# AN APPLICATION OF A HYDROSTATIC PRESSURE LIFT SYSTEM FOR CONTROL OF VARIABLE THRUST LOADS

by

**Essie Noori**
**Senior Turbine Engineer**
**Southern California Edison Corporation**
**Rosemead, California**

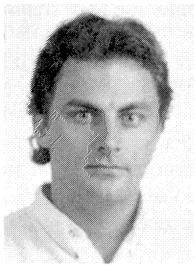
**Michael J. Harrington**
**Station Engineer**
**Southern California Edison**
**Long Beach Generating Station**
**San Pedro, California**

and

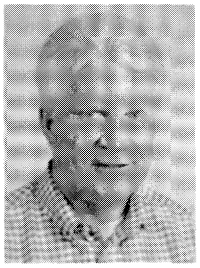
**David R. Stenson**
**District Sales Manager**
**TurboCare/Division of Demag Delaval Turbomachinery Corporation**
**Perris, California**

*Essie Noori is a Senior Turbine Engineer of Engineering and Technical Services, a Division of Southern California Edison Corporation. He has also held field engineering and job managerial positions with General Electric Company for several years.*

*He holds a B.S. degree (Mechanical Engineering) from Los Angeles State University. He has also completed several specialized courses through General Electric Company, universities, and seminars. He has made several operational, mechanical, and design improvements in the area of turbine generator sets throughout the Edison system. He is a member of ASME.*



*Michael J. (Mike) Harrington is a Station Engineer for Southern California Edison at the Long Beach Generating Station. Long Beach Generating Station is a combined cycle plant that provides backup and peaking power for the base loaded units in the Edison systems. He has been working for Southern California Edison since February 1990. Station Engineering responsibilities include reliability, betterment, and quality control for seven gas turbines, seven best recovery boilers, and two steam turbines. He holds a B.S. degree (Mechanical Engineering) from the University of Arizona (1989).*



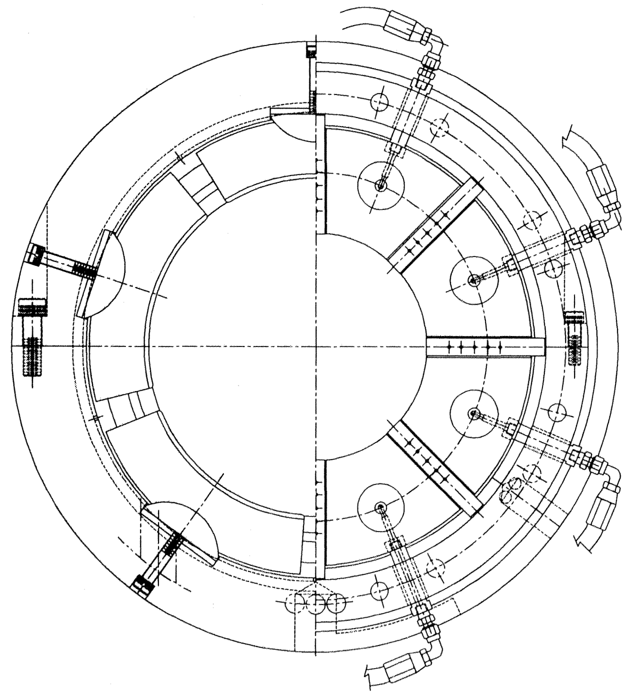
*David R. (Dave) Stenson is a District Sales Manager of TurboCare, a Division of Demag Delaval Turbomachinery Corporation. He previously held sales positions with Creole Production Services and Solar Turbines Incorporated. He presented a paper at the 1972 ASME Gas Turbine Conference on air Filtration Experience in Arctic Applications. He holds a B.S. degree (Mechanical Engineering) from San Diego State University. He is a member of the Pacific Energy Association.*

## ABSTRACT

Thrust bearing failures on older equipment, especially large steam turbines, can be costly problems to remedy. A unique solution to a steam turbine thrust bearing problem that confronted Southern California Edison (SCE) is examined. The prohibitive cost of correcting the problem had forced SCE to consider mothballing the turbine. An evaluation of the situation by experts in the area of thrust bearing design produced a cost effective solution—a hydrostatic assisted thrust bearing design. The solution was implemented, and the results have proven satisfactory.

## INTRODUCTION

Southern California Edison Long Beach Generating Station was facing a decision about mothballing Unit 9 steam turbine. The Long Beach Generating Station is one of two combined cycle facilities in the SCE system. This generating station produces 570 megawatts of electrical power for the surrounding communities. Seven combustion gas turbines, providing 420 megawatts, are used to power the boilers that drive Units 8 and 9 steam turbines. Over the years, continued uprates of the



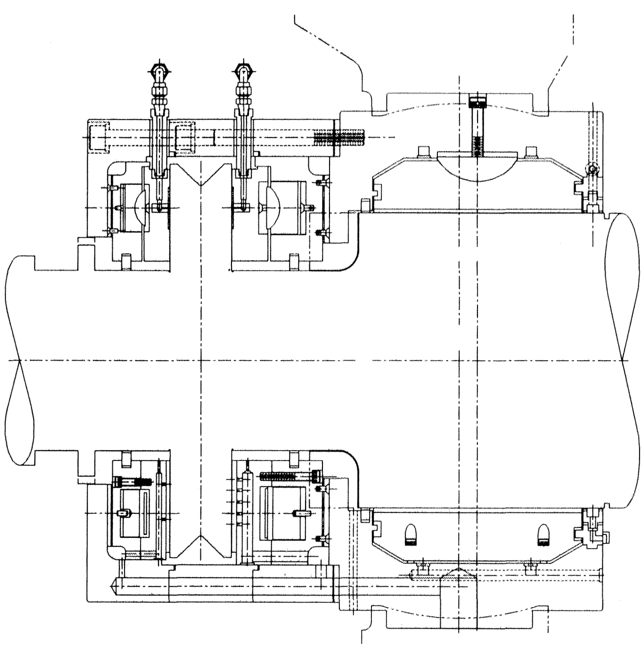


*Figure 2. Thrust Bearing.*

during startup and shutdown and during low speed operation, such as when the turbine is on the turning gear. In addition, the hydrostatic pressure lift system provides additional thrust bearing cooling during high load operation. In the HPL system, oil is supplied at required pressure to both active and inactive thrust bearings, and the flow is controlled by separate flow control valves for the inactive side and for the active side. Since the flowrates are fixed, the pressure in the system, and therefore hydrostatic performance, is a function of the bearing load only.

### *Components*

The hydrostatic pressure lift (HPL) system is independent of the thrust and journal bearings lubrication oil system. The HPL

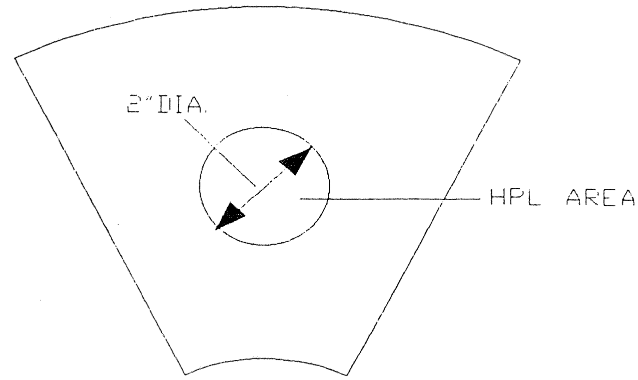



*Figure 3. Thrust Pad.*

oil is delivered by an electric-driven pump to both thrust bearings. Each thrust bearing pad has an individual flexible line to one of the two lift oil manifolds, and each line is fitted with a calibrated orifice and a check valve. Refer to Figure 4 for a diagram of the HPL system.

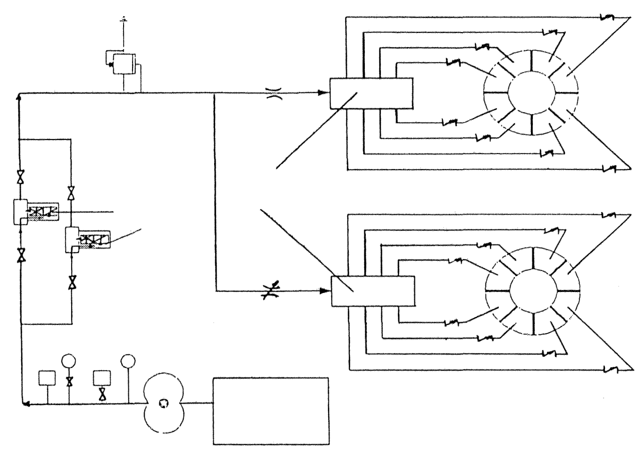


*Figure 4. Hydrostatic Pressure Lift System.*

The HPL system is made up of the following components:

- Booster pump
- Electric motor
- Filters
- Temperature gauges
- Pressure gauges
- Adjustable range relief valve
- Adjustable range flow control valve
- Adjustable pressure switch

### *Design Calculations*

The hydrostatic performance of the thrust bearing is a function of the total load and the flowrate. The flowrate to each bearing is fixed by the flow control valves (FCV) at 10 gpm to the inactive side and 12.5 gpm to the active side. Since the flowrates are fixed, the pressure in the system, as mentioned, is a function of bearing load only. Pressure upstream from the FCV is maintained by the pressure relief valve. From Equation (1), it can be estimated that for a 300 psi total thrust load with an approximately 25 $in^2$ lift surface, the system should supply approximately 2300 psig.

*Art-Equation 1 MUST go here-GUIDES . . .*

## ADVANTAGES OF THE REDESIGNED SYSTEM

The journal bearing ball-to-socket improves bearing load distribution. The ball-to socket contact allows each pad to tilt both axially and circumferentially. This ensures that any misalignment will be evenly distributed across the bearing load area. The use of this type pad support system eliminates the problems associated with possible lock-up of the spherical seated bearings previously used. Also, the ball-and-socket design reduces stresses at the pad to housing contact by allowing the load to be distributed over a larger pivot area. This maintains a constant bearing-to-shaft clearance, which changes in other designs because of wear.

Direct lubrication of the bearing pads improves efficiency. By supplying oil through fixed orifices at the edge of each journal pad, this system supplies only the oil needed and avoids extra oil in the bearing cavity, which would just increase the temperature of the bearing through churning. This situation is similar in the thrust bearing. The oil is injected through the nozzles to the leading edge of each pad assuring positive lubrication and continuous cool oil supply.

The self-equalizing feature of the thrust bearings compensates for angular misalignment between the thrust collar and thrust bearing support and distributes thrust loading circumferentially to give equal loading on all pads. Ball-and-socket thrust pad supports reduce contact stresses over point contact eliminating brinneling of the thrust pad pivots, and, therefore, maintaining axial tolerances to extend run times.

The HPL system has proven successful in three important stages of turbine operation: at startup or shutdown, while on turning gear (when slow speeds occur), and at high thrust bearing temperatures (high speed and high thrust load). While on the turning gear, the system provides additional lubrication for the bearings. At high thrust bearing temperatures, this system provides additional cool oil to the bearing.

The major change in design of the active thrust bearing to a self-equalizing type with the HPL system provide significant advantages over the old style thrust plate. Specifically, these advantages are the following: compensation is made for misalignment, pad-to-pivot contact stress is reduced, bearing load is more evenly distributed among the pads, thrust bearing lubrication is improved at low speed, thrust bearing cooling is improved at high turbine loads, and parasitic oil churning losses are reduced.

## CONCLUSION

The redesigned thrust bearing system has allowed SCE to continue using a vital low-pollution component of their power generation system. The redesigned thrust bearing with HPL allows continued use of the steam turbine without the expensive capital outlay for thrust bearing repairs. In addition, the redesigned system allows increased output from Unit 9.

SCE is presently using the HPL system in the following manner: With the HPL supply off, the power output can be increased to 46MW, where the temperature on the active thrust bearing rises to approximately 220°F. At this point, the HPL system is placed in operation. With the HPL system in operation, the thrust bearing temperature decreases to 170º F. This improved cooling allows SCE to continue to raise power output to 68MW.

From September 1993, to March 1995, the following steps were taken:

· Installing the redesigned thrust bearing

· Added a hydrostatic pressure lift system to the tilt-pad thrust bearing

· Testing the new thrust bearing system

Among the advantages accrued from the redesigned thrust bearing system are the following:

· Eliminates premature bearing failure at startup

· Eliminates premature bearing failure while on turning gear

· Eliminates progressive thrust bearing wear

· Decreases thrust bearing operating temperature

· Decreases temperature differential between individual thrust bearing pads

· Allows operating on turning gear with existing axial misalignment

## ACKNOWLEDGMENTS

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