Undertaking 86

Page 49, lines 1-4

Re: Documentation surrounding the development of the new test that relates to what the industry standard was at the time, what other utilities were doing in North America.

Undertaking to provide...any documentation that shows whether other jurisdictions were already doing these tests in 2012.

Following Hydro's investigation of the January 11, 2013 issues, it became apparent that enhancements to Hydro's testing process were warranted. Subsequent to Hydro's investigation on the failure on January 11, 2013, Holyrood staff contacted a GE Generator Turbine interest group. A representative from a US utility forwarded a Technical Information Letter (TIL) dated September 8, 1980 centered around back-up lube oil pump reliability issued by GE to a US owner of a similar machine (see attached Undertaking 86, Attachment 1).

After reviewing all files pertaining to this equipment, Hydro confirmed that it was not provided this TIL by GE. The GE TILs are issued in relation to specific serial numbered generating units, and Hydro has confirmed with GE all of the TILs issued with respect to Holyrood Units 1 and 2, and this TIL is not on this list. Hydro had a partnering agreement on the turbine generator and auxiliary systems with GE covering the period from the mid-1990s until 2010 and this TIL was never raised as applicable to Holyrood Units 1 or 2 by the GE representatives working on Hydro's behalf.

GE TECHNICAL INFORMATION LETTERS
914-2: BACK-UP LUBE OIL SYSTEM RELIABILITY

CUSTOMER VERSION

914-2: BACK-UP LUBE OIL SYSTEM RELIABILITY

*** Supercedes TIL's 443 and 490. ***

September 8, 1980

PURPOSE

The purpose of this Technical Information Letter (TIL) is to transmit recommendations to improve the reliability of the back-up lubricating oil system. This action has been prompted by a significant increase in the number of incidents where turbine-generators have lost lubricating oil during coastdown.

DISCUSSION

Historically, the back-up lube oil system on Large Steam Turbine-Generator (LST-G) Department units has always had at least two (2) independent power sources for the pumps. This double protection is an absolute necessity due to the critical function of this back-up system. Its failure to operate invariably leads to extensive damage to the unit and a long outage. On a modern large unit, repair expenditures can run into millions of dollars and outage times can extend for several months.

The back-up lube oil system is defined as the set of pumps (at least two) intended to provide lubricating oil to the bearings whenever the main pump(s) are inoperative. On mechanical-hydraulic controlled (MHC) units these are the auxiliary oil pump (AOP), and either one or both of the turning gear oil pumps (TGOP) and the emergency bearing oil pump (EBOP). On electro-hydraulic controlled (EHC) units, these are the TGOP and the EBOP.

To assure maximum reliability of the back-up lube oil system, all its elements must be considered critical.

In the past, considerable attention has been given to the last line of defense, usually the EBOP. We have previously issued three TIL's related to this subject, as follows:

TIL 443 entitled "Emergency Bearing Oil Pumps", dated 12/15/67

TIL 490 entitled "Emergency Bearing Lube Oil Pump; Summary of Results", dated 5/29/69

TIL 775-3 entitled "DC Motor Emergency Bearing Oil Pump Starting Circuits", dated 4/25/75.

These TIL's made recommendations as to the required actions needed to achieve maximum reliability of the Emergency Bearing Oil Pump (EBOP) subsystem.

By issuance of this TIL both TIL 443 and 490 are superceded. TIL 775 will remain in effect.

Experience now indicates that more emphasis needs to be given to improving the reliability of the first line(s) of defense of the back-up lube oil system, typically the AOP and/or the TGOP. This pump subsystem is just as critical as the EBOP subsystem. Any reliability deficiency in either subsystem greatly detracts from the reliability of the total system.

Most loss of lube oil incidents have been due to pump power supply failures and operator's erroneously turning pumps off. Few have actually been attributed to mechanical failure of components, particularly pumps or motors. On electrically powered pumps, failures have been predominantly related to starting or power supply switching circuitry - both hardware and logic. On units with steam powered pumps, invariably the steam supply was valved off due to steam leaks, and the situation allowed to go uncorrected for a long period of time. In some other cases, the units were operated with one or all of the pumping subsystems out of service.

This TIL makes numerous recommendations aimed at improving the reliability of the critical back-up lube oil system on your units. These recommendations, which are primarily based on the experience gained from recent incidents, need your immediate and dedicated attention.

RECOMMENDATIONS

The CRITICAL NATURE OF THE BACK-UP LUBE OIL SYSTEM REQUIRES ALL ASPECTS RELATING TO ITS RELIABILITY BE REVIEWED. Proper design, operating procedures, maintenance practices and periodic testing must be given due consideration.

OPERATION

WHENEVER A TURBINE-GENERATOR SHAFT IS ROTATING, LUBRICATING OIL MUST BE SUPPLIED TO THE BEARINGS CONTINUOUSLY. This requirement must be fully understood by all operating personnel. In reference to this we recommend the following:

A. NEVER ATTEMPT TO START A TURBINE UNIT UNTIL IT HAS BEEN VERIFIED THAT A DC PUMP PLUS ONE OTHER SUB-SYSTEM OF THE BACK-UP IS FULLY OPERATIONAL.

   A recent incident serves to illustrate the wisdom of this. During an outage of a large modern unit it was discovered that a relay in the DC starter of the EBOP had burned out. The unit was rolled with the EBOP system unable to start automatically. When the unit reached rated speed a vibration trip was experienced along with loss of AC power. Before the EBOP could be manually started at the reservoir, severe damage occurred resulting in a sixteen week outage.

B. NEVER CONTINUE TO OPERATE A TURBINE UNIT FOR AN EXTENDED PERIOD WITH KNOWN BACK-UP SYSTEM DEFICIENCIES. ANY DEFICIENCIES SHOULD BE CORRECTED IMMEDIATELY.

   An extreme example of this rule not being followed is an incident where the steam driven AOP had been valved out because of steam leaks. The situation went uncorrected for quite some time. Concurrently the AC driven TGOP was locked out for motor maintenance while the unit was running. Operators forgot about both deficiencies and proceeded with a planned shutdown of the unit. Severe unit damage resulted.

C. DO NOT SHUT OFF BACK-UP SYSTEM PUMPS WHICH HAVE COME ON AUTOMATICALLY, UNLESS SUCH ACTION IS EXTREMELY NECESSARY AND CAREFULLY CONSIDERED.

There are numerous examples of loss of oil incidents where the back-up pumps have come on automatically as designed and then were unexpectedly stopped. Saving battery capacity, for example, is not a sufficient reason to shut down the back-up system pumps when compared against the potential consequences of premature loss of lube oil.

D. Based on recent experience A THOROUGH REVIEW OF YOUR OPERATING PROCEDURES IS RECOMMENDED. Such procedures should encompass both normal and abnormal conditions.

BACK-UP SYSTEM DESIGN

The critical nature of the back-up lube oil system mandates that reliability be the prime consideration in its design. Experience has shown a good record of both system design and hardware for the portions provided with the Turbine-Generator unit. Continuous monitoring of operating experience has pointed to various improvements which were incorporated into new designs and have been recommended for retrofit into existing units. An example of this is TIL 775 referred to earlier.

However, particularly on electrically driven pumps a major portion of the system including the power supply is designed and provided by others. This leads to many design variations and our latest experience shows most problems are occurring in the power supply. Therefore, IT IS RECOMMENDED THAT A COMPLETE DESIGN REVIEW BE MADE ON EACH OF YOUR UNITS.

A. AC POWERED PUMPS

The AC motor driven lube oil pumps are usually the first line of defense in the back-up system. RELIABLE OPERATION OF THESE PUMPS IS JUST AS IMPORTANT AS FOR THE LAST LINE OF DEFENSE (usually the EBOP). In reviewing station circuitry which provides power for these pumps you should ensure that the following features are included:

1. These pumps are in a very critical system. It is imperative that as long as AC power is available anywhere in the station it should be positively available to the AC lube oil pumps.

2. It is highly desirable that the power supply be from the single most reliable source available (a critical buss). This eliminates the need for complex switching provisions which can introduce additional failure possibilities.

3. If other considerations require a design which provides for multiple sources of power (i.e. primary and back-up), then emergency switching must be accomplished automatically. Timely or correct manual transfer cannot be accomplished reliably. There are too many activities and events going on during a unit trip for operators to properly cope with manual switching.

4. The design of the automatic switching needs to be carefully reviewed. The following must be considered:

   (a) Redundant power sources must be provided to actuate the transfer.

   For example, if DC station power is lost, boiler control can also be lost, resulting in a boiler and turbine trip. Power for the AC lube oil pumps may then have to be transferred from unit buss to a back-up critical buss, supplied by outside power. If the only means of initiating the automatic transfer is by actuation of a DC powered relay, then the single loss of DC will also result in no AC power being available for the AC motor driven lube oil pumps. A redundant AC powered relay, powered by an AVAILABLE AC buss, is needed in such a design.

   While the deficiency of such a design may seem obvious, exactly such a situation occurred recently. Two (2) units in the same station came down without oil. One had been in service for twenty (20) years, the other twelve (12) years.

   (b) If more than one source of back-up power is provided, switching to a dead buss must not be possible. This also applies if the transfer is manual.

   (c) Once switching has occurred the circuit should "lock-in" to the back-up power source as long as the primary source remains dead. This again applies to manual transfer modes.

   (d) On automated units, software and hardware design must not allow a failure of the automation equipment to cause a failure of power supply to the back-up lube pumps.

   A very recent incident again serves to illustrate. A momentary loss of power to the automated plant control system of a six month old turbine unit caused a boiler trip. The Turbine-Generator was then manually tripped. The control logic was such that on power loss to the controller many of the motors in the station became locked out and remained locked out even on restoration of power to the automatic controller. Included in this scheme were all motors of the back-up lube oil system. When the low bearing header pressure alarm came on the back-up lube oil pumps were started manually, but too late to prevent serious damage to the unit.

B. DC POWERED PUMPS

The DC motor driven lube oil pump is usually the last line of defense in the back-up system and IT MUST OPERATE PROPERLY. In your review of the design of this subsystem, due consideration must be given to the following features:

1. STARTING CIRCUITS

TIL 775, mentioned earlier, made two (2) important recommendations. One, was the conversion from a one to a four pressure switch DC pump starting scheme. The other, was that de-energized type DC motor starters be replaced with an energized type. The reliability gains to be achieved by implementing these changes are fully delineated in that TIL.

IF TIL 775 DOES APPLY TO YOUR TURBINE-GENERATOR UNIT AND HAS NOT YET BEEN IMPLEMENTED WE AGAIN STRONGLY RECOMMEND THAT THIS BE DONE.

2. CIRCUIT PROTECTIVE DEVICES

Particular attention must be given to the use of thermal overload and short circuit protection on the DC motor and motor starter.

(a) Overload protective devices MUST NOT BE WIRED TO TRIP THE MOTOR, but only to sound an alarm. Keeping the DC motor running a few minutes longer to pump oil to the unit is of far more importance than protecting a relatively inexpensive motor.

(b) Short circuit protection should be in the form of a magnetic type circuit breaker, not fuses. Fuses possess several undesirable characteristics that make them unacceptable for use in the emergency pump circuit:

- The fuse element experiences deterioration from the chemical and physical stresses produced during repeated short duration overloads which may occur during motor starting. Though not present long enough to blow a correctly applied fuse, deterioration may cause failure which would go undetected until the next motor startup.

  This type of failure was the cause of a lengthy forced outage on an LST-G unit. Following a loss of station service AC the DC EBOP started automatically. But after running for about a minute the fuse in the DC supply failed causing a loss of lube oil incident and severe damage to the Turbine-Generator.

- Since a fuse depends on the melting of a metal link the exact failure point is subject to considerable variation.

- When a fuse fails it must be replaced. This introduces the risk of an incorrectly rated fuse being placed in the circuit.

- The fuse clip size and its condition, together with the size of the conductor attached to it can have a considerable influence on fuse performance. Additionally, corrosion of fuse and connecting clip, leads to fuse heating problems.

- Fuses cannot be tested whereas magnetic circuit breakers can be.

Magnetic circuit breakers will in general, have two (2) ratings indicating their time delay and instantaneous modes of operation. The "Nameplate" rating is that value below which the breaker will support continuous current without opening the circuit. The "Instantaneous" rating is that value of current surge that will cause the breaker to trip instantaneously. The "Instantaneous" rating MUST be at least 150 percent of the maximum in-rush current measured during motor startup. This maximum in-rush current can be as high as five (5) times rated full load current. The in-rush current MUST be measured to verify that the 150 percent margin exists.

3. DC SYSTEM ALARMS

Studies of LST-G's operating experience with DC powered EBOP's indicate that an improvement in subsystem reliability can be effected by the provision of a group of alarms which monitor the integrity of the DC power supply and controls for this pump. A list of these recommended DC components and alarms is given in Attachment A. Your design review should consider the addition of any of these alarms which are not already installed.

C. STEAM DRIVEN PUMPS

Most failures of steam driven pump subsystems have been attributed to the steam source being valved out of service. Invariably this disabling action had been taken to stop steam leaks which had developed in the steam supply system. While this may be considered more of a maintenance deficiency, it may be that a review of the design of this steam supply system may lead to hardware improvements which would alleviate leakage probability. In your review, the following should be considered:

- Hardware reliability (valves, flanged connections, etc.) improvements.
- Supply piping designed such that it is kept free of water.
- Isolation valve(s) between the steam source and the pump governor valve have provisions for LOCKING open.
- Exhaust line has no valves and is well drained.
- Alarm is provided to indicate "Low steam supply pressure".

PERIODIC MAINTENANCE & TESTING

Proper, timely maintenance and testing of the back-up lube oil pumping system components will contribute significantly to its reliability. Our analysis of loss of lube oil incidents indicates that lack of timely maintenance is a major cause of such failures. A number of other failures on record were the result of malfunctions that are likely to have been discovered in a test.

The attached Table B, summarizes our recommendations for periodic maintenance and testing of the back-up lube oil system. It represents what we consider to be the MINIMUM level of activity necessary to keep the system in reliable condition. Any deficiencies found during system testing or otherwise must be corrected promptly as indicated in the remarks column of Table B.

We recommend that you review your maintenance and testing procedures using Table B as a guide.

NOTE: Table B only addresses hardware normally provided as part of the Turbine-Generator set.

EMERGENCY BEARING OIL PUMP (EBOP) SYSTEM - PERFORMANCE DATA

Performance Data Sheets for the EBOP System are appended to this TIL as Attachment C. These sheets supercede the Check-off List which was issued by TIL 490 published in 1969 and currently in use.

All data required to complete these Data Sheets are available once the "Every 6 to 12 Months" tests prescribed in Attachment B are completed. If these tests have been done on a unit, within twelve (12) months of your receipt of this TIL, such data can be used to fill out the Data Sheets.

We request that you perform the tests described in Attachment C if this has not been done within the last twelve months and answer ALL applicable questions of the Data Sheets and return a copy of these completed Data Sheets for each of your units to your I&SE Service Representative for review. Upon completion of this review specific action will be recommended, if required. We recommend completion of these data sheets within twelve (12) months after receipt of this TIL.

When you conduct subsequent periodic testing of the EBOP system, test data should be recorded similarly and compared to previous results. Any EBOP system deterioration noted should be investigated and corrected immediately.

GE TECHNICAL INFORMATION LETTERS
914-2: BACK-UP LUBE OIL SYSTEM RELIABILITY

ATTACHMENTS

ATTACHMENT A

EMERGENCY BEARING OIL PUMP DC SYSTEM

RECOMMENDED ALARMS

DC SYSTEM COMPONENT	CONDITION TO ANNUNCIATE ALARM
1. DC Pump Control Switch	Switch in Stop Position or Pump Locked Out
2. DC Switch, Power to DC Pump	Switch in Open Position
3. Circuit Breaker, Power to DC Pump	Breaker in Open Position
4. Battery, Power to DC Pump	Low Voltage
5. Switch or Breaker, Between Charger and Battery	Switch or Breaker in Open Position
6. Battery Charger	Out of Service
7. DC Pump Pressure Switch Test Valve	Valve Left in Open or Test Position

ATTACHMENT B

(TIL 914, 9/8/80 - Attach.)

*Revised 10/15/80

BACK-UP BEARING OIL SYSTEM

PERIODIC MAINTENANCE & TESTING SUMMARY

PERIOD	COMPONENT	ACTIVITY	REMARKS
WEEKLY	Motor driven lube oil pumps	Actuate pump starting pressure switches using test valves. Verify that pumps start automatically.	Investigate and correct immediately all malfunctions of all motor or steam driven pumps.
	Steam driven lube oil pumps	Turn test handle on pump governor to test position. Verify that pump starts automatically. Assure steam isolation valves are locked open.	Ascertain that all test valves are left in correct stand-by position.
MONTHLY	DC Motor and steam driven lube oil pumps	During weekly test of DC motor and/or steam powered pumps, check pump speeds. Voltage to DC pump should also be checked.	Maintain record of monthly readings. Beware of sudden changes or long term degradation.
EVERY 6 to 12 MONTHS	Emergency bearing oil pumps	Simulate turbine trip with loss of AC power. Check & record performance of emergency bearing oil system.	Follow test procedure described in Attachment C, of TIL 914-2* Observe bearing header pressure as pumping burden is transferred to emergency bearing oil pump.
EVERY 12 MONTHS	Pressure gages, pressure switches, transducers	Calibrate	
	DC motor starter	Check for accumulation of dirt, flyash, etc. on internal components which might inhibit proper closing of contacts or disrupt electrical continuity.	Maintain electrical reliability through preventive maintenance.
	Steam driven pumps	Check steam supply strainers.	
EVERY 4 - 5 YEARS	All oil pumps mounted in the oil tank	Check condition of oil strainers, impellers, bucket wheels, bearings and journals.	Refer to appropriate article in Instruction Book.
	Motor driven pumps	Lubricate upper shaft bearing.	Refer to appropriate article in Instruction Book.
	Pump Motors	1. Grease motor shaft bearings 2. Check condition of brushes, DC motors 3. Check vent openings for open air path 4. Check integrity of electrical connections in junction box	Refer to appropriate article in Instruction Book.
	DC motor starter	1. Check internal components and wiring for deterioration 2. Check integrity of electrical connections	Maintain electrical reliability through preventive maintenance
	Steam Pump Governor	Look for worn or sticking linkages, dirt accumulations. Check steam supply strainers.	Inspect for anything which might hinder rapid governor action.
	Pressure Switches	Check integrity of electrical connections.	
	Pressure Gages	Remove snubbing needle valve, inspect for dirt.	Assure unrestricted sensing line to gage.
	Check Valves	Remove and inspect. Look for: 1. Proper seating 2. Freedom of movement 3. Worn hinge parts 4. Obstructions in pipe that could cause disc to become stuck in any position	Assure freedom of movement and proper seating

ATTACHMENT C

(TIL 914, 9/8/8- - Attach.)
*Revised 10/15/80, see pg. 2.

EMERGENCY BEARING OIL SYSTEM - Performance Data

Customer: ______________ *Station/Unit #:* ______________ *Turbine #:* ________
Date of Tests: ______________ *Data by:* ______________

I. *ELECTRICAL CONSIDERATIONS*

A. Emergency Bearing Oil Pump (EBOP) DC Motor

1. Is motor thermal overload device wired to alarm only? ______________
2. Motor Nameplate Data
   Horsepower ________ HP Speed ______________ RPM
   Voltage __________ Volts Armature Current ________ AMPS
   Field Current ______________ AMPS

B. DC Motor Starter

1. Manufacturer of Starter ______________
2. a. Is DC motor starter supplied with a thermal overload device? ______________
   b. If answer to 2a is yes, is device wired to alarm only? ______________

C. Short Circuit Protection

1. a. Is there a circuit breaker in the DC power supply? ______________
   b. If it is a thermal-magnetic type, what is its "Nameplate Rating"? ______________ AMPS
   c. Within what range can its "Instantaneous" trip point be set? ______________ AMPS
   d. What current is the Instantaneous trip point set at? ______________ AMPS
   e. Has this been functionally tested? ________
2. Is there a fuse anywhere between the motor and the battery? __________

II. *STEAM SUPPLY TO STEAM POWERED PUMPS*

A. Are there any isolating valves between the steam source and the pump governor? ____________
B. If answer to A is yes, are isolating valves locked open? ____________
C. Is this line continuously drained? ______________
D. Are there any strainers in the steam supply? ____________
E. What is normal steam pressure available to governor valve? ____________
F. Is there an alarm pressure switch sensing this pressure? ________ If so, what is its setting? ________

III. *PRESSURE SWITCH SETTINGS*

NOTE All lube oil system pressure switch settings must be checked and set to proper values prior to tests. Refer to TIL 484 and/or Instruction Book for proper setting instructions.

A. EBOP pressure switch which senses bearing header pressure:

At Tank	At Front Standard
Decreasing/Increasing _____/_______ PSIG	Decreasing/Increasing ______/__________PSIG

B. EBOP pressure switch which senses hydraulic header pressure (If such a switch is present):

At Tank	At Front Standard
Decreasing/Increasing _____/_______ PSIG	Decreasing/Increasing ______/__________PSIG

IV. *EMERGENCY BEARING OIL PUMP (EBOP) MOTOR PERFORMANCE*

NOTES

1. The purpose of the following tests is to measure the ability of the EBOP to function properly under emergency conditions. The system parameters of interest occur during transient conditions lasting less than one second. A brush recorder is needed to measure and record the data.
2. For Tests A and B, battery chargers should be turned off and the battery loaded by all systems it would have to support in an actual emergency.
3. Test C will verify that circuit protective devices will not trip upon motor startup. Battery chargers should be on in order to achieve the highest possible starting currents.
4. The turbine should be on turning gear during all tests.

ATTACHMENT C

TEST A - TURNING GEAR OIL PUMP (TGOP) to DC or Steam Powered EBOP

PROCEDURE:

Step 1 - a. Battery chargers off, system loaded.
b. EBOP stopped, control switch in AUTO.
c. TGOP running.
d. Auxiliary Oil Pump (AOP) locked out (MHC units only) or Motor Suction Pump (MSP) locked out (EHC units only).
e. Steam pressure on governor valve.

Step 2 - Manually shutoff TGOP; EBOP should start automatically.

*Step 3 - Run EBOP for 30 minutes.

DATA:	Step 2	*Step 3 DATA:
1. Steady state bearing header pressure at turbine centerline with TGOP running. (Minimum allowable is 17 PSIG.)	________ PSIG	
2. Minimum bearing header pressure at turbine centerline during EBOP startup. (Minimum allowable is 2 PSIG.)	________ PSIG	
3. Steady state bearing header pressure at turbine centerline with EBOP running. (Minimum allowable is 12 PSIG.)	________ PSIG	________ PSIG
4. EBOP speed.	________ RPM	________ RPM
5. Motor running current.	________ AMPS	________ AMPS
6. Voltage across starter terminals to motor.	________ VDC	________ VDC
7. Time for EBOP to come to speed.	________ SECS	
8. Minimum steam pressure during startup and with EBOP at speed.	________/________ PSIG	

TEST B - AOP to DC or Steam Powered EBOP (MHC Units Only)

PROCEDURE:

Step 1 - a. Battery chargers off, system loaded.
b. EBOP in AUTO.
c. AOP running.
d. TGOP locked out.

Step 2 - Manually shutoff AOP; EBOP should start automatically.

DATA:

Minimum bearing header pressure at turbine centerline during EBOP startup. ____________ PSIG
(Minimum allowable is 5 PSIG.)

TEST C - Manual Startup of EBOP - DC Powered Only

PROCEDURE:

Step 1 - a. Battery chargers on.
b. All pumps locked out.

Step 2 - Start EBOP manually and allow to come to steady speed.

Step 3 - Shutoff EBOP.

Step 4 - Repeat Steps 2 and 3 two more times.

DATA:

	First Start	Third Start
1. Maximum measured inrush current of EBOP during startup.	____________ AMPS	____________ AMPS
2. Time for EBOP to come to speed.	____________ SECS	____________ SECS

TEST D - Steam Powered Pump Discharging to Hydraulic Header

PROCEDURE:

Step 1 - a. AC motor driven main pump(s) or AOP running.
b. TGOP locked out.
c. DC power EBOP (if any) locked out
d. Steam pressure at governor valve.

Step 2 - Turn off AC pump(s).

DATA:

1. Minimum hydraulic header pressure at turbine centerline during transfer to steam pump. (Minimum acceptable is 50% of rated.) __________ PSIG
2. Minimum bearing header pressure at turbine centerline during startup of steam pumps. (Minimum acceptable is 10 PSIG.) __________ PSIG
3. Minimum steam pressure during EBOP startup. __________ PSIG
4. Minimum steam pressure with EBOP at speed. __________ PSIG