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HX-01

HEAT EXCHANGER CONDITION ASSESSMENT PROGRAM

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1.0 PURPOSE

1.1 The purpose of the Heat Exchanger Condition Assessment Program(HXCAP) is to maximize plant reliability and to forecast repair or replacement of important plant heat exchangers due to material degradation, while at the same time minimizing inspection and cleaning cost. This is accomplished by utilizing various Non Destructive Examination (NDE) methods to assess material flaws and corrosion/erosion of the different parts of certain heat exchangers to identify and trend the more common material degradation problems that occur in heat exchangers. This procedure also provides general cleaning recommendations to prevent further material degradation where bio/silt fouling or scale buildup is expected.

1.2 This program is also used to implement parts of the PBNP GL 89-13 program. Specifically for monitoring GL 89-13 HX's for erosion and corrosion (GL 89-13 Action Item III). In addition this program will be used to report as found Heat Exchanger Bio/Silt fouling (GL 89-13 Action Item II and III).

1.3 This program includes all plant heat exchangers except for the Steam Generators. The program classifies the heat exchangers into groupings based on their importance to the plant and their inspectability. Most inspection efforts will be focused on the inspectable heat exchangers that are important for plant operations.

1.4 This program document excludes all Section XI weld inspections and the FW Heater shell thinning as they are covered under the PBNP Inservice Inspection Program, and the PBNP Flow Accelerated Corrosion Program. This program excludes thermal performance testing.

how is thermal testing governed ?

2.0 DISCUSSION

2.1 Point Beach Nuclear Plant operates in a competitive market where the focus is on reducing maintenance cost and maximizing plant reliability to remain competitive. As such, inspection resources for balance of plant (BOP) heat exchangers must be spent wisely and effectively to minimize tube leaks, extend the availability, and forecast timely replacement of essential heat exchangers.

Keys to a successful BOP heat exchanger condition assessment program include:

- Minimizing tube leaks in critical equipment by targeting key heat exchangers for inspection.
- Devising an appropriate sample based inspection scheme to ensure that an inspected component will remain trouble free during operation.
- Assessing conditions of the heat exchangers using appropriate and reliable inspection techniques.
- Applying realistic tube plugging criteria and reducing insurance plugging.
- Planning for timely heat exchanger replacement by calculating remaining heat exchanger operating life.

3.0 RESPONSIBILITIES

3.1 The Engineering Programs Manager has overall responsibility for the development, approval, administration, and implementation of the Heat Exchanger Condition Assessment Program at PBNP. The Engineering Programs Manager shall be responsible for designating an individual who shall function as the Heat Exchanger Condition Assessment Program Engineer, and ensure that appropriate training is provided for individuals involved in Heat Exchanger Condition Assessment.

3.2 The Engineering Programs Inspection Supervisor reports to the Engineering Programs Manager and provides administrative and technical direction to the Heat Exchanger Condition Assessment Program Engineer.

3.3 The Heat Exchanger Condition Assessment Program Engineer shall be responsible for the following program actions:

3.3.1 Develop and maintain Heat Exchanger Condition Assessment Program documents in accordance with the applicable NMC Implementing Standards.

3.3.2 Ensure cost effective implementation and administration of the Heat Exchanger Condition Assessment Program.

3.3.3 Ensure effective communication between plant personnel and/or other organizations responsible for providing support services directly related to heat exchanger inspection for the Heat Exchanger Condition Assessment Program.

3.3.4 Review and approval of NDE contractor's techniques, procedures, equipment, calibration standards, and personnel qualifications prior to the start of exams.

3.3.5 Track and trend degrading heat exchanger conditions on a component basis to provide system engineers and plant management with information related to the estimated life of the heat exchangers.

3.3.6 Ensure corrective actions are initiated and coordinated for tube plugging and tube pulling for metallurgical examination.

3.3.7 Maintain eddy current database program and picture records of as found heat exchanger conditions where pictures are required or suggested in this program document.

3.3.8 Preparation of unit and annual cycle reports for the heat exchangers inspected during the previous cycle. This report shall include heat exchangers inspected, as found conditions, and recommendations for future inspections or corrective actions.

3.3.9 Maintain tube plugging criteria for in-scope HX's and overall amount of tube plugging per heat exchanger

4.0 QUALIFICATIONS

4.1 Visual Assessment Upon Opening:

4.1.1 Material Degradation:

There is no specific qualification required for this inspection as the emphasis is identifying areas of material degradation that are clearly visible with a specific inspection of the component areas (look at, not just glance at).

4.1.2 Bio/Silt Inspections:

GL 89-13 Bio/Silt inspections shall be performed by an engineer with experience and the knowledge to recognize the different types of bio/silt fouling (silt, mussel or clam, slime, tubercles, debris, weeds, etc), and who is knowledgeable on determining when tubes are effectively plugged from a thermal performance standpoint.

4.2 NDE Test Technicians:

Technicians performing any form of UT, Eddy Current Testing (ECT), and Remote Field Testing (RFT) shall be qualified to SNT-TC-1A, or an equivalent program. Personnel performing NDE data analysis shall be qualified as a level II, or higher.

4.3 Program Engineer:

The HXCAP Engineer is qualified in accordance with NMC Fleet Mentoring Guide, Eddy Current Testing, and any other specific mentoring guide developed in the future.

4.4 Vendors:

Vendors shall submit their test procedures for review and acceptance by PBNP prior to the start of any work. Vendors shall submit appropriate certification papers for their personnel to the HXCAP Engineer prior to the start of any exam.

5.0 HEAT EXCHANGER INSPECTION SCOPE

5.1 Classification of Heat Exchangers:

In order to utilize resources effectively the heat exchangers at PBNP are sorted into two groups: Those that are "In Scope" for scheduled inspections and those that are not. The second group is also a Run –To-Failure (RTF) classification by definition (it is RTF if we are not going to inspect to prevent failure). The later group may have corrective maintenance or special inspections done when appropriate.

The design of PBNP is such that there are no HX's who's isolated failure could directly affect the health and the welfare of the public or nuclear safety, which provides a sorting criteria based more on plant reliability and on heat exchangers that are important to the operation of the plant (including nuclear safety) even though they may have back-ups. The following is the list of criteria used to determine how a HX is sorted:

- Will failure of the HX require downpower or shutdown for repairs.
- Is the HX testable by normal maintenance and BOP NDE techniques (accessible via bolting, tube configuration allows access for probes, etc)
- Is the HX in the GL 89-13 Program.
- Would the HX require an LCO for maintenance.
- Would a leaking tube probably cause substantial damage to other equipment
- Is the HX important to plant operations, has a backup, but it is economical for us to inspect and trend its condition due to the likely cost of repairs or replacement.
- Is the equipment not being used, or likely to be abandoned soon.
- Is the HX part of the general HVAC system or an electric heater.
- Is there sufficient information about a HX in order to determine its inspectability and materials of construction.
- Plant Management Discretion

U1/U2 CAC cooling coils are included (blue tabs)

The "In Scope" heat exchangers are listed in Appendix A, and those not scheduled for routine inspection / RTF heat exchangers are listed in Appendix B.

5.2 Inspection Type & Scope

All "In Scope" heat exchangers (Appendix A) shall have an inspection schedule developed concerning the type of inspection, the technology used, the extent of the inspection, and the planned interval of the inspections.

5.2.1 Inspection type is driven by the anticipated or known condition specific to each heat exchanger: Bio/silt, channel or shell corrosion, tube degradation, etc. (See section 6 below for more information).

5.2.2 The technology used will be controlled by the types of defects you are looking for and the materials of construction. For example channel or shell corrosion typically can be seen with a simple visual inspection or with ordinary UT with in-house people. Tube degradation mechanisms usually require specialized test equipment.

5.2.3 The extent of the inspection is driven by the two factors cost and location of expected HX degradation areas. Tube degradation inspection using ECT, RFT, and other specialized testing typically involves outside vendors and set-up time. Thus, smaller heat exchangers typically will have 100% of the tubes tested as the cost to test the remaining tubes is minimal once the vendor is set-up. Sample patterns are typically used with larger HX's.

The break point between 100% tube inspection and use of a sample pattern is typically between 300 and 500 tubes depending on the length of the tubes in the HX. This is not a hard rule, as there are cases where samples will be used on smaller HX's and other cases where 100% of the tubes will be tested on larger HX's. Importance of the HX, level of concern on tube condition, ALARA, difficulty of gaining access, and other factors all weigh into the decision as to what is the appropriate test sample for a given HX and a given test.

100% baseline inspection of all new or retubed HX's is recommended to identify all existing tube flaws and construction damage. A test pattern sequence to sweep all the tubes over a series of inspections is recommended for large HX's if an initial baseline cannot be done.

5.2.4 An established interval is essential to uncovering an inherent or developing problem before failure occurs. This interval is dependent on the materials of construction, the type of degradation you are monitoring for, the known extent of the problem and expected growth of degradation. EPRI's PM optimization program has general industry tube degradation monitoring intervals for where there is no known specific problem. Alternately, EPRI's Heat Exchanger Component Risk Calculator can also be utilized. The EPRI guidelines are general in nature and actual plant equipment history and local tube material/application issues should control test intervals for affected HX's.

not complete completion schedule not met - see CAP 55143

5.2.5 Specific inspection schedules, component history, and recommendations are listed in appendices C, D, and E (Unit 1 Outage, Unit 2 Outage, and Annual Cycle inspection schedules). Also, these appendices may be used to compile known construction and plugging data for HX's that are not inspected in order to provide a standard location for such information.

6.0 MATERIAL DEGRADATION ISSUES

6.1 Channel, Cover, and Shell Degradation Modes.

Heat exchanger channels, covers, and shells are typically made of either carbon steel or a 300 series SS. General corrosion and degradation is typically a concern only in raw water applications. Controlled chemistry loops (condensate, CCW, etc) rarely have any significant or unusual degradation.

Raw water applications provide the mixture of a constant supply of oxygenated water and various forms of biological organisms , silt , and debris. This combination can readily attack and degrade carbon steel and may attack stainless steels.

Raw water heat exchangers are built with a corrosion allowance to provide "excess" material to be degraded away without affecting design function.

The most common form of unusual degradation is under-deposit pitting from biofouling. These inspections need to be done after all biofouling and silt is cleaned from the channel and cover.

Another form of degradation that needs to be watched for is galvanic corrosion of the tubesheet or channel when a raw water heat exchanger has been retubed with a more noble tube material than it was designed for. There are known industry problems with certain common retube options such as using SeaCure tubes with a carbon steel tubesheet. These problems are typically controlled by epoxy coating the tubesheet and channel shortly after retubing.

These forms of degradation are easily seen with a simple visual inspection of the channel and cover when the heat exchanger is opened. Very heavy and loose rust scale, pits or depressions in the normal shape is all that is needed for initial detection. Once detected UT measurements can be taken to trend and predict remaining life. UT inspection of shell thickness can be done for any heat exchangers with SW on the shell side (such as the PBNP SFP Coolers).

Epoxy coating of channels and covers needs to be done carefully and properly to avoid a situation where galvanic corrosion will effectively drill a hole through the base metal wherever there is a defect in the epoxy coating. Pits and cracks in epoxy coating should be promptly repaired.

6.2 Tube Degradation Modes

EPRI's "Heat Exchangers: An Overview of Maintenance and Operations" (TR-106741) list the 15 typical failure modes of heat exchanger tubes. This list is far from complete as there are many other known degradation mechanisms that can affect tubes under the right situation. For example, the mechanism for the KNPP 2002 CCW failure is not listed (circumferential cracking in the roll transition zone).

Only 2 of the 15 typical failure modes relate to bio/silt fouling of tubes from raw water sources (debris pits, under deposit pitting). Several of the other 13 typical modes of tube failure apply to any heat exchanger. Fatigue damage will typically be the most common mode of failure of heat exchanger tubing in the event that a HX is designed, manufactured, and operated properly for its service.

6.3 Raw Water Tube Material Issues

There are some local issues related to the raw water heat exchangers and choices of tube materials at PBNP due to the use of Lake Michigan as our heat sink.

6.3.1 Copper and Copper Alloys:

As of 2003, lake Michigan contains a bacteria that rapidly degrades CuNi tube materials to the point that CuNi tubing typically last only a few years (CuNi is not recommended for any raw water application at PBNP, and has failed in numerous heat exchangers).

This bacterium did not exist here 40 years ago. Plants on Lake Michigan used 90/10 CuNi tubing successfully at that time. Dumping of bacteria contaminated bilge water from shipping and barge traffic has spread the bacteria here. Currently, other forms of bacteria that will attack other copper alloy tubing exist in areas frequented by both national and international shipping (these bacterium are often alloy specific). It is projected that those bacteria will at some point spread and establishes themselves in Lake Michigan. The timing of this is an unknown and could occur in the next several years, or may take decades. Olin Fineweld, who used to be the largest manufacturer of copper alloy tubing in the USA, no longer recommends the use of copper based tube alloys on any raw water lake or river application because of the expected spread of these bacterium.

has PBNP identified all Cu-alloy HX tubes exposed to L. Mich for replacement?

Currently both Copper and Admiralty Brass tubing are showing a normal good life at KNPP and PBNP (15-30 years) in raw water service. These materials are being reused in replacement and retubing of smaller heat exchangers (larger heat exchangers should be switched away from copper alloys due to the financial risk). However, continued monitoring of the HX tube condition is required due to the expected future arrival of bacteria that would start the degradation process. This degradation mechanism would probably take a few years providing time for a focused replacement program of the affected heat exchangers).

Recommended eddy current inspection should be staggered such that PBNP is looking at a few copper alloy heat exchangers every year or so. This way it will be possible to see early indications of any bacteria based degradation. Some Admiralty Brass heat exchangers should be routinely tested just to trend this issue and assess how other Admiralty Brass tubed heat exchangers are affected.

6.3.2 300 & 400 Series SS:

Material used for CAC cooling coils
(alloy) Copper Brass
Stainless Steel
" Sea-Cure

In 2003, KNPP confirmed the presence of a bacteria that will cause under-deposit MIC pitting in 300 and 400 series SS tubing (KNPP has 439 SS condenser tube leaks that have been traced to under-deposit MIC pitting). These bacteria types have been known to have been active in the Milwaukee area since the late 90's.

Trent Tube has confirmed that the bacteria types that attack 439 SS will also attack 300 series SS as there is not any real difference in the protection level of these alloys to under-deposit pitting.

PBNP has had good results to date with 304SS in constant flow raw water applications. It is now critical that extra attention be paid to proper cleaning of the tubes to prevent hard deposits. The problem can probably be managed (if not prevented) by keeping the tubes clean.

All 304 SS tubes in lake water applications should be frequently monitored because this type of degradation would probably be fairly rapid under the right conditions. Recommended inspection interval is 1.5 years on the PB Main Condensers because this problem will probably show up in the hot zones of the condenser before it would affect other raw water heat exchangers with 304 SS.

There is a special concern with the SFP heat exchangers due to the fact that the SW is on the shell side where the tube deposits cannot be seen or cleaned and access for eddy current testing is more difficult due to the SFP water on the tube side and the resulting hot particle and ALARA issue (tent and bubble suit is required for eddy current testing). In addition it is not practical to test the U-bend section of the tubes.

6.3.3 SeaCure

SeaCure is highly resistant to the various bacteria induced corrosions and erosion. However eddy current inspectability is limited due to its ferritic nature. The tube must be magnetically saturated, the saturation also saturates a steel baffle such that vibration induced fretting wear and fatigue cracking at the baffle cannot be seen.

PBNP has seen excellent results with SeaCure in raw water applications

Recommended inspection intervals for good condition SeaCure tubes range from 6 to 10 years depending on how critical the heat exchanger is and the consequence of leaks.

7.0 INSPECTION TECHNOLOGIES

7.1 Visual inspection is good for seeing unusual degradation of the channel, cover, and tube end erosion.

7.2 Ultrasonic Thickness measurement (UT) is good for detecting plate thickness loss on heat exchanger channels, covers, shells, and tubesheets.

7.3 Eddy Current Testing (ECT) is the most common method of inspecting HX tubes for defects. It works very well on non-ferritic tube materials (Copper alloys, 300 Series SS, Titanium, etc). Ordinary "bobbin" ECT typically can see over 90% of all common tube degradation mechanisms and the probes are inexpensive.

ECT's principal limitation in non-ferritic tubing is that ordinary bobbin coils cannot go around U-Bends or see circumferential crack indications. There are specialized probes, at substantially increased cost, that can go around the larger U-Bends, look for circumferential cracking, and look for other rare defects. Use of these specialized probes is typically only warranted in the balance of plant heat exchangers if strong evidence exist of these specific degradation mechanisms. A cost benefit analysis may need to be done on small to medium sized HX's before proceeding with the specialty technology (it may be cheaper to replace the HX than to test it with the special probes).

Magnetic Saturation "bobbin" probes expand eddy current testing into the straight tube thin wall ferritic tube materials (439 SS, SeaCure, etc). This comes at a modest increase in cost for typical tube sizes and wall thickness seen in most power plant heat exchangers as the magnetic saturation probes are more expensive and wear out quickly (the probe sticks to the tube). This testing gets more expensive for 3/8" or 1/2" tube OD's because of the cost of the small and powerful magnets required for those applications (and the probes ~~were~~ wear out faster yet). The limitations are that magnetic saturation probes are blinded by the baffles and support plates, and that they cannot go around U-Bends.

7.4 Remote Field Testing (RFT) is an electromagnetic technique similar to eddy current, but which can be used on heavy wall ferritic tubing. It is also possible to build an RFT probe to go around U-Bends (however, normal manufacturing stress relief heat treatment of the U-bend may limit sensitivity to smaller defects). RFT is typically not as sensitive to small pits and cracks as magnetic saturation ECT.

7.5 Internal Rotary Inspection System (IRIS) is a Ultrasonic Thickness (UT) method that uses a rotating probe with water as the couplant. This technology measures the thickness of the tube wall to several thousands of an inch and is not sensitive to the tube material or wall thickness. As such, in power plant applications, it can provide data on baffle fretting for ferritic tubing. The probe also can get past and see dents providing a method of examining a heat exchanger tubing with a denting problem. IRIS, however, cannot detect small pits or cracks.

7.6 Radiography (RT) is sometimes used to try and spot a displaced impingement plate, or gross fouling on the shell side of a heat exchanger. This has had limited success as the tube bundle or other construction features may interfere with the necessary details; however it is worth trying as this is often much cheaper than opening a heat exchanger shell.

8.0 CLEANING OF HX'S

8.1 General Cleaning Recommendations

Deposits in heat exchanger tubes cause several problems. The deposits provide a place for Microbiologic Induced Corrosion (MIC) to occur if bacteria is in the system. Deposits promote chloride concentration cells if chlorine is present, reduce heat transfer, and with time forms hard scale which can be difficult to remove (removal techniques can damage the tubing). Bio/Silt fouling can make it impossible to get a inspection probe down a tube. Deposits also can affect the sensitivity of eddy current techniques if there is enough iron in the deposits.

Not all deposits are limited to the raw water systems. Scale buildup is known to occur in feedwater heaters (PBNP's #5 affected the fastest due to temperature), and the Steam Generator Blowdown HX's.

The rule of thumb to remember is: "a clean tube is a happy tube."

All lake water cooled heat exchangers (SW and CW systems) should be cleaned on a regular basis to prevent tube degradation and scale buildup, and prior to tube degradation inspection.

Feedwater Heaters and SG Blowdown HX's should be cleaned prior to any tube degradation inspection. Note that PBNP was named in 2002 as one of the most thermally efficient nuclear stations in the nation. The fact that we routinely hydrolance clean the FW Heaters about every 6 years played a part in this.

8.2 GL 89-13 Heat Exchangers

Cleaning of the GL 89-13 heat exchangers is controlled by the PBNP GL 89-13 program document (not all of these HX's are routinely cleaned). The GL 89-13 heat exchangers are:

HX-12A/B/C/D	CCW
HX-13A/B	Spent Fuel Cooler
HX-15A/B/C/D	CFC Motor Oil Cooler
HX-15A1-A8/B../C../D1-D8	CFC Cooling Coils
HX-055A-1/A-2/B-1/B-2	G01/G02 Glycol Coolers
HX-105A/B	PAB Battery Room Cooler

Cont. Fan Coolers are included in GL 89-13 program

9.0 BIO/SILT FOULING INSPECTIONS

9.1 General inspection requirements

All SW or CW cooled heat exchangers should be monitored for changes in Bio/Silt fouling. This can be done by filling out the "Bio/Silt Fouling Inspection Form" (PBF-7061) upon initial opening of the heat exchanger. Copies of the filled out Bio/Silt Fouling Inspection Form are provided to the Biofouling Control Program Administrator, the System Engineer, and the HXCAP Engineer. There is no formal record retention requirement for general CW and SW cooled heat exchangers.

9.2 GL 89-13 Heat Exchangers

Bio/Silt Fouling inspection schedules of the GL 89-13 heat exchangers is controlled by the PBNP GL 89-13 program document (not all GL 89-13 HX's are routinely Bio/Silt Fouling inspected).

Bio/Silt Fouling inspections shall be conducted by an appropriate engineer for the G01/G02 Glycol Coolers (HX-55's) and the PAB Battery Room Coolers (HX-105A/B) as "cleaning and inspecting" is being used to meet GL 89-13 Action Item II for these HX's. Specific records and trending must be maintained for these coolers.

The acceptance criteria shall comply with section 9.3 below. Records of inspection results are to be documented in the WO for the specific heat exchanger. The original Bio/Silt Fouling Inspection Form shall be filed with the work order, with copies being provided to the Biofouling Control Program Administrator, the SW System Engineer, and the HXCAP Engineer.

The SW System Engineer is responsible for trending the results (as per GL 89-13 Program Document).

9.3 Bio/Silt Fouling Acceptance Criteria

The most common acceptance criteria for GL 89-13 heat exchangers is number of effective tubes in service, or counted another way the number of tubes effectively plugged. This demonstrates a pass/ fail on thermal performance when using a known plugging limit and where there is not unusually heavy fouling on the tubes.

Less common is the situation where the amount of heavy fouling or scale on tubes is estimated.

The specifics of how to count plugged tubes, or the effect of various bio/silt fouling is difficult to define up front for all forms of possible bio/silt fouling. Lake Michigan is constantly changing and the bio/silt fouling issues of the future may have no resemblance to the past. To provide for the unknown there are two possible methods which can be followed:

9.3.1 Simple Method of Counting Bio/Silt Fouled Tubes.

This method is typically used when most of the tubes are clear and there are isolated tubes with blockage. Carefully inspect the tubesheet noting the type of bio/silt fouling and the degree to which the bio/silt fouling is blocking water flow down the tube. Count the tube plugged if there is any question on the ability of water to easily flow down the tube compared to an unfouled tube.

Compare the number of tubes counted, and add to the number of permanently plugged tubes. Compare against the known plugging limit for the heat exchanger. Document any fouling that exceeds the plugging limit by CAP.

The Heat Exchanger is to be cleaned prior to return to service unless suitable determination of operability with fouling condition is documented by an SRO.

Engineering may need to perform a previous operability determination depending on the results of this inspection and the SW temperature history.

9.3.2 Specific Bio/Silt Fouling method.

This method is to be used when new fouling issues arise or where the simple method above fails and where there is reasonable cause to expect that the heat exchanger may be operable (such as a general tube fouling issue where there is clearly sufficient water flow through the heat exchanger. Examples are lakeweed matting of the ends of the tubes or certain forms of slime like biofouling).

Carefully study the type of fouling and determine the facts of operation (flow ok, etc), and how the fouling is affecting the heat exchanger (just at the ends, the length of the tubes, etc).

Work out a conservative logical explanation to determine where there is sufficient flow down the tubes, that there is sufficient heat transfer of the tubes (tubes not heavily fouled), and a criteria for determining which tubes are effectively out of service. Get peer review of the method, and supervisor review.

Use the method to count effectively fouled tubes, and compare the number of effective tubes blocked against the plugging limit. Document the method used via Engineering Evaluation or Calculation prior to the HX being declared back in service. Document the results of the inspection in a CAP (at a minimum describe the unusual fouling that occurred and the results of the inspection method).

The Heat Exchanger is to be cleaned prior to return to service unless suitable determination of operability with fouling condition is documented by an SRO.

Engineering may need to perform a previous operability determination depending on the results of this specific inspection method and the SW temperature history.

10.0 PLUGGING OF HEAT EXCHANGER TUBES

10.1 Tube plugging is performed to isolate leaky tubes or to isolate tubes that have the potential to leak in the reasonable future (based on known condition or test indications).

10.2 Tube plugging is a normal maintenance activity and not a modification as long as it does not exceed the plugging limit for the HX. Tube plugging beyond the plugging limit will require evaluation by the modification process.

10.3 A CAP shall be written to document all tube plugging activities. Tube plugging on a Safety Related HX shall not exceed the plugging limit without an evaluation and an operability determination documented by a SRO.

10.4 A-Criteria for Plugging tubes based on ECT, RFT, or IRIS inspection results shall be developed for all heat exchangers prior to inspecting with those technologies. This criteria shall be documented by engineering evaluation or calculation.

10.5 Tube plugging Limits for In-Scope or any Safety Related heat exchangers will be determined before any additional tubes are plugged (legacy plugs, installed prior to 2003 exist in a number of heat exchangers). Tube plugging limits are not required for non-safety related Appendix B heat exchangers (but may be appropriate to use in certain cases).

10.6 Safety Related HX tube plugging limits will be documented via engineering evaluation or calculation except for 1 and 2 tube heat exchangers where logic indicates that there is not an acceptable plugging limit.

10.7 Non-Safety Related HX tube plugging limits will be documented by internal memo, engineering evaluation, or calculation.

10.8 Sources of plugging limit information for commercial quality heat exchangers can be vendor letters, e-mails, etc. General industry "rule of thumb" (5% or 10% depending on the application) can be used in the case of non-safety related HX's in the event that a source of other design information cannot be located.

not complete
not on schedule

10.9 Appendices C, D, and E (Unit 1 Outage, Unit 2 Outage, and Annual Cycle inspection schedules) shall contain tables of HX tube plugging limits and the known number of tube plugged for both In-Scope and Other not inspected plant heat exchangers.

11.0 PROGRAM IMPLEMENTATION

11.1 Inspections are to be normally conducted in accordance with the inspection schedules in appendices C, D, and E (Unit 1 Outage, Unit 2 Outage, and Annual Cycle inspection schedules).

11.2 This program document shall be reviewed annually and updated if appropriate. The review shall include a verification of all active HX equipment numbers to ensure that the equipment list in appendices A & B are correct.

11.3 Appendices C, D, and E, which are issued separately, shall be updated in accordance with their cycle schedule listed in section 3 of each appendix.

11.4 Reports shall be issued to the appropriate PBNP management and system engineers after the completion of the cycle schedule for appendices C, D, E containing a list of inspections performed over the cycle, the results, and recommended actions

11.5 Inspections shall be implemented by use of the normal PM process, including working within acceptable schedule limits and subject to deferral under the established PM deferral processes. Specific PM's used are listed in appendices C, D, and E (Unit 1 Outage, Unit 2 Outage, and Annual Cycle inspection schedules). (B: 16.10)

11.6 Changes to PM intervals shall be communicated back to the HXCAP engineer via procedure feedback form (PBF-0026p) to be included in the next update of the appropriate appendix. The HXCAP Engineer shall create a Ttrack PCR action item request with the details of the required changes.

11.7 Nothing in this program shall prevent the HXCAP engineer from scheduling special test or additional test more frequently than the scheduled PM if there is a concern with the condition of a heat exchanger, or from expanding the sample size on larger heat exchangers if there is an opportunity to test additional tubes at minimal cost. Additional or special inspections may be implemented by Work Order. (B: 16.10)

11.8 All Service Water Cooled heat exchangers shall be visually inspected after opening and after cleaning for degradation of the channel, tubesheet, cover, and any epoxy coating. The "Visual Inspection of Heat Exchanger Condition" (PBF-7060) form is to be filled out and filed with the work-order to document results, with a copy sent to the HXCAP Engineer. Pictures are to be taken of any unusual degraded conditions noted and copies forwarded to the HXCAP Engineer. A CAP shall be written for newly identified or unusual degradation (the Visual Inspection of Heat Exchanger form should have known conditions from previous inspections listed on it prior to any scheduled inspection). This inspection may be performed by the lead maintenance mechanic.

12.0 TUBE DEGRADATION TESTING: DATA GATHERING & ANALYSIS

12.1 Testing shall be done with qualified procedure that includes criteria for calibration, test method, inspection speed (where relevant), analysis method, and reporting criteria.

12.2 Data gathering and analysis personnel shall be trained on the proper technique and typical flaws identifiable with the test method.

12.3 Calibration of test equipment shall be made using appropriate calibration standards for the test method being used.

12.4 Existing tube numbering systems shall be maintained to maintain consistency of acquired data for comparison and trending.

12.5 Analysis and reporting shall consider previous equipment history and previous test results if available.

12.6 Periodic progress reports shall be provided to appropriate PBNP supervision, support groups, and system engineers for multi-day inspections (Type of reports and frequency based on managements needs).

12.7 If possible, the final test results should be provided in an electronic data form that is importable into the heat exchanger tube condition database. Contractor personnel may be asked to build necessary tube maps, set up appropriate databases, and import test data into the database as part of their responsibilities.

12.8 If possible, original data and copies of reports shall be provided in CD optical disc form to the HXCAP Engineer at the conclusion of the exam.

12.9 Preliminary reports, with significant changes or situations and recommendations on tube plugging shall be provided to PBNP prior to any inspection contractor leaving site.

13.0 EQUIPMENT PROGNOSES

13.1 Results shall be analyzed considering the equipment history, trends, changes in trends, and for unusual or unexpected results to enhance future inspections or to initiate actions for additional inspection, retube, or replacement. Inspection results, and the conclusions about them, are to be recorded into the equipment history section of appendices C, D or E on the next revision of that appendix.

13.2 Any indications exceeding the plugging criteria for that heat exchanger shall be evaluated and, if appropriate, plugged prior to closing the system.

13.3 Tube samples shall be taken for any major plant critical heat exchanger showing unusual defect indications in multiple tubes that are not typical of common degradation mechanisms for that heat exchanger, and may be taken for any heat exchanger with unknown degradation cause. This will allow the determination of the defect cause and provide data for life estimation of the heat exchanger.

13.4 Appropriate system engineers, supervisors, and management shall be notified should any recommended plugging exceed the existing plugging limit.

14.0 REMAINING LIFE CALCULATION

14.1 Remaining life calculations will be performed on any heat exchanger where there is a comparable inspection technique data set, and indications of degradation in the heat exchanger.

14.2 Remaining life calculations shall be classified Not-Applicable (N/A) if there is no previous comparable data set from which to work from, and shall be classified as No Degradation Detected (NDD) for cases where there is no evidence to support a degradation rate.

14.3 Remaining life for tube degradation shall be done in accordance with EPRI methods, with the exception that the maximum HX life predicted should be reported as >30 years. The reason for this change from EPRI methods is that otherwise the equations can generate "expected" heat exchanger life's in the hundreds, and even thousands, of years; which is not realistic.

14.4 Remaining life calculations are valid only for the degradation mode being trended. It is quite possible to predict a long remaining life due to, for example, pitting growth and then have fatigue cracking, or another problem, become apparent in the heat exchanger (the reason for continuing to look at a heat exchanger periodically even when there is no evidence of past problems). Separate remaining life calculations must be done for each type of degradation identified in a heat exchanger.

15.0 REFERENCES

15.1 NMC CD 5.9: Eddy Current Implementation Standard, issued March 27, 2002

15.2 GL 89-13 Program Document, issued September 18, 2001

15.3 EPRI TR106741s: Heat Exchangers: An Overview of Maintenance and Operations, issued March 1997

15.4 EPRI TR1008009: Balance-of-Plant Heat Exchanger Condition Assessment and Inspection Guide, issued December 1999

16.0 BASES

16.1 CA001250 (CR 01-1006 / CAP000540) & Apparent Cause:

- Develop a basis document for ECT of HX's.
- History of HX's & Inspection Schedules.
- Classify HX's into tested and not tested list.
- Define how work is deferred.
- Explain Sample plan for larger HX's, and need to test other tubes (or sweep them).
- Limits of technologies for the different tube types.
- Degradation mechanism (why HX's fail, typical life).

16.2 CA002545 (CAP001369):

- Plugging limits, records, and criteria for SR HX's.
- Plugging "Normal maintenance activity."

16.3 CA003219 (CAP001352):

- Acceptance Criteria for bio/silt fouling.
- Which HX's should be tracked for "As Found" conditions.
- Procedures and Record Keeping requirements.

16.4 CA003642 (CAP001998):

- NNC Gap Analysis – Program deficient in 6 areas.

16.5 CA26059 (CAP003257):

- Identify in program document which HX's need to be tracked for Circ Cracks.

16.6 CA026294 (CAP029275):

- Classify program document as Controlled Reference (under NP1.1.2).

16.7 CA026995 (CAP028885):

- List in program document which inspections we do to support GL 89-13.

16.8 CA029936 (CAP032951):

- MIC Concerns with 304SS.

16.9 CA031079 (CAP033440):

- Excellence Plan: Bring program document up to fleet standards.

16.10 CA031080 (CAP033440):

- Excellence Plan: Issue implementing procedures as needed.

HX-01

HEAT EXCHANGER CONDITION ASSESSMENT PROGRAM

APPENDIX A

IN SCOPE HEAT EXCHANGERS

1.0 UNIT 1 HEAT EXCHANGERS

1.1 Downpower/Shutdown to fix Unit 1 Heat Exchangers (inspectable with normal NDE).

SC-1A/B	MAIN CONDENSER (WATERBOXES 1-4)
HX-003A/B	NON-REGENERATIVE HEAT EXCHANGERS
HX-005	SEAL WATER HEAT EXCHANGER
HX-011A/B	RESIDUAL HEAT REMOVAL HEAT EXCHANGERS
HX-017A/B	LP FEEDWATER HEATER 1A/2A & 1B/2B
HX-019A/B	LP FEEDWATER HEATER 3A/B
HX-020A/B	LP FEEDWATER HEATER 4A/B
HX-021A/B	HP FEEDWATER HEATER 5A/B
HX-024	CONDENSATE COOLER
HX-027	BUS COOLING UNIT
HX-046A/B	AIR EJECTOR INTER & AFTER CONDENSERS
HX-048	GLAND STEAM CONDENSER
HX-051A/B/C/D	GENERATOR HYDROGEN COOLERS
HX-052	EXCITER COOLER
HX-053A/B	HYDROGEN SEAL OIL COOLERS
HX-056A/B	P-28A/B SGFP OIL COOLERS
HX-225A/B	P-1A/B RCP MOTOR UPPER OIL COOLERS

Ex. 4

2.0 UNIT 2 HEAT EXCHANGERS

2.1 Downpower/Shutdown to fix Unit 2 Heat Exchangers (inspectable with normal NDE).

SC-1A/B	MAIN CONDENSER (WATERBOXES 1-4)
HX-003A/B	NON-REGENERATIVE HEAT EXCHANGERS
HX-005	SEAL WATER HEAT EXCHANGER
HX-011A/B	RESIDUAL HEAT REMOVAL HEAT EXCHANGERS
HX-017A/B	LP FEEDWATER HEATER 1A/2A & 1B/2B
HX-019A/B	LP FEEDWATER HEATER 3A/B
HX-020A/B	LP FEEDWATER HEATER 4A/B
HX-021A/B	HP FEEDWATER HEATER 5A/B
HX-024	CONDENSATE COOLER
HX-027	BUS COOLING UNIT
HX-046A/B	AIR EJECTOR INTER & AFTER CONDENSERS
HX-048	GLAND STEAM CONDENSER
HX-051A/B/C/D	GENERATOR HYDROGEN COOLERS
HX-052	EXCITER COOLER
HX-053A/B	HYDROGEN SEAL OIL COOLERS
HX-056A/B	P-28A/B SGFP OIL COOLERS
HX-225A/B	P-1A/B RCP MOTOR UPPER OIL COOLERS

outside scope
Ex. 4

3.0 COMMON PLANT HEAT EXCHANGERS

Ex. 4

HX-01

HEAT EXCHANGER CONDITION ASSESSMENT PROGRAM

APPENDIX B

NO SCHEDULED INSPECTIONS RUN TO FAILURE HEAT EXCHANGERS

1.0 UNIT 1 HEAT EXCHANGERS

1.1 Not testable Downpower/Shutdown to fix Unit 1 Heat Exchangers.

HX-002	REGENERATIVE HEAT EXCHANGER
HX-004	EXCESS LETDOWN HEAT EXCHANGER
HX-246A/B	X-01-A MAIN POWER TRANSFORMER OIL COOLERS
HX-247A/B/C	X-01-B MAIN POWER TRANSFORMER OIL COOLERS
HX-248A/B/C	X-01-C MAIN POWER TRANSFORMER OIL COOLERS
HX-249A/B	X-02 UNIT AUXILIARY TRANSFORMER OIL COOLERS
HX-250A1/A2/A3/A4	X-04 LV STATION AUX XFMR OIL COOLERS
HX-250B1/B2/B3/B4	X-04 LV STATION AUX XFMR OIL COOLERS

1.2 Not testable or not considered economical to test Unit 1 Plant Heat Exchangers.

HX-014A/B/C	SAMPLE HEAT EXCHANGERS
HX-016A1/A2/A3/A4	PURGE SUPPLY PREHEATING COILS
HX-016B1/B2/B3/B4	PURGE SUPPLY HEATING COILS
HX-030A1/A2/A3/A4	CONTAINMENT CAVITY COOLING COILS
HX-030B1/B2/B3/B4	CONTAINMENT CAVITY COOLING COILS
HX-037A/B	P-14A/B CONT SPRAY PUMP SEAL WATER HEAT EXCHANGERS
HX-057A1 THRU A5 HX-057A5-1 THRU A5-8	SAMPLE HEAT EXCHANGERS
HX-059A/B	HX-1A/1B SG BLOWDOWN SAMPLE HEAT EXCHANGERS
HX-084A/B	P-25A/B CONDENSATE PUMP MOTOR COOLERS
HX-114A/B	P-10A/B RHR PUMP SEAL WATER HEAT EXCHANGERS
HX-130A/131A/132A 133A/134A/135A	LETDOWN GAS STRIPPER HEAT EXCHANGERS
HX-176A/B	P-15A SI PUMP SEAL WATER HEAT EXCHANGERS
HX-179A/B	P-15B SI PUMP SEAL WATER HEAT EXCHANGERS
HX-268	C-198 CORROSION PRODUCT MONITOR PANEL SAMPLE COOLER
HX-352A/B	P-1A/1B RCP MOTOR LOWER OIL COOLERS
HX-353A/B	P-1A/1B RCP THERMAL BARRIER HEAT EXCHANGERS

1.3 HVAC or Electric Heater

HX-057B1	SECONDARY SAMPLING CONDENSER
HX-057B2	SECONDARY SAMPLING CHILLER
HX-062	CONT FAÇADE ELEV FIRE DETECTION EQUIP ELECT HTR
HX-067	UNIT 1 FACADE ELEVATOR MACHINE ROOM UNIT HEATER/MOTOR
HX-068	UNIT 1 FACADE STAIRWELL UNIT HEATER/MOTOR
HX-069	UNIT 1 FACADE PUMP ROOM UNIT HEATER/MOTOR
HX-070	UNIT 1 ELECTRICAL EQUIPMENT ROOM COOLING COIL
HX-071A-E/ 071-G/H/J/K	TURBINE BLDG 1 INDUSTRIAL HEATERS
HX-071A-M THRU D-M/G-M/H-M/J-M/K-M	TURBINE BLDG 1 INDUSTRIAL HEATER MOTORS
HX-072	TURBINE BLDG 1 OVERHEAD DOOR UNIT HEATER/MOTOR
HX-077A/B/C	UNIT 1 PIPEWAY HEATER/MOTORS
HX-081A/B/C/D	UNIT 1 FAN RM HEATER/MOTORS
HX-082A/B	NON-NUCLEAR ROOM UNIT HEATER/MOTORS
HX-090	ELECTRICAL EQUIPMENT ROOM HEATING COIL
HX-104/104-M	RE-211/212 U1C SAMPLING CUBICLE UNIT HEATERS
HX-259	RK-74A/B ANION/CATION ION CHROMATOGRAPH AC
HX-377	C-198 CORROSION PRODUCT MONITOR PANEL CHILLER

2.0 UNIT 2 HEAT EXCHANGERS

2.1 Not testable Downpower/Shutdown to fix Unit 2 Heat Exchangers.

HX-002	REGENERATIVE HEAT EXCHANGER
HX-004	EXCESS LETDOWN HEAT EXCHANGER
HX-246A/B/C	X-01-A MAIN POWER TRANSFORMER OIL COOLERS
HX-247A/B/C	X-01-B MAIN POWER TRANSFORMER OIL COOLERS
HX-248A/B	X-01-C MAIN POWER TRANSFORMER OIL COOLERS
HX-249A/B	X-02 UNIT AUXILIARY TRANSFORMER OIL COOLERS
HX-250A1 THRU A4	X-04 LV STATION AUX XFMR OIL COOLERS
HX-250B1 THRU B4	X-04 LV STATION AUX XFMR OIL COOLERS

2.2 Not considered economical to test or not testable Unit 2 Plant Heat Exchangers.

HX-014A/B/C	SAMPLE HEAT EXCHANGERS
HX-016A1-A4	PURGE SUPPLY PREHEATING COILS
HX-016B1-B4	PURGE SUPPLY HEATING COILS
HX-030A1-A4	CONTAINMENT CAVITY COOLING COILS
HX-030B1-B4	CONTAINMENT CAVITY COOLING COILS
HX-037A/B	P-14A/B CONT SPRAY PUMP SEAL WATER HX's
HX-057A1 THRU A5 & B	SAMPLE HEAT EXCHANGERS
HX-057A5-1 THRU A5-8	SAMPLE HEAT EXCHANGERS
HX-059A/B	HX-1A/1B SG BLOWDOWN SAMPLE HEAT EXCHANGERS
HX-084A/B	P-25A/B CONDENSATE PUMP MOTOR COOLERS
HX-114A/B	P-10A/B RHR PUMP SEAL WATER HEAT EXCHANGERS
HX-130B THRU 135B	LETDOWN GAS STRIPPERS
HX-176A/B	P-15A SI PUMP SEAL WATER HEAT EXCHANGERS
HX-179A/B	P-15B SI PUMP SEAL WATER HEAT EXCHANGERS
HX-268	C-198 CORROSION PRODUCT MONITOR SAMPLE COOLER
HX-352A/B	P-1A/B RCP MOTOR LOWER OIL COOLERS
HX-353A/B	P-1A/B RCP THERMAL BARRIER HEAT EXCHANGERS

2.3 HVAC or Electric Heater

HX-057B1	SECONDARY SAMPLING CONDENSER
HX-057B2	SECONDARY SAMPLING CHILLER
HX-067	UNIT 2 FACADE ELEVATOR MACHINE ROOM HEATER
HX-068	UNIT 2 FACADE STAIRWELL UNIT HEATER/MOTOR
HX-069	UNIT 2 FACADE PUMP ROOM UNIT HEATER/MOTOR
HX-070	UNIT 2 ELECTRICAL EQUIPMENT ROOM COOLING COIL
HX-071A-D/G/H/J-M/P/Q/R	& HX-071A-M THRU D-M/ G-M/H-M/J-M THRU M-M TURBINE BLDG 2 INDUSTRIAL HEATER MOTORS
HX-072	TURBINE BLDG 2 OVERHEAD DOOR UNIT HEATER/MOTORS
HX-077A/B/C	UNIT 2 PIPEWAY HEATER/MOTORS
HX-081A-D	EL 66' UNIT 2 FAN RM UNIT HEATER/MOTORS
HX-082A/B	NON-NUCLEAR ROOM UNIT HEATER/MOTORS
HX-090	ELECTRICAL EQUIPMENT ROOM HEATING COIL
HX-104/104-M	RE-211/212 U2C SAMPLING CUBICLE UNIT HEATERS
HX-259	RK-74A/B ANION/CATION ION CHROMATOGRAPH AC
HX-377	C-198 CORROSION PRODUCT MONITOR PANEL CHILLER

3.0 COMMON PLANT HEAT EXCHANGERS

3.1 Not testable Downpower/Shutdown to fix PBO Heat Exchangers

None.

3.2 Not considered economical to test or not testable Common Plant (PB0) heat exchangers.

HX-006A/B	U1 BORON RECYCLE GAS STRIPPER HEAT EXCHANGER
HX-007A/B	GAS STRIPPER PREHEATER
HX-008A/B	U1 BORIC ACID EVAPORATORS
HX-009A/B	HX-8A/B EVAPORATOR CONDENSATE HX's
HX-010A/B	BORIC ACID EVAP DISTILLATE COOLER HX's
HX-025	WASTE EVAPORATOR
HX-026	HX-25 WASTE EVAPORATOR HOT WATER CONVERTER
HX-049A/B	K-2A/B IA COMPRESSOR AFTERCOOLER
HX'sHX-050A/B	K-3A/B SERVICE AIR COMPRESSOR AFTERCOOLER HX
HX-094	HX-25 WASTE EVAPORATOR DISTILLATE COOLER
HX-137A/B	CRYOGENIC DEOXO AFTERCOOLERS
HX-138A-D	CRYOGENIC WATER COOLED GAS SEPARATORS
HX-139	CRYOGENIC WATER CHILLER
HX-140	BLOWDOWN EVAPORATOR (this is not a tube & shell HX)

Note: Future of Blowdown Evap is unknown: Abandon or replace study underway.

HX-142	BLOWDOWN EVAPORATOR OVERHEAD CONDENSER
HX-143	BLOWDOWN EVAPORATOR DISTILLATE COOLER
HX-144	BLOWDOWN EVAPORATOR REBOILER
HX-145	BLOWDOWN EVAPORATOR BOTTOMS COOLER
HX-146	BLOWDOWN EVAP BOTTOMS COOLER PREHEATER
HX-148A/B	CRYOGENIC PROCESS GAS PREHEATERS
HX-149	CRYOGENIC REGEN NITROGEN GAS HEATER
HX-151	BLOWDOWN EVAPORATOR SAMPLE COOLER
HX-177A/B	K2A/B IA COMPRESSOR INTERCOOLER
HX-225A/B SPARE	SPARE 1/2HX-225A/B RCP MOTOR UPPER OIL COOLERS
HX-244	BLOWDOWN EVAPORATOR VENT CONDENSER
HX-262A/B	G-03/04 EDG AFTERCOOLERS
HX-265A/B	G-03/04 EDG RADIATORS
HX-266A/B	G-03/04 EDG LUBE OIL COOLERS
HX-352A/B SPARE	SPARE 1/2HX-352A/B RCP MOTOR LOWER OIL COOLERS

HX-504	G-05 GT GENERATOR GLYCOL COOLER
HX-506A/B	G-05 GT GENERATOR AIR COOLERS

3.3 HVAC, Potable Water, or Electric Heater

HX-028	SOUTH SERVICE BLDG AC CHILLER
HX-028A/B SPARE	SPARE SSB/TBO AC CHILLER/MOTORS
HX-028A1/A2 & A3/A4	SOUTH SERVICE BLDG AC CHILLER/MOTORS
HX-028B & B1/B2	TURBINE BLDG OFFICE AC CHILLER/MOTORS
HX-031A1-A4	PAB STEAM PREHEATERS
HX-031B1-B4	PAB STEAM HEATERS
HX-031C1-C4	PAB STEAM HEATERS
HX-032A/B	PAB COOLING COILS
HX-033A/B	G-01/02 EDG LUBE OIL HEATERS
HX-034	SSB CONTRACTOR'S OFFICE ELECTRIC UNIT HEATER
HX-035A1-A4	DRUMMING AREA STEAM PREHEAT COILS
HX-035B1-B4	DRUMMING AREA STEAM HEATING COILS
HX-036	POTABLE WATER HEATER
HX-038A & A1/A2 & A3/A4	CABLE SPREADING ROOM AC UNITS
HX-038B/ & B1/B2 & B3/B4	CONTROL ROOM AIR CONDITIONING UNITS
HX-039A/B	SOUTH SERVICE BLDG COOLING COILS
HX-040A	TURBINE BLDG OFFICE HOT WATER CONVERTER
HX-040B	CR/CSR/SSB HOT WATER CONVERTER
HX-041	TURBINE BLDG OFFICE HEATING COIL
HX-042A/B	SOUTH SERVICE BLDG AC HEATING COILS
HX-043A1/A2/B1/B2	SOUTH SERVICE BLDG FAN HEATING COILS
HX-044	SOUTH SERVICE BLDG CHILLED WATER COIL
HX-045	TURBINE BLDG OFFICE CHILLED WATER COIL
HX-060A/B/C	SEC COMPUTER MULTIPLEXER AIR CONDITIONERS
HX-061	SOUTH CLEAN LOCKER RM ELECTRIC DUCT HEATER
HX-065A/B	G-01 EDG ROOM INDUSTRIAL HEATERS
HX-065A-M/B-M	G-01 EDG ROOM INDUSTRIAL HEATER MOTORS
HX-066/A	AUX FEED PUMP ROOM COOLERS
HX-073A-H/J/K	TURB BLDG OFFICE AREA HOT WTR CONVECTOR HTR
HX-074A-G	SSB CAFETERIA HOT WATER CONVECTOR HEATERS
HX-075A/B	CAUSTIC TANK AREA UNIT HEATER/MOTORS
HX-078/078-M	AIR COMPRESSOR RM INDUSTRIAL HEATERS

HX-079/80A/B	WT AREA COOLING COILS
HX-083AB/C	EL 8' PAB FAN ROOM UNIT HEATER/MOTORS
HX-085A/B	DRUMMING AREA UNIT HEATER/MOTORS
HX-086A/B	PAB TRUCK ACCESS INDUSTRIAL HEATER
HX-086A-M/B-M	PAB TRUCK ACCESS INDUSTRIAL HEATER MOTOR
HX-087	COMBINED AIR EJECTORS DELAY DUCT FILTER HEATER
HX-088	CTLD SIDE MTN SHOP OVERHEAD DOOR UNIT HEATER
HX-089A/B	HEATING BOILER ROOM UNIT HEATER/MOTORS
HX-091A/B	CONTROL ROOM WATER DUCT HEATERS
HX-092	COMPUTER ROOM WATER DUCT HEATER
HX-093A/B	CSR WATER DUCT HEATERS
HX-095A/B	CAUSTIC DILUTION WATER HEATERS
HX-097A/B	PAB COVERED WALKWAY UNIT HEATER/MOTORS
HX-098	RESIDUAL HEAT REMOVAL PUMP AREA COOLING COIL
HX-099	CONTAINMENT SPRAY PUMP AREA COOLING COIL
HX-100A/B	CONTROL ROOM CHILLED WATER COOLING COILS
HX-101A/B	CSR CHILLED WATER COOLING COILS
HX-102A-D	FOPH ELECTRIC UNIT HEATERS
HX-107A	K-7 CR TEMP CTL STANDBY AIR COMPAFTERCOOLER HX
HX-107B	TSC REFRIGERATED AFTERCOOLER HX
HX-107C	SBCC REFRIGERATED AFTERCOOLER HX
HX-107D	MTN BLDG OFFICE REFRIGERATED AFTERCOOLER HX
HX-108A	SEWAGE TREATMENT PLANT ELECTRIC UNIT HEATER
HX-108B	SEWAGE TREATMENT PLANT ELECTRIC UNIT HEATER
HX-109	PAB TRUCK ACCESS ELECTRIC UNIT HEATER
HX-111	SOUTH GATEHOUSE ELECTRIC UNIT HEATER
HX-115-117	CABINET HEATERS
HX-118-119	DUCT HEATERS
HX-121	EXT BLDG SEC COMPUTER RM/CAS PRIMARY AC
HX-122-123	WALL HEATERS
HX-125A	EXT BLDG FIRST FLOOR AIR HANDLER
HX-125B	EXT BLDG FIRST FLOOR MIDDLE CONDENSER
HX-127	SOUTH GATEHOUSE ELECTRIC BASEBOARD HEATER
HX-128C	SOUTH GATEHOUSE CABINET HEATER
HX-136	DI WATER HEATER
HX-141A	TSC ADMIN AREA COOLING COIL
HX-141B	TSC ADMIN AREA BACKUP COOLING COIL

HX-141C	TSC ADMIN RECORDS AREA COOLING COIL
HX-152A/C	CRYOGENIC REFRIGERATION UNITS
HX-153-159	ELECTRIC CONVECTORS (BB-4 THRU BB-8/ BB-1/2)
HX-160A/B	TSC OFFICE ELECTRIC HEATER COILS COIL #2
HX-161A/B	TSC ELECTRIC HEATERS
HX-162	TSC BACKUP AC PANEL (AHU-2)
HX-163	TSC NORTH EMERGENCY AIR SUPPLY PREHEATER
HX-164	TSC EL 8' SAMPLE RM/LAB ELECTRIC HTR COIL #4
HX-165	TSC ELECTRIC HEATER ACCIDENT FILTERS
HX-166A/B/C	TSC LOCAL UNIT HEATERS
HX-167A/B/C	CLEAN SIDE MTN SHOP NORTH CEILING HEATERS
HX-168A/B	SEWAGE TREATMENT PLANT UNIT HEATERS
HX-169A/B	MTN BLDG OFFICE AIR HANDLING UNIT FANS
HX-169C	CLEAN SIDE MTN SHOP AIR HANDLING UNIT FANS
HX-170	MTN BLDG OFFICE ELECTRIC CONVECTOR HEATER
HX-171	CLEAN SIDE MTN SHOP CABINET HEATER (CH-1)
HX-172	CLEAN SIDE MTN SHOP STAIRWELL CABINET HEATER
HX-175A/B/C/D	SOUTH GATEHOUSE UPPER BASEBOARD HEATERS
HX-177A/B	K-2A/2B IA COMPRESSOR INTERCOOLER HX
HX-180	SBCC MECH RM HEATING BOILER
HX-181	SBCC AIR COOLED WATER CHILLER
HX-182	SBCC GLYCOL DRY COOLER (RADIATOR)
HX-183	SBCC AIR HANDLING UNIT
HX-184/185/186	SBCC RM 101 STAGING AREA HEATERS
HX-187A THRU K	SBCC STAGING AREA HEATERS
HX-188	SBCC EOF ROOM WATER HEATER
HX-189	SBCC MECHANICAL RM WATER HEATER
HX-190A/B	SUPPLEMENTAL COMPUTER ROOM AIR CONDITIONERS
HX-191A/B	SUPPLEMENTAL AIR CONDITIONING CONDENSING UNITS
HX-194	Z-46 GAS ANALYZER SAMPLE COOLER
HX-194A	Z-46 GAS ANALYZER REGENERATIVE HEAT EXCHANGER
HX-195A/B/C/D	WAREHOUSE #3 SOUTHWEST OVERHEAD HEATERS
HX-196	TELEPHONE EQUIPMENT ROOM AIR CONDITIONER
HX-197D	W-126D SGH ELECTRIC UNIT HEATER (EUH-6)
HX-199A/B	COMPUTER ROOM AIR CONDITIONER HEAT EXCHANGERS
HX-200	HX-234 NSB 3RD FLOOR CHILLED WATER COOLING COIL
HX-201	HX-234 NSB 4TH FLOOR CHILLED WATER COOLING COIL

HX-202	HX-234 NSB 5TH FLOOR CHILLED WATER COOLING COIL
HX-203	NSB RM 312ELECTRIC DUCT HEATERS (EH-1)
HX-204	NSB RM 516 ELECTRIC DUCT HEATER (EH-2)
HX-205B-H/J/K/N-S	NSB RM ELECTRIC UNIT HEATERS
HX-206A-H/J-T	NSB RM ELECTRIC BOOSTER COILS
HX-207A-E/G/J/L-T	NSB RM ELECTRIC BASEBOARD HEATERS
HX-207F1 THRU F8	NSB RM ELECTRIC BASEBOARD HEATERS
HX-207H1/2	NSB RM ELECTRIC BASEBOARD HEATERS
HX-207K1/2	NSB RM ELECTRIC BASEBOARD HEATERS
HX-207/U1/U2	NSB RM ELECTRIC BASEBOARD HEATERS
HX-208A/B	NSB RM ELECTRIC WALL HEATER (EWH-1, 2)
HX-208C	NSB CORRIDOR 300 ELECTRIC CEILING HEATER (CH-1)
HX-210A/B/C	H-02/01/03 SWGR RM AIR CONDITIONER UNITS
HX-211A THRU 211F	H-02 SWGR RM HEATER UNITS
HX-212	NORTH GATEHOUSE AIR COOLED WATER CHILLER
HX-213A/B/C/D/E	NORTH GATEHOUSE AIR CONDITIONING FAN COILS
HX-214A/B	NORTH GATEHOUSE WALL AIR CONDITIONERS
HX-215	SGSF PORTABLE HEATER
HX-216A/B/C	CATION SAMPLE HEAT EXCHANGERS
HX-217A/B/C	ANION 2/3 BED SAMPLE HEAT EXCHANGERS
HX-218A/B/C	ANION EFFLUENT SAMPLE HEAT EXCHANGERS
HX-219A/B	MIXED BED EFFLUENT SAMPLE HEAT EXCHANGERS
HX-220A-220S/220U/V	NSB VAV REHEAT BOXES
HX-221	SAS AIR CONDITIONING UNIT
HX-222	C-217 WT SAMPLE CONTROL PANEL TEMPERING HX
HX-223A/B	BATTERY ROOM HEATERS
HX-224	CAS BACKUP AIR CONDITIONING UNIT
HX-226	NITROUS OXIDE HEATER
HX-227A/B	CSB-1 CHEMICAL STORAGE BUILDING WEST HEATERS
HX-228A/B	CSB-2 CHEMICAL STORAGE BUILDING WEST HEATERS
HX-229A/B	CSB-3 CHEMICAL STORAGE BUILDING WEST HEATERS
HX-230A-230H/230J-0	NSB VARIABLE AIR VOLUME BOXES
HX-231/232	EXT BLDG RM 121/123 MSF ELECTRIC WALL HEATERS
HX-233A	EXT BLDG MSF/NORTH LOCKER RM HEATING COIL
HX-233B	EXT BLDG MSF/NORTH LOCKER RM AC CONDENSING UNIT
HX-234	NSB WATER CHILLER
HX-235A THRU H	SSB ELECTRIC DUCT HEATERS

HX-236A/B	SSB ELECTRIC UNIT HEATERS
HX-237A/B	SSB ELECTRIC UNIT HEATERS
HX-238	WAREHOUSE #4 OFFICE AIR HANDLING UNIT
HX-239	WAREHOUSE #4 OFFICE AIR CONDITIONING UNIT
HX-240	SOUTH SERVICE BLDG AIR CONDITIONING UNIT
HX-241A/B/C	SSB RM ELECTRIC WALL HEATERS (
HX-242A-H/J-K	SSB RM ELECTRIC BASEBOARD HEATERS
HX-243A/B	D-105/D-106 PAB BATTERY ROOM DUCT HEATERS
HX-245A	OPS BLDG AIR HANDLING UNIT
HX-245B/C	OPS BLDG COOLING COILS
HX-251	SOUTH GATEHOUSE RADIANT HEAT PANEL
HX-252A/B	POTABLE WATER WELLHOUSE ELECTRIC HEATERS
HX-253A-F	NSB RM ELECTRIC BOOSTER COILSOIL (EBC-3)
HX-254A/B	NSB RM 512 AIR CONDITIONERS
HX-255A/B	HX-254A NSB RM 512 AC DRY COOLER UNITS
HX-256	NSB RM 602 AIR CONDITIONING CONDENSING UNIT
HX-257	NSB RM 602 AIR CONDITIONING FAN COIL UNIT
HX-258	TELEPHONE EQUIPMENT RM AC UNIT
HX-260	ANION OUTLET CHLORIDE ANALYZER CHLR/MTR
HX-261	MB OUTLET CHLORIDE ANALYZER CHILLER/MTR
HX-263A/B/C/D/E/F	WAREHOUSE #4 OFFICE ELECTRIC BASEBOARD HEATERS
HX-264A/B	SGSF ELECTRIC UNIT HEATERS
HX-267A/B	G-03 EDG COOLANT IMMERSION HEATERS
HX-269	DGB AIR HANDLING UNIT
HX-270	DGB AIR CONDITIONING CONDENSER UNIT
HX-271A/B	G-01/G-02 EDG FOTP RM UNIT HEATERS
HX-271C/D/E/F	G-03 EDG RM UNIT HEATERS
HX-271G/H	DGB MECHANICAL EQUIPMENT RM UNIT HEATERS
HX-272A/B	G-04 EDG FOTP/DAY TANK RM UNIT HEATER
HX-272C/D/E/F	G-04 EDG RM UNIT HEATERS
HX-274A/B	POTABLE WATER WELLHOUSE PROPANE GAS HEATERS
HX-275A/B	WAREHOUSE #4 OFFICE ELECTRIC UNIT HEATERS
HX-275C/D/E/F/G/H/J	WAREHOUSE #4 ELECTRIC UNIT HEATERS
HX-277A/B	BUTLER BLDG OVERHEAD DOOR AREA EAST HEATERS
HX-278	SGSF AIR HANDLING UNIT
HX-279	WAREHOUSE #3 HEATING/AIR CONDITIONING UNIT
HX-280A	PARKUT-6652 UNIT AIR CONDITIONER

HX-281	D-305/1/2D-205 STN BATTERY RM AIR HANDLING UNIT
HX-281A	D-305/1/2D-205 STN BATTERY RM AC UNIT
HX-281B	D-305/1/2D-205 STN BATTERY RM HEATER
HX-281C	D-305/1/2D-205 SWING/STN BATT RM CONDENSER UNIT
HX-282	SWITCHBOARD CHARGER RM AIR HANDLING UNIT
HX-282A	SWITCHBOARD CHARGER RM AIR CONDITIONING UNIT
HX-282B	SWITCHBOARD CHARGER RM CONDENSER UNIT
HX-283A/B	CSB-4 NORTH CHEMICAL STORAGE BLDG SOUTH HEATERS
HX-284A/B	CSB-5 NORTH CHEMICAL STORAGE BLDG SOUTH HEATERS
HX-285	EXT BLDG SECOND FLOOR AIR CONDITIONER UNIT
HX-286A	NSB RM 120 ELECTRIC BOOSTER COIL (EBC-1)
HX-286B	NSB RM 118/119 ELECTRIC BOOSTER COIL (EBC-2)
HX-288	OPS SHOP AIR HANDLING UNIT
HX-289A/B	OPS SHOP ELECTRIC DUCT HEATER
HX-290	OPS SHOP AIR CONDITIONING CONDENSER
HX-291	WATER TREATMENT EFFLUENT SAMPLE HEAT EXCHANGER
HX-292A/B	WAREHOUSE #1 GARAGE PROPANE HEATER
HX-293	SSB UTILITY RM RADIANT CEILING HEATER (RCP-1)
HX-294/295	LETDOWN GAS STRIPPER BLDG B/A HEATER
HX-296	BLOWDOWN EVAPORATOR BLDG HEATER
HX-297A/B/C/D/E	TRANSPORTER STORAGE BLDG ELECTRIC UNIT HEATER
HX-298	CASK REFLOODING REFLOOD HEAT EXCHANGER
HX-299	WCC HEATING/AIR CONDITIONING UNIT
HX-300	NORTH WELLHOUSE ELECTRIC UNIT HEATER
HX-301A/B/C/D	ISFSI SECURITY BLDG ELECTRIC UNIT HEATER
HX-302A/B	ISFSI SECURITY BLDG HEATING/AC UNIT
HX-303	WAREHOUSE #1 OFFICE NORTH HEATING/AC UNIT
HX-304	WAREHOUSE #1 OFFICE SOUTH HEATING/AC UNIT
HX-305	WAREHOUSE #1 OFFICE ELECTRIC BASEBOARD HEATER
HX-306	WAREHOUSE #1 OFFICE ELECTRIC BASEBOARD HEATER
HX-307	WAREHOUSE #1 OFFICE ELECTRIC BASEBOARD HEATER
HX-308	WAREHOUSE #1 OFFICE ELECTRIC CEILING HEATER
HX-309	WAREHOUSE #1 MALE WASHROOM ELECTRIC HEATER
HX-310	WAREHOUSE #1 FEMALE WASHROOM ELECTRIC HEATER
HX-311	WAREHOUSE #1 OFFICE ELECTRIC CEILING HEATER
HX-312	CLEAN SIDE MTN SHOP AIR CONDITIONER
HX-313	SOUTH GATEHOUSE HVAC UNIT

HX-314	SOUTH GATEHOUSE ELECTRIC CABINET HEATER
HX-315	SOUTH GATEHOUSE ELECTRIC WALL HEATER
HX-316	SOUTH GATEHOUSE STAIRWELL ELECTRIC WALL HEATER
HX-317A/B/C/D/E/F	SOUTH GATEHOUSE ELECTRIC BASEBOARD HEATER
HX-318A/C/D/E	WAREHOUSE #2 PROPANE HEATER
HX-320	SOUTH GATEHOUSE SAS AC CONDENSING UNIT
HX-321	HEATING STEAM RETURN DRAIN COOLER
HX-322/323	UNITED COOLAIR PORTABLE AIR CONDITIONING UNIT
HX-327	NES BLDG HEATING/AIR CONDITIONING UNIT
HX-335	EIC UNIT HEATER #1
HX-336	EIC UNIT HEATER #2
HX-337	EIC UNIT HEATER #3/AIR CONDITIONER
HX-338	EIC UNIT HEATER #4
HX-344	EIC SPACE ELECTRIC DUCT HEATER
HX-354	STP CHEMICAL STORAGE ROOM UNIT HEATER
HX-355	STP WEST TREATMENT ROOM UNIT HEATER
HX-356	STP EAST TREATMENT ROOM UNIT HEATER
HX-357	STP WEST BLOWER ROOM UNIT HEATER
HX-358	STP LABORATORY HEATING/AIR CONDITIONING UNIT
HX-359	STP RESTROOM BASEBOARD HEATER
HX-360	STP WEST TREATMENT ROOM MAKEUP AIR HEATING UNIT
HX-361	STP EAST TREATMENT ROOM MAKEUP AIR HEATING UNIT
HX-362	HX-360 STP WEST TRTMT RM MUA HTG UNIT HEAT RECOVERY COIL
HX-363	W-265 STP WEST TRTMT RM EXHAUST FAN HEAT RECOVERY COIL
HX-364	HX-361 STP EAST TRTMT RM MUA HTG UNIT HEAT RECOVERY COIL
HX-365	W-264 STP EAST TRTMT RM EXHAUST FAN HEAT RECOVERY COIL
HX-366/367/368/369/370	SEC-HUT 01 SECURITY HUT AIR CONDITIONERS
HX-371/372/373/374/375	SEC-HUT 01-05 SECURITY HUT ELECTRIC UNIT HEATERS
HX-376	WAREHOUSE #4 ELECTRIC HEATER/AC UNIT
HX-378A/378B	SBCC COMPUTER ROOM AIR CONDITIONING UNITS
HX-379/380	SEC-HUT 06/07 SECURITY HUT AIR CONDITIONERS
HX-381	SEC-HUT 07 SECURITY HUT ELECTRIC UNIT HEATER
HX-500/501/502	G-05 GAS TURBINE BLDG UNIT HEATERS #1/#2/#3
HX-505A/B	G-05 GAS TURBINE BLDG UNIT HEATERS #4/#5

HX-507	B-500 GAS TURBINE BLDG MCC SPACE HEATER
HX-508	G-05 GT GENERATOR INLET DUCT DE-ICING HEATER
HX-509	G-05 GT GENERATOR LUBE OIL HEATER
HX-510	G-501 GT GEN AUX PWR DIESEL ENGINE WATER JACKET HEATER
HX-511	G-500 GT GEN STARTING DIESEL ENGINE WATER JACKET HEATER
HX-600A/B/C/D/E/F	CWPH OVERHEAD UNIT HEATERS
HX-601 THRU 610	CIRCULATING WATER PUMPHOUSE UNIT HEATER
HX-702	BORIC ACID WASTE EVAPORATOR VACUUM SYSTEM
HX-704	WAREHOUSE #1 HEATER
HX-705	NORTH GATEHOUSE SECURITY BADGE ROOM AC UNIT
HX-800A/B/C/D	SWYD CONTROL BLDG HEATER #1/#2/#3/#4