# Emergency diesel generator testing essay

EMERGENCY DIESEL GENERATOR HEAT EXCHANGER TESTING C. M.

D’Angelo M. E. Kerst Proto-Power Corporation 591 Poquonnock Road Groton, CT 06340 and S. M. Ingalls Northeast Nuclear Energy Company Rope Ferry Road Waterford, CT 06385 EMERGENCY DIESEL GENERATOR HEAT EXCHANGER TESTING C. M.

D’Angelo M. E. Kerst Proto-Power Corporation 591 Poquonnock Road Groton, CT 06340 and S. M.

Ingalls Northeast Nuclear Energy Company Rope Ferry Road Waterford, CT 06385 AbstractNuclear Regulatory Commission (NRC) Generic Letter 89-13 requires periodic testing of all raw-water-cooled safety-related heat exchangers to ensure that the General Design Criteria of 10 CFR Part 50 are being met. Specifically, GL 89-13 addresses the requirements of GDC 44–Cooling Water, GDC 45–Inspection of Cooling Water System, and GDC 46–Testing of Cooling Water System. The heat exchangers associated with the Emergency Diesel Generators (EDG) at most nuclear power plants are raw-water cooled and safety-related, and therefore, fall under the requirements of GL 89-13. Whereas most of the larger safety-related heat exchangers can be tested and the resulting data reduced to an easily understood baseline value such as fouling factor, the EDG heat exchangers usually can not be tested in this manner due to lack of instrumentation, complex piping configurations, and automatic temperature-sensing flow control valves.

The operational questions posed by GL 89-13 could be resolved readily if the EDG heat exchangers could be tested exactly at the conditions required or postulated by the most limiting accident scenario. Some of these parameters, such as kilowatt loading, can be easily attained; however, certain parameters such as the cooling water inlet temperature, or the external ambient air temperature may not be controllable. Such is the case with the Emergency Diesel Generator heat exchangers at Millstone Point Unit 1 (MP1). This paper details a test procedure that determined the operability of the MP1 EDG heat exchangers using test results with inference rather than absolute means.

The procedure was used to determine the operability of the EDG heat exchangers during August 1995, and will again be used during August of 1996. Although the procedure detailed here is specific to that used at MP1 and which will be used at Millstone Point Unit 2 (MP2), the concepts can be applied to heat exchangers that pose similar testing restrictions. Background The Millstone Point Unit 1 Emergency Diesel Generator is equipped with a heat exchanger assembly consisting of an Intercooler Water (IW) Cooler, Lube Oil (LO) Cooler and Jacket Water (JW) Cooler, that provides cooling for the respective EDG operating fluids. These three heat exchangers are installed in series and are cooled by the plant Service Water System (SWS). This paper details the theory and methods applied to evaluate the Emergency Diesel Generator (EDG) test data gathered during the August 1995 test.

The August 1995 test served as the initial evaluation to verify that the EDG heat exchangers have sufficient heat transfer capacity to perform their safety related functions at design basis accident conditions, and to provide baseline data for future test comparison. In accordance with the Reference (1) requirements regarding performance esting and evaluation of safety-related, open-water-system cooled heat exchangers, Northeast Nuclear Energy Company (NNECO) used special instrumentation to gather test data on the EDG heat exchangers operating under controlled conditions which simulated, as close as was practical, the design basis accident conditions for the EDG heat exchangers. The design accident conditions and the test conditions are shown in Table 1. Table 1: DESIGN ACCIDENT vs. TEST CONDITIONS ParameterDesign Accident ConditionDesign Accident Ref.

Test Value SWS Flow (GPM)340Reference (2)369. 68 Kilowatt Load26652665 SWS Temp. (? F)75 (77)Reference (3)72. 16 Outside Air Temp. (? F)92Reference (4)70.

9 Tubes Plugged5% PER HXReference (5)0/IW 7/LO 0/JW Fouling (Hr-Ft2-? F/BTU)TBDTBDTBDNACLEAN/Tubeside TBD/Shellside The data gathered during the test procedure was extrapolated to the design basis accident conditions to provide baseline performance criteria for the three heat exchangers. Approach In order to extrapolate the performance data gathered during the test to the postulated accident scenario, several characteristic curves were developed. These characteristic curves were then used to develop correction factors for changes in SWS temperature and flow and for the number of active tubes. The effects of an increase in EDG inlet air temperature on the heat exchangers were predicted via calculation. The measured test values for the process fluid temperatures were then corrected, based on the curves and calculations, for the differences between the as tested conditions and the design basis conditions.

A final set of characteristic curves was developed to determine the fouling limit on each heat exchanger. SWS Temperature and Flow Correction Figures (1a), (1b) and (1c) were developed using data generated by the heat exchanger modeling software, PROTO-HX Version 2. 00 [Reference (6)]. The curves illustrate the variation in process-side inlet conditions as a function of variations in cooling-side temperature and flow.

From these characteristic curves, correction factors were obtained and used to extrapolate the differences between the tested and design temperature and flow conditions. Figure 1a: IW COOLER CHARACTERISTIC CURVE Figure 1b: LUBE OIL COOLER CHARACTERISTIC CURVEFigure 1c: JACKET WATER COOLER CHARACTERISTIC CURVE EDG Inlet Air Correction The air coolant system removes heat, via an aircooler, from the combustion air after it leaves the turbocharger and before it enters the engine. This rejected heat is transferred to the process fluid of the IW Cooler. The effect on the IW Cooler caused by an increase in outside air from the test condition of 70.

9 °F to the design accident condition of 92°F was calculated. This information was then used to determine the impact on the downstream LO and JW Coolers. Percent of Tubes Plugged Correction Figures (2a), (2b) and (2c) were developed using data generated by the heat exchanger modeling software, PROTO-HX Version 2. 00 [Reference (6)] to indicate the rate at which the process fluid temperature increases as the number of tubes plugged increases for each of the heat exchangers. From these characteristic curves, correction factors were obtained and used to extrapolate the differences between the as tested and design basis number of active tubes. Figure 2a: AFTERCOOLANT INLET TEMPERATURE vs.

NUMBER OF ACTIVE TUBES Figure 2b: LUBE OIL INLET TEMPERATURE vs. NUMBER OF ACTIVE TUBES Figure 2c: JACKET WATER INLET TEMPERATURE vs. NUMBER OF ACTIVE TUBES Projected Process Temperature The process fluid temperatures measured during testing were compensated based on each of the correction factors described above. The resulting process fluid temperatures indicated adequate heat removal capacity of each heat exchanger at the design basis accident condition with margin.

The margin between the projected process fluid temperatures at the design basis conditions and process fluid temperature limits was ascertained for each heat exchanger. This margin allows for a certain reduction in performance, primarily due to fouling, in each heat exchanger before the process temperature limits are reached. Characteristic curves were developed to determine overall fouling correction factors and the maximum overall fouling limit was derived. Assumptions Assumptions Used to Generate Figures (1a) through (1c) and Figures (2a) through (2c) 1.

The heat exchanger is “ clean” on the tube-side i. . : the assumed value of overall fouling used in generating the performance prediction curves for the heat exchanger is equal to 0. 0 Hr-ft2-°F/BTU. This is a reasonable assumption since all three heat exchangers were tube-side cleaned just prior to performance of the test, and the amount of shell-side fouling has a negligible effect on the slopes of the generated curves.

2. The heat load transferred is equal to the design heat load as indicated on the design data sheets. This is required in order to obtain the design characteristic curves and the associated correction factors. . It is assumed

that there are no tubes plugged in the heat exchanger for the generation of Figures (1a) through (1c) because for the limited number of tubes plugged there is no discernible effect on the slope of the curves. 4.

The heat transfer rate, SWS inlet temperature and flow rate, and the process flow rates are considered fixed, therefore, characteristic curves are predicted by calculating the required process inlet temperature, process outlet temperature, and cooling water outlet temperature necessary to balance the governing equations. 5. During the test, the LO and JW Cooler outlet temperatures remained constant as the SWS flow was reduced. The IW Cooler outlet temperature, however, increased by several degrees beyond one point. This increase in IW temperature corresponded to the IW Cooler bypass valve shutting.

The LO Cooler bypass valve, based on the flow meter readings, never totally closed, thus explaining the constant temperature as SWS flow was reduced. The JW Cooler bypass line was not instrumented during the test, however, the JW Cooler outlet temperature remained constant, indicating that this bypass valve also never totally shut. For purposes of this calculation, the process fluid bypass valves are assumed to be closed. The shell-side conditions were assumed to be turbulent since the amount of fluid bypassed during the test is small compared to the design value.

These are reasonable assumptions that result in a conservative approach since the open bypass valve, and potentially non-turbulent flow, is an indication that full heat exchanger heat removal capacity is not required for adequate cooling, yet no correction is made to the results to reflect this additional margin. Assumptions Used in Calculating Effect of Increased Inlet Air temperature to EDG 1. Assumed a polytropic ideal gas process across the turbocharger since heat is carried away during compression and there is an increase in internal energy and temperature through the turbocharger. 2. Assumed that the air delivered is equal to the specification volumetric air flow rate of 11000 ft3/min per Reference (7).

3. Assumed a compressor efficiency of 0. 727 which was determined iteratively and was verified with the turbocharger vendor, Elliott Company, as being reasonable. 4. Assumed constant heat transfer characteristics (UAF) for the inlet air temperature correction.

Design Inputs-Heat Exchanger Model Information The models for MP1 EDG IW Cooler, LO Cooler and JW Cooler were developed in the Reference (8) calculation. For the purposes of this evaluation the PROTO-HX model inaccuracies were considered negligible since the models were used to develop general HX characteristics – not specific parameter outputs. Total Measurement Uncertainty In measuring the temperatures and flows during the performance of this test, two types of uncertainty were considered. The first, total bias uncertainty, accounts for the baseline inaccuracy of the measurement system (instrument bias uncertainty) and the uncertainties associated with measuring a bulk parameter using point measurements (spacial bias uncertainty).

The second, precision measurement uncertainty, accounts for the random scatter of repeated measurements of a given parameter. The total parameter measurement uncertainty, derived by combining the total bias and precision measurement uncertainties as the square-root-sum-squares, was then applied to the test measured parameters to obtain the conservative results. A summary of the uncertainties is provided in Table 2. These uncertainties are applied in a conservative manner to the final result calculation in Table 4. Table 2: TOTAL PARAMETER MEASUREMENT UNCERTAINTY ParameterTotal Parameter Measurement Uncertainty SWS Inlet Temp (? F)+/- 2. 3 SWS Flow (gpm)+/- 17 IW Cooler Inlet Temp (? F)+/- 1.

5 LO Cooler Inlet Temp (? F)+/- 2. 8 JW Cooler Inlet Temp (? F)+/- 2. 4 A detailed description of the methods used in determining the total parameter measurement uncertainty can be found in Reference (9). Detailed Analysis of the August 1995 Test DataTable 3 provides the baseline test data for the process fluid temperatures.

The measured process fluid temperatures were corrected for differences in SWS flow and temperature, inlet air temperature and percentage of tubes plugged. The resulting process temperatures, having been corrected to design basis accident conditions, were then compared to the process temperature limits, also shown in Table 3. The difference between the two values is the margin in which heat exchanger performance can degrade due to fouling. Characteristic curves were developed to determine the fouling limits based on the margins.

Table 3: PROCESS FLUID MEASURED and LIMITING TEMPERATURES HEAT EXCHANGERIW COOLERLO COOLERJW COOLER Measured Process Temp (? F)112. 934202. 388167. 283 Process Temp Limit (? F)140225190 The

following sections detail how the corrections for each parameter were estimated. SWS Temperature and Flow Correction Method PROTO-HX models of the IW Cooler, LO Cooler, and JW Cooler were used to develop a relationship of how process-side inlet temperatures vary with changes in SWS inlet temperature.

This was accomplished by inputting design tube flow, shell flow and heat load for each heat exchanger while varying the tube inlet temperature. In each case, a linear relationship between the increase in process-side inlet temperatures and increasing SWS temperatures was observed. The rate of change of the process-side inlet temperature with respect to the SWS temperature was then calculated as the correction factor. The correction factor was then multiplied by the difference between the test condition SWS temperature and the design SWS temperature. The resulting value was added to the measured temperature to compensate for the difference in SWS temperatures.

For example, the correction factor obtained from the Figure 1a curve for 375 gpm for the IW Cooler is (1) The difference between the design basis condition SWS inlet temperature and the as tested condition is (2) and the resulting temperature correction is obtained as follows; (3) Therefore, the process inlet temperature would rise approximately 2. 35? F if the SWS was at the design temperature of 75? F in lieu of the tested condition of 72. 16? F ignoring the instrument uncertainty. To correct for instrument uncertainty in a conservative manner, subtract the 2. 3? F error from the uncorrected value of 72.

16? F [69. 86? F]. This yields a greater temperature difference, and thus a greater correction. To correct for SWS flow rate differences, curves similar to those developed for the SWS temperature correction were developed by varying the SWS flow rate rather than the SWS inlet temperature. The resulting curve, also linear, was plotted on the same graph as the temperature correction curve. The rate of change of the process-side inlet temperature with respect to the change in SWS flow rate was calculated as the correction factor.

The correction factor, as before, was multiplied by the difference between the test condition SWS flow and the design minimum SWS flow and the resulting value added to the measured process-side inlet temperature to compensate for flow rate differences. For example, the correction factor obtained from the Figure 1b curve for the LO Cooler is (4) The difference between the design basis condition SWS flow rate and the as tested condition is (5) and the resulting temperature correction is obtained as follows; (6) Therefore, the process inlet temperature would rise approximately 1. 685? F if the SWS was at the design flow rate of 340gpm in lieu of the tested condition of 369. 58 GPM ignoring the instrument uncertainty. To correct for instrument uncertainty in a conservative manner, add the 17 GPM error from the uncorrected value of 369.

568 GPM [386. 568 GPM]. This yields a greater flow difference, and thus a greater correction. EDG Inlet Air Temperature Correction Method During the performance of the test, the outside air temperature was measured at 70. 9°F.

The design basis accident ambient temperature condition is 92°F. Extrapolation of the operating condition to the design condition is important for the following reasons. An increase in the inlet air temperature to the turbocharger will increase the air temperature at the aircooler inlet, increase the IW Cooler process water temperature and ultimately increase the SWS temperature at the outlet of the IW Cooler, thus impacting the downstream LO Cooler and JW Cooler. An estimation of these effects follows. Figure 3 shows the turbocharger and heat exchanger assembly arrangement with the as tested measurements.

Figure 3: TURBOCHARGER and HEAT EXCHANGER ASSEMBLY ARRANGEMENTFirst the temperature downstream of the turbocharger, at tested conditions, was estimated. This was performed as follows. Assume a polytropic – ideal gas process through the turbocharger to determine the turbocharger outlet temperature, To [Equation per Reference (10) K = 1. 4 for air]. (7) The turbocharger outlet temperature was then corrected for compressor efficiency.

Compressor efficiency was initially assumed as 0. 725 and the final efficiency of 0. 727 was arrived at iteratively by performing the following: (8) Verifying that the temperature was reasonable, the specific volume was obtained by calculating the air density as follows: 9) By specification, the volumetric air flow delivered is 11, 000 ft3/min. Using this to determine the mass flow rate of air yields; (10) Assuming that the heat transfer from the aircooler is equal to the heat transfer from the IW Cooler, the inlet air temperature to the aircooler is recalculated, using the test data, as follows; (11) This temperature differs from the initially calculated value of T1’ by only 0. 9 °F.

The difference may result from the assumed value of efficiency for the turbocharger or from the fact that the actual delivered air flow may have been greater than the specification rate or from instrumentation error.

T1’= 229. 96? F was used for the turbocharger outlet air temperature for the remainder of the calculation. With the inlet and outlet temperatures for both the aircooler and the IW Cooler known, their heat transfer characteristics were calculated. For the aircooler: (12) therefore; (13) For the IW Cooler: (14) therefore; (15) Now considering the increase in outside air temperature from 70. 9°F at test conditions to 92°F for the design maximum, the new temperature downstream of the turbocharger is obtained as follows: (16) Using a turbocharger efficiency of 0. 27, as before, determining the new turbocharger discharge temperature is as follows; (17) From T1’ the new mass flow rate for air is obtained as follows; (18) As before, using the specification volumetric air flow rate, (19) The effects of the increased delivered air temperature on the IW Cooler heat load and outlet temperature are determined as follows: The arrangement is shown in Figure 4.

Figure 4: AIRCOOLER and IW COOLER ARRANGEMENT Calculating the process fluid mass flow from the test yields; (20) Now a series of equations is written to solve for the unknowns, TPW 1, TPW 2, TA out, TSW out, and Q. Aircooler; (21) Process fluid; (22) IW Cooler; (23) Solving for the unknowns using a simultaneous equation solver results in the following: Tair out = 128. 32°F TPW1 = 107. 94°F TPW2 = 118. 71°F TSW out = 84. 42°F Q = 2213922.

14 BTU/hr Back substitution of these values into the equations verifies the results. The results indicate that the 21. 1°F increase in inlet air temperature to design conditions results in an approximate 6. 32°F increase in deliverable air temperature to the cylinders, a 5. 77? F increase in IW Cooler process water inlet temperature and approximately a 1. 2°F increase in SW temperature out of the IW Cooler.

From the results, 5. 77? F was calculated as the temperature correction for the IW Cooler process fluid inlet temperature. Correcting the LO Cooler and the JW Cooler process-side inlet temperatures was accomplished by multiplying the 1. 52°F increase in SWS temperature by the SWS temperature correction factors derived previously for each cooler. Percent of Tubes Plugged Correction Method PROTO-HX models of the IW Cooler, LO Cooler, and JW Cooler were used to develop a relationship of how process-side inlet temperatures vary with changes in the number of tubes plugged.

This was accomplished by inputting design tube flow, shell flow, tube inlet temperature and heat load for each heat exchanger while reducing the number of active tubes. In each case, a linear relationship between the increase in process-side inlet temperatures and the reduction in the number of active tubes was observed. The rate of change of the process-side inlet temperature with respect to the number of active tubes was then calculated as the correction factor. The correction factor was then multiplied by the difference between the test condition active tubes and the design basis active tubes and the resulting value was added to the measured process fluid temperature to compensate for the difference in the number of active tubes. Process Fluid Temperature Correction Method By the methods described above, the corrections for SWS flow and temperature, number of plugged tubes and inlet air temperature were computed and added to their respective measured process fluid temperatures. This resulted in process fluid temperatures that would be expected at the exact design basis operating conditions.

Table 4 shows the results and the process temperature margins for the measured test conditions. For comparison purposes, Table 4 also shows results and process temperature margins based on data recorded during pre-test EDG operation before the heat exchangers were tube-side cleaned. Since the IW Cooler inlet temperature was not a recorded parameter in the pre-test, 113? F was used for the pre-test measured process temperature for the IW Cooler. This value was derived by adding the test condition T across the IW Cooler (approximately 9? F) to the pre-test measured air cooling system inlet temperature (104? F).

It should be noted that the design basis SWS temperature is currently 75? F, however, the calculations were also performed based on a potential increase in the design basis SWS temperature to 77? F. Table 4: EDG PERFORMANCE TEST RESULTS CORRECTED FOR DESIGN CONDITIONS IW CoolerLO CoolerJW Cooler Pre-test SWS Inlet Temp70. 9 SWS Inlet Temp @ Test Conds. Corrected for Instrument Error69. 86 Design Basis SWS Temp 75 Mod Design Basis SWS Temp77 Pre-test SWS Flow450 SWS Flow @ Test Conds.

Corrected for Instrument Error386. 568 Design Basis Min. SWS Flow 340Pre-test measured Process Temp113202165 Test Measured Process Temp (°F)

Corrected for Instrument Error114. 434205. 188169. 683 d(Process T)/d(SWS T)Figs.

1 a, b, c0. 82860. 52860. 8429 Pre-test SWS T Correction3. 397262. 167263.

45589 SWS T Correction (°F) for 754. 2590042. 7170044. 332506 SWS T Correction ( F) for 775. 9162043. 7742046.

018306 d(Process T)/d(SWS Q)Figs. 1 a, b, c-0. 0629-0. 0429-0. 1314 Pre-test SWS Q Correction6. 9194.

71914. 454 SWS Q Correction2. 92912721. 99776726. 1190352 Air Inlet Temp Correction to PW5. 7730.

8034721. 281208 Test Cond # of Active Tubes164405164Design Basis # of Active Tubes156391156 d(process T)/d(# Active Tubes)Figs. 2 a, b, c-0. 108-0. 22-0. 1833 Tube Plugging Correction0.

8644. 41. 5 Pre-test Process Temp Projected129. 95214. 09185. 69 Process Temp Projected (75 F)128.

26215. 11182. 92 Process Temp Projected (77 F)129. 92216.

16184. 60 Process Temp Limit140225190 Pre-test Projected Margin10. 0510. 914.

31 Projected Margin (75 F)11. 749. 897. 08 Projected Margin (77 F)10.

088. 845. 40 Overall Fouling The resulting margins shown in Table 4 indicate that the current performance of the EDG heat exchangers is acceptable in all

cases. The current performance, however, is based on clean tubes on the service water side of each heat exchanger.

As the overall fouling of the heat exchangers increases, the margin to design limits will decrease. Figures 5a, 5b and 5c are characteristic curves developed using the PROTO-HX model for each heat exchanger. The curves indicate the rate at which the process fluid temperature increases as the overall fouling increases. From these curves, the overall fouling limit was calculated for each heat exchanger. Figure 5a: IW COOLER OVERALL FOULING CHARACTERISTIC CURVEFor the IW Cooler the overall fouling limit was found by obtaining a correction factor (CFIW) as follows: (24) Then dividing the IW Cooler process fluid temperature margin (MIW) by CFIW yields; (25) which represents the amount of overall fouling that will result in the aftercoolant reaching its limit. At the increased SWS inlet temperature of 77? F the overall fouling limit would be (26) Figure 5b: LUBE OIL COOLER OVERALL FOULING CHARACTERISTIC CURVE Similarly, the overall fouling limit for the LO Cooler was found as follows; (27) Dividing the LO Cooler process fluid temperature margin (MLO) by the CFLO ields; (28) which represents the amount of overall fouling that will result in the LO reaching its limit.

At the increased SWS inlet temperature of 77? F the overall fouling limit would be (29) Figure 5c: JACKET WATER COOLER OVERALL FOULING CHARACTERISTIC CURVE Lastly, the overall fouling limit for the JW Cooler was found as follows; (30) Then dividing the JW Cooler process fluid temperature margin (MJW) by the CFJW yields; (31) which represents the amount of overall fouling that will result in the JW reaching its limit. At the increased SWS flow rate of 77? F the overall fouling limit would be (32) Discussion Of Results The results established the initial design basis performance for the EDG heat exchangers in accordance with the requirements of Reference (1). Since design basis accident conditions were not attainable during testing, the data was extrapolated to design conditions. Correction factors, which can be used to correct an actual operating condition back to any other desired condition, were developed for operating parameters that were not at design basis conditions. These correction factors are summarized in Table 5.

Table 5: CORRECTION FACTORSCORRECTION FACTORIW COOLERLO COOLERJW COOLER SWS Temp (? F)0. 82860. 52860. 8429 SWS Flow (GPM)0. 06290. 04290.

1314 Plugged Tubes (# of Tubes)0. 1080. 220. 1833 The performance assessment of each heat exchanger was made in terms of available margin until design basis accident condition process fluid temperature limits were reached. Based on the predictions, all of the heat exchangers were found to be acceptable at the design basis conditions when they are clean.

When overall fouling is considered, however, there is a limit when heat exchanger performance will not meet the process fluid inlet emperature requirements. Table 6 summarizes those fouling factor limits based on each heat exchanger operation at its design basis accident condition. It should be noted that a slightly higher overall fouling factor limit would be available if the heat exchangers do not have 5% tubes plugged. Table 6 also shows the fouling factor limits for each heat exchanger operating at design basis accident conditions but with test condition number of tubes plugged. Table 6: ADDITIONAL OVERALL FOULING FACTOR ALLOWABLE IW CoolerLO CoolerJW Cooler Overall Fouling – SWS Flow @75? F (5% Tubes Plugged)0.

000790. 01430. 00037 Overall Fouling – SWS Flow @77? F (5% Tubes Plugged)0. 000680.

001280. 00028 Overall Fouling – SWS Flow @75? F (Test Cond. Tubes Plugged)0. 000820.

001470. 00039 Overall Fouling – SWS Flow @77? F (Test Cond. Tubes Plugged)0. 000710. 001310.

00030 Recommendations Reference (1) requires an initial test to establish baseline data for future monitoring of heat exchanger performance. It is planned that the initial test will be followed by three periodic tests to determine the optimal testing frequency to assure that the heat exchangers will perform their intended safety functions. It is planned that the initial three follow-up tests will be performed annually during the month of August. As a minimum, Reference (1) requires that the testing frequency be at least every five years.

Prior to running the baseline test, data was gathered during a routine EDG operational surveillance to indicate whether the EDG heat exchangers were likely to fail the actual baseline test. This “ pre-test” data was evaluated to provide an opportunity to develop a contingency plan should the EDG heat exchangers fail the baseline test. This pre-test data was gathered using existing instrumentation under normal operating conditions, i. e. the SWS flow was not throttled close to design accident flow and, the heat exchangers had been in service for approximately two years since their last cleaning [MP1 was on a refueling schedule for EDG heat exchanger cleaning].

This test data was evaluated and the results are shown in Table 4. The pre-test projected margins are corrected to design basis accident conditions, but reflect approximately two years of fouling build-up. Table 4 also shows the results from the official test which indicate that the EDG heat exchangers are capable of performing their safety related functions under design basis accident conditions. Based on this information, it was recommended that the EDG heat exchangers be tested, using the approach detailed in this calculation, in accordance with the schedule summarized in Table 7. Table 7: EDG HX TEST SCHEDULE PERIODIC TEST #FREQUENCYESTIMATED TEST DATE BaselineNAAugust 1995 112 monthsAugust 1996 224 monthsAugust 1997 336 monthsAugust 1998 Testing on the heat exchangers should be performed before and after the heat exchangers are cleaned.

Cleaning should not be conducted between tests in order to allow the calculation of the rates of fouling. The test results will be trended to determine the rates at which fouling and blockage accumulate. Based on the cumulative information obtained from the series of periodic tests, the optimal testing frequency will be determined and new inspection and cleaning intervals will be determined. References 1. United States Nuclear Regulatory Commission Generic Letter, “ Service Water System Problems Affecting Safety-Related Equipment (Generic Letter 89-13)”, dated July 18, 1989.

2. NNECO Calculation 90-073-01127-M1, Rev 0, Millstone Unit No. 1- Maximum Allowable Heat Exchanger Tube Pluggage Levels for an Assumed EDG Service Water Flow of 340 gpm, dated 6/30/94. 3. Millstone Point Unit 1 Technical Specifications page 3.

5. G. 4. General Electric Specification 22A1105, Rev.

0, dated July 9, 1966 – Design Specification for Turbine Building Ventilating, Cooling and Heating Systems. 5. Proto-Power Calculation 93-051, Rev A, Performance Analysis of RBCCW, TBSCCW and TBCCW Heat Exchangers for Purposes of Generic Letter 89-13 System Design Basis Review, dated 4/8/94. . PROTO-HX Version 2.

00 User Documentation. 7. Colt Industries, Fairbanks Morse Power Systems Division, Service Manual for Model 3800TD8-1/8 Engine Generating Set and Accessories. 8.

Proto-Power Calculation 95-013, Rev -, TBSCCW, RBCCW, EDG and LPCI HX Model, dated 5/12/95. 9. ASME OM21 Standard: Inservice Performance Testing of Heat Exchangers in LWR Plants. 10. M. David Burghardt, Engineering Thermodynamics with Applications, Harper & Row Publishers, 1978.

11. Proto-Power Calculation