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Filtration. Separation. Solution.SM

Increase Power Output and Reduce Fugitive Emissions By Upgrading Hydrogen Seal Oil System Filtration

Introduction

A turbine generator consists of a turbine attached to an electrical generator via a common shaft. Inside the generator shell a large rotor spins at 1800 to 3600 RPM to produce electricity. Drag is created as the rotor spins at these high speeds. Because the effect of drag (known as windage loss) is more pronounced in the generators of larger steam turbines, hydrogen gas (having the lowest molecular weight) is used to fill the generator shell in order to minimize resistance. By reducing drag, more energy is available to generate electricity, which means more revenue to the utility. Hydrogen is also used because it has superior cooling qualities to air.

Because of the highly combustible nature of hydrogen, it is important to prevent the gas from leaking out into the power plant environment. To prevent leakage, oil lubricated seal rings (gland seals) are used to contain the hydrogen in the generator shell. The oil system is maintained at a higher pressure than the hydrogen gas pressure to minimize leakage. Clean oil is required to prevent mechanical wear of seal rings and the turbine shaft, and thus reduce hydrogen leakage (fugitive emission).

Generators coupled to gas turbines and hydroelectric turbines are typically smaller than steam turbine generators and, therefore, experience lower windage losses. These smaller generators use air instead of hydrogen so they do not have hydrogen seal oil systems.

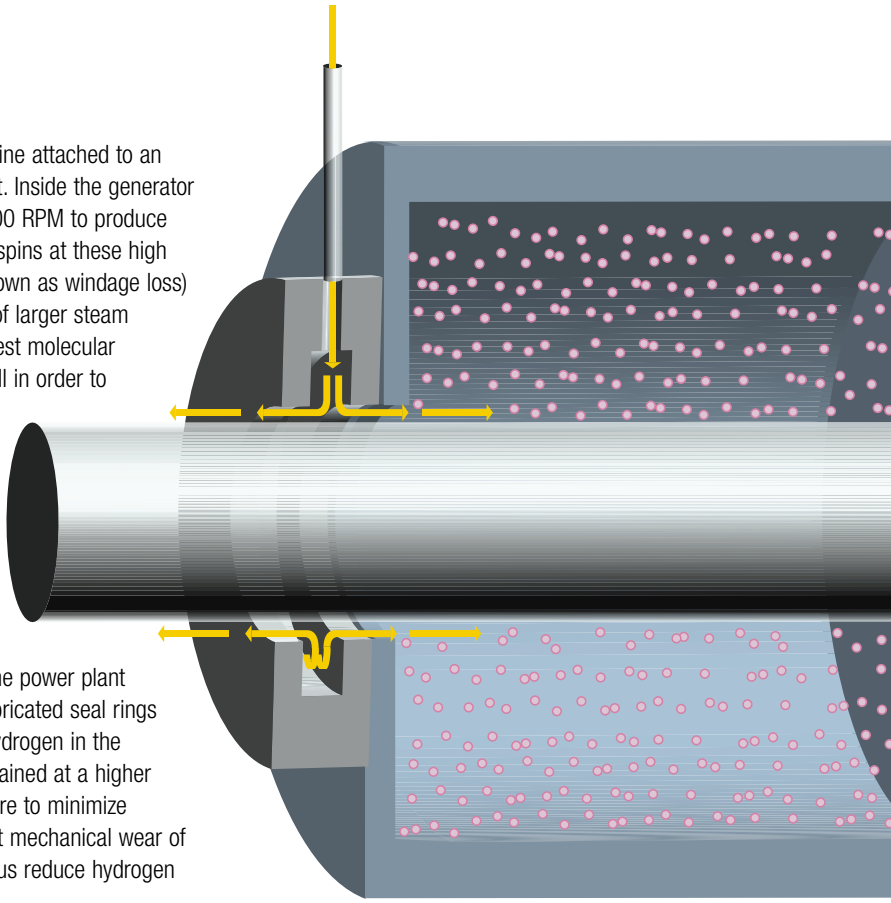


Figure 1*: Oil flowing through a seal ring forms a barrier between the ring and shaft that prevents hydrogen from escaping the generator shell.*

Description

Though there are several different seal oil designs, they all consist of seal rings that separate the hydrogen inside the generator shell from the air outside of the generator. To ensure that there is no hydrogen leakage, oil is pumped from the main turbine lube system through each seal ring to form an oil seal between the ring and the turbine generator shaft. The oil also lubricates the shaft and seal interface to prevent mechanical wear. By keeping the pressure of the oil slightly above the pressure of the hydrogen inside the generator, the hydrogen is confined within the generator shell (see figure 1).

Applications

Application Update for the Power Generation Market

Increase Power Output and Reduce Fugitive Emissions

By Upgrading Hydrogen Seal Oil System Filtration

Pall 8950 duplex filter assembly in use on a seal oil system

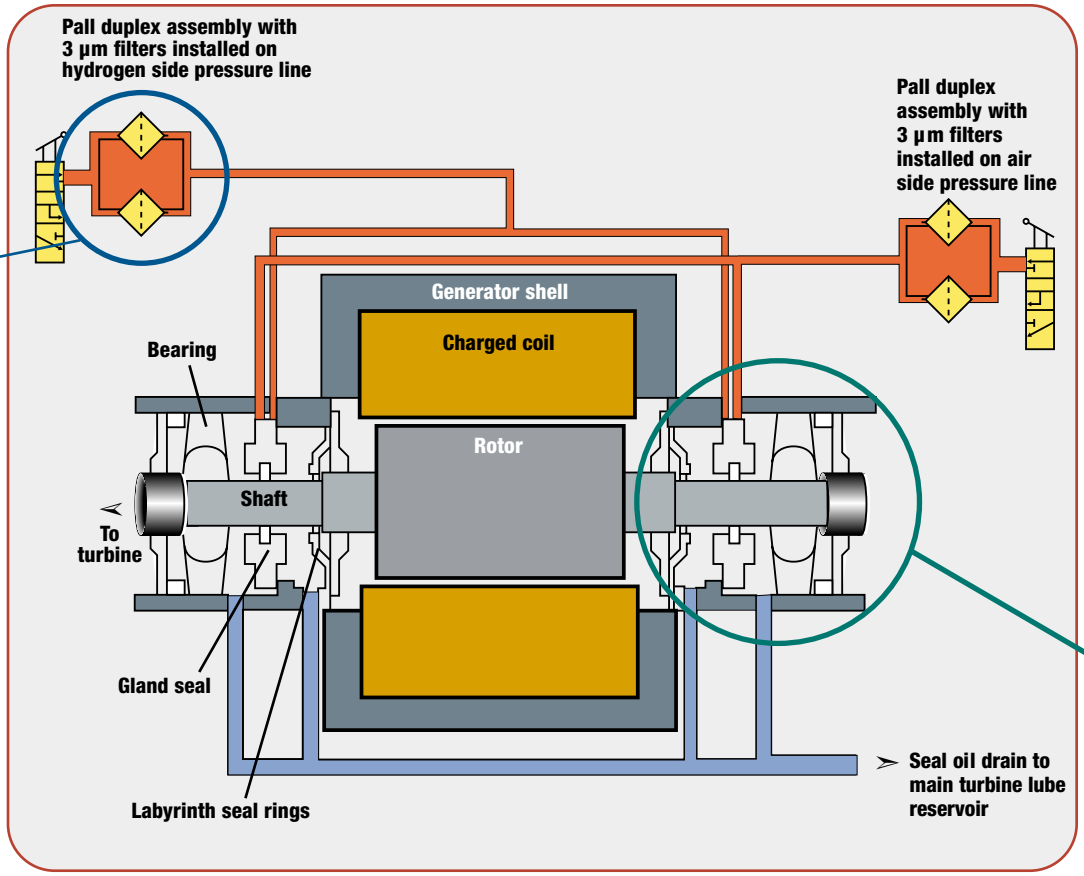


Figure 2: *Diagram of a Westinghouse type seal oil system (some details have been omitted for simplification)*

The General Electric hydrogen seal oil system uses a single pressure line (often with a separate backup seal oil pump line) for each seal ring. Other designs incorporate two or more seal oil pressure lines for each seal ring to provide redundant sealing. For example, the Westinghouse hydrogen seal oil system has an air side and a hydrogen side oil pressure line, each drawing oil from the main turbine lube reservoir. Separate pumps are used to feed seal oil to the air and hydrogen sides (figure 2).

Cleanliness is Critical

While the number of seal oil circuits per seal ring may vary from one design to another, the effect of contamination is the same. Wear of the gland seals caused by particulate contaminant in the oil can eventually cause failure of the shaft sealing system, allowing hydrogen to escape the generator. This can result in a forced outage. More often, though, particulate contamination in the system causes abrasive and erosive wear that requires costly machining of the shaft or replacement of seal rings.

Recommended Filtration Upgrade

OEM supplied filtration is typically nominally rated at 40 µm to 100 µm, and is far too coarse to provide adequate contamination control. In order to reduce contamination induced wear and to maximize component life within seal oil systems, it is recommended that seal oil be kept at an ISO 14/12 cleanliness level. To accomplish this a Pall Duplex filter assembly with 3 micron ($\beta_3 \geq 200$) Ultipor III® elements and a 25 psi full flow integrated bypass valve should be installed on each pressure line of the seal oil system. Allowable pressure drop should be confirmed by appropriate station personnel as designs vary. If there are both air side and hydrogen side oil circuits, then each should have a duplex assembly. The use of Pall Ultipor III filters provides the hydrogen seal oil system with the protection against particulate contamination required for safe and efficient operation. The duplex assembly will allow one filter to be changed, while the other element is in service without any interruption in flow. The system is continuously protected from harmful contaminants and does not need to be shut down to service the elements.

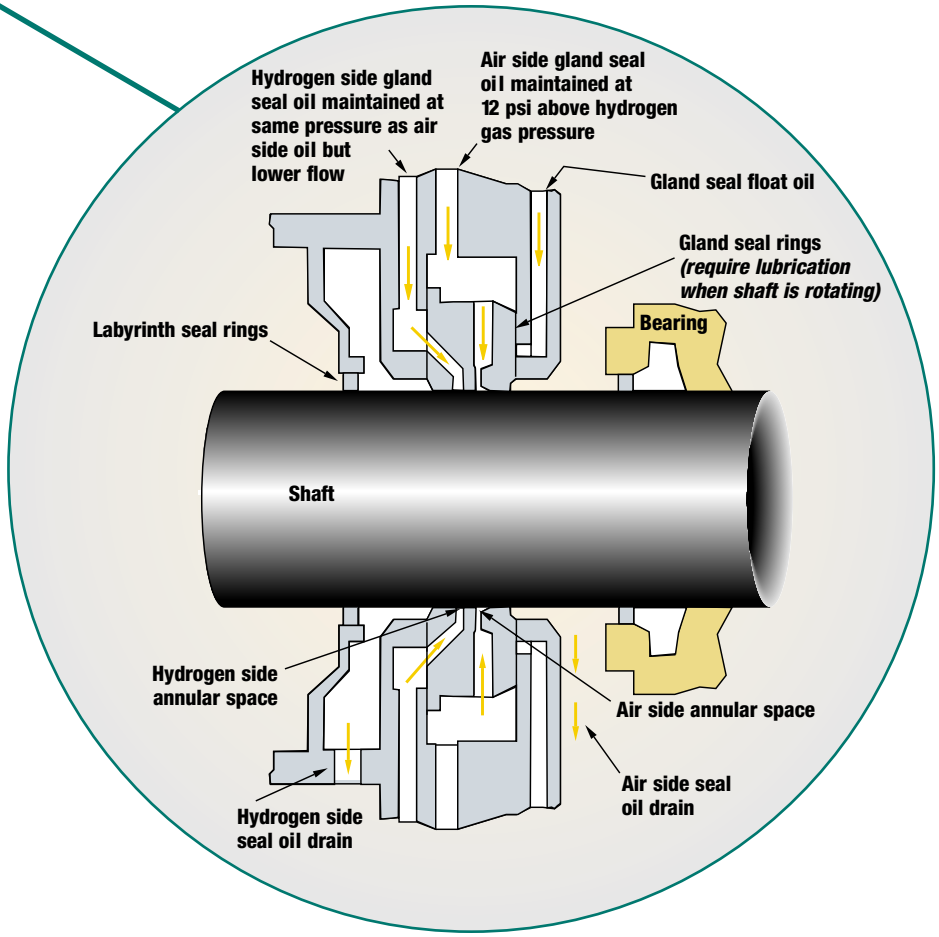
Flow	Recommended Pall Assembly
≤ 30 gpm	8640, 3140
30-80 gpm	8950, 3140
> 80 gpm	8340, 3142

Since the seal oil is drawn from the main turbine lube oil reservoir, measures must also be taken to control particulate contamination there. See *Application Update AU-ML* for specific recommendations on upgrading the filtration to the main turbine lube oil system.

Water and Air Contamination in Seal Oil

Water contamination in seal oil can vaporize when it comes in contact with the spinning turbine shaft. This water vapor can enter the generator shell, and cause a reduction in the purity of the hydrogen gas. Lower dew point readings are consequently noted. Also, entrained air can be released from the oil and into the hydrogen, again reducing hydrogen purity. Decreased hydrogen purity results in increased windage loss which reduces the amount of usable energy available to produce electricity. This can result in lost revenue to the utility!

To minimize these losses, the concentration of water and entrained air in the oil should be kept well below the saturation level. Since the seal oil is drawn from the main turbine lube oil reservoir, measures must be taken to control water and air contamination there. It is recommended that a Pall Vacuum Dehydration Purifier be used on the main turbine lube oil reservoir to remove 100% of the free water and air, and up to 80% of the dissolved water and air present in the oil. This will result in improved performance and reliability of both the hydrogen seal oil and main turbine lube systems.



Detail of the Westinghouse type seal ring (Note separate air side and hydrogen side pressure orifices)

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