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BECo. Ltr. #81-247

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Office of Inspection and Enforcement
Region I
U.S. Nuclear Regulatory Commission
631 Park Avenue
King of Prussia, PA 19406

License No. DPR-35
Docket No. 50-293

RESPONSE TO FLOW BLOCKAGE OF COOLING WATER TO SAFETY SYSTEM COMPONENTS BY CLAMS AND MUSSELS, IE Bulletin 81-03

Ref: a) Boston Edison Company Semi-Annual Marine Ecology Report No. 17

b) Boston Edison Company Semi-Annual Marine Ecology Report No. 16

c) IE Information Notice 81-21

Dear Sir:

In reference to IE Bulletin 81-03, Flow Blockage of Cooling Water to Safety System Components by Clams and Mussels, BECo would like to submit the following responses for questions 1 through 5:

1. Determine whether Corbicula sp. or Mytilus sp. is present in the vicinity of the station (local environment) in either the source or receiving water body. If the results of current field monitoring programs provide reasonable evidence that neither of these species is present in the local environment, no further action is necessary except for items 4 and 5 in this section for holders of operating licenses.

RESPONSE #1

The benthic ecology monitoring program in the vicinity of Pilgrim Nuclear Power Station has been conducted for 10 years, representing pre- and post operational studies. These have been reported on in Boston Edison Company (BECo.) Semi-Annual Marine Ecology Reports to the NRC and EPA. The most recent report is Semi-Annual No. 17, Ref. a), (see Benthic Studies). The

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benthic studies to date emphasize community analysis, including population analysis of the mussels Mytilus edulis, in the vicinity of PNPS. At least three locations have been sampled four times per year as part of the community analysis program (See Ref. a). Also in 1980 BECc conducted intensive qualitative sampling along transects radiating out from the end of the discharge canal (See Ref. b).

The following discusses data from this transect sampling program (See Ref. b).

One of the most characteristic and persistent features of the Pilgrim Station area hard-bottom benthic communities is the seasonal appearance and disappearance of vast numbers of juvenile mussels (M. edulis). Densities of up to several million mussel spat per square meter have been recorded in samples taken during the benthic monitoring program (Semi-Annual #13). Although a few of these will remain to develop into adults, most will be devoured by starfish and other predators long before reaching adulthood. In spite of their somewhat transient contribution to faunal densities in the area, their numbers are sufficient to make them an extremely important faunal component of the benthos.

The potential impact of the Pilgrim Station discharge on mussel population was evaluated by performing length-frequency measurements on mussels collected from each of the stations where they were found. Results were evaluated by comparing length-frequencies in each of three zones (denuded, stunted, and normal) identified via bottom observation as described in Sect. IIIB.2., Benthic Transects of Ref. b).

Length-frequency histograms for each of the 86 mussel samples collected during the January 1980 study are presented in Figure 11 (Benthic Transects, Ref. b). The samples may be grouped into two classes: samples comprising exclusively small juvenile individuals ($<$ 5 mm) and samples with numbers of larger ($>$ 20 mm) individuals. Few individuals were found in the size range between these two groups. Large mussels were more common at the shallower sampling locations from about 10 to 60 meters out from the end of a discharge canal, on a transect and they were also more numerous to the left (west) of the discharge on Transects I, A, and B, as well as on the center C Transect. Juvenile mussels only were found to the right (east) of the center line of the discharge.

For those sampling locations which contained large mussels, the data were summarized separately for the juvenile mussels only. For the purposes of this report a mussel smaller than 5 mm is considered to be juvenile. The juveniles are apparently the result of a settlement which occurred in the late fall or early winter and it is possible to compare them across locations.

The data shows that juvenile mussels are significantly larger in the denuded area in front of the discharge.

Possible reasons for the observed pattern of larger mussels in the denuded area include increased growth rate due to the heated discharge and enhanced availability of planktonic food carried by the discharge current. A third possible

mechanism which may be responsible for the observed results concerns the settling behavior of Mytilus edulis. Primary settlement appears to occur on filamentous algae when the planktonic larvae are approximately 0.3 mm in length. The newly settled mussels remain on the algae until they are approximately 1 mm to 2 mm in length. They then leave the algae and colonize bare rock surfaces.

This pattern of behavior could explain the observed distribution pattern of larger mussels occurring in the denuded zone. Since algal growth in this zone is minimal, primary settlement would be absent and the mean length of newly-settled mussels would be greater than 1.0 mm, as was observed. Areas with extensive algal growth would be limited to less than 1.0 mm. Secondary settlement would be most prominent on bare rock surfaces which occur in abundance in the denuded zone of the discharge canal.

If increased temperature or more abundant food supply were primarily responsible for the larger mussels in the denuded zone we would also expect enhanced growth in the stunted area. However, there is no difference between the stunted and normal areas in terms of mussel length. There seems to be a scenario of mussels settling throughout the area whenever sufficient algal cover occurs, developing until they reach a length 1.0 to 2.0 mm and then moving onto bare rock areas, particularly those in the denuded zone.

In the August, 1980 transect study, the stunted zone was similiar in shape to the January stunted zone but was markedly larger. This area was somewhat less extensive in the deeper areas to the right of the plume but was considerably wider in the shallower water to the left of the centerline.

2. If it is unknown whether either of these species is present in the local environmental or is confirmed that either is present, determine whether fire protection or safety-related systems that directly circulate water from the station source or receiving water body are fouled by clams or mussels or debris consisting of their shells. An acceptable method of confirming the absence of organisms or shell debris consists of opening and visually examining a representative sample of components in potentially affected safety systems and a sample of locations in potentially affected fire protection systems. The sample shall have included a distribution of components with supply and return piping of various diameters which exist in the potentially affected systems. This inspection shall have been conducted since the last clam or mussel spawning season or within the nine month period preceding the date of this bulletin. If the absence of organisms or shell debris has been confirmed by such an inspection or another method which the licensee shall describe in the response (subject to the NRC evaluation and acceptance), no further action is necessary except for items 4 and 5 of actions applicable to holders of an operating license.

RESPONSE #2

The Salt Service Center Water System (SSW) is the only safety related system which directly circulates water from the station source or receiving body, i.e. Cape Cod Bay. The fire protection system is not of concern for this problem because it utilizes fresh water from storage tanks, with town water as a backup.

The safety related function of the SSW system is to provide a heat sink for the reactor building closed cooling water system under transient and accident conditions. The service water system consists of five vertical service water pumps located in the intake structure, and associated piping, valving, and instrumentation. The pumps discharge to a common header from which independent piping supplies each of the two cooling water loops, each loop consisting of one reactor building (safety related) and one turbine building (non safety related) cooling water heat exchangers. Two division valves are included in the common discharge header to permit the salt service water system to be operated as two independent loops. The water then returns to the bay from the outlet of the heat exchangers.

Components most susceptible to mussel growth or fouling are the RBCCW heat exchangers and the SSW supply pipes, between the SSW pumps and RBCCW heat exchangers. The heat exchangers are valved such that they can be individually backwashed without interrupting system operation, and this is normally done three times per week during the mussel season to remove mussels and shell debris. In addition, it has been Pilgrim's experience that the heat exchangers require periodic mechanical cleaning to remove mussels and shells which have become lodged in the tubes or intermediate passes of the heat exchangers. This operation requires the affected loop to be taken out of service. Mussel growth on the inside walls of the supply pipes leading to the RBCCW heat exchangers is also evident at Pilgrim Station. These pipes were mechanically cleaned during the 1980 refueling outage and heavy growth was removed at that time. A borescope inspection on March 2, 1981 and pressure readings taken along the system and compared to a reference hydraulic grade line for a clean system, both indicate significant new mussel growth, probably along most of the length of the supply line to the RBCCW heat exchangers.

The following is a summary of visual examinations* (with regard to mussel growth) of components and piping of the SSW System within the past 9 months:

6-9-81: "E" SSW pump discharge check valve opened for maintenance.
Findings: No mussel growth observed in pump discharge piping (12" line) between the pump and its discharge isolation valve.

6-4-81: "D" SSW pump discharge check valve opened for maintenance
Findings: No mussel growth observed in pump discharge piping (12" line) between the pump and its discharge isolation valve.

4-23-81: "B" RBCCW heat exchanger opened for cleaning
Findings: Mussels and shells found lodged in tubes and intermediate passes. Cleaned shells, blew tubes.

3-3-81: "B" RBCCW heat exchanger opened for cleaning
Findings: Mussels and shells found lodged in tubes and intermediate passes. Cleaned shells, blew tubes.

3-2-81: "A" RBCCW heat exchanger opened for cleaning
Findings: Mussels and shells found lodged in tubes and intermediate passes. Cleaned shells, blew tubes.

3-2-81: Inlet pipe to "A" RBCCW heat exchanger boroscope examination at Flow Element 6240.
Findings: A boroscope inspection showed approximately 1½" to 2"

*More recent examination discussed in Response #3

of mussels growth on the "A" RBCCW heat exchange supply pipe (18" line). This condition existed as far as the boroscope could traverse along the line (approximately 12 feet)

10-10-80: "A" RBCCW heat exchanger opened for cleaning
Findings: Mussels and shells found lodged in tubes and intermediate passes. Cleaned shells, blew tubes.

9-29-80: "B" RBCCW heat exchanger opened for cleaning
Findings: Mussels and shells found lodged in tubes and intermediate passes. Cleaned shells, blew tubes.

9-27-80: "A" RBCCW heat exchanger opened for cleaning
Findings: Mussels and shell debris found lodged in tubes and intermediate passes. Cleaned shells, blew tubes.

3. If clams, mussels or shells were found in potentially affected systems or their absence was not confirmed by action in item 2 above, measure the flow rates through individual components in potentially affected systems to confirm adequate flow rates i.e. flow blockage or degradation to an unacceptably low flow rate has not occurred. To be acceptable for this determination, these measurements shall have been made within six months of the date of this bulletin using calibrated flow instruments. Differential pressure (DP) measurements between supply and return lines for an individual component and DP or flow measurements for parallel connected individual coolers or components are not acceptable if flow blockage or degradation could cause the observed DP to be masked in parallel flow paths.

   Other methods may be used which give conclusive evidence that flow blockage or degradation to unacceptable low flow rates has not occurred. If another method is used, the basis of its acceptance for this determination shall be included in the response to this bulletin.

   If the above flow rates cannot be measured or indicate significant flow degradation, potentially affected systems shall be inspected according to item 2 above or by an acceptable alternative method and cleaned as necessary. This action shall be taken within the time period prescribed for submittal of the report to NRC.

   Response #3

   The method used to determine that flow blockage or degradation to unacceptable low flow rates has not occurred is described in station procedure TP80-76 "Salt Service Water Performance Test". This procedure has been in effect since October, 1980 to confirm adequate flow rates in the SSW system. The procedure establishes a valving configuration such that the SSW system is divided into two independent loops, each with two operating SSW pumps aligned to pump full flow through the RBCCW heat exchangers and no flow through the TBCCW heat exchangers (In this alignment parallel flow path through TBCCW is isolated so as not to mask any flow blockage or degradation of the SSW flow to the RBCCW loop). Data are collected and then used to measure the SSW flow rates to the RBCCW heat exchangers using the head versus flow curves for the SSW pumps. Using the pump curves to measure flow rate is considered

acceptable on the basis that the pumps are routinely demonstrated to be operating on the pump curves, by means of pump shutoff head tests conducted quarterly during surveillance testing. Each SSW loop is equipped with a flow instrument, but these are not calibrated to compensate for the mussel build-up observed in the 18" lines and, hence, are not used for the purposes of this test.

The results of the flow measurements taken in response to this bulletin are as follows:

DATE	SSW Loop "A" Flow (GPM)	SSW Loop "B" Flow (GPM)
6/15/81	3300*	5300
6/16/81	5650	3550**
6/17/81	5300	5500

*"A" RBCCW heat exchanger subsequently backwashed prior to 6/16/81 test

**"B" RBCCW heat exchanger subsequently backwashed prior to 6/17/81 test

Boston Edison Company's (BECo's) Nuclear Engineering Department (NED) has performed calculations and has determined that the minimum flow required by the Salt Water Side of the RBCCW Hx, during accident conditions is 5000 gpm based on 65°F SSW inlet temperature and design fouling factors, to maintain 165°F Torus Water Temperature in accordance with PNPS Final Safety Analysis Report (FSAR). RBCCW cleanliness greater than design, and SSW temperatures less than design, could reduce the minimum flow requirements. This information was presented to PNPS on August 13, 1981 via a telephone conference call. As demonstrated by the above tests, and subsequent testing, back washing is effective in un-plugging the RBCCW heat exchangers and enabling maintenance of minimum flow.

A safety evaluation was subsequently performed to consider the following items:

1. Ability of operators to manually isolate TBCCW Hx during post-accident conditions to increase flow to the RBCCW Hx.

2. Ability of operators to backflush RBCCW Hx's within a 24-hour period following an accident.

The conclusion of the safety evaluation results are as follows:

1. The TBCCW Heat Exchanger discharge valves, MO-3801 & MO-3805 will automatically close to 10% open following a blackout or accident. The hand switches (HS) are located on Panel C-1 in the control room. Since operator action is required to initiate RHR, then it would be feasible to manually close MO-3801 and MO-3805 at the same time or in response to high RBCCW system temperatures or high torus temperatures.

2. Backflushing the RBCCW Hx's requires the operator to access the Reactor Aux. Bay and manually operate back flush valves. With daily back flushing of RBCCW Hx's during normal operation, it is assumed that back flushing following an accident would be required within a 24-hour period. Operator action would be feasible based on the available time of 12 to 24 hours and estimated duration of ½ hour.

On July 24, 1981, BECo recieved IE Information Notice 81-21 "Potential Loss of Direct Access to Ultimate Heat Sink" and BECo's Nuclear Engineering Department (NED) was asked to investigate the potential for this problem at PNPS. It was ascertained that PNPS may indeed have a similiar problem as described in the IE Notice 81-21. The "A" Loop RBCCW heat exchanger was taken out of service, cleaned and inspected. The inspection revealed that the heat exchanger showed signs of partition plate deformation but no significant signs of by-passing. Subsequently the "B" Loop RBCCW heat exchanger was removed from service, cleaned and inspected. The inspection revealed flow by-passing which rendered the heat exchanger ineffective. On September 3, 1981, LER #81-049/01X-0 was initiated by PNPS personnel. The heat exchanger has been repaired and tested satisfactorily and returned to service.

To address further concerns of IE Bulletin 81-03 and IE IN81-21, the following actions will be taken during the 1981 Refueling Outage:

(a) BECo's Nuclear Organization has initiated actions to acceptably stiffen the RBCCW partition plates and add DT and DP instrumentation across the RBCCW Hx. tube side to improve reliability, and permit some short-term reduction in flow or cross-sectional areas. It is recognized that after the 1981 Refueling Outage the immediate concerns regarding SSW/RBCCW Hx. macro-fouling should be reduced by partition plate stiffening, improved instrumentation for measuring SSW flow and RBCCW Hx. DP and DT, mechanically cleaned SSW piping, and sodium hypochlorite injection sufficient to control mussel growth and attachment to critical areas.

(b) SSW Chlorine minimization tests shall be rigorously followed to facilitate determining the concentration (residual chlorine) and frequency of sodium hypochlorite addition required to eliminate and control mussel fouling of SSW piping and associated heat exchangers.

4. Describe methods either in use or planned (including implementation date) for preventing and detecting future flow blockage or degradation due to clams or mussels or shell debris. Include the following information in this description:

a. Evaluation of the potential for intrusion of the organisms into these systems due to low water level and high velocities in the intake structure expected during worst case conditions.

b. Evaluation of effectiveness of prevention and detection methods used in the past or present or planned for future use.

Response #4a

PNPS is designed to maintain a constant intake volume of water. The intake water velocity approaching the intake structure will vary by approxmately 0.35 fps between the minimum low tide and the maximum high tide. The design low water line is five feet above the bottom of the skimmer wall. Also mussel larvae and very small juveniles have practically no intake avoidance ability.

Thus the potential for intrusion of mussels into safety systems will not vary, even in worst conditions. The biology of the mussels, e.g., spawning peaks and changes in population density, will at times allow for greater intake of mussels, but this is due to natural biological variation and not to plant design.

Response #4b

The detection method used in the past to detect flow blockage or degradation, due to mussels or shell debris, consisted primarily of operator awareness to instrumentation available to alert him of such conditions. Symptoms and instrumentation which alert the operator of degraded conditions include: high pressure at the SSW loop header pressure indicators, low flow at the SSW loop flow indicators, high temperature at the RBCCW loop temperature indicators, high temperature at the temperature indicators on various components cooled by the RBCCW system, etc.

This method most likely would detect flow blockage, but is not considered an effective means for monitoring flow degradation because it does not isolate the RBCCW sub-loop from the TBCCW sub-loop of the SSW system and hence flow degradation may be masked by parallel flow through the TBCCW sub-loop. In recognition of this special test procedure was implemented in October 1980 to periodically measure the flow in the RBCCW sub-loop of the SSW system. This procedure is discussed in Response #3 to this bulletin. In addition to providing a determination of flow, the procedure also provides for pressure readings to be collected at five points along the SSW loop. These pressure points enable a comparison to be made to a reference hydraulic grade line for a clean system, for the purpose of determining the likely areas of flow resistance. This method has proved to be effective in identifying both mussel buildup in the SSW pipes and the need for backwashing or mechanically cleaning the heat exchangers.

Design modifications are being prepared to add improved flow measurings devices and ΔP instrumentation. Installation is scheduled to start during the 1981 Refueling Outage and be completed in the early Spring of 1982.

Past methods for preventing mussel growth have relied on the effectiveness of hypochlorination to control such growth. The SSW system supply water is common to the Circulating Water system, which is normally hypochlorinated two hours each day during the mussel season. However, because of strict limits imposed on concentration of residual chlorine by the discharge permit issued by the EPA, hypochlorination has not been effective in controlling mussel growth, although it does control microfouling (slime).

On December 23, 1980, BECo. wrote the Chief, Permit Branch, U.S. EPA Region I proposing a mussel fouling control program for the SSW system of PNPS. BECo. indicated then that "these measures are needed to improve flow capacity of the heat exchangers and piping of the SSWS by eliminating build-up of mussels". On February 4, 1981, the U.S. EPA responded with tentative approval for BECo's proposed experimental use of chlorine to control mussel growth in the SSWS. At their request a test plan was submitted by BECO for approval by the EPA and the Mass. Division of Water Pollution Control (MDWPC). BECo. was requested to insure the plan was consistent with the chlorine minimization program outlined in the proposed Power Plant Guidelines of October 14, 1980 (FR Vol 45, No 200). BECo was asked to take measurements of total residual chlorine at several specific locations prior to discharge, and to estimate the dilution ratio of the Circulating Water System (CWS) to the SSWS.

BECo. submitted its two-part test program to the EPA on March 20, 1981. The program details both:

1. An in-plant continous chlorination program to rid the SSWS of mussels. This actual plant chlorination program will begin with high chlorine concentrations. Once the tests of part two indicate the minimum concentration needed, the SSWS chlorination will be adjusted accordingly. After this the NPDES Permit would be modified.

2. A Chlorine Minimization Program

   This experimental setup is intended to determine the minimum combination of time and concentration of chlorine needed to control mussel fouling in the SSWS. This program is consistent with the chlorine minimization program in the proposed Power Plant Guidelines of October 14, 1980.

Once the first phase of part 2, the Chlorine Minimization Program, is complete there will be an evaluation of devised treatment regimes under operating conditions within the SSWS, to see which experimental combinations of chlorine concentration and treatment cycles can work to keep the SSWS free of mussel fouling. The test program also includes an evaluation of scaling severity in heat exchange tubes under the optimal chlorine schedule. Continuous chlorination of seawater has been observed to produce a brown scale composed primarily of maganese dioxide, silica, and carbonate. To determine the severity of this problem heat exchange tubes shall be exposed to chlorinated seawater in side stream flows from the SSWS. Measurements before and during chlorination tests shall be performed to evaluate the amount of scale build-up.

BECo. received approval for these programs on April 9, 1981 from the State WPC and on April 20, 1981 from the EPA. The Chlorine Minimization Program began in June 1981.

The SSWS chlorination program, both the in-plant and the Chlorine Minimization portions, are part of the Nuclear Organization's proposed Service Water System Betterment Program. This program is intended to consider a number of other aspects of the SSWS and component cooling water systems.

5. Describe the actions taken in items 1 through 3 above and include the following information:

   a. Applicable portions of the environmental monitoring program including last sample date and results.

   Response #5a

   This is covered in response #1 to this bulletin.

   b. Components and systems affected.

   Response #5b

   This is covered in response #2 to this bulletin.

   c. Extent of fouling if any existed.

   Response #5c

   This is covered in response #2 to this bulletin.

   d. How and when fouling was discovered.

   Response #5d

   This is covered in response #2 and #4b to this bulletin.

   e. Corrective and preventive actions.

   Response #5e

   This is covered in response #4b to this bulletin.

Should you have any additional questions on this subject, please do not hesitate to contact us.

Very truly yours,

John M Fulton for AVM