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GE Power Systems

Shaft Sealing System

$7H_2$ and $7FH_2$ Generators

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes the matter should be referred to the GE Company.

I. PURPOSE

To safely and effectively employ hydrogen for generator cooling, it is necessary to contain the gas in the generator casing. Therefore, shaft seals are required at each end of the generator where the rotor extends through the end shield. A radial oil film type seal is used for this purpose.

II. DESIGN FEATURES (SEE THE BEARING AND SEAL OIL PIPING DIAGRAM AND GAS CONTROL PIPING DIAGRAM)

A. Shaft Seal

The shaft seal at each end of the generator consists of a two-piece hydrogen seal casing containing a pair of babbitted steel rings. Each ring is made up of two 180° segments to facilitate assembly of the seal rings into the hydrogen seal casing. The ring segments are assembled against the side walls of the seal casings using garter springs, and are held concentric with the shaft by the hydraulic pressure of the seal oil. The rings, which have a bore diameter only a few mils greater than the shaft journal, are free to float radially but are prevented from rotating with the shaft by a stop in the upper half of each seal casing. Oil from the seal oil control system at a pressure of about 5.5 psi (0.387 kg/cm^2) above the hydrogen pressure in the generator is supplied to the seal casing. The oil then passes radially through the space between the rings and axially along the shaft between the shaft and seal rings in both directions. It is this thin film of oil between the shaft surface and the rings that actually seals the hydrogen within the casing.

The total oil flow to the inner- or hydrogen-side rings of the two shaft seals is approximately two and a half gallons (9.46 liters) per minute, while the flow from the outer- or air-side rings may be several times that amount. A large air-side flow is needed to cool the rings while a low hydrogen-side flow is essential for satisfactory operation of the continuous scavenging system.

B. Seal Oil Control

Pressurized oil for the seals is supplied from the main lubrication system to the seal oil controls where it is regulated to maintain the 5.5 psi (0.387 kg/cm^2) differential. The quantity of the total seal oil flow can be read directly from the flowmeter.

C. Differential Pressure Regulator

A pilot-operated differential pressure regulator is provided for controlling the seal oil pressure at the shaft seal. The pilot-operated valve uses inlet pressure as the operating medium, which is reduced through pilot operation to load the actuator diaphragm. Outlet or downstream pressure opposes loading pressure in the actuator and also opposes the pilot control spring. The pilot-operated regulator is designed to maintain a constant differential pressure across the hydrogen seals.

The upper connection of the pilot valve diaphragm is piped to the seal drain enlargement and senses the gas pressure in the generator casing. The lower connection of the pilot valve diaphragm is piped to one of the two lower connections of the regulator diaphragm. The other lower connection of the regulator diaphragm is piped to the seal oil supply line and senses oil pressure being supplied to the shaft seals. When the outlet pressure drops below the setting of the pilot control spring, pilot control spring force in turn opens the pilot valve plug, providing additional loading pressure to the actuator diaphragm. This loading pressure tends to open the main body valve thus supplying the required flow downstream to the seals. When the downstream pressure is satisfied the outlet pressure tends to increase which in turn acts on the pilot and actuator diaphragms. This pressure exceeds the pilot control spring setting thus letting the valve plug spring close the pilot valve plug. Reduced actuator loading pressure permits the main valve to close. Once adjusted, the regulator will maintain a nearly constant 5.5 psi (0.387 kg/cm^2) pressure differential between the seal oil and the generator hydrogen through the complete range of hydrogen pressures.

D. Instrumentation

A flowmeter is provided for obtaining an instantaneous reading of the total seal oil flow. Pressure gauges are provided to measure seal oil pressure upstream of the differential pressure regulator, at the turbine end seal oil feed line, and at the collector end seal oil feed line.

A differential pressure gauge and three differential pressure switches are mounted on the switch and gauge panel. These instruments sense seal oil differential pressure at the seals with respect to gas pressure in the casing. The switches are electrically connected to actuate both the dc emergency seal oil pump located on the main lube oil tank and the annunciator upon low differential pressure. Valving is provided for adjusting these switches.

E. Seal Drain Enlargement and Float Trap

The seal drain enlargement, consisting of two small detraining chambers, is mounted at the collector end of the generator. Hydrogen gas in suspension with the drain oil (from the hydrogen-side drains of the hydrogen seal casings) will bubble out in the chambers. Both chambers drain through a common line to a float trap. The float trap allows oil to pass through to drain, both automatically and manually (if necessary), while preventing hydrogen from passing with the drain oil. The float trap assembly contains a vent line, which allows any built up hydrogen to pass back to the seal oil drain enlargement. Oil leaving the float trap drains to the bearing drain enlargement.

Vertical pipes extend from the upper part of each chamber of the seal drain enlargement to sense cavity purity. The lines are equipped with oil traps to prevent oil from filling the hydrogen control panel in the event of an abnormally high oil level in the seal drain enlargement.

Another vertical open pipe is installed in the collector end chamber of the seal drain enlargement to collect the oil which results from an abnormally high oil level in the enlargement. This overflow is piped to a liquid level detector with an alarm switch. Since the two chambers of the enlargement are connected by a common drain line, a high level in either chamber would normally result in the operation of the alarm. An abnormally high oil level is usually caused by incorrect operation of the drain valves or float trap.

F. Bearing Drain Enlargement

The air-side seal oil, the generator bearing oil, and the hydrogen-side seal oil (after passing through the seal drain enlargement and float trap) drain to a chamber mounted on the generator casing. This chamber, which has been designated as the bearing drain enlargement, provides a large surface area for defoaming and detraining the oil before it is returned through a loop seal to the main lubricating oil tank. In addition, hydrogen that is in solution in the oil will be released due to the drop to atmospheric pressure in this chamber. The bearing drain enlargement is vented by a customer connection to the atmosphere.

In the event of failure of the shaft seal oil supply, hydrogen will pass from the generator into the bearing drain enlargement and be vented to the atmosphere. The oil loop seal provides a barrier to prevent the hydrogen from entering the main lubricating oil tank.

III. OPERATION (SEE THE BEARING AND SEAL OIL PIPING DIAGRAM AND THE GAS CONTROL PIPING DIAGRAM)

A. General

Whether the generator is running with air or hydrogen, it is necessary at all times to have the shaft seals in operation.

When running with air, shaft sealing is necessary in order to supply oil to the seal rings to prevent their heating up and seizing the shaft (due to small diametral clearance between seal rings and the shaft).

When running with hydrogen, shaft sealing is necessary in order to confine the hydrogen in the generator casing.

B. Checking the High Oil Level Alarm

The high oil level alarm switch, 71SD-1, actuates an alarm when there is an abnormal rise in the oil level in the seal drain enlargement.

To test the operation of this switch, first close valve (74), then remove the fill pipe cap and pour in water. This should cause the float in the switch to rise and close the alarm contacts. After testing, drain the water by removing the drain pipe cap. Replace both pipe caps and open valve (74).

C. Putting the shaft Seals in Operation

The shaft seals may be put into operation, and adjustments made to the seal oil components, any time after the lubrication system and seal oil system have been completely flushed and are ready for operation. Adjustments to the seal oil system must *only* be made when seal oil is being properly supplied from the main lubrication system.

When putting the shaft seals in operation the following steps should be followed:

- Valves V-103, V-105, V-109, and V-108 should be closed. (No pressure in the downstream line)
- Valves V-109 and V-105 are then to be placed in the full open position.
- Next, open valve V-103 just enough to hear flow start running through regulator valve (V-102).
- Once flow can be read on the flowmeter slowly open valve V-103 to full open.
- When valve is regulating steadily, slowly open valve V-108 to full open.

Oil from the main lubrication system is supplied through the pressure regulator and flowmeter to the shaft seals. Following the steps listed above will ensure sudden pressure changes will not damage the diaphragm of the pilot valve and/or pressure regulator. The main valve diaphragm is designed for a maximum differential pressure of 125 psid (8.788 kg/cm^2), and care should be taken never to exceed this value. Valve (V-108) is in the gas pressure sensing line, while valve (V-109) is in the seal oil pressure sensing line. All other valves on the seal oil control system should be open or closed as shown on the P&ID for normal operation. Check to make sure that seal oil is flowing to the seals. This will be indicated by the flowmeter.

D. Charging the Casing with Air (See also Gas Control Valve Operation Diagram)

Adjustments of the seal oil control components should be made with the hydrogen supply disconnected and air pressure in the generator casing. Start the seal oil pump. Remove the pipe plug from the air test/purge connection located in the purging control valves assembly and admit dry air to the casing through this connection. Adjust the valves in accordance with the illustration and charge the casing with 15 psi (1.055 kg/cm^2) of air as read on the casing pressure gauge on the hydrogen manifold and/or the hydrogen control panel pressure gauge.

E. Adjustment of Pressure Regulator

NOTE

Gas in the differential pressure regulator or the pilot lines will create system instability resulting in alarm or trip. Thus it is necessary to bleed all gas from all the sensing lines prior to differential pressure adjustment to ensure optimum regulator valve performance.

To set the shaft seal oil pressure to the required 5.5 psi (0.387 kg/cm^2) above machine gas pressure:

- Adjust the pilot-operated differential pressure regulator valve to hold the shaft seal oil pressure as read on the differential pressure gauge, 63SDG-1, at about 6.5 psi (0.457 kg/cm^2) above machine gas pressure. (Differential pressure gauge, 63SDG-1, displays a value roughly 1 psi (0.070 kg/cm^2) above the actual 5.5 psi (0.387 kg/cm^2) shaft seal oil vs. machine gas pressure reading due to oil head between the machine and 63SDG-1.)

- Confirm the adjustment by subtracting the reading from the machine gas pressure transmitter, PT-2950, from the seal oil feed pipe pressure reading, found at the endshield, to achieve a 5.5 psi (0.387 kg/cm^2) differential.

- If the differential between the machine gas pressure transmitter and the seal oil feed pressure is not 5.5 psi (0.387 kg/cm^2), adjust the differential pressure regulator accordingly. Ultimately the reading at the differential pressure gauge, 63SDG-1, should lie between 6-7 psi (0.422-0.492 kg/cm^2), however, the differential pressure reading between the seal oil pressure, found at the endshield, and the machine gas pressure transmitter, PT-2950, must be 5.5 psi (0.387 kg/cm^2).

To make the actual adjustment, remove the adjusting screw cap on the pilot valve and loosen the hex nut. To increase the differential pressure setting, turn the adjusting screw clockwise; to decrease the differential pressure setting, turn the adjusting screw counterclockwise. Tighten the hex nut while holding the adjusting screw and replace the adjusting screw cap.

It should be noted that while the differential pressure regulator will hold a nearly constant 5.5 psi (0.387 kg/cm^2) differential over the entire range of casing gas pressures, slight manual adjustments may be required at some operating pressures.

F. Adjustment of Seal Oil Pressure Switches

The seal oil differential pressure switches are adjusted to:

1. (LOW) Sound an alarm on the annunciator panel when the seal oil differential pressure drops to approximately 4.5 psi (0.316 kg/cm^2) (pressure switch 63SA-1).

2. (LOW/LOW) Start the DC emergency seal oil pump, begin the automatic purge sequence, and sound an alarm on the annunciator panel when the seal oil differential pressure drops to approximately 3.5 psi (0.246 kg/cm ^{2}) (redundant pressure switches 63ST-1A and 63ST-1B).

To adjust pressure switch 63SA-1, close valve (V-114) and crack open valve (13A-1 or 13B-1) until gauge (63SDG-1) reads 4.5 psi (0.316 kg/cm ^{2}) above the machine gas pressure. Make any internal adjustments necessary to pressure switch 63SA-1 to actuate the contacts when this differential pressure is reached.

Further reduce the seal oil pressure at gauge 63SDG-1 to 3.5 psi (0.246 kg/cm^2) above the machine gas pressure. Adjust redundant pressure switches 63ST-1A and 63ST-1B internally to actuate the contacts at this pressure.

When the emergency seal oil pump has come into service, it will run for 30 minutes and then shut off automatically.

G. Shaft Seal Oil Flow Check

The total quantity of oil passing through the shaft seals may be determined by reading the flowmeter. The flow values should be equal to or less than those given on the Hydrogen Design Data sheet.

NOTE

The main lubrication system should be properly supplying oil to the seals during the following check of seal oil flows.

The hydrogen-side seal oil flow is determined by draining from valve (V-106) into a measuring container for a fixed period of time. This can be done by bypassing the float trap by closing valves (V-110) and (V-125) and opening valves (V-106, V-107, V-111). Throttle valve (V-124) to hold the level of the sight indicator between valves (V-107, V-111) at approximately one-half full during the measuring period.

An alternative method of determining the hydrogen-side seal oil flow is to close valve (V-123) and slowly drain oil from the float trap by opening valve (V-106) - maintaining the oil level within the sight glass of the float trap.

The total flow through the flowmeter, minus the hydrogen-side flow past valve (V-106), equals the air-side flow.

After flow measurement, all valves should be returned to normal operating positions as per diagram.

H. Float Trap Vent Line

Valve (V-122) is normally left open and is closed only when it is necessary to isolate the float trap for servicing.

I. Operation at Reduced Gas Pressures

It may be necessary to operate with the float trap bypass open when operating at lower generator casing gas pressures in order to avoid flooding the seal drain enlargement. When the generator casing gas pressure is low, approximately 5 psi (0.352 kg/cm^2) or less, the gas pressure in the seal drain enlargement may not be sufficient to overcome the friction in the piping between the seal drain enlargement and bearing drain enlargement, and flooding of the seal drain enlargement may occur. As casing gas pressure builds up to approximately 5 psi (0.352 kg/cm^2), the bypass valve (V-124) must be closed so that gas will not be blown into the bearing drain enlargement. Bypassing is accomplished by operating valves (V-110, V-111, V-107, V-124) as described in paragraph III. G.

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General Electric Company
One River Road, Schenectady, NY 12345
518 • 385 • 2211 TX: 145354