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TITLE

LABORATORY DETERMINATION OF NORMAL
OPERATING FLOW RATES WITH A FLEXIBLE
OUTLET CONNECTOR - BDF REACTORS

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LABORATORY DETERMINATION OF NORMAL OPERATING FLOW RATES
WITH A FLEXIBLE OUTLET CONNECTOR - BDF REACTORS

By E. D. Waters

LABORATORY DETERMINATION OF NORMAL OPERATING FLOW RATES
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SUMMARY

This report is essentially an addendum to HW-63756 1* which presented energy loss data for various enlarged outlet fitting assemblies for possible use on the old reactors. The current report presents data for another candidate outlet fitting assembly which would tend to reduce the energy losses in the process tube outlet fittings. This outlet assembly was developed by the Materials Development Operation, IPD. The data show that the flexible connector assembly would result in a 6.9 per cent increase in normal single tube flows without modifications to existing headers or nozzles or a 13.5 per cent increase if the existing header (Parker) fittings were reamed to 0.610 inch ID. These percentages are based on comparison with the standard helical connector outlet assembly.

The reader is advised to review HW-63756 1 for comparison with other outlet assemblies as well as a discussion concerning the importance of outlet fitting assemblies. It was pointed out that the flow characteristics in the outlet fittings can appreciably affect reactor operating limits. Final selection of any new outlet assembly will require careful analysis of operating limits and probably will require verification by laboratory heat transfer experiments.

EQUIPMENT

The present experiments were conducted in the Thermal Hydraulics laboratory in 189-D. The equipment arrangement consisted of a dummy loading of heavy metal upstream of a standard downstream support charge in a BDF type process tube. A standard BDF rear nozzle was used.

The new flexible outlet connector assembly under consideration consists of a nozzle cap attached to a flexible (braided wire) connector which attaches directly to the existing rear header (Parker) fitting. The assembly is represented in the following sketch.

* HW-63756 1, Laboratory Determination of Normal Operating Flow Rates with Enlarged Outlet Fittings - BDF Reactors, February 2, 1960

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The nozzle cap attaches to the three lug pins on the nozzle barrel in the usual manner. The water seal between the nozzle barrel and the cap is attained by an O-ring on the cap. The flow path is directly out the center of the cap and into the flexible connector. Relative movement between the rear nozzle and the cross header was easily absorbed by the flexible connector which was of braided wire very similar to the CG-558 front connectors (pigtails). No mechanical difficulties were encountered with the new assembly during the course of these experiments.

The assembly was developed by R. R. Henderson of the Materials Development Operation, IPD.

DISCUSSION OF DATA

Data are presented on Figure 1 to show the flow characteristics of the new outlet assemblies at near normal rear header pressures and outlet water temperatures. By combination of supply and demand curves, as discussed in HW-63756 1, one can then determine the normal operating point for a single tube equipped with either assembly.

For the flexible connector assembly with a standard (0.469) header (Parker) fitting, the normal operating flow rate would be 6.9 per cent above the normal flow rate for the helical pigtail assembly. (This assumes that the front header pressure remains constant at 575 psig.) When the rear header (Parker) fitting was reamed to 0.610 inch ID, then the normal flow rate would be 13.5 per cent above the standard helical assembly. (Of course the downstream end adapter of the flexible connector was made to correspond in inside diameter to the header fitting.) For the 0.469 header fitting and 110°C water as shown on Figure 1, critical flow occurs in the header fitting over the entire flow range tested. For the 0.610 header fitting, the points shown on Figure 1 were not in critical flow. Similar conditions were found for the larger fittings discussed in HW-63756 1.

Data are shown on Figure 2 to show pressure drop comparison for the two flexible connector assemblies and for the standard helical pigtail assembly under conditions of high rear header pressure which prevents critical flow from occurring. These data are not particularly applicable to present reactor operating conditions, but would be useful in studies which involve pressurization of the rear cross headers.

It is interesting to note that the difference (psi) between the two demand curves on Figure 1 for the flexible connector assemblies is much greater than the difference (psi) between the curves for the two flexible connector assemblies on Figure 2 for high rear header pressures. This illustrates the pressure build-up effect which is typical of critical flow conditions and which is one cause of the high trip Panellit back-up protection which exists at the old reactors.

The reader is reminded that the pressure-flow characteristics of the outlet fittings largely determine the allowable temperature operating limits. Hence, final selection of any particular outlet assembly will require careful analysis of allowable limits. Since these flow characteristics cannot always be predicted under reactor transient conditions, final selection of a new outlet fitting assembly may require experimental verification of the limits.

E.D. Waters
Thermal Hydraulics Operation

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FIGURE 1

SUPPLY-DEMAND ANALYSIS OF NORMAL OPERATING FLOW RATES

Supply Curve Conditions: $3\frac{1}{2}$ - O-II-N I&E fuel elements
 Average coolant temperature - 60°C
 CG-558 front fittings with 0.310 venturi

Demand Curve Conditions: Outlet water temperature - 110°C
 Rear header pressure - 30 psig
 Shaded symbols indicate presence of critical flow conditions

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FIGURE 2
ENERGY LOSSES WITH HIGH REAR HEADER PRESSURES

Conditions: Water temperature 10 to 12°C
Rear header pressure - about 100 psig
Non-critical flow

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