APPENDIX D

VISCOSITY MEASUREMENTS OF H-COAL LIQUIDS

In this appendix, additional details are reported regarding the PDU sampling technique and the viscometer used by Battelle.

PDU Sampling Technique

The samples were obtained from the PDU using the sampling system shown in Figure D-1. The main two components of the system are a slop vessel and a sample vessel. The sampling procedure was quite simple. First the unit was connected to the PDU sampling point. The system was then purged with nitrogen and the system tubing and vessels were heated to approximately 300°F. After the purge was complete, the system was sealed to the atmosphere and the valves on the PDU were opened, allowing H-Coal liquids to flow into the slop bomb. After the slop bomb was filled, the valves leading to the sample vessel were opened and a sample was taken. After the sample was taken, the sample vessel was isolated and the valves connecting the system to the PDU were closed. The slop vessel and connecting lines were vented and purged with nitrogen. The sample vessel was removed from the unit and allowed to cool. After it had cooled, Valves A and B between the sample vessel and the outage vessel were opened to provide a void volume for shipment to Battelle. Both Battelle and HRI took precautions to see that the samples were not exposed to air.

Viscosity Measurement.--The viscometer used by Battelle is shown in Figure D-2. The viscometer consisted of:

1) Stainless steel body of a 300 cc Autoclave.

2) Hollow stainless steel bob of a diameter 1 mm less than the inside diameter of the Autoclave.

3) Stainless steel tube which supports the bob and serves to keep the pressure inside the bob the same as the Autoclave pressure.

4) Connector.

5) Alnico magnet.

6) Two coils.

7) Furnace supplied with the Autoclave.

8) Additional furnace for better temperature control.

9) Sheathed 1/16" thermocouple.

10) Three of the gas inlet-outlet connections.

Viscosity measurements are made by passing a current through one of the coils, thus exerting a force on the bob, moving it either up or down. As the bob moves through the sample, the magnet moves through the other coil, thus generating an emf in the coil. This emf can be related to the velocity of the bob. Thus, from the current applied in one coil and the emf generated in the other coil, the relationship between shear stress and shear rate of the fluid in the viscometer can be determined. A more complete description of the viscometer, the sample loading technique, and its operation is contained in Reference 51.

The measured values of viscosity n' and θ for the H-Coal samples (Amoco Nos. 1, 2, 4) and the char kerosene samples are listed in Table D-I, which has been reproduced from Battelle's report. It should be noted that the kerosene/char samples sent to Battelle were incorrectly identified; the actual coal concentrations were 5.1, 10.4, and 17.8 vol%. Inspection of the results indicates that the viscosity and yield stress of the char kerosene samples at ambient conditions are in the same range as those of the H-Coal samples at H-Coal reactor conditions (1 to 10 cp and 1000 to 2000 milli-Newtonians/m^2, respectively). There is considerable scatter in the yield stress data. A discussion of the scatter can be found in Battelle's report (51).

Figure D-1

Sampling system at HRI PDU

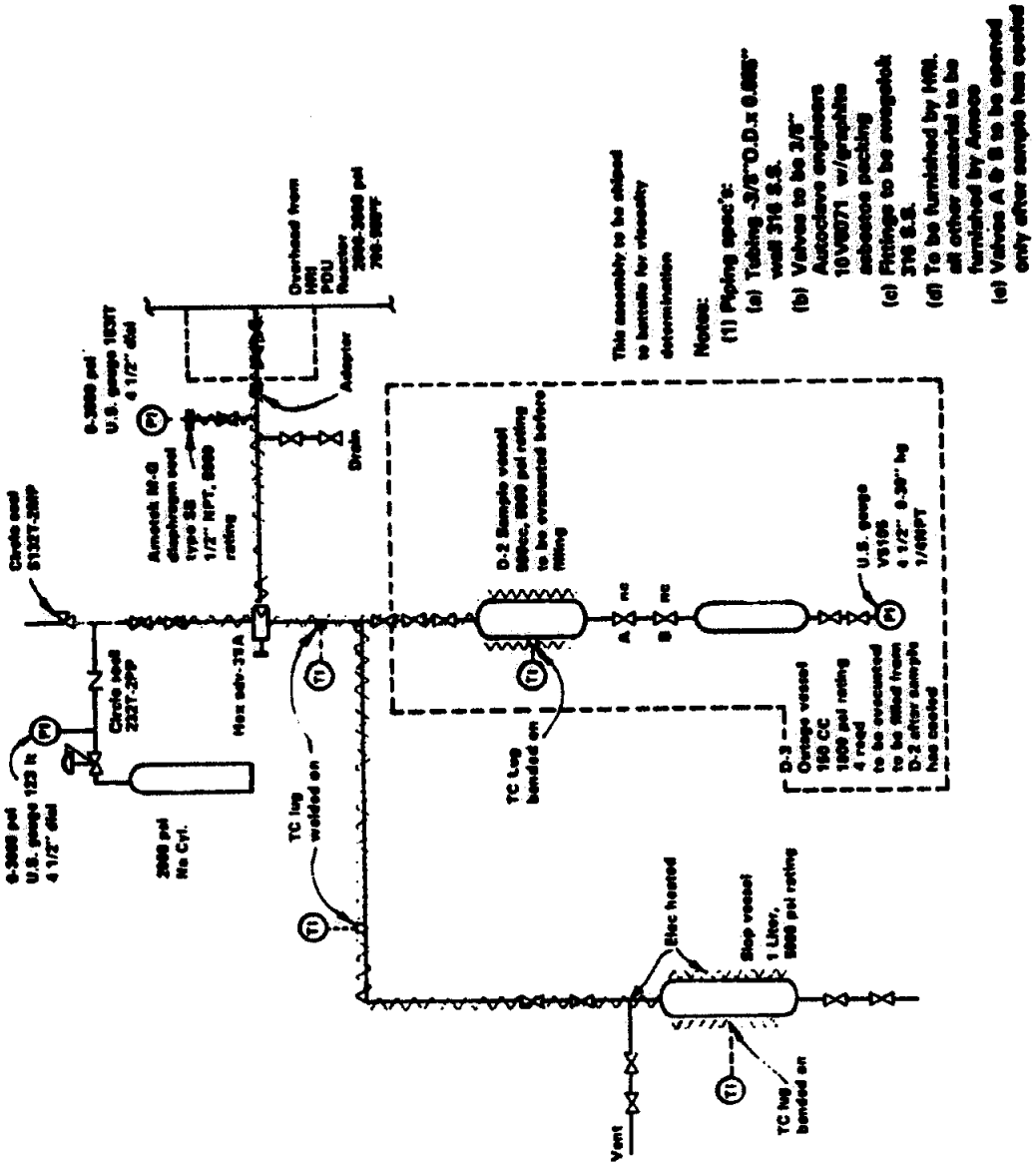

Figure D.2
Battelle Viscometer