AEGIS

Loss Control

Turbine Lubricating Oil Systems

White Paper

Operation & Maintenance Considerations
An Insurer's Loss Control Perspective (Rev 1 – 2024)

Introduction

The function of the turbine-generator lubricating oil system is to provide lubrication and cooling oil to the power train equipment. Neglecting to maintain, operate and test the system properly could result in catastrophic failure and serious consequences for both rotating equipment and personnel.

Analysis of data gathered by AEGIS Loss Control reveals that turbine-generator lubricating oil loss events and associated lost revenue from business interruption are key contributors to probable maximum loss occurrences and are often times preventable. Extreme caution is warranted as an industry to prevent these avoidable events. This paper discusses proactive practices employed by AEGIS members to ensure lubricating oil system readiness and reliability. This paper does not discuss environmental, health and safety concerns, or fire protection measures.

Lubricating Oil Systems

The lubricating oil system is often complex in design, with varying degrees of instrumentation and built-in automation. In addition to lubricating and cooling the power train equipment, the lubricating oil system may also be used to provide:

- Oil for generator hydrogen seal oil system
- Control oil for valve actuation where a separate control oil system is not provided
- Lift oil for combustion turbine, steam turbine and generator bearings
- Oil to self-shifting and synchronizing clutches

Regardless of system complexity or configuration, the control elements provide oil to the system components within certain desired parameters, such as proper temperature, adequate pressure, design flow, etc.

System Components

The lubricating oil system consists of the following major subsystems:

1. **Storage System:** The primary function of this system is to provide a storage space for the bulk quantity of the oil. This subsystem may consist of a storage tank and heaters, vapor extractors and instrumentation for level, temperature, etc.

2. **Forwarding System:** This subsystem supplies pressurized oil to the system components at design conditions. This subsystem typically consists of redundant AC motor-driven main bearing oil pumps, strainers, check valves and accumulators. Other configurations may include a turbine shaft-driven or steam-driven gear oil pump.

3. **Conditioning System:** This subsystem provides clean oil at an appropriate temperature to the various system components and typically consists of redundant coolers and filters.

4. **Instrumentation and Control Equipment:** These components monitor and regulate oil temperature, pressure and flow, and consist of gauges, sensing elements and transmitters, temperature control valves, pressure limiting valves, etc.

5. **Emergency Oil Forwarding System:** This subsystem acts as a backup lubricating oil system for use under emergency operating conditions, such as loss of power to the main pumps, and provides emergency oil supply to the turbine bearings. The subsystem typically consists of a DC motor-driven emergency bearing oil pump and check valves. Alternate system configurations may include an AC motor-driven main bearing oil pump acting as the emergency bearing oil pump powered by the emergency battery bank through an inverter.

6. **Piping System:** The piping subsystem provides the path for the oil to flow to and from various components – for example, the turbine bearings and back to the oil reservoir.

System Operation and Maintenance

The onus of system availability and reliability lies on the proper operation and maintenance of the system components. Key factors to ensure a robust operation and maintenance program include:

- Routine operational testing
- Maintenance management
  - Planned maintenance schedules
  - Industry model practices and OEM recommendations
  - Availability of replacement parts
  - Safe work practices
- Operational awareness
- Operator and maintenance training
- Readily available technical documents
- Document review and management of change programs

Recommended Model Practices

Lessons learned within the power generation industry have led to significant advancements in equipment, system design and monitoring capabilities. Incorporating the following configuration, inspection, maintenance, testing, training and record-keeping practices will minimize avoidable lubricating oil system-related incidents.

System Configuration

- Each unit should have a dedicated battery bank with sufficient capacity to provide emergency power to allow a safe coast-down of the unit.
- Battery room(s) should be designed to applicable regulatory standards (including but not limited to applicable OSHA, IEEE, NFPA and UL) to ensure optimal performance.
- The system should be configured with a loss of DC power annunciator in the control room or a similar centralized location.
- The loss of DCS power should not prohibit operation of the emergency pumps.
- The lubricating oil system should include dedicated redundant pressure-sensing switches/sensors to assess the system operating condition and initiate a start of the emergency bearing oil pump.
- The starting circuit for the emergency bearing oil pump motor should include normally energized relays to ensure starting reliability of the pump.
- The thermal overload protection for the emergency bearing oil pump motor should be configured for alarm only.

Routine Checks

- Functionally test the emergency bearing oil pumps based on configuration:
  - Steam turbine and generator:
    - Pressure drop test monthly
  - Frame and aero-derivative type combustion turbines (with emergency oil pumps):
    - Pressure drop test quarterly (or)
    - Oil pump motor startup logic permissive test at each start with annual pressure drop test
  - Aero-derivative (when equipped with run-down oil tanks)
    - Weekly verify that the isolation valves between oil tank(s) and bearings are open
    - Run-down tank(s) shall be equipped with calibrated level detectors and low-level alarms
- Routine training should be conducted on the test procedure. Although beneficial, emergency oil pump starting as part of the startup sequence is not a substitute for a functional test.
- Emergency battery banks should be maintained and capacity tested in accordance with the applicable IEEE standards to ensure sufficient capacity and operational readiness.
- Review alarm logs during assigned shifts and address unusual parameters or alarms to ensure timely troubleshooting.
- Routine oil analysis should be conducted to ensure the oil meets OEM "in service" specifications.
- Ensure functionality of lubricating oil system supervisory instrumentation, such as low lube oil pressure alarms, high lube oil temperature alarms, low lube oil reservoir level alarms, etc.

Training

Onsite qualified and knowledgeable personnel are crucial to ensure reliable system operation. The facility should develop training programs to:

- Ensure adequate system-level knowledge and proficiency regarding critical system parameters, alarms, trip points and testing.
- Provide refresher training including various emergency loss of oil scenarios.
- Review planned and implemented upgrades for modifications that impact lubricating oil system components.
- A lessons-learned evaluation should be conducted after an emergency oil system event which should include a review of procedures and training.

Record Keeping

The importance of documentation and proper record-keeping cannot be emphasized enough. This includes:

- Archiving day-to-day operating data.
- Periodically reviewing and updating operating and maintenance procedures according to company guidelines.
- Maintaining a library of technical manuals and OEM-issued technical service bulletins.
- Adopting appropriate change management controls to ensure that all drawings accurately reflect current configurations.
- Maintaining personnel qualification and training records.

Conclusion

The integrity and reliability of the turbine-generator lubricating oil system are paramount for the safe and efficient operation of power generation equipment. As illustrated in this whitepaper, the lubricating oil system's complexity requires meticulous attention to detail in its operation, maintenance and emergency preparedness. By adhering to the recommended model practices and incorporating lessons learned from industry experience, the likelihood of preventable failures can be significantly reduced. Continuous training, routine testing and diligent record-keeping are essential components in ensuring that the lubricating oil system performs its vital role without interruption. Embracing these proactive measures will not only safeguard equipment and personnel but also contribute to the overall resilience and profitability of power generation operations.

References

OEM guidelines were used in the compilation of this document. Although the following references were designated for certain steam and combustion turbines, the principles are sound and can be applied to most types of turbine generators, if not all. For questions regarding applicability, contact the OEM for unit-specific guidance.

GE TIL 775 – Addresses the issues of multiple pressure switches and the use of de-energized type motor controllers.

GE TIL 914 – Supersedes TILs 443 & 490 and provides recommendations to improve the reliability of emergency lubricating oil systems concerning the auxiliary oil pump, turning gear oil pump, and the emergency oil pump (both DC and steam-driven pumps).

GE TIL 968 – Provides updated recommendations for improving the reliability of the DC emergency oil pump starter.

GE TIL 1420-2R1 – Recommendations to protect the turbine bearings following a plant AC power loss by maintaining the continued operation of the DC oil pump.

GE TIL 1456-2R1 – Recommendations for required maintenance on vertically mounted motor-driven lubrication pumps.

GE TIL 1469-2R1 – Recommendations to ensure reliability of the emergency DC pumps and to mitigate failure of the emergency bearing oil pump and the resulting potential resultant damage.

GE TIL 1548-2 – Information regarding modification needed on the overload relays for the DC motor starters.

GE TIL 1632 – Recommendations for journal-bearing operation and maintenance.

GE TIL 1852 – Recommendations to replace mechanical latch block relays in the emergency oil and seal oil motor control circuits.

GE TIL 2062 – Recommendations to verify relay settings and provide emergency bearing oil pump validation testing procedure.

Siemens TA PB2-12-0030-GT-EN-01 – Provide instruction on DC emergency bearing oil pump, pressure switch, inspection and recommendation for W501F and SGT6-5000F gas turbines.

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