GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

no action ask

Date: December 8, 1976

Project Title: Gas Turbine Bearing Program -- Task I

Project No: E-25-669

Project Director: Dr. Ward O. Winer

Sponsor: General Electric Co.; Gas Turbine Mfg. Dept.; Schenectady, NY 12345

Agreement Period: From 11/3/76 Until 12/31/76

Type Agreement: Purchase Order No. 087-ETBM-73224

Amount: $15,000 (Fixed Price)

Reports Required: Task I Report

Sponsor Contact Person (s):

Technical Matters

Mr. J. D. McHugh
Bearing and Sealing System Design
Building No. 53-334
General Electric Company
One River Road
Schenectady, NY 12345

Contractual Matters
(thru OCA)

C. J. Kowalski
Purchasing
Gas Turbine Manufacturing Dept.
General Electric Company
P. O. Box 952
Schenectady, NY 12345

Defense Priority Rating: None

Assigned to: Mechanical Engineering (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director—EES
Accounting Office
Procurement Office
Security Coordinator (OCA)
Reports Coordinator (OCA)
Library, Technical Reports Section
Office of Computing Services
Director, Physical Plant
EES Information Office
Project File (OCA)
Project Code (GTRI)
Other

CA-3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: June 24, 1977

Project Title: Gas Turbine Bearing Program - Task I

Project No: E-25-669

Project Director: Dr. Winer

Sponsor: General Electric Co.

Effective Termination Date: 12/31/76

Clearance of Accounting Charges: 12/31/76 (Fixed Price)

Grant/Contract Closeout Actions Remaining:

X Final Invoice ~~XXXXXXXXXXXXXXXXX~~
_ Final Fiscal Report
_ Final Report of Inventions
_ Govt. Property Inventory & Related Certificate
_ Classified Material Certificate
_ Other ______________

NOTE: TASK I; SEE E-25-668 for TASKS II & III

Assigned to: Mechanical Engineering (School/Laboratory)

COPIES TO:

Project Director	Library, Technical Reports Section
Division Chief (EES)	Office of Computing Services
School/Laboratory Director	Director, Physical Plant
Dean/Director—EES	EES Information Office
Accounting Office	Project File (OCA)
Procurement Office	Project Code (GTRI)
✓ Security Coordinator (OCA)	Other ______________
Reports Coordinator (OCA)	

CA—4 (3/76)

E-25-669

NO. 2 BEARING OIL FLOW INVESTIGATION

Final Report

GENERAL ELECTRIC CORPORATION

P.O. #087-ETBM-73224

by

Ward O. Winer
Professor
and
Principal Investigator

David M. Sanborn
Associate Professor

Scott Bair
Research Engineer

Georgia Institute of Technology
School of Mechanical Engineering
Atlanta, Georgia

March, 1977

NO. 2 BEARING OIL FLOW INVESTIGATION

SUBMITTED TO

G. Robson and J. D. McHugh
General Electric Corporation
Bearing & Sealing System Design
Schenectady, New York 12345

SUBMITTED BY

Ward O. Winer
Professor
and
Principal Investigator

David M. Sanborn
Associate Professor

Scott Bair
Research Engineer

Georgia Institute of Technology
School of Mechanical Engineering
Atlanta, Georgia

March, 1977

Ward O. Winer, Professor
School of Mechanical Engineering

SUMMARY

The oil flow rate as a function of feed pressure for the No. 2 bearing of the MS 7000 Model General Electric Gas Turbine was studied. Five oil feed configurations were evaluated including the current production configuration. Oil flowrate to the No. 2 bearing is larger than that required for generating the hydrodynamic lubrication film because of bearing housing cooling requirements. The objective of this study was to reduce the supply pressure required for a given oil flowrate to the bearing. A reduction in supply pressure was accomplished by introducing flow passages at the bearing split line to permit a portion of the total oil flow to go directly from the inlet to the drain groove bypassing the hydrodynamic film (Configuration IV and V). The entire oil flow passes through the drain groove spray system to cool the housing.

The liner modifications are shown in Figure 2 and the flow rate - pressure results are shown in Figures 3 and 4.

FACILITY

The same bearing test facility as used on previous No. 2. bearing studies for General Electric* was used for this study. However, the pressurized hot environment was not used. The chamber top was removed for all studies described in this report. The bearing liner was installed in the up drain configuration. The shaft was positioned using dial indicators to have a radial gap between the shaft and bearing surface of 0.0025 inches at an angle of 57° measured clockwise from the six o'clock position as viewed from the engine end.

Oil was supplied from the 600 gallon reservoir at approximately 130F (54C). The flowrate of from 30 to 80 gpm was controlled by a hand valve between the pressure relief valve and the coaxial feed-drain pipe. The lubricant in every test was a phosphate ester (tri aryl phosphate, Fyrquel 150 R & O) from Stauffer Chemical Company.

The liner used in the study is shown schematically in Figure 1 (instrumentation) and Figure 2 (modifications). The liner feed configurations studied are shown in Figure 2 and listed in Table I.

*"Bearing and Seals Investigation of a No. 2 Bearing in Model MS 7000 Gas Turbine", General Electric Corporation, January 1973 (with D. M. Sanborn, and S. V. Shelton).

"Evaluation of Cooling Techniques for a No. 2, MS 7000 Gas Turbine Bearing", General Electric Corporation, February 1974 (with D. M. Sanborn and S. V. Shelton).

"Bearings and Seals Investigation of No. 2 Bearing with Air Cooled Housing in Model MS 7000 Gas Turbine", The General Electric Company, Large Gas Turbine Division, July 1975, (with D. M. Sanborn, S. V. Shelton, S. Bair).

INSTRUMENTATION

Instrumentation consisted of five thermocouples, three pressure taps, an orifice plate flowmeter, and a tachometer. The temperatures were measured with an Omega digital thermometer type 2809 connected to the thermocouples. The thermocouple probes were inserted into the oil flow at both feed spreaders and between two of the top up-drain nozzles in both the fore and aft drain groove as shown in Figure 1. Another thermocouple was located in the coaxial feed pipe. Static pressure probes were installed in each of the feed spreaders (Figure 1) facing in the direction of normal oil flow. These pressures were measured with one bourdon tube gauge. Another similar gauge was mounted in a stand-pipe in the coaxial feed pipe so that both gauges were at approximately the elevation of the bearing split line. The bourdon gauges were four inches diameter with 100 psig full scale reading.

An orifice plate between the oil flow regulating valve and coaxial feed was connected to an oil over mercury manometer for measurement of flowrates. A Hasler hand held tachometer was driven off the exposed end of the shaft opposite the drive engine for rotational speed measurements.

TEST PROCEDURE

The engine was run at full throttle and the oil supply at full flow until oil operating temperature was achieved. Cooling water flow through a heat exchanger was manually adjusted to provide oil inlet temperature control at approximately 54C. An oil inlet pressure was selected with the flow regulating valve and once steady state was reached the data was sampled and recorded.

DISCUSSION

A summary of all data is shown in Table II. Liner modifications studied are shown in Figure 2. Configuration I was the standard configuration and the results are comparable to those previously reported.

In Figure 3, oil flowrate is plotted against supply pressure for tests with shaft rotation. For configurations I, II and III the flow for a given supply pressure remained essentially unchanged while configurations IV and V showed an increase in flowrate throughout the range for any given supply pressure. In configurations I, II, III the oil was forced to travel through a hydrodynamic film of the liner before exiting the bearing film. In configurations IV and V passages were provided for direct flow from the feed to the drain cavities bypassing the fluid film.

Oil flowrate versus supply pressure is plotted in Figure 4 for no shaft rotation. There was no hydrodynamic film generated and the flowrate was controlled by the restrictions to oil flow from the feed line to the drain.

Configurations IV and V with one and two passages, respectively, from the feed spreader to the drain groove give the highest flow at a given pressure.

Oil, in excess of that required for hydrodynamic lubrication, is supplied to this bearing because of the bearing and housing cooling requirements. By installing the passages at the split-line between the oil feed spreader and the drain groove, lower feed pressure is required to supply the necessary cooling flow and still providing adequate flow for the hydrodynamic film.

TABLE I

Liner

Configurations

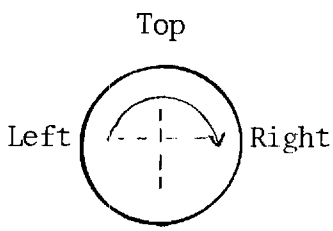
I. Standard Up-drain Liner.

II. Oil flow blocked to right spreader groove by .75 x 2.8 in. plug in entrance.

III. Entrance to right spreader blocked and .50 x .25 in. channel opened between right spreader and drain grooves, fore and aft.

IV. Entrance to right and left spreader open and .50 x .75 in. channel opened between right spreader and drain grooves, fore and aft.

V. Entrance to right and left spreader open and .50 x .75 in. channel opened between right and left spreader and drain grooves, fore and aft.



Viewed from engine side.

TABLE II: OBSERVATIONS

		OIL INLET			LINER PRESS PSIG		LINER TEMP °C			
CONFIGURATION	SHAFT RPM	FLOW RATE (GPM)	TEMP °C	PRESS PSIG	LEFT FEED	RIGHT FEED	RIGHT FEED	LEFT FEED	FWD DRAIN	AFT DRAIN
I	3600	71.7	55	42	41	42	59	60	67	66
	3600	63.4	53	34.5	35	36	57	57	66	65
	3600	52.4	57	22	22	21	66	65	69	74
	3600	48.4	57.5	15	17	15.5	69	67	70	76
	3600	33	54.5	8	8	8.5	71	65	73	78
	0	74.8	54	24	25.5	23.5	53.5	54	54	54
	0	62.5	55	18	19	19	55	55	55	55
	0	50.0	55	12	15	14.5				
	0	29.9	55	7	9	9				
II	3400	62.0	57	30	31	27	66	64	71	72
	3200	73.0	56.5	45	45	41	62	62	70	69
	3400	49.3	55	19	20	17	66.5	63	72	73
	3550	37.4	54	12	12	12	68	63	73	76
	0	72.6	55.6	45	45	12	55.9	55.8	56.2	56.6
	0	49.7	55.4	30	33	10.5	55.4	55.7	55.5	55.6
	0	30.4	55.0	16	17	7.5				
III	3300	76	56.5	48	43	25	62	61.5	66	65.5
	3300	62.5	53	30	28.5	14	61	59	66	68
	3300	51	53	18	18.5	10	63	61	68	70
	3500	40.5	52	10	10.5	7.5	66	66	68	72
	0	71.7	54	50	48	7				
	0	53.7	51	30	28	5				
	0	29	54	15	15	3.5				

-continued-

TABLE II: OBSERVATIONS (Continuation)

CONFIGURATION	SHAFT RPM	OIL INLET FLOW RATE (GPM)	OIL INLET TEMP °C	OIL INLET PRESS PSIG	LINER PRESS PSIG LEFT FEED	LINER PRESS PSIG RIGHT FEED	LINER TEMP °C RIGHT FEED	LINER TEMP °C LEFT FEED	LINER TEMP °C FWD DRAIN	LINER TEMP °C AFT DRAIN
IV	3250	77	51	22	21	22	54	51	59	60
	3400	70.4	54	17	16	16	60	56	63	66
	3400	55	56	10	9.5	9	65	61	67	74
	0	70.4	55	8.5	9	9				
	0	78.3	50	11	11	11				
	0	50.2	54	5.5	*	*				
V	3200	79.2	51	25	25	25	54	51	59	59
	3300	65.6	52	17	17	17	60	54	68	66
	3350	48.4	56	11	11	11	68	59	73	70
	3400	40.9	50	8	8	8	62	52	69	63.4
	0	40.5	51	4	4	4				
	0	66.9	54	6	6	6				
	0	79.2	54	8	7	7				

*Pressure too low to read.

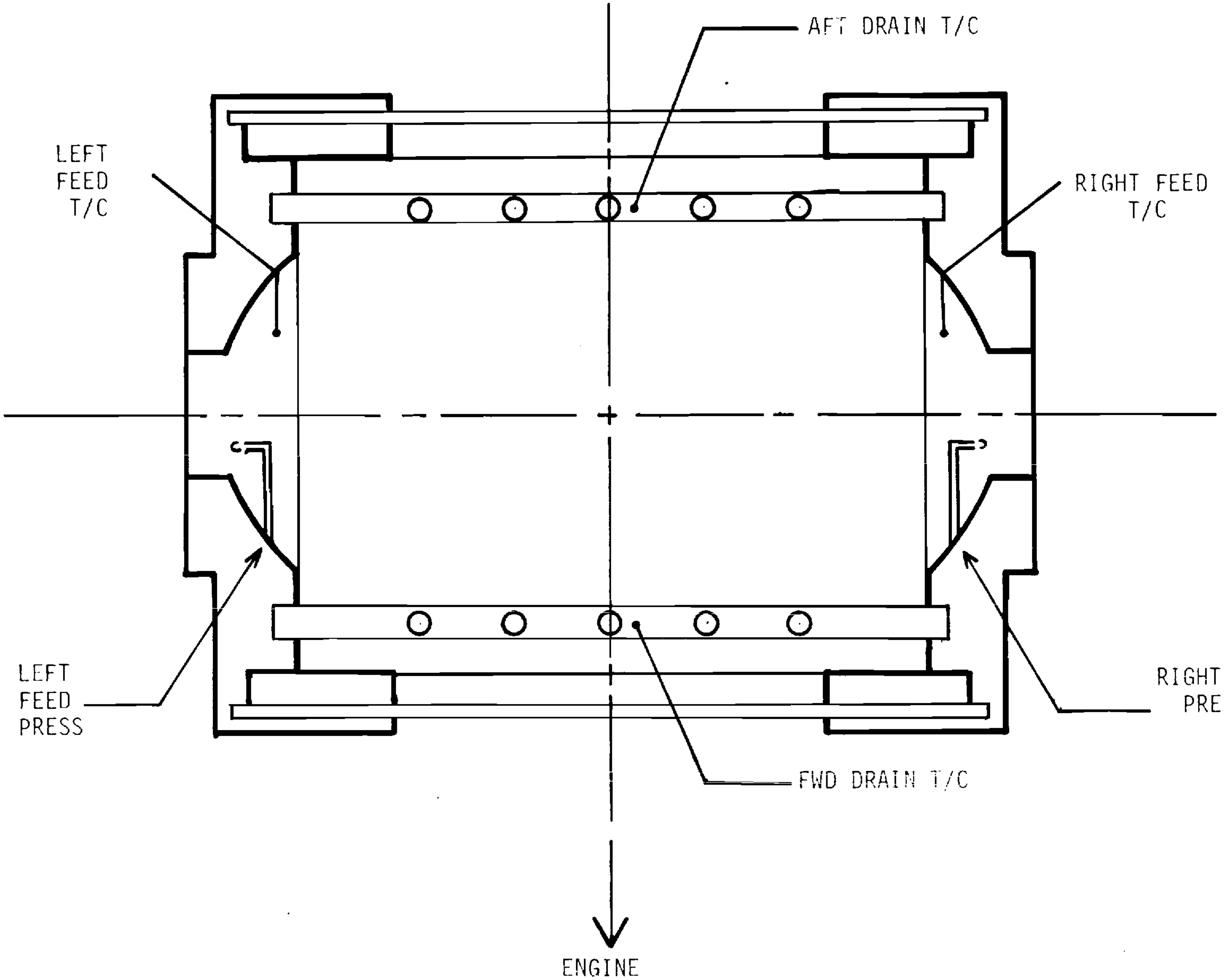


Figure 1. Liner instrumentation looking down, clockwise rotation when viewed from engine.

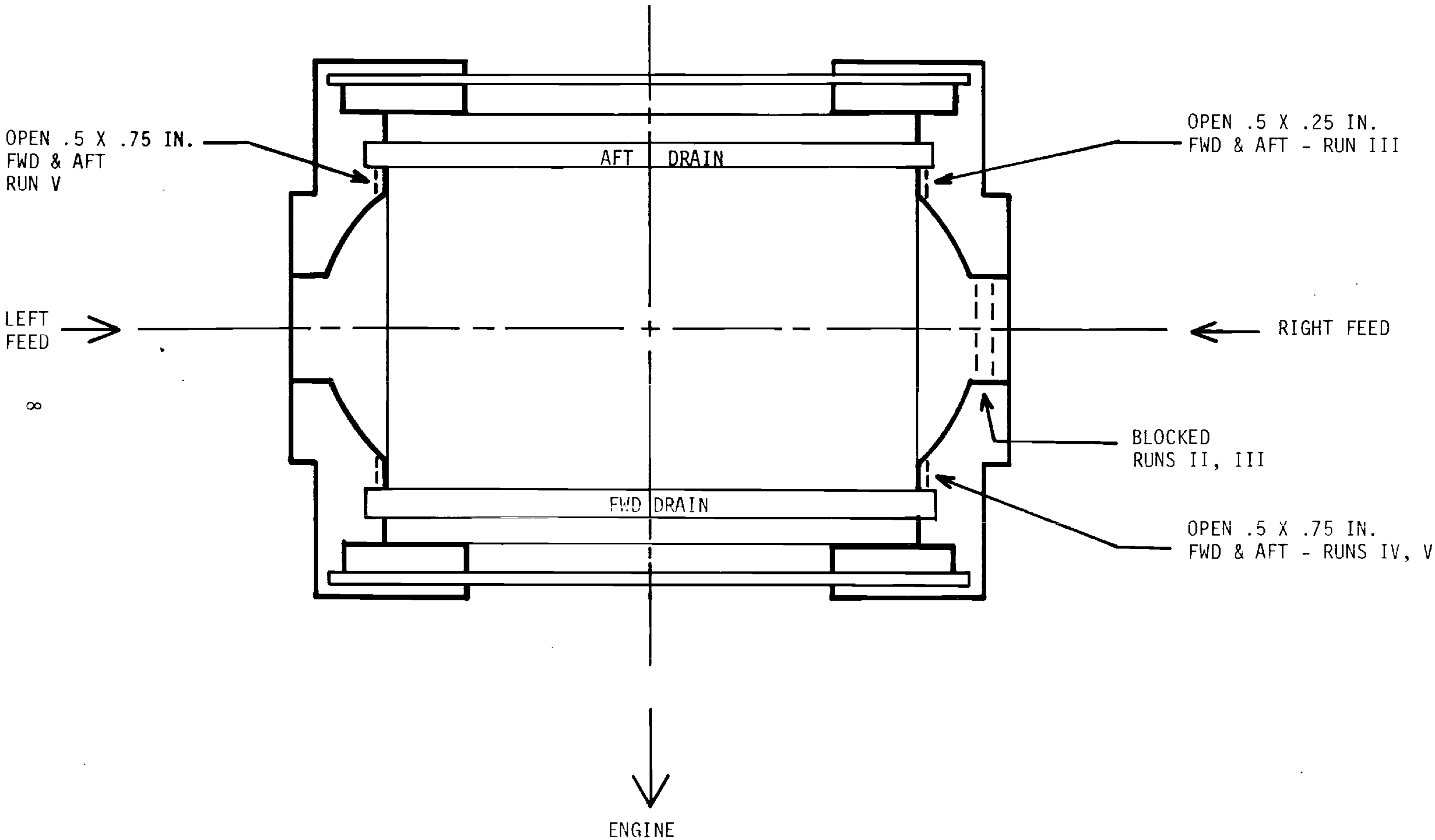


Figure 2. Liner Modifications (looking from top-standard configuration shown in solid lines). Shaft rotation clockwise when viewed from engine end.

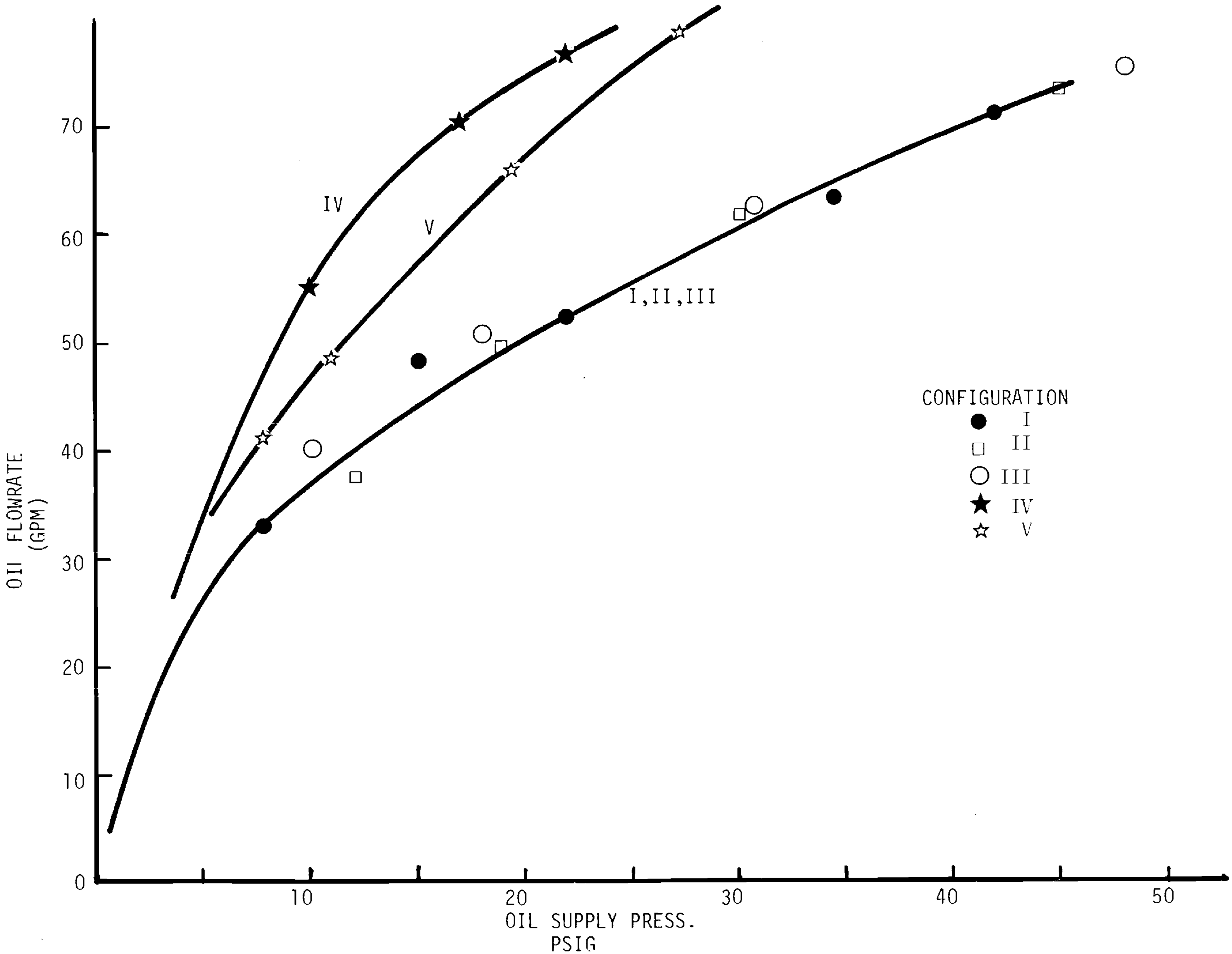


Figure 3. Oil Flow for Rotating Shaft.

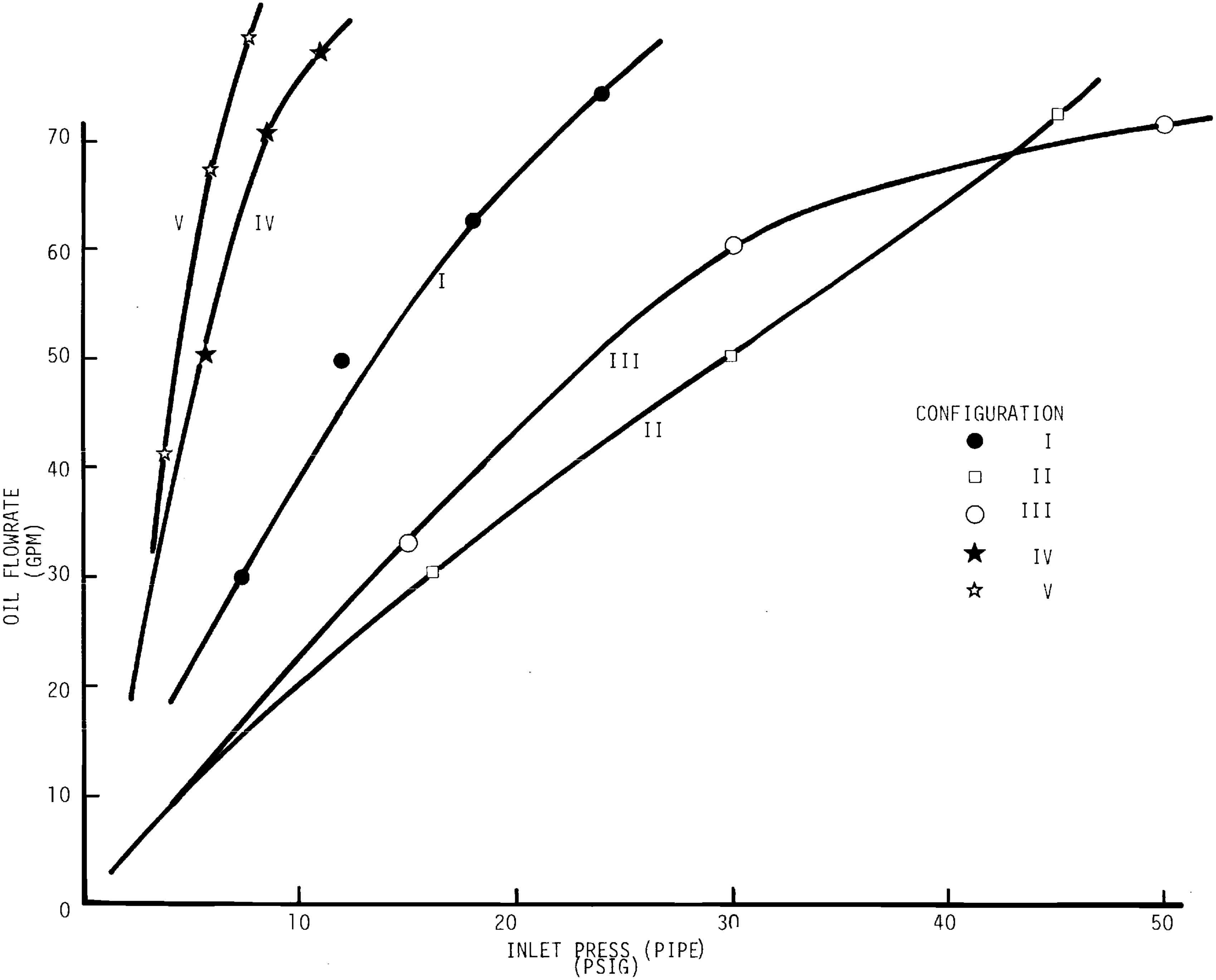


Figure 4. Oil Flowrate for No Rotation.