1.648 - 1.655
6	1.648 - 1.657	1.645 - 1.645

Inside Diameter - Inches

	<u>Male End</u>	<u>Female End</u>
1	0.376	0.378
2	0.375	0.380
3	0.375	0.378
4	0.376	0.377
5	0.370	0.379
6	0.372	0.377

* Two measurements taken 90° apart

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FIGURE I - EXPERIMENTAL DATA

- - 32 C-IV-N Self-supported I&E Fuel Elements
- - 32 K-I-N Self-supported I&E Fuel Elements
- 15 Eight-inch Self-supported Perfs Downstream
- 1.600 inch ID Zirconium Ribless Process Tube

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