APPENDIX V

SPECIAL REPORTS

2008

August 15, 2008
EPA Acceptance of Supplemental Environmental Project

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

AUG 15 2008

REPLY TO THE ATTENTION OF:
SC-6J

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Lawrence J. Weber, Site Vice President
Indiana Michigan Power Company
One Cook Place
Bridgman, MI 49106

Re: Indiana Michigan Power Company, Bridgman, Michigan, Consent Agreement and Final Order Docket No.: CERCLA-05-2004-0010, EPCRA-05-2004-0043, MM-05-2004-0003

Dear Mr. Weber:

The U.S. Environmental Protection Agency (EPA) had received and evaluated the Supplemental Environmental Project (SEP) completion report from Indiana Michigan Power Company. This review compared the SEP completion report to the Consent Agreement and Final Order. Based on the terms of the CAFO and the information that you have provided, the EPA accepts the SEP completion report. Indiana Michigan Power Company has completed the SEP and the SEP completion report as per the terms of the CAFO.

If you have any questions or concerns about this matter please contact James Entzminger at (312) 886-4062. If you have any legal questions, please contact Richard Wagner, Associate Regional Counsel, at (312) 886-7947. Thank you for your assistance in resolving this matter.

Sincerely yours,

James Entzminger

Mark J. Horwitz, Chief
Chemical Emergency Preparedness
and Prevention Section

cc: Richard Wagner (C-14J)

Kevin D. Mack, Esq.
American Electric Power
1 Riverside Plaza
Columbus, OH 43215-2373 (certified)

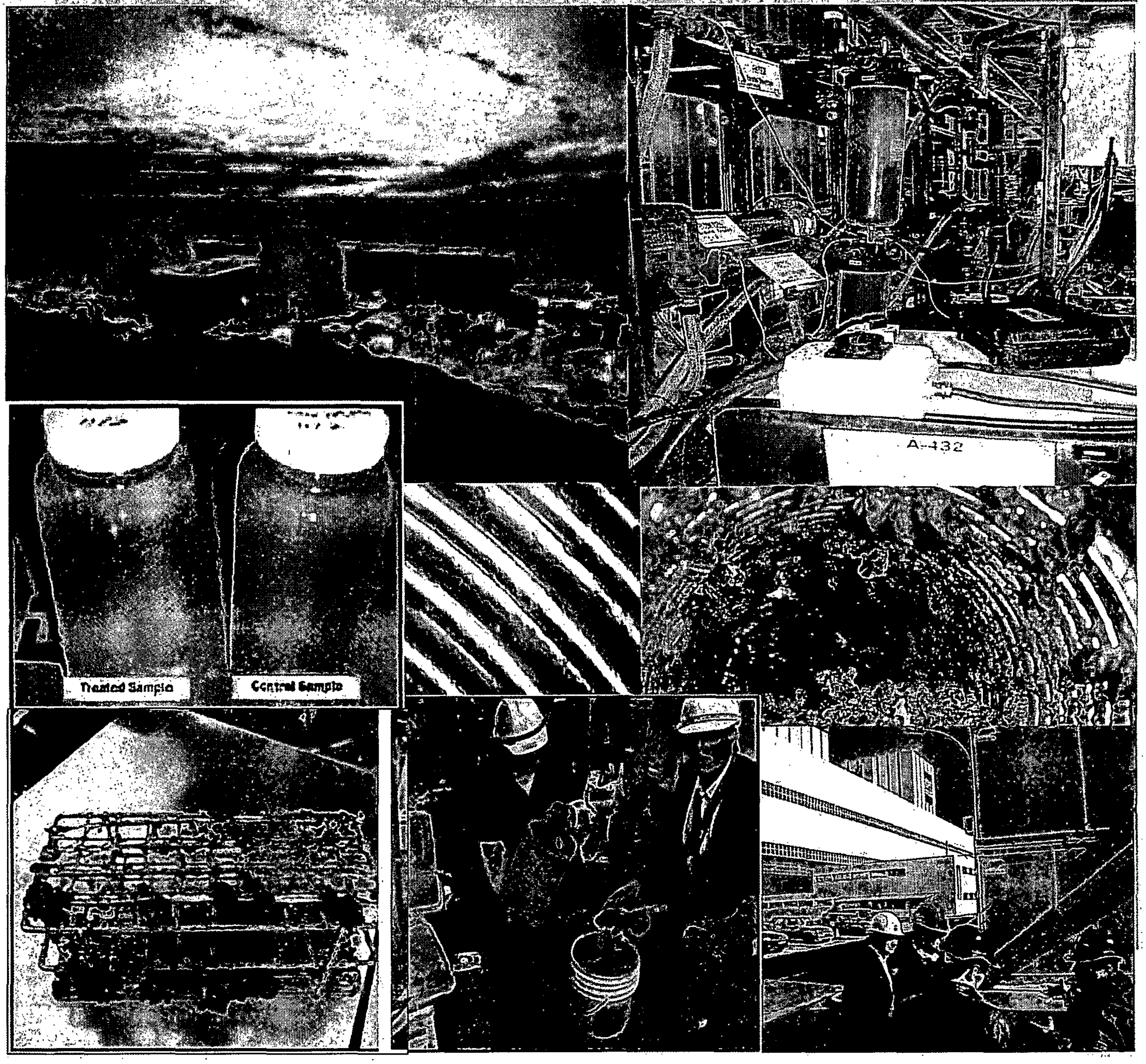
February, 2008
Mexel Efficiency Study

HOH
water technology

Mexel Efficiency Study
DC Cook Nuclear Plant

Bridgman, Michigan

AEP INDIANA MICHIGAN POWER
A unit of American Electric Power



Final Report February 2008

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Mexel Efficiency Study

DC Cook Nuclear Plant

Final Report February, 2008

Thomas Armon, Darius Barkauskas, Jon J. Cohen, Eric C. Mallen

Abstract

Mexel, a chemical product in the general classification of filming amines, has been evaluated for use as a preventive molluscicide control program at AEP's Indiana Michigan Power Company Donald C. Cook Nuclear Power Plant, Bridgman, Michigan (CNP). Mexel is marketed as a corrosion inhibitor, dispersant and control agent for cooling water system fouling species such as mussels and hydroids. A unique on-site research facility was constructed and operated continuously for 365 days to evaluate Mexel efficiency in preventing zebra mussel infestation on cooling water intake tunnels at CNP. Standard and custom testing methods were used to determine the performance of Mexel on modeled intake tunnels using natural populations of zebra mussel trans-locators and larvae under dynamic conditions.

The findings indicate that a Mexel product dosage regimen of 4 ppm for 40 minutes/day illustrated:

- **Effectiveness in preventing infestation of zebra mussel colonies in corrugated pipes patterned after CNP intake tunnels.**
- **Reduced silt and sludge accumulation in flowing water circuits.**
- **No degenerative fouling of reverse osmosis membranes.**
- **No rapid mussel detachment (sloughage) of existing colonies from tunnel surfaces.**
- **Minimal increase in organic loading of treated water circuits or receiving waters.**
- **No negative impact on Great Lakes fisheries, aquatic life or wildlife when discharged un-neutralized into Lake Michigan as measured by whole effluent toxicity tests.**

Introduction:

CNP has dealt with zebra mussel infestation since 1990 and has employed many different treatment alternatives. Three intake tunnels constructed of 16-foot diameter corrugated, galvanized steel pipe extend about 2,250 ft. from a common forebay. Corrugations in this pipe are 6 inches wide (peak to peak) and 2 inches deep. Flow patterns enable zebra mussel attachment to the tunnels typically in the top and downstream side of the corrugations. Once zebra mussels have attached to the tunnels, they populate and grow as individuals or in "clumps" as they attach to one another.

Zebra mussels can accumulate to a thickness of two to four inches during periods of reduced flow but are typically limited to one to two inches at normal velocity. This is due to mussels sloughing off the tunnel walls when the mussel layers exceed 2 inches. The water velocity in the intake tunnels is 6 to7 fps, strong enough to carry clumps of detached mussels into the intake forebay. Mussels in these clumps will either reattach to the intake forebay walls or be gathered by the traveling water screens. When sloughing rates are naturally high or following shock treatments (treatments designed to kill all accumulated mussel populations within a 2 to 4 day period) the traveling water screens and the trash removal system are challenged to remove the mussel debris at the same rate at which the debris enters the intake forebay. The traveling screens have been overcome by large influxes of debris as washing operations require traveling screen shutdown to allow the trash collection baskets to be emptied and fork lifted to 20 cubic yard dumpsters for removal by a waste hauler off site. The clay used to detoxify shock treatment biocides has resulted in plugging of small bore piping systems downstream of the traveling screens. The effect of these difficulties is degraded operation of CNP's cooling water system.

To reduce this risk, CNP replaced the flow through traveling water screens with multi-disc traveling water screens in 2004, and upgraded the screen wash system to handle higher trash and shell debris loading rates. In addition, the new screens preclude all carry over debris. These improvements have reduced the challenges posed by mussel debris but have not eliminated the problem. The sloughage of shells can potentially block flow in the safety related service water systems. Given this challenge, CNP has continued to search for a zebra mussel preventive control program that does not require a shock feed cycle, prevents infestation, does not cause rapid sloughage of existing populations, and does not require detoxification for safe discharge into Lake Michigan. Mexel was chosen for careful evaluation as a water treatment additive under standard and custom techniques described later in this report.

Background

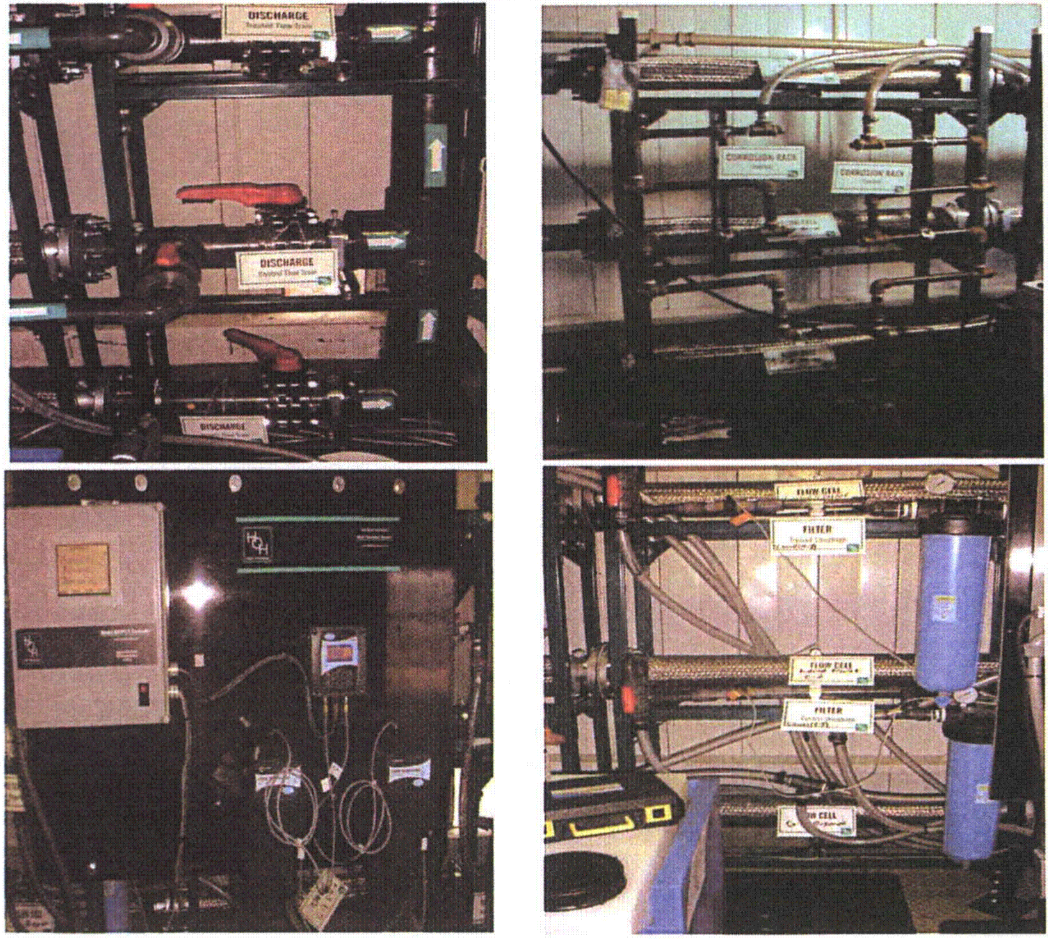
Mexel is a proprietary molluscicide that has been used in freshwater and saltwater systems worldwide. Kreuser et al, (1997), wrote a review of the efficacy of Mexel in fresh and salt water cooling systems. Mexel is a filming amine which, when properly applied to a cooling system, forms a film on system surfaces that is believed to prevent zebra mussel settlement as the control mechanism rather than creating a toxic water column as the controlling effect. Toxicological effects of Mexel have been widely studied in both freshwater and saltwater (Ghillebaert, 1997 & McCaulley, 2005). Biodegradation of Mexel was also demonstrated and documented. However, prior to this study there had been little published information concerning the effect of Mexel on existing zebra mussel infestations on corrugated pipe in freshwater applications. Information had been especially limited regarding the application of Mexel on the CNP intake tunnels, Lake Michigan water, and the removal of a previously established population.

Power plants are complex industrial facilities that contain integrated components constructed of different materials performing a variety of functions. Any chemical product added at the intake must be compatible with all materials of construction that treated water contacts in the plant. For example, membranes in the reverse osmosis (R/O) units are susceptible to contamination by complex organic molecules. In part, the design of this study was to provide more information regarding Mexel's compatibility with plant systems and impact on corrosivity.

To provide robust modeling data, this study was designed using a modular custom fabricated continuous flow research test rig. The goal was to design and safely operate a model that assimilated tunnel conditions without interrupting normal plant operations. Continuous flow research facilities have been used to model effectiveness of molluscicide control programs on once through cooling water systems, (Ackerman/Claudi, 1994). Modular flow-through design using natural populations have previously provided robust data that enabled treatment modeling for plant systems under dynamic conditions.

Once installed, the rig was operated for 365 consecutive days to ensure accurate representation of a complete growing and larval season, fluctuating water temperatures, and dynamic silt loadings. In summary, the pilot test rig experienced a contiguous year of the naturally variable conditions imparted by Lake Michigan on CNP.

Images of the Modular Test Rig



Methods

I. Design

The design specifications, as built diagram, and scope of the modular apparatus can be found in Appendix I. Briefly, the apparatus was constructed with three separate flow trains of corrugated pipes to simulate the corrugation of the intake tunnels. One pipe was used as a **control,** receiving only untreated lake water at flow velocities comparable to those in the intake tunnels. A second pipe operating at the same velocity as the control was **treated** with the daily Mexel dosage projected for full scale tunnel treatment. The third pipe was operated at a lower velocity to enable zebra mussel **growth** and colonization without rapidly moving water streams. It is believed the velocity within the third section accurately models the velocity within the tunnel corrugation trough bottoms. Sections of the growth pipes were also used to study Mexel's effect on existing infestations to comparatively evaluate sloughage under the normal dosage regimen. To accelerate the fouling process in the growth section, several handfuls of live mussels were collected from the traveling screen trash baskets and loaded into this section.

II. Chemical and Biological Evaluations By Standard Procedures:

1. The efficacy of Mexel was studied using CNP procedure 12-EA-6090-ENV-101 Zebra Mussel Sampling and Analysis, found in Appendix 2 attached. Results of these procedures can be found attached under Appendix 3. This procedure is based on "Standard Protocols for Monitoring and Sampling Zebra Mussels" by J. Ellen Marsden, *Illinois Natural History Survey 1992.*

2. The method used for determining safe Mexel discharge concentration to Lake Michigan is based on "Mixing Zone Evaluation" by D.J. McCauley of GLEC, 2005 found in Appendix 4. Whole effluent toxicity (WET) testing was performed by GLEC in accordance with EPA/600/4-90/027 and EPA-821-R-02-012.

3. Corrosion evaluation was performed in accordance with the Annual book of ASTM Standards, Section 11 Water & Environmental Procedure D2688, *Standard Test Method for Water Corrosivity by Weight Loss* found in Appendix 5 attached.

4. Water analyses were performed in accordance with Standard Methods for the Examination of Water and Wastewater 20th Edition.\

5. Total Suspended Solids residue was also performed in accordance with Standard Methods for the Examination of Water and Wastewater 20th Edition.

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III. Custom Techniques for Evaluation

1. The test rig was constructed of three stainless steel corrugated pipe sections. Flow was controlled by throttling valve position and flow shunting through the stand-by water delivery pump installed in parallel to the main delivery pump. Flow velocity was confirmed by both paddle wheel and magnetic type flow meters. At the surface in the tunnels the velocities are much lower (1 to 2 fps). Eddies created by the corrugations allows larval and juvenile mussels to settle on the downstream side of the corrugations (Zebra Mussel monitoring and control assessment report #CR-03344013 Appendix 8).

   The test rig modeled the reduced velocity at the tunnel surface and in the troughs by two techniques;

   i. Installed rig pipe corrugations
   ii. The velocity (1 to2 fps) of the third section (growth).

2. Boroscopic inspections of the test rig corrugated pipe sections were performed monthly to progressively evaluate settlement control and to compare with previous remote operated vehicle inspections (ROV) of the main tunnels.

3. Artificial substrates were deployed and analyzed under Standard Procedure #1 above. The artificial substrate analysis included carbon steel metal specimen corrosion coupons installed in a controlled velocity test rack. Plexiglass baffle plates installed in the bioboxes to produce more uniform flow patterns were also treated as artificial substrates and used to estimate zebra mussel accumulation rates. After the study was complete (2) 1-inch scrapings were taken from each baffle plate and analyzed using the same procedure for the slides and coupons.

4. To quantify and compare total settlement during the study, a simple collection procedure was developed. The middle pipe section of each flow train (treated, control, and growth) was saved post project and sealed to preserve collected shell and debris loads. The pipes were power washed at 2,200 psi and articulated to ensure removal from trough corrugations. The water slurry (debris loaded wash water) was collected for filtration through coarse mesh filter screens. The separated solids were photographed, transferred to a storage pail, dried and then weighed to determine the amount of debris that was collected in each flow cell. The relative quantities were used to extrapolate the treated reduction of shell debris at the studied treatment regime.

5. Given the risk that rapid de-infestation upon initial full scale Mexel treatments could challenge the screen house, two custom techniques were employed. To understand Mexel's impact on existing populations, filter baskets were added to capture mussel sloughage detaching from the surface of both treated and untreated pipe sections. Each week the baskets were removed from the flow streams, observed, cleaned, and placed back in service. The volume and mass of mussel debris collected in the baskets was assumed to be an estimate of the relative debris in treated vs. untreated intake tunnels. Flow rate indicators were used to quantify consistent volume of flow. Comparative photographic inspections were used to judge rates of sloughage and overall system cleanliness. Relative mussel sloughage rates by Mexel were made with this technique by comparative visual observation of the filter baskets.

6. A Mexel mortality experiment was devised to further understand the impact Mexel would have on healthy colonies. It is believed that a more rapid "die off" of healthy mussels treated with Mexel would model a rapid detachment of healthy colonies in the tunnels at full scale treatment. Two hundred live healthy zebra mussels collected from screen house trash baskets were loaded into separate stainless steel wire cages, one for the treated and one for the control biobox. The treated biobox received its normal daily dosage of Mexel while the control received untreated lake water. Each week, mortality was evaluated by counting the numbers of surviving mussels in the treated cage and the control cage.

7. To evaluate the impact on the make-up plant system, a model reverse osmosis (R/O) system was placed on the treated flow stream. The R/O was operated continuously and received untreated Lake Michigan water as its make-up source for 23 hours 20 minutes per day, and for the final 40 minutes the R/O received Lake Michigan water treated with Mexel at the studied dosage regimen. The R/O membranes treated with Mexel were autopsied by H-O-H procedure #RO123 and compared against autopsies from the Avista Technologies membrane autopsy report (Appendix 6) from July 2003, which had been performed to evaluate the impact of GE Spectrus CT1300 (a competing chemical additive product) on fouled R/O membranes.

8. To measure the impact of organic loading that a preventive treatment approach would add to the CNP water distribution system as well as Lake Michigan, total organic carbon and total organic nitrogen were analyzed. Organic loading imparts unintended deleterious effects on water systems such as microbial contamination and growth as well as unwanted sediment. Grab samples were collected weekly from the test rig sample ports and analyses for TOC, TON, and general water chemistry, were performed at H-O-H Chemicals' laboratories in Palatine, IL.

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Results:

The analytical data gathered during the study are in Appendices 3 and 7. This includes water and corrosion analyses performed by H-O-H laboratories in Palatine IL, whole effluent toxicity testing by GLEC Laboratories, Traverse City MI, density and size evaluation by CNP personnel, collection of data from online instrumentation, field testing, and custom techniques by CNP and H-O-H personnel. The following is a graphic illustration of the results accompanied by written interpretation.

Zebra Mussel Sampling-Biobox Data

Post–veliger biobox data for zebra mussel population density and average size as measured by CNP procedure 12-EA-6090-ENV-101 Zebra Mussel Sampling and Analysis protocol are shown in Table 1 for those slides exposed during the experiment. The table shows the mean value of the population density as well as the standard deviation for each sampling date. The final set of slides which were exposed for one full year is shown graphically in Figure 1.

Table 1 – Post-Veliger Biobox Data

	Control		**Treated**	
Sample Date	**Mean Post-Veliger Population Density (Number/m^2)**	**Standard Deviation**	**Mean Post-Veliger Population Density (Number/m^2)**	**Standard Deviation**
September 13, 2006	427	754	1,067	533
September 28, 2006	1,173	911	1,813	1,917
October 12, 2006	2,560	3,096	14,933	19,827
October 25, 2006	8,960	4,453	13,653	10,966
November 9, 2006	40,107	8,057	28,907	18,456
December 7, 2006	85,440	40,100	60,800	12,672
June 7, 2007	108,978	17,804	39,289	4,473
August 23, 2007	553,600	125,205	131,947	41,204

The standard deviation was determined by calculating the mean value of each sample date. The squared difference of each sample from the mean value was then calculated. The average of the squared difference is the variance of the sample date. The standard deviation is the square root of the variance. This is illustrated in Equations 1 and 2 below.

Equation (1): Sample Mean of Sample Date

$$\text{Sample Mean} = \bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$$

Where:

- $(\bar{x})$ is the mean of the sample date
- (N) is the numbers of samples on the sample date
- (x_i) is the sample value

Equation (2): Standard Deviation

$$\text{Standard Deviation} = \sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2}$$

Where:

- (σ) is the standard deviation
- (N) is the numbers of samples on the sample date
- (x_i) is the sample value
- $(\bar{x})$ is the mean of the sample date

Initial data from September 13, 2006 to October 25, 2006 suggests that the control slides were performing better than the treated slides. The November 9, 2006 sampling marked the first time when the treated slides were performing better than the control slides. During this same sampling date an independent observer noticed that water flow in the bioboxes was potentially short-circuiting and not getting to the surface of the slides. The observer recommended installing baffle plates to redirect the flow to the bottom of the biobox to prevent the short circuiting and direct the flow across the slides. The biobox baffle plates were installed on November 16, 2006. (See Figures 3 & 4 for baffle plate images.) All subsequent sampling dates showed a dramatic improvement in the treated slide data. This suggests that Mexel performs best when it is allowed to reach the surface of the test substrate.

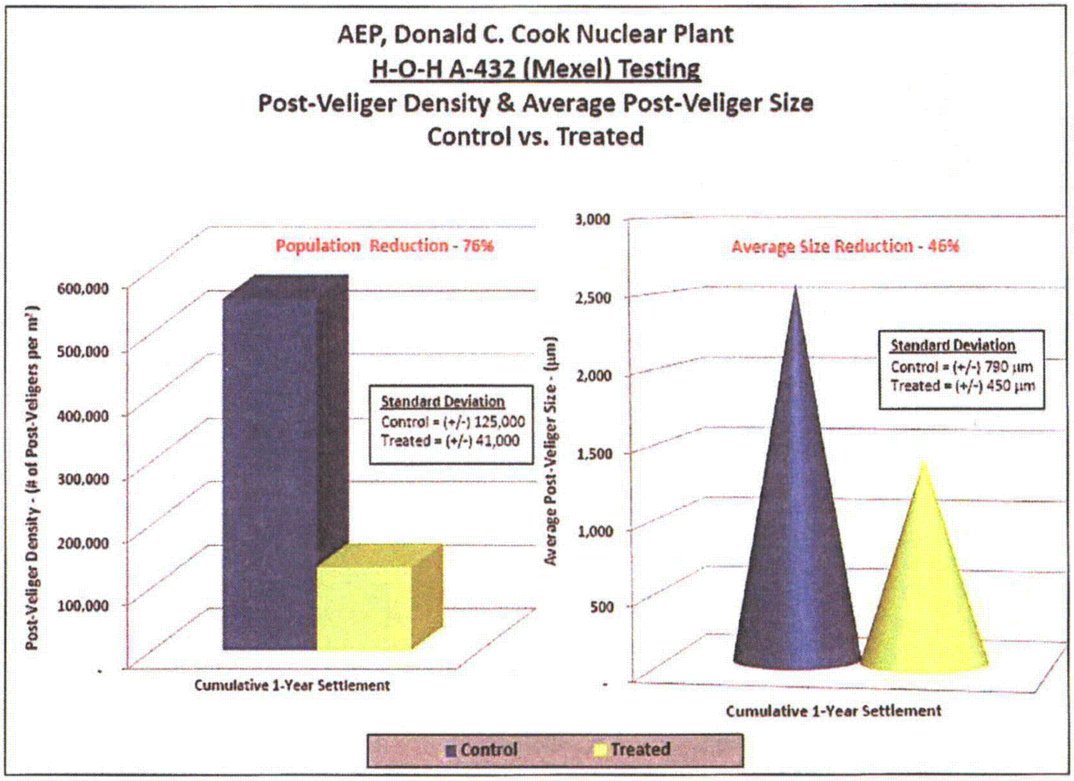

Figure 1 – Post- Veliger Density, Treated vs. Control (Glass Microscope Slides)

Figure 1 illustrates Mexel treated and control biobox slides. Cumulative settlement (1 year) population density was reduced by **76%** as compared to the control group. Average post-veliger size, also illustrated in Figure 1, indicates a reduction in size by a cumulative average of **46%.** The population and size reduction shown is based on an average of 5 slides in each biobox that were exposed for one year.

Artificial Substrate Analysis (Carbon Steel Metal Coupons)

Metal coupon strips were also used to determine post-veliger density and size by CNP procedure 12-EA-6090-ENV-101 Zebra Mussel Sampling and Analysis protocol and are shown graphically in Figure 2. Standard corrosion coupon racks, built to ASTM standards, were incorporated into both treated and control flow trains. Flow velocities were also controlled accurately through Dole flow control valves designed to maintain consistent velocity (6.0 ft/sec) through these assemblies.

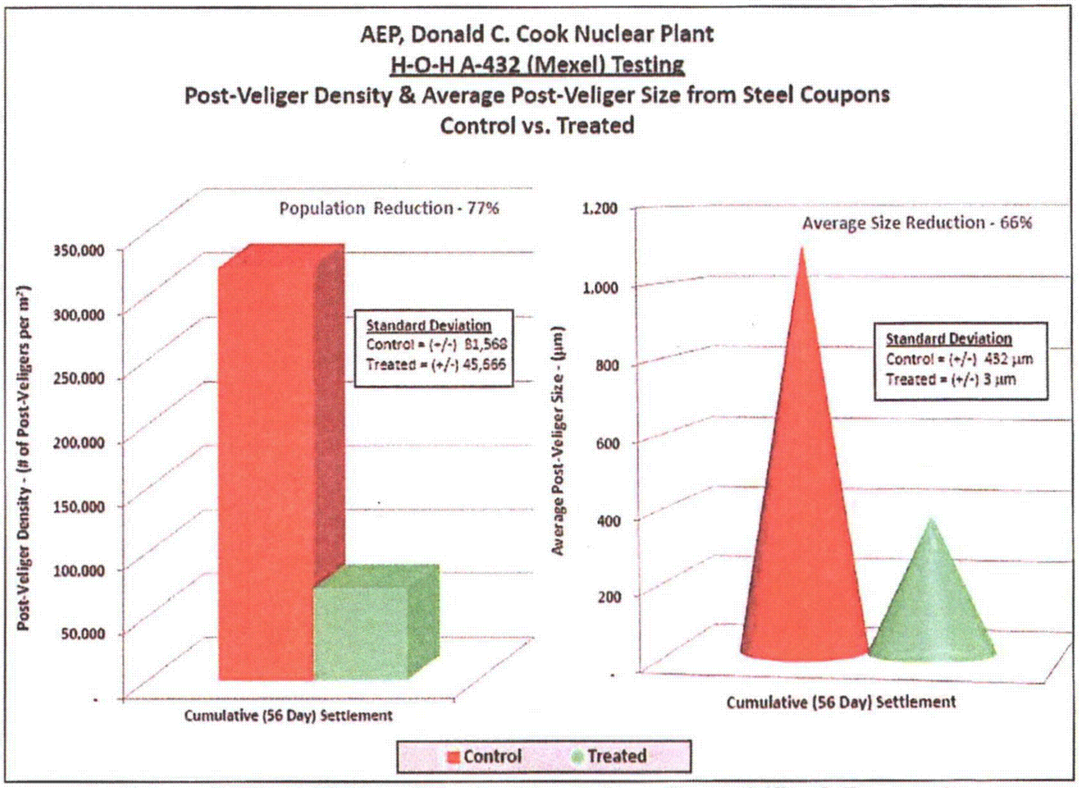

Figure 2 – Post-Veliger Density, Treated vs. Control (Steel Coupons)

Figure 2 illustrates Mexel treated and control corrosion coupons. Cumulative settlement (56 days) population densities were reduced by **77%** as compared to the control group. Average post-veliger size, also illustrated in Figure 2, indicates a reduction in size by a cumulative average of **66%** as measured on metal coupons. The population and size reduction shown is based on two carbon steel metal coupons that were exposed for 56 days.

Artificial Substrate Analysis (Plexiglass Baffle Plates)

Baffle plates were installed to prevent short-circuiting and to direct flow to the bottom of the biobox where the slide racks were located. Images of the baffles were taken for the record and can be seen as Figures 3 & 4. The results are shown in Figure 5.

Figure 3 – Treated Baffle Plate

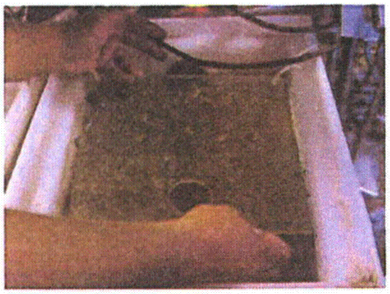

Figure 4 – Control Baffle Plate

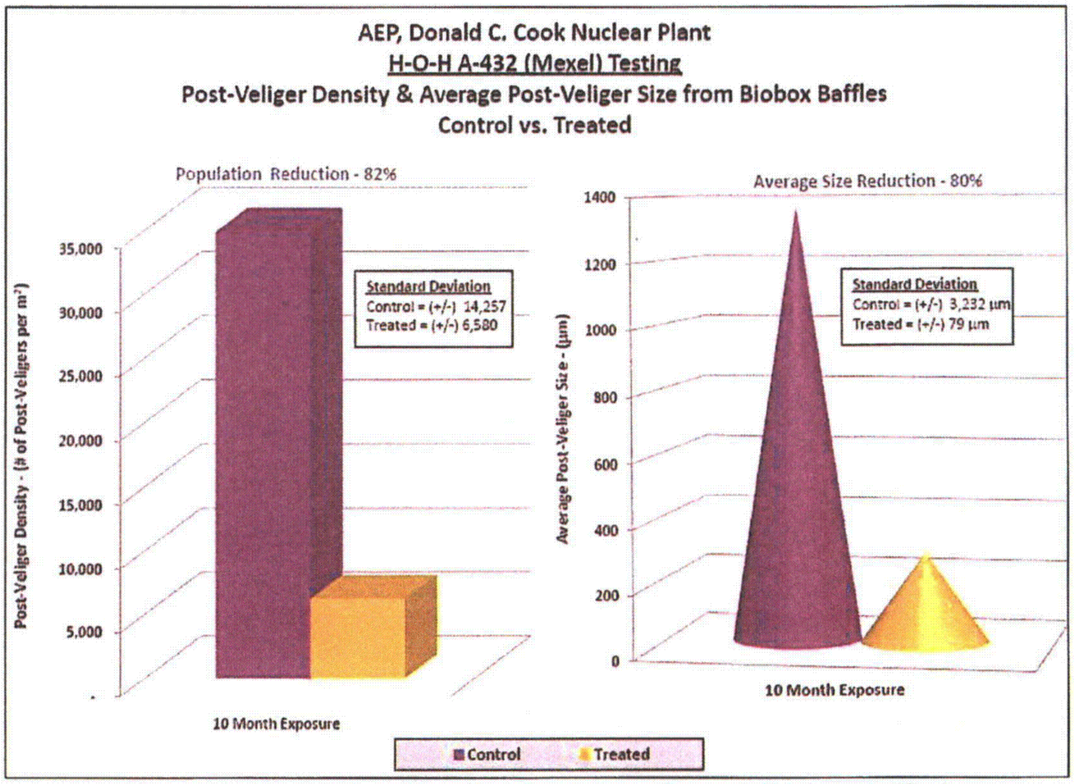

Figure 5 – Post Veliger Density, Treated vs. Control (Biobox Baffles)

Figure 5 illustrates Mexel treated and control baffle plates. Cumulative settlement population densities were reduced by **82%** as compared to the control group. Average post–veliger size, also illustrated in Figure 5, indicates a reduction in size by a cumulative average of **80%** as measured on baffle plates. The population and size reduction shown is based on two baffle plates that were exposed for ten months.

Total Mussel Debris Collection / Quantification

Flow to the test rig was established after installation on August 30, 2006. Other than periodic maintenance and inspection outages (2 hours max.) flow to the rig ran uninterrupted until project completion on August 29, 2007. Upon completion, the center section of each of the flow trains was sealed to capture mussels and debris. Each cell was carefully disassembled off-site and the debris was collected by Custom Technique #4 above. This sample represents the expected difference between treated and untreated intake tunnels.

Figure 6 - Cleaning Rig

Figure 7 - Power Washing

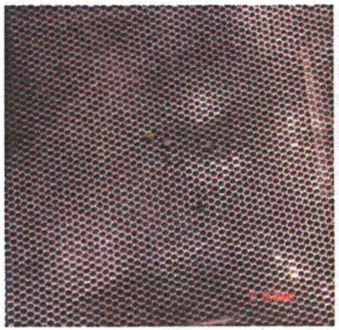

Figure 8 – Treated Filter

Figure 9 – Control Filter

Figure 10 – Growth Filter

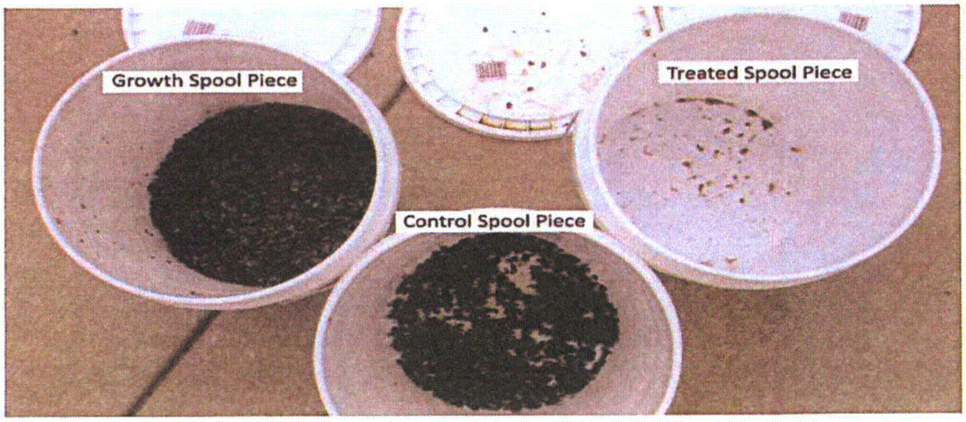

Figure 11 - Final Mussel Debris Collection Amounts

Total Mussel Debris Collection / Quantification, continued

The mussel debris was collected and transported to H-O-H Chemicals to determine volume and weight collected from all three spool pieces. Table 2 illustrates that a total reduction of 98.7% in mussel shell debris by weight in treated vs. untreated and 95% reduction by volume. Figure 12 displays this data graphically.

Table 2 - Total Mussel Debris Collection / Quantification Data Table

Sample	Weight Collected, (g)	Volume Collected, (mL)
Treated	1.72	< 10
Control	136.26	200
Growth	1764.50	4000
Treated vs. Control		
Weight Reduction, (%)	98.7 %	
Volume Reduction, (%)	95.0 %	

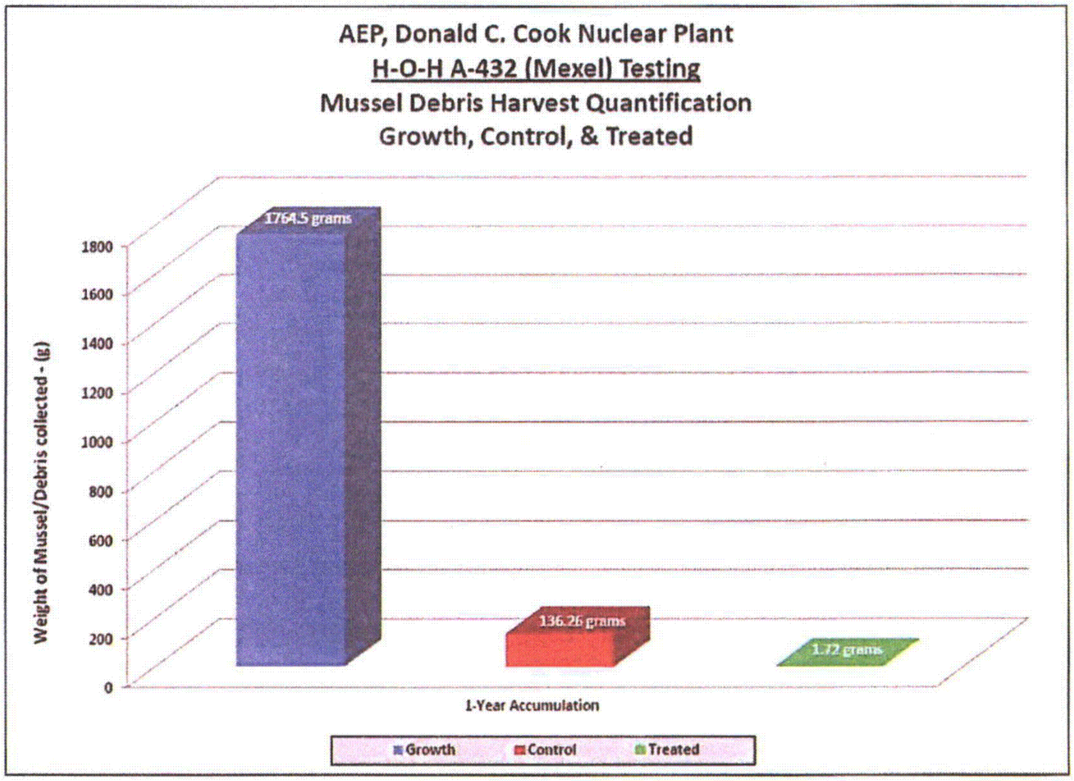

Figure 12 – Mussel Debris Collections Quantification Graph

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Corrosion Rates Using Mexel

Table 3 shows corrosion rates for steel coupons exposed to Mexel treated water versus untreated water. Mexel treated coupons had a **23%** reduction in corrosion rates. This is based on the weight loss differential in treated vs. untreated. Corrosion rate evaluations in mils per year (MPY) are established by H-O-H guidelines for cooling water systems and are listed in Table 4.

Table 3 – Corrosion Coupon Results

Treated Coupons, Cumulative

Coupon No.	Material	Days Exposed	Treatment	Weight Loss, (g)	Corrosion Rate, (MPY)	Evaluation
T-75K	Steel	43	Mexel	0.2989	3.89	Fair
T-75J	Steel	43	Mexel	0.2947	3.84	Fair
T-80P	Steel	56	Mexel	0.4109	4.11	Fair
T-80R	Steel	56	Mexel	0.6190	6.19	Poor
T-83K	Steel	200	Mexel	0.4594	1.29	Good
Average	**Steel**	**100**	**Mexel**	**0.4166**	**3.86**	**Fair**

Control Coupons, Cumulative

Coupon No.	Material	Days Exposed	Treatment	Weight Loss, (g)	Corrosion Rate, (MPY)	Evaluation
T-75I	Steel	43	None	0.6537	8.51	Unacceptable
T-75L	Steel	43	None	0.6093	7.94	Unacceptable
T-80Q	Steel	56	None	0.3446	3.45	Fair
T-80S	Steel	56	None	0.3594	3.59	Fair
T-83L	Steel	200	None	0.4761	1.33	Good
Average	**Steel**	**100**	**None**	**0.4886**	**5.00**	**Poor**

Table 4 – Corrosion Coupon Evaluation Standards (MPY)

Evaluation	**Steel**
Excellent	0.00 – 0.99
Good	1.00 – 2.99
Fair	3.00 – 4.99
Poor	5.00 – 6.99
Unacceptable	7.00 - Over

Internal Investigation and Observations

Video boroscope evaluations of treated, control, and growth flow trains (pipes) were performed at regular intervals during this study. Figures 13, 14, and 15 illustrate typical results of the internal investigation of the spool pieces.

Figure 13 – Mexel Treated Spool Piece

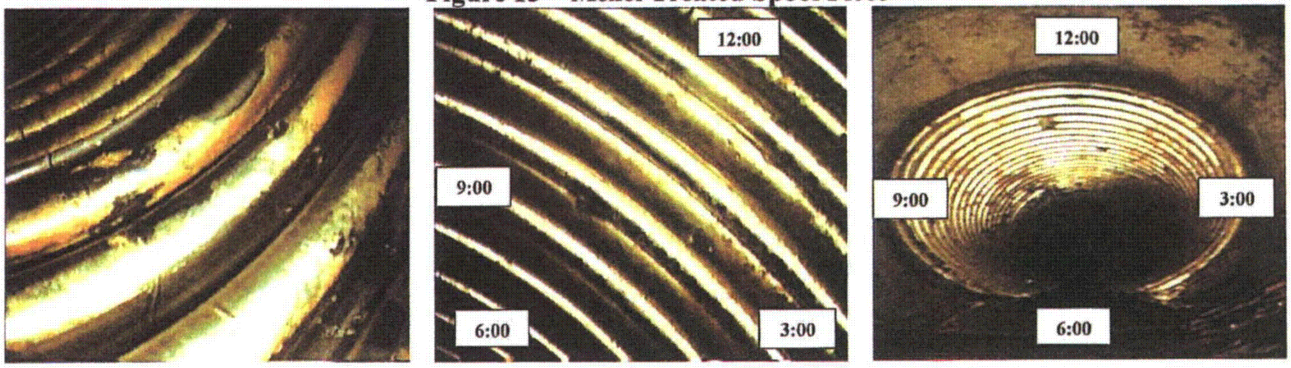


Figure 14 – Control Spool Piece

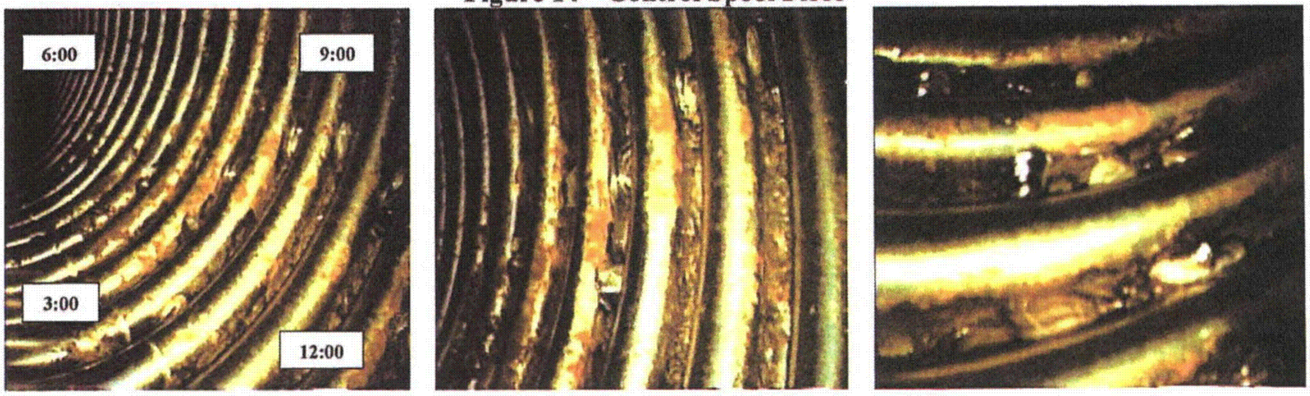
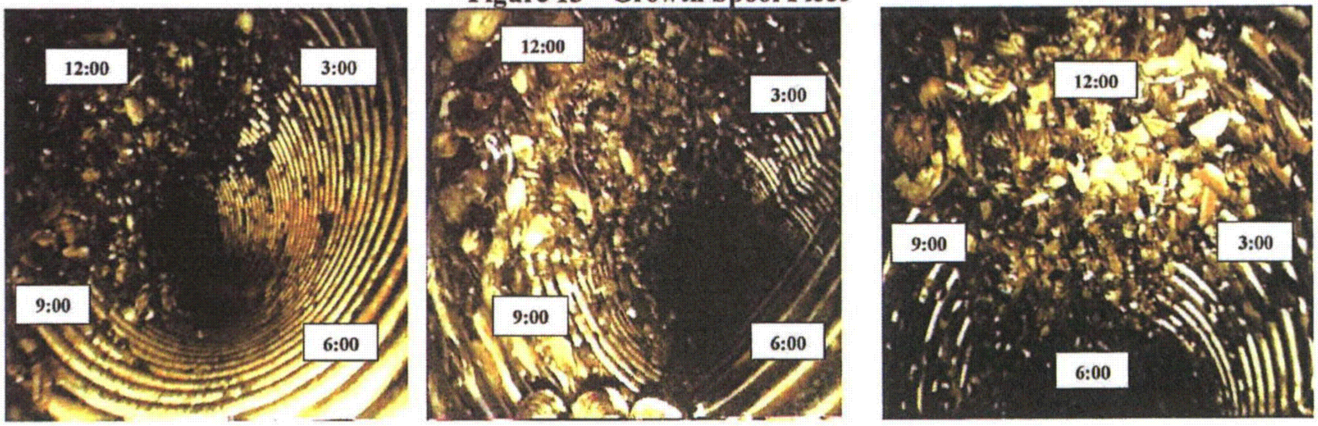


Figure 15 – Growth Spool Piece



Internal Investigation/Observations, continued

Figures 13, 14 & 15 are still photographs captured from boroscopic video inspections near the completion of the trial. The video inspections indicate the test rig compares well with observations made during previous remote operated vehicle (ROV) inspections of the 16-foot diameter tunnels. The untreated control and growth sections of the test rig reveal similar fouling patterns. The mussel attachment is observed in the upper portions (9 o'clock to 3 o'clock) of the tunnels and flow trains while the bottom sections are cleaner. This is believed to be the result of the scouring effect suspended solids and debris have on the bottom sections of the tunnels as well as the control and growth sections of the test rig.

Also, the mussel attachment is found on the downstream side of the corrugations. Colonies up to several inches thick have been observed in the 16-foot diameter tunnels as they attach to the metal within the corrugation troughs. This pattern is clearly observed in both the control and growth section of the test rig. Figure 14 shows colonization within the corrugation troughs and Figure 15 illustrates clumps of zebra mussels thriving in the low velocity environment. The velocity in this section is believed to be parallel to the downstream side of the corrugation troughs and trough bottoms in the 16-foot diameter tunnels.

In the test rig the dimension of the trough limits the numbers of colonies in the control section. However, the attachment and infestation mechanics are the same. The growth section confirms similar behavior as the tunnel corrugation troughs illustrated by colonization and clumping.

Figure 13 is a snapshot of a Mexel treated section of the flow train. Infestation patterns are not found in this section. The trough bottoms are free of attached zebra mussels and only widely scattered individual mussels were observed in this section of the test rig.

Figures 16 and 17 show the bioboxes after completion of the study. The orifices shown are the biobox outlets. From a visual inspection, the difference in population density and size is apparent.

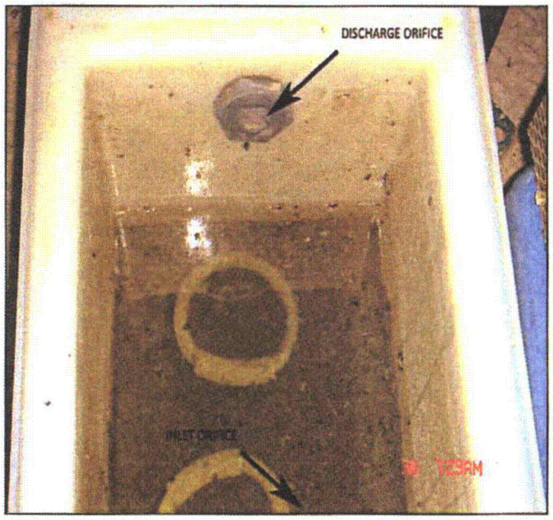


Figure 16 – Treated Biobox

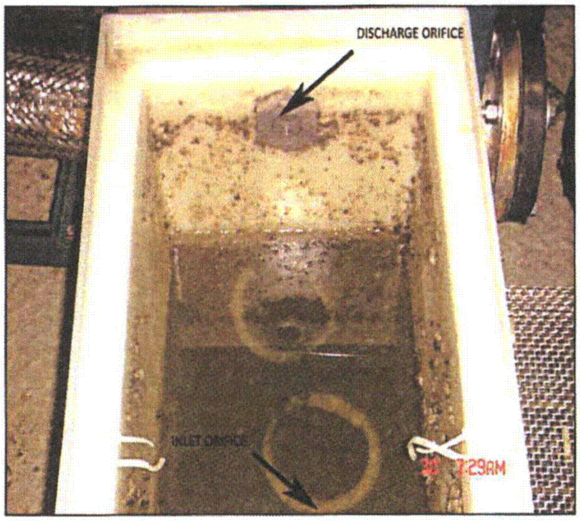


Figure 17 – Control Biobox

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Total Suspended Solids

Suspended Solids in any water system typically contribute to flow restrictions, plugging and debris loading. In an effort to understand solids loading, each week water samples were collected from both the treated and untreated flow circuits of the test rig. Total suspended solids were measured on each sample as the residue on a 0.22 micron filter in accordance with Standard Methods. The results show a reduction in suspended solids in the treated samples. These results are shown graphically in Figure 18 below.

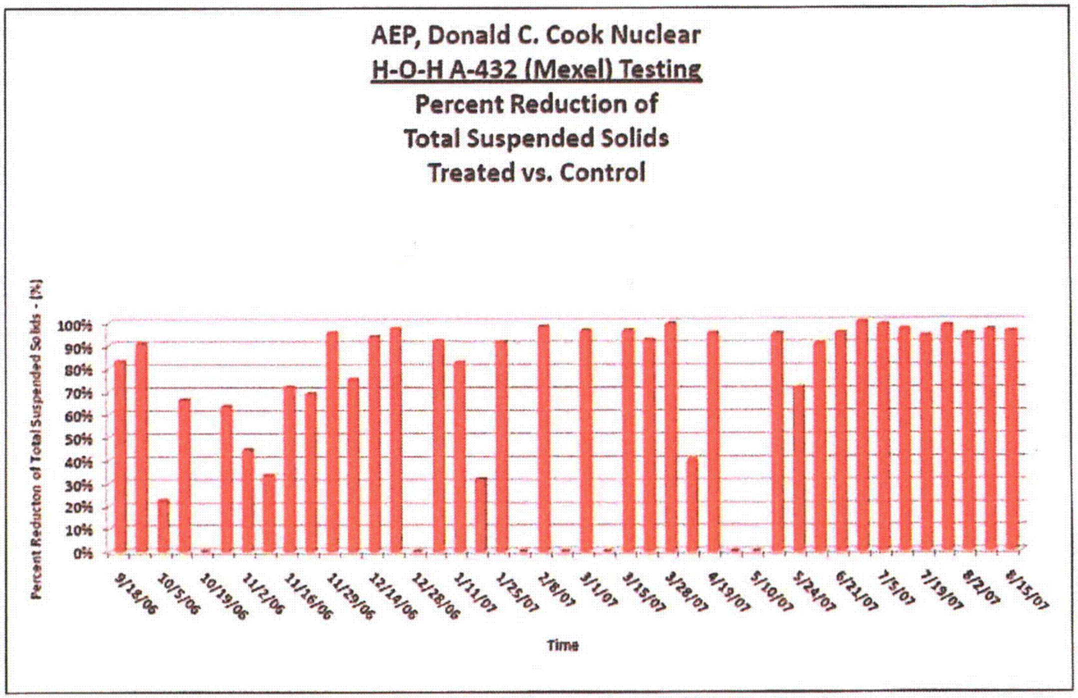


Figure 18 – Total Suspended Solids Reduction

Figure 19 shows the visual difference of a treated vs. control sample in water clarity photographically. This potentially impacted the cleanliness of the bioboxes and test rig. It seems safe to conclude, that for reasons undetermined from the sampling, Mexel causes the rate of settling of particulate matter in the lake water to pass through the bioboxes and the test rig. Mexel will likely have a similar affect on the particulate matter passing through CNP's cooling water distribution system.

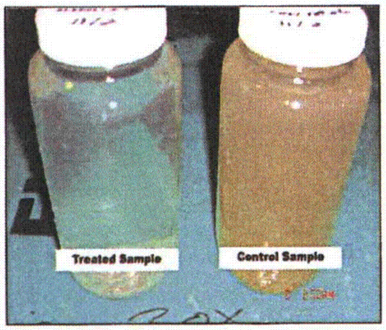


Figure 19 – Water Clarity (Treated vs. Control)

Figure 20 is a typical picture of two filter baskets during a weekly inspection, one from the Mexel treated flow train and one from the control flow train. Based on visual observation, the filter baskets from the Mexel treated flow stream consistently showed fewer mussel trans-locators, less mud, and less silt in the treated filter baskets compared to the untreated filter baskets.

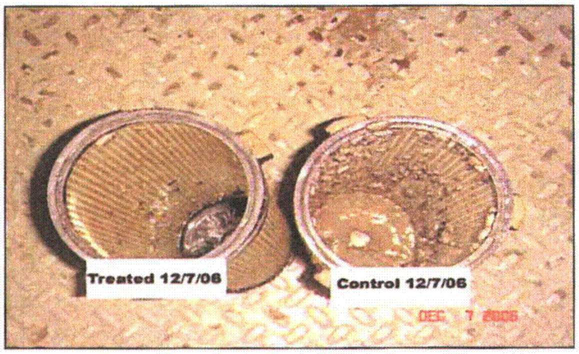


Figure 20 – Sloughage Filter Baskets

Sloughage Rate

Figure 20 also illustrates that the Mexel treated circuit caught fewer mussel debris and trans-locators. No increase of debris was found when fouled pipe sections of the growth flow train were installed in place of clean pipe sections on the treated flow train. Under this line-up healthy attached colonies were exposed to normal treatment dosage.

Mexel Mortality Experiment

To quantify potential impact on sloughage, a zebra mussel mortality experiment was devised. Two hundred live healthy zebra mussels collected from screen house trash baskets were collected and placed into the treated and control bioboxes. The treated biobox received the daily dosage of Mexel and the control received untreated lake water. Live vs. dead mussel counts were made each week for five weeks. Zebra mussels exposed to Mexel illustrated a mortality rate equal to those not exposed to Mexel in the control biobox. Table 5 illustrates the relative mortality rate over a 5 week period. Therefore a massive sloughage of zebra mussel debris would not be expected should a daily application of Mexel at the 4 ppm dosage be initiated on a pipeline infested with zebra mussels.

Table 5 – Zebra Mussel Mortality Study

	Live Treated Mussels	Live Control Mussels
Start	100	100
1 Week	81	76
2 Weeks	80	75
3 Weeks	80	75
4 Weeks	78	73
5 Weeks	74	70

Reverse Osmosis Membranes (R/O)

Zebra mussel chemical control agents can severely damage R/O membranes within the CNP make-up plant. (Water & Power Technologies, Technical Analyses Report, 2003 Appendix #9). As part of this study water from the Mexel treated flow stream was fed through a small R/O unit that contained the same membrane material that is in the CNP R/O system, Dow Filmtec Polyamide (PA) thin-film.

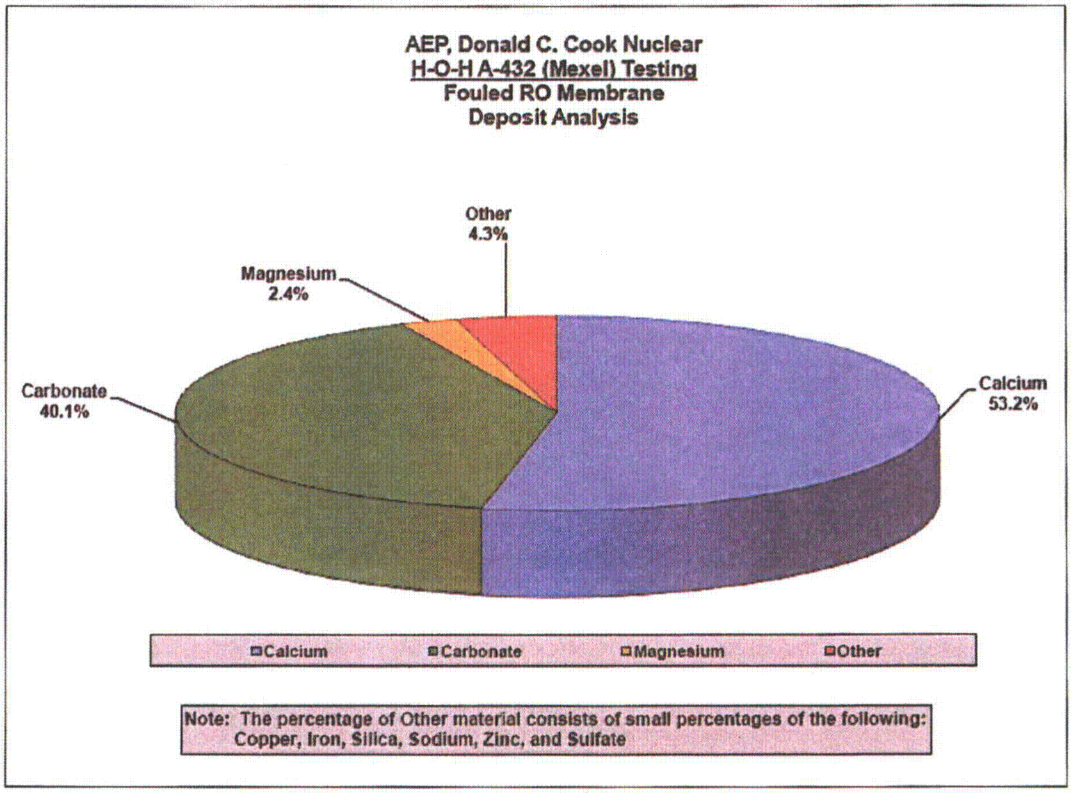


Figure 21 – Fouled Membrane Analysis

R/O membrane autopsy results are shown in Figure 21. The test rig model illustrated no contamination with Mexel. Calcium and magnesium carbonates were analyzed to be 95.7% of the deposit material on the R/O membranes. Autopsy results from the membrane failure in 2003 were determined to be deposits of clay and biota. The membranes installed in the test rig make-up plant model are the same as those operated by CNP, Dow Filmtec Polyamide (PA) thin-film. PA membranes are a thin layer of aromatic polyamide extruded onto a polysulfone substrate. The PA membranes intentionally have a negative (anionic) surface charge and are commonly fouled by cations. Highly charged cationic surfactants and cleaning chemicals are typically not recommended for contact with PA membranes. The fouling that occurred during dosage of GE Spectrus CT1300, a cationic quaternary ammonium compound, is theorized to have conditioned colloidal particles to attach to the membranes or impacted the surface charge of the membrane itself to attract colloids. This mechanism increased the normal fouling rate by rapidly depositing particles on membrane surfaces reducing salt rejection while increasing differential pressure. (Water & Power Technologies, Technical Analyses Report, 2003 Appendix #9) Mexel is non-ionic and did not illustrate the same behavior as Spectrus CT1300 in this test. These results illustrate typical membrane fouling by the insoluble salts of unconditioned positively charged cations.

20

Organic Loading

Total organic carbon (TOC) and total organic nitrogen (TON) were monitored to determine what affects Mexel may have on organic loading, both as the effective biocide and byproducts. Increased concentrations of organics by more than a factor of 10 over the control condition can have adverse effects on microbial fouling and in this case may be indicative of excess residual Mexel concentrations.

TOC and TON results are found in Figures 22 and 23. Concentrations of TOC and TON were comparable in treated and control flow samples. As any TOC/TON concentration increases due to Mexel were less than a factor of 10 over the control condition, there were no adverse effects on organic loading. This suggests that Mexel does not significantly contribute to TOC or TON in bulk water solutions.

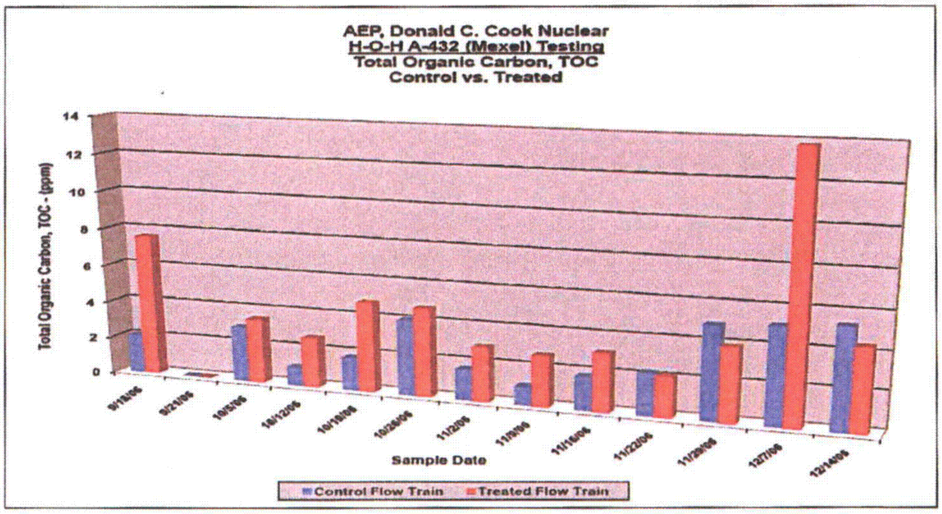


Figure 22 – Total Organic Carbon (TOC) Results from Lab Samples

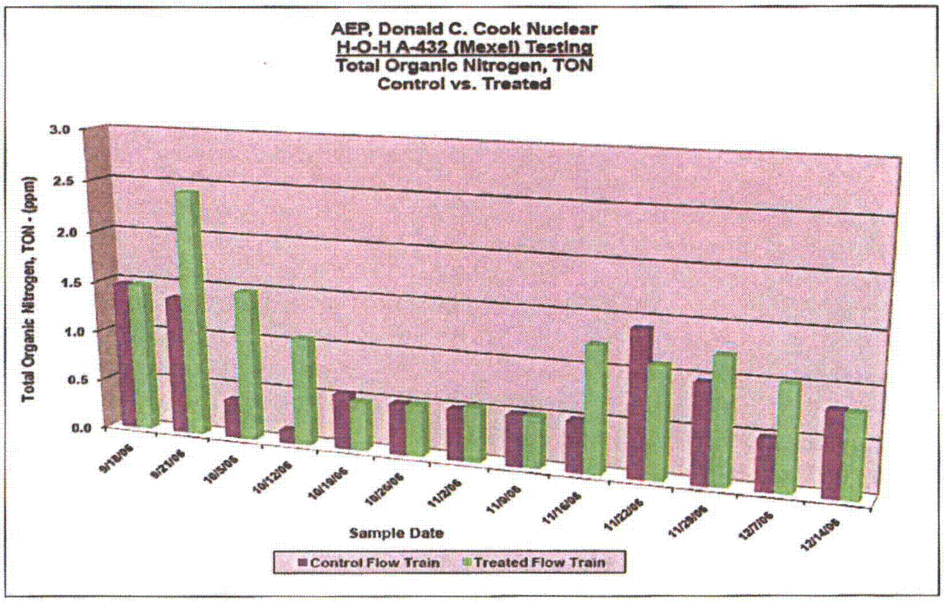


Figure 23 – Total Organic Nitrogen (TON) Results from Lab Samples

Whole Effluent Toxicity Testing Summary

Two AEP Cook Nuclear Plant cooling water samples were collected by HOH and AEP/CNP plant employees on November 29-30, 2006 for whole effluent toxicity (WET) testing by Great Lakes Environmental Center (GLEC).

Figure 24 – WET Test Collection

The first sample was a 24-hr. composite sample collected using an automatic composite sampler. Effluent samples were collected every hour beginning on the morning of Nov. 29th. Sample collection continued for 24-hours with the last sample collected the next day, Nov. 30th, during the 30-minute Mexel treatment period. The 24-hr. composite sample was collected to represent the effect, if any, on aquatic life during a typical 24-hr. Mexel treatment regime. Figure 24 shows collection of wet test samples at CNP.

The second sample was a grab sample collected on the morning of Nov. 30th during the 30-minute treatment period. This sample was collected to represent the plant discharge conditions at a maximum Mexel concentration and the effect, if any, on aquatic life if the treatment were to be run continuously for 24 hours, which is not the recommended dosage regime for this product.

The two samples and a sample of untreated lake water for dilution and laboratory control were packed on ice immediately after collection in coolers on the morning of November 30th and delivered that day to the GLEC laboratory in Traverse City, MI. The toxicity testing was initiated following sample delivery to the laboratory. GLEC conducted a 48-hour *Daphnia magna* and a 96-hour fathead minnow acute toxicity test on each of the 24-hr. composite and 30- minute grab samples following standardized USEPA testing protocols.

The 24-hour composite sample was not acutely toxic to *D. magna* or fathead minnows, (See Figure 25). There was 100 percent survival of both *D. magna* and fathead minnows in this sample. The 48-hour *D. magna* LC_{50} (median lethal toxicant concentration) and EC_{50} (median effect concentration) estimates were both greater than 100 percent in that sample. The 96-hour fathead minnow LC_{50} was also greater than 100 percent in that sample.

The 30-minute sample was acutely toxic to both *D. magna* and fathead minnows. The acute toxicity tests that were initiated with the 30-minute sample had an estimated LC_{50} of 35.4 percent sample in the *D. magna* test and 27.7 percent sample in the fathead minnow test. If we assume an estimated concentration of 2.5 ppm Mexel residual in the sample, these LC_{50} estimates equate to estimates of 0.88 mg/L Mexel for *D. magna* and 0.69 mg/L Mexel for fathead minnow respectively.

22

Whole Effluent Toxicity Testing Summary, continued

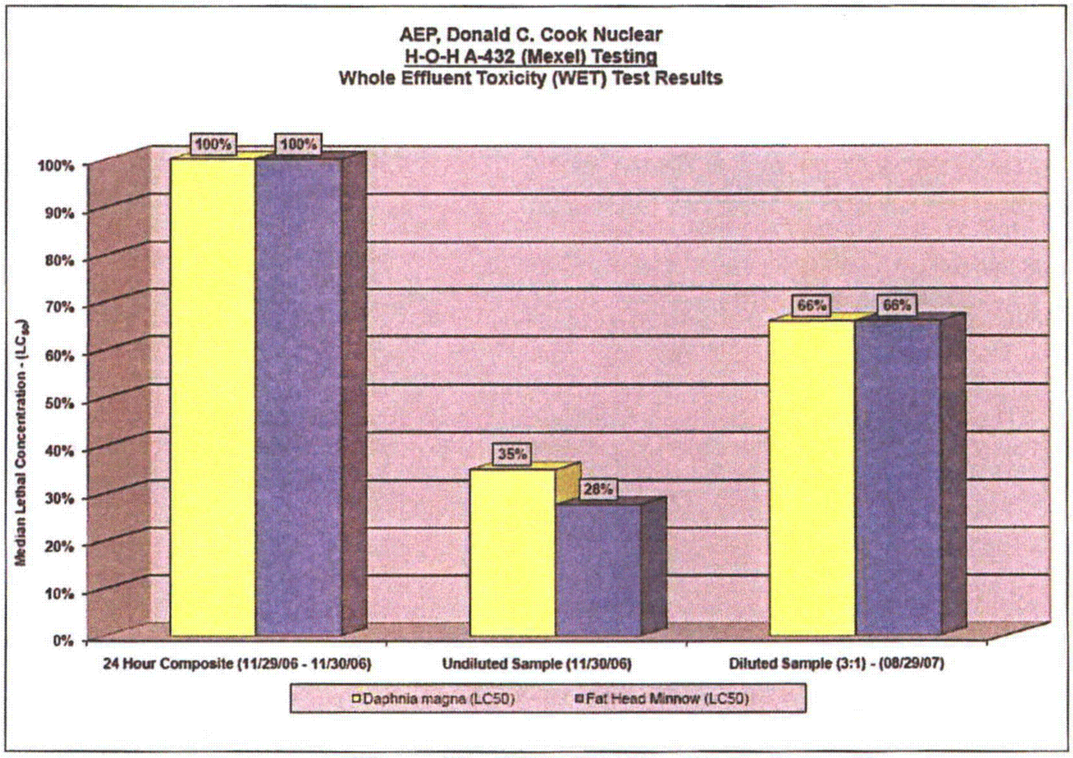


Figure 25 – WET Test Results

The toxicity tests with the 24-hour composite sample demonstrated that the recommended treatment regime of 4 ppm dosage Mexel to obtain a 2.5 ppm residual concentration for 30 minutes per day caused no negative impacts to the aquatic life using the indicator organisms *D. magna* and fat head minnows. The toxicity tests with the 30-minute grab sample demonstrated that a hypothetical continuous treatment regime of 4 ppm dosage Mexel to obtain a 2.5 ppm residual concentration would exceed the threshold toxicity for these indicator organisms without a 3:1 dilution credit (0.83 ppm) for the plant's high velocity discharge diffusers.

Based on this data, it is logical to hypothesize that given a 3:1 dilution factor (GLEC Mixing Zone Evaluation 2005) the Mexel treated effluent sample would not be toxic to aquatic life within the discharge mixing zone in Lake Michigan. To confirm the hypothetical treatment regime described above, another (WET) test was conducted using the same indicator organisms with a Mexel treated sample. On August 28, 2007, a one gallon sample of Mexel treated cooling water was collected from the pilot test rig and mixed with two gallons of untreated lake water to simulate a 3:1 dilution. That sample and an untreated lake water sample were packed on ice in coolers on the same day and transported immediately to the GLEC laboratory in Traverse City. The toxicity testing was initiated following sample delivery to the laboratory.

The August 2007 diluted 3:1 Mexel treated effluent sample was acutely toxic to both *D. magna* and fathead minnows. The 48-hour *D. magna* and 96-hour fathead minnow LC_{50} (median lethal toxicant concentration) and *D. magna* 48-hour EC_{50} (median effect concentration) estimates were all 65.9 percent effluent.

Whole Effluent Toxicity Testing Summary, continued

A direct comparison of LC_{50} estimates between the two tests cannot be made. A relative comparison of the two sets of WET tests may be possible by extrapolating the toxicity test results to simulate a 3:1 dilution with the November 2006 results or to simulate no dilution using the August 2007 results. Using that comparison, the results of the August 2007 Mexel treated cooling water toxicity tests after a 3:1 lake water dilution are similar to the November 2006 toxicity test results in that the results are within the expected variability of whole effluent toxicity tests. In interlaboratory comparisons, EPA determined that WET test results may vary by one test concentration between laboratories and over time. Likewise, in single chemical toxicity tests with Mexel against *Daphnia magna* and fathead minnow, a similar degree of variability was observed. In the Mexel toxicity database, the toxicity of Mexel to *Daphnia magna* varied between 0.120 mg/L and 0.595 mg/L. The toxicity of Mexel to fathead minnow varied between 0.360 mg/L and 0.660 mg/L. However, these comparisons should also take into consideration the differences in the physical and chemical attributes that may affect the toxicity of Mexel in different water types or treatment scenarios, because of seasonal changes in water quality, or because of different sources of test organisms.

Conclusions

Zebra mussels were probably introduced into the Great Lakes in 1988. Since then many water intake facilities have been affected and have initiated a control strategy.

The continuous flow research facility has enabled an on-site evaluation of a zebra mussel control technique to test the effect of Mexel on natural populations of veligers and trans-locators. Corrugated pipe sections accurately simulated the plant's intake tunnels as confirmed by the observation of similar fouling patterns. Robust data have been collected to predict the impact Mexel will have on plant systems, and the environment without the cost of a full scale application. The insight provided by this evaluation enables a better understanding of the proposed Mexel application while mitigating risk and failure.

1. Mexel treated circuits illustrated an aggregate **78% reduction in post-veliger population density** and a **64% reduction in post-veliger size** compared to untreated circuits as evaluated by CNP procedure 12-EA-6090-ENV-101 Zebra Mussel Sampling and Analysis.

2. Mexel treated circuits illustrated no discernible pattern of infestation, colonization or clumping. Rather the mussels exhibited a pattern of isolated individuals compared with the control where mussels formed clumps and were abundant.

3. Mexel treated circuits realized a 95% reduction by volume in mussel and total debris compared to untreated circuits as measured by the total material removed from the flow circuit piping at the end of the pilot test experiment.

4. Mexel reduced silt accumulation in the treated biobox and test rig components when compared to the untreated biobox and components.

5. Mexel treated circuits did not illustrate a mortality or sloughage rate greater than control circuits, thus improving the understanding that normal product application to a fouled tunnel will not result in a massive release of mussel debris or overload of the traveling screens and debris handling systems.

6. R/O membranes were not fouled with colloidal particles conditioned by Mexel or Mexel molecules.

7. Whole effluent toxicity testing illustrates species survival in 100% of the effluent of a 24 hour composite indicating no impact to indicator organisms under studied treatment regimen.

8. Whole effluent toxicity tests using Mexel treated water showed a 48 hr LC_{50} toxicity of 35.4% to *Daphnia magna* and 27.7% to fathead minnows for an undiluted acute sampling and 65.9% for both species for a 3:1 diluted acute sampling.

The results of this study indicate that Mexel is effective at preventing infestation and can be safely applied at the prescribed dosage regimen without negative consequence at CNP or the biota in Lake Michigan.

Acknowledgement

H-O-H Water Technology would like to thank the following contributors:

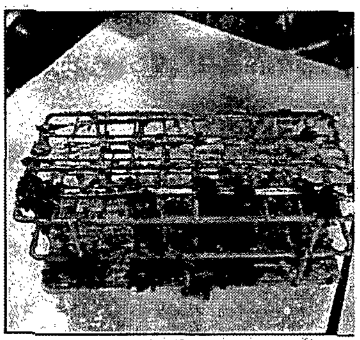
1. American Electric Power (AEP)
    - ➢ Eric Mallen – Environmental Specialist
    - ➢ John Carlson – Environment Safety & Health Manager
    - ➢ Jon Harner – Environmental Manager
    - ➢ Alan Gaulke – Consulting Environmental Specialist
    - ➢ AEP Cook Nuclear Environmental Department Staff

2. RTK Technologies
    - ➢ Rick Kreuser

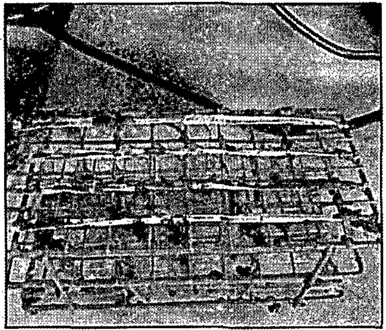
3. Ecotox, Inc.
    - ➢ Francois Ghillebaert – Aquatic Toxicologist, PhD

4. Great Lakes Environmental
    - ➢ Dennis McCauley – Operations Co-Manager/Principal Research Scientist

5. Michigan Department of Environmental Quality (MDEQ)
    - ➢ Sylvia Heaton – Aquatic Biologist, Senior Level


Control Slide Rack


Test Rig on Unit 2 Discharge Platform


Treated Slide Rack

References

1. Ackerman, J.D., Claudi, R., Spencer, F.S., Sim, B., Evans D., A Continuous Flow Research Facility for Zebra Mussel Research & Control presented at the 4th international zebra mussel conference Madison Wisconsin 1994.
2. Ghillebaert, F. 1997 Toxicological File of Mexel 432, Summary of the Studies.
3. Kreuser, R., Vanlaer, A., Damour, A. 1997 A Novel Molluscicide, Corrosion Inhibitor and Dispersant, Corrosion 1997, Paper No. 409.
4. McCauley, D.J. , Endicott, D., 2005 Mixing Zone Evaluation for the DC Cook Nuclear Plant Discharge Plume in Lake Michigan.
5. Mexel Skid Baffle Analysis 2-15-07, E. Scott Rose AEP.
6. Water & Power Technologies, Job #7574, Technical Analyses Report, July 2003.

APPENDIX 1

Project: Impact Study of Mexel on Zebra Mussel Infestation Continuous–Flow Research Facility

Authors: Jon J. Cohen, Tom Armon, Dave Junge, Darius Barkauskas, Henry A. Becker
Rick Kreuser, Francois Ghillebart

Summary: Mexel, a filming amine proposed for zebra mussel control, will be studied using native colonies and plant intake water at the Cook Nuclear Facility. A unique continuous-flow research facility built to model Cook flow and operational conditions is proposed for this project. Data will be developed to test the effectiveness of Mexel under realistic conditions using natural populations of larvae and translocators. It is believed that this facility will provide valuable insight into the use of Mexel as a preventive molluscicide as well as techniques for optimization and protection of critical plant water systems. Control of new zebra mussel infestation, injection of Mexel, affects of Mexel on existing mussel infestation and Mexel deposition on pipe will be examined.

Continuous Flow Research Facilities have been used to model effectiveness of molluscicide control programs on once through cooling water systems. (Ackerman/Claudi 1994). Modular flow through design using natural populations have previously provided robust data that enabled treatment modeling for plant systems under dynamic conditions.

Background: Mexel is a filming amine used in many freshwater and saltwater systems worldwide. Toxicological effects of Mexel have been widely studied in both freshwater and saltwater (Ghillebaert, 1997), while there is little published data concerning Mexel's affects on existing zebra mussel infestations, deposition on corrugated pipe with existing infestation and effectiveness in freshwater applications. An overview study of Mexel's use as a molluscicide, inhibitor and dispersant (Kreuser et al, 1997), demonstrated efficacy in fresh and salt water when proper film formation was accomplished. Biodegradation of Mexel was also demonstrated and documented.

Specifically with respect to Cook Nuclear Facility, intake tunnel modeling, use with Lake Michigan water and infestation currently within their water intake tunnels must be studied before continuous application can be initiated. Application of Mexel at Cook must be accomplished without interruption of plant operation including plant water intake and plant water pretreatment equipment.

Cook Nuclear Facility has dealt with zebra mussel infestation for several years and has employed many different treatment alternatives. Three intake tunnels constructed of 16 foot diameter corrugated, galvanized steel pipe extend out one half mile from a forebay. Corrugations in this pipe are six inches wide and two inches deep. Preventative and shock zebra mussel chemistry has been discontinued for multiple spawning seasons, allowing colony growth along all three intake tunnels; with accumulation contained within the corrugations.

Chemical injection piping, which had previously run from inside the plant to injection assemblies at the tunnel entrances, has been damaged and will be replaced prior to continuous Mexel injection. Injection assembly design is critical to Mexel effectiveness and results of this study due to the filming nature of this product.

Contact between Mexel and pipe surface must be ensured to allow a uniform film along the intake tunnels. Film formation on clean and infested pipe must be studied with near in-situ flow and distribution characteristics to model effectiveness in the Cook plant.

Redesigned traveling screens in place at Cook have proven to be more effective at handling debris and dislodged mussel colonies prior to plant water distribution to condensers and service water systems. However, a sudden or massive release of colonies and shell debris in theory have the potential to over load the traveling screens As well as compromise the plants ability to dispose of shell debris. While it is desirable to remove existing colonies in part the goal of this study is to extrapolate a rate of sloughage at recommended normal Mexel dosage regime.

Experiment: A novel experimental apparatus is proposed for study of zebra mussels at the Cook Nuclear Facility. This apparatus is comprised of horizontal corrugated spool pieces acting as a substrate for zebra mussel growth, translocation and Mexel deposition. Spool pieces will be manufactured from stainless steel pipe and four feet in length. Pipe diameters will be four inches. Two identical piping trains will provide a control scenario in which Mexel will not be introduced and one where Mexel's effects will be studied.

The train will be provided a service flow of 750 gpm with a sixty horse power pump. The flow train manifold diverts flow to service a total of three trains and maintain velocity consistent with normal tunnel velocity. This flow rate will allow a velocity range of 6 to 7 fps in the treated and control pipes while the growth flow pipe will run at 1 fps. Varying flow velocity will allow for changes in shear stresses and contact time between the flow stream and surface. Since Cook's intake tunnels are 16 foot diameter corrugated pipe with zebra mussel infestation, calculating boundary layer depth, actual flow velocity within the boundary layer and shear forces at surfaces is difficult and unreliable. Through studying various flow streams multiple scenarios will be evaluated to ensure that any worst case circumstance can be determined experimentally before introducing product into Cook's intake tunnel.

Our experimental apparatus is comprised of three sections a treated, control and growth. Make-up plant modeling is also included. The attached drawing details the entire experimental apparatus with diagnostic equipment sections, pumps and plant pretreatment equipment. A branch with a booster pump will provide water through pretreatment equipment for make-up plant modeling.

Experimental design allows several configurations of both horizontal trains providing a means to test all four main parameters. Spool piece sections are twelve feet long, consisting of three four foot sections. Section lengths provide enough axial length to normalize flow characteristics. For each length, the third spool piece will provide best data available for each flow train due to projected achievement of laminar.

Precise flow measurement will provide accurate flow velocities in spool piece sections. All other monitoring equipment for measurements in the horizontal experimental section will be located in a pipe section subsequent to the final spool section. A detailed list of monitoring equipment is attached.

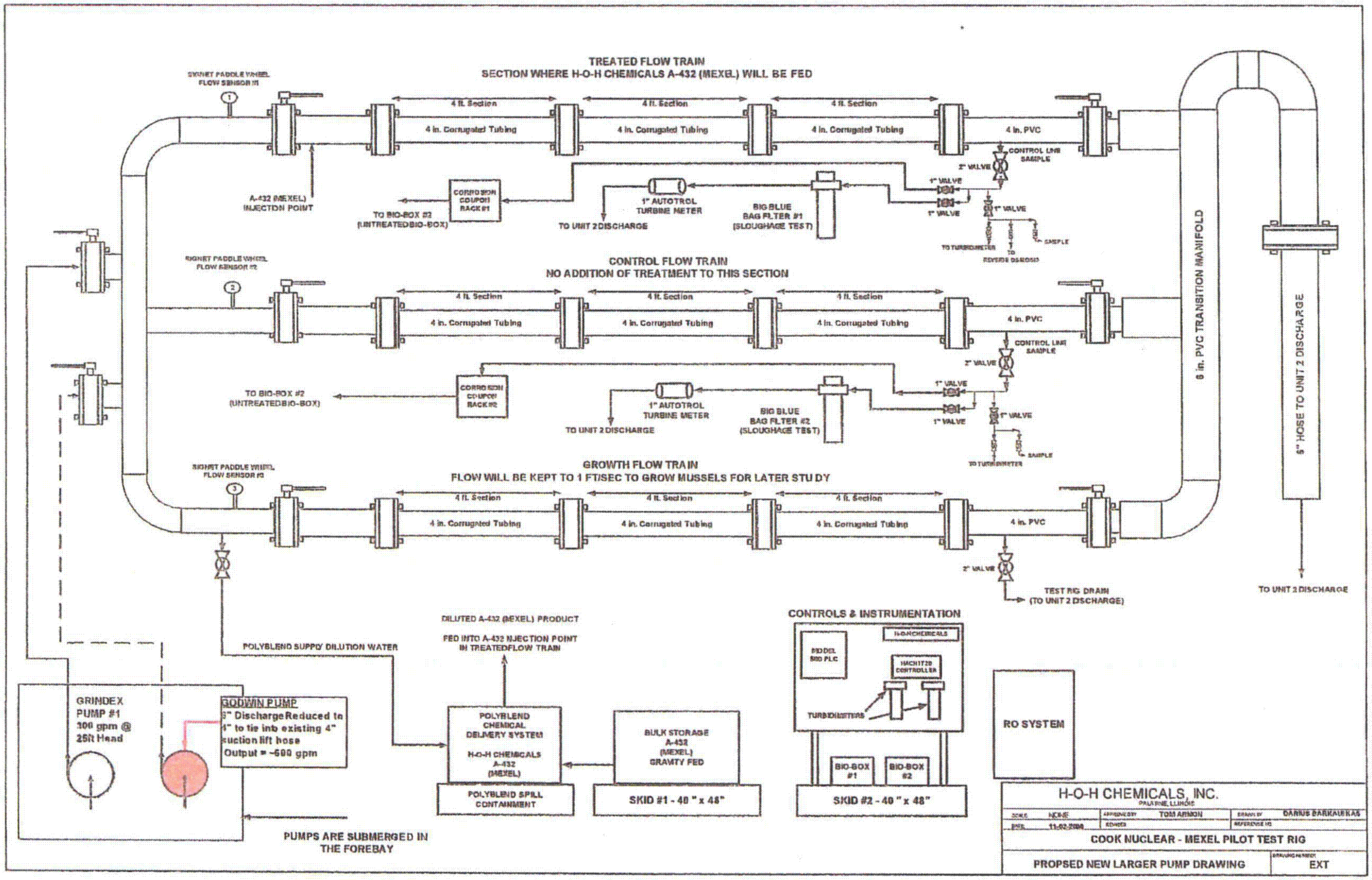
In addition to on-line instrumentation weekly grab samples will evaluate general chemistry, Mexel concentration; Total organic carbon (TOC), total organic nitrogen (TON) and turbidity will provide information on degradation of organic material. Turbidity will be useful in determining macroparticulate released from colonies and mussels after Mexel addition. TOC and TON will provide data on more finely released material, metabolic byproducts and a measurement of Mexel in the water. Corrosion coupons will measure potential differences on metal surfaces and are commonly used to determine corrosion rates.

Spool pieces can be rearranged to provide alternate experimental configurations. Spool pieces with well developed growth will be relocated to treated sections to understand sloughage and cleanup rates.

Plant pretreatment equipment is a critical component to plant operation at Cook Nuclear Facility. Previous zebra mussel treatments have caused significant damage to reverse osmosis membranes among other equipment difficulties. Multimedia filtration, carbon filtration, particle filtration and reverse osmosis will be fed by a ten gallon per minute booster pump. Effects of Mexel on each piece of pretreatment equipment will be determined to prevent impediments to operation of plant equipment and plant shutdown.

Conclusions will provide plant specific information for continual use of Mexel at Cook Nuclear Facility. Data collected will detail how Mexel should be injected, effects on existing infestation in Cook's intake tunnels, prevention of future growth and effects on pretreatment equipment. Experimental data will also provide a roadmap to circumvent obstacles to proper plant operation.

1. Ghillebaert, F. 1997 Toxicological File of Mexel 432, Summary of the Studies
2. Kreuser, R., Vanlaer, A., Damour, A. 1997 A Novel Molluscicide, Corrosion Inhibitor and Dispersant, Corrosion 1997, Paper No. 409
3. Ackerman, J.D., Claudi, R., Spencer, F.S., Sim, B., Evans D., A Continuous Flow Research Facility for Zebra Mussel Research & Control presented at the 4th international zebra mussel conference Madison Wisconsin 1994


TREATED FLOW TRAIN
SECTION WHERE H-O-H CHEMICALS A-432 (MEXEL) WILL BE FED
SIGNET PADDLE WHEEL FLOW SENSOR #1
1
4 ft. Section
4 in. Corrugated Tubing
4 in. PVC
A-432 (MEXEL) INJECTION POINT
CORROSION COUPON RACK #1
TO BIO-BOX #2 (UNTREATED BIO-BOX)
1" AUTOTROL TURBINE METER
TO UNIT 2 DISCHARGE
BIG BLUE BAG FILTER #1 (SLOUGHAGE TEST)
CONTROL LINE SAMPLE
2" VALVE
1" VALVE
SAMPLE
TO TURBIDIMETER
TO REVERSE OSMOSIS
CONTROL FLOW TRAIN
NO ADDITION OF TREATMENT TO THIS SECTION
SIGNET PADDLE WHEEL FLOW SENSOR #2
2
CORROSION COUPON RACK #2
TO BIO-BOX #2 (UNTREATED BIO-BOX)
1" AUTOTROL TURBINE METER
TO UNIT 2 DISCHARGE
BIG BLUE BAG FILTER #2 (SLOUGHAGE TEST)
GROWTH FLOW TRAIN
FLOW WILL BE KEPT TO 1 FT/SEC TO GROW MUSSELS FOR LATER STUDY
SIGNET PADDLE WHEEL FLOW SENSOR #3
3
TEST RIG DRAIN (TO UNIT 2 DISCHARGE)
6 in. PVC TRANSITION MANIFOLD
6" HOSE TO UNIT 2 DISCHARGE
TO UNIT 2 DISCHARGE
DILUTED A-432 (MEXEL) PRODUCT
FED INTO A-432 INJECTION POINT IN TREATED FLOW TRAIN
POLYBLEND SUPPLY DILUTION WATER
GRINDEX PUMP #1 300 gpm @ 25ft Head
GODWIN PUMP
6" Discharge Reduced to 4" to tie into existing 4" suction lift hose
Output = ~600 gpm
PUMPS ARE SUBMERGED IN THE FOREBAY
POLYBLEND CHEMICAL DELIVERY SYSTEM
H-O-H CHEMICALS A-432 (MEXEL)
POLYBLEND SPILL CONTAINMENT
BULK STORAGE A-432 (MEXEL) GRAVITY FED
SKID #1 - 40 " x 48"
CONTROLS & INSTRUMENTATION
H-O-H CHEMICALS
MODEL 500 PLC
HACH 1720 CONTROLLER
TURBIDIMETERS
BIO-BOX #1
BIO-BOX #2
SKID #2 - 40 " x 48"
RO SYSTEM
H-O-H CHEMICALS, INC.
PALATINE, ILLINOIS
SCALE NONE
APPROVED BY TOM ARMON
DRAWN BY DARIUS BARKAUSKAS
DATE 11-02-2006
REVISED
REFERENCE NO
COOK NUCLEAR - MEXEL PILOT TEST RIG
PROPSED NEW LARGER PUMP DRAWING
DRAWING NUMBER EXT

APPENDIX 2

REVIEW AND APPROVAL TRACKING FORM

Section 1 - Procedure Information:

Number: 12-EA-6090-ENV-101 Rev. 3

Title: Zebra Mussel Sampling and Analysis

Section 2 - Alteration Category:

☐ Minor Editorial Correction ☐ Cancellation

☐ Major Editorial Correction (Full Review) ☐ Superseded by (list superseding procedures):

☒ Minor Revision

☐ Major Revision (Full Review) ☐ New Procedure (Full Review)

Section 3 - Temporary Procedure / Revision:

☒ N/A ☐ Temporary Procedure ☐ Temporary Revision AR No.:

Expiration Date / Ending Activity: N/A

Section 4 - Associated Configuration Impact Assessments:

Change Driver / CDI Tracking No(s). ☒ N/A

Section 5 - Reviews:

Department (Refer to Figure 6, Determination of Required Reviews)	Validation (Figure 11)	Cross-Discipline (Figure 7)	Special (Figure 8 or Figure 10)	Technical (Figure 9)
Environmental	☒	☐	☐	☐
Environmental	☐	☐	☐	☒
	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐

Section 6 - Technical Review:

Updated Revision Summary and Implementation Plan (if applicable) attached? ☒ Yes

Implementation Plan developed? If yes, AR No.: ☐ Yes ☒ N/A

Are there implementation actions to be completed prior to the effective date? ☐ Yes ☒ No

10 CFR 50.59 Requirements complete? Tracking No.: ☐ Yes ☒ N/A

Technical Reviewer: Jon H. Harner / Jon K. Har Date: 11-5-06

Section 7 - Ready for Approval:

Administrative Hold Status: ☐ Released ☐ Reissued ☒ N/A CR No.:

Writer: Date: 11-9-06

☐ Ops Manager Concurrence: N/A Date:

Section 8 - Approvals:

PORC Review Required: ☐ Yes ☒ No Mtg No.:

Approval Authority Review/Approval: Date: 11-9-06

Effective Date: 11-15-06

Section 9 - Follow-up Actions:

Commitment Database update requested in accordance with PMP-2350-CMS-001? ☐ Yes ☒ N/A

NDM notified of new records or changes to records that could affect record retention? ☐ Yes ☒ N/A

NDM Use Only		***Office Information For Form Tracking Only - Not Part of Form***
		This form is derived from the information in PMP-2010-PRC-002, Procedure Alteration, Review, and Approval, Rev. 19, Data Sheet 1, Review and Approval Tracking Form. Page 1 of 1

AEP AMERICAN ELECTRIC POWER AEP: America's Energy Partner	**12-EA-6090-ENV-101**	**Rev. 3**	**Page 1 of 10**
Zebra Mussel Sampling and Analysis			
Information			

Marcia Strefling	John Carlson	Environmental
Writer	Document Owner	Cognizant Organization

TABLE OF CONTENTS

1 PURPOSE AND SCOPE

1.1 To establish the proper methods for monitoring Zebra Mussels in the Donald C. Cook Nuclear Plant in support of NRC commitments, Zebra Mussel Monitoring and Control, and the Generic Letter 89-13 Programs. (Ref. 7.2.1b, 7.2.1d, 7.2.1e)

2 PREREQUISITES

2.1 Environmental develops a sampling schedule for work. Deviations may be made at the discretion of Environmental.

2.2 The following sampling and analytical tools are available for evaluating zebra mussel densities in the whole water and settlement on substrates.

- bio-monitors
- test tube racks
- microscope slides
- plankton net with cod-end bucket
- stereo-microscope with polarizing filters
- magnetic stirrer
- plastic barrel
- pump
- flow meter or bucket and timing device
- 1 liter plastic collection jars
- PVC pipe sampler
- 1 ml Sedgewick-Rafter counting cell
- pipette

2.3 Access the D. C. Cook Plant Zebra Mussel Monitoring Program Worksheet Excel™ spreadsheet from the Environmental "S" drive at ESR/Zebra Mussel Data/Zebra(year).xls. This is a non-QA record and is not filed in the Nuclear Document Management system.

3 PRECAUTIONS AND LIMITATIONS

3.1 Technicians are versed in standard practices for sampling and monitoring Zebra Mussel counts in whole water and artificial substrate samples. [Ref. 7.1.1]

3.2 Use ground fault interrupters or ground faulted outlets when plugging in sample pumps.

3.3 Use fall protection when working over openings in decking or grating.

NOTE: The use of the Personnel Tool and Material Accountability Log (PMAL) is not required for the artificial substrates attached to a weighted rope at the screenhouse intake forebay location as they are designed to be installed/removed at this location.

3.4 When installing/removing sampling equipment at the screenhouse intake forebay location(s), use the FME Task Plan established for Environmental Sampling activities in the screenhouse. Sampling equipment adjustments and repairs should be made using tools outside of the FMEA whenever possible.

4 DETAILS

4.1 Whole Water Veliger Sampling

NOTE: Whole-water sampling may be conducted in the plant's intake forebay or off of plant sidestreams or bio-monitors to determine veliger density in the lake water being drawn into the circulating water system or service water systems. Collect two replicates (approx. 2,000 liters or 528 gal. each) within an 8-hr period on each sampling date (determined by the sampling schedule).

In the event a flow meter is not available, a 2,000 liter sample can be estimated using a bucket and timing device to determine the flow rate.
1 gal. = 3.785L

4.1.1 Direct a measured flow into a plankton net that is suspended in a partially filled plastic barrel to minimize organism abrasion.

4.1.2 Direct the flow from the barrel back to a floor grating or floor drain to minimize the flow of water onto the floor.

4.1.3 Stop flow to net when approximately 2,000 L/528 gal. has been pumped thru net.

4.1.4 Gently wash down the plankton net into the cod-end bucket.

4.1.5 Use filtered water to transfer the sample into a 1-liter plastic jar.

4.1.6 **IF** needed, **THEN** add filtered water to the jar to ensure that a full liter is collected.

4.2 Whole Water Veliger Analysis

CAUTION: The sharp edges on the cover slip are capable of injuring personnel. Handle with care.

4.2.1 Obtain and stage the following pieces of analytical equipment.

- stereo-microscope with polarizing filters
- Sedgewick-Rafter cell (S-R-C) or equivalent with cover slip
- pipette capable of delivering a 1 ml. sample
- magnetic stirring plate with stir bar
- copy of "Standard Protocols for Monitoring and Sampling Zebra Mussels" by J. Ellen Marsden

4.2.2 Stir sample slowly prior to withdrawing 1 ml. sub-sample for analysis.

4.2.3 Load S-R-C with 1 ml. sub-sample and cover.

4.2.4 Read S-R-C.

NOTE: Use "Standard Protocols for Monitoring and Sampling Zebra Mussels" as a guide for identifying viable veligers. Do not include broken or dead veligers in the count.

4.2.5 Determine whether dilution of 1-liter sample is necessary per the Whole Water Density Dilution Table maintained on the Whole Water Veliger and Artificial Substrate Post-Veliger Density Counting Form of the D. C. Cook Plant Zebra Mussel Monitoring Program Worksheet.

4.2.6 Dilute 1-liter sample as needed.

NOTE: Size measurements may be taken simultaneously with counts.

4.2.7 Count number of live veligers per 1 ml. sub-sample.

4.2.8 Record counts for WW Sample Sets #1 & #2 on the Whole Water Veliger and Artificial Substrate Post-Veliger Density Counting Form.

4.2.9 Measure the breadth (widest part) of up to 50 veligers (chosen "at random"), but not more than 10 from each sub-sample.

4.2.10 Record micrometer reading on the Service Water Systems Veliger Size Calculation Sheet for each veliger measured.

4.2.11 Remove and carefully clean slide and cover slip.

4.2.12 Repeat steps 4.2.2, 4.2.3, 4.2.4, and 4.2.7 thru 4.2.11 until 10 (or an appropriate number of) separate sub-samples have been analyzed.

4.2.13 Enter "Multiplier used" from the Magnification Factors Table on the Whole Water Veliger and Artificial Substrate Post-Veliger Density Counting Form to auto-calculate sizes.

4.3 Artificial Substrate Sampling

NOTE: To determine postveliger settlement in the circulating water, essential service water, non-essential service water, and miscellaneous sealing and cooling water systems, artificial substrates may be placed in designated location(s) in the circulating water intake forebay, and in bio-monitors placed on plant system side-streams. Artificial substrates measure cumulative settlement over time. The sampling of the bio-monitors will be determined by the sampling schedule.

4.3.1 Artificial substrate samplers will consist of slide holders containing microscope slides placed in side stream bio-monitors or, as for the circulating water intake forebay, specially designed cages attached to a rope and weighted by a suitable weight. These substrate samplers are modified test tube racks or holders specifically designed to hold microscope slides.

4.3.2 Artificial substrate samplers, used for the circulating water intake forebay study, may also consist of a section of PVC pipe cut in half length-wise and held together by a hose clamp(s) and attached in a vertical orientation to rope or cable that is anchored via a concrete block or other suitable weight.

4.3.3 Obtain and stage the following pieces of equipment:

- empty test tube/slide collection rack or equivalent

4.3.4 Remove the bio-box or cage cover.

NOTE: Handle slides by the edges and transport them carefully so that no Zebra Mussels are inadvertently damaged or removed.

4.3.5 Carefully remove the appropriate number of glass slides (typically 5-10) from installed slide rack.

4.3.6 Place slides in collection rack.

4.3.7 Replace cover on bio-box or cage.

4.3.8 Restore flow thru bio-box as necessary.

4.4 Artificial Substrate Analysis – Microscope Slides

4.4.1 Obtain and stage the following pieces of analytical equipment:

- stereo-microscope with polarizing filters
- "Standard Protocols for Monitoring and Sampling Zebra Mussels" by J. Ellen Marsden
- single-edge razor blade or similar scraping device

4.4.2 Carefully remove a slide from the collection rack being careful to touch only the edges.

4.4.3 Carefully scrape clean one side of the slide.

4.4.4 Place slide on microscope stage clean side down.

4.4.5 **IF** density is > ~60 organisms per slide; **THEN** refer to the Artificial Substrate Density Dilution Table maintained on the Whole Water Veliger and Artificial Substrate Post-Veliger Density Counting Form for sub-sampling to determine the number of organisms per slide.

NOTE: Size measurements may be taken simultaneously with counts.

4.4.6 Count number of settled veligers/adults.

4.4.7 Record counts on the Artificial Substrate Size and Density Calculation Sheet and sizes on the Service Water Systems Veliger Size Calculation Sheet.

4.4.8 Measure the breadth (widest part) of up to 50 organisms (chosen "at random") but no more than 10 veligers/adults per slide.

4.4.9 Record micrometer reading on the Service Water Systems Veliger Size Calculation Sheet for each organism measured.

4.4.10 Repeat steps 4.4.2 thru 4.4.9 until 10 (or an appropriate number of) slides have been analyzed.

4.4.11 Enter "Multiplier used" from the Magnification Factors Table on the Whole Water Veliger and Artificial Substrate Post-Veliger Density Counting Form to auto-calculate sizes.

4.5 Artificial Substrate Analysis - PVC Substrates

4.5.1 Pull PVC sampler from the intake forebay.

4.5.2 Remove the clamp(s) and open up the two halves.

4.5.3 Scrape a representative one square inch section and transfer it to a S-R-C.

4.5.4 **IF** there is too much settlement that all mussels will not fit into the S-R-C, **THEN** smaller portions of scraping may be transferred to the S-R-C.

NOTE: Size measurements may be taken simultaneously with counts.

NOTE: Number of zebra mussels per square meter (density) is determined by the following formula and is automatically calculated on the PVC Substrate Section of the Artificial Substrate Size and Density Calculation Sheet.

Density (Zebra Mussels/m^2) = [(#Sample 1 + #Sample2)/2] x 10,000/6.4516

Where: 6.4516 cm^2 = 1 $inch^2$

4.5.5 Count the number of zebra mussels and record on the PVC Substrate section of the Artificial Substrate Size and Density Calculation Sheet.

4.5.6 Measure breadth of 50 randomly chosen zebra mussels and record micrometer readings on the PVC Substrate Section of the Artificial Substrate Size and Density Calculation Sheet.

4.5.7 Repeat steps 4.5.3 thru 4.5.6 for a second sample.

4.5.8 Enter "Multiplier used" from the Magnification Factors Table on the Whole Water Veliger and Artificial Substrate Post-Veliger Density Counting Form to auto-calculate sizes.

4.5.9 Clean and return PVC sampler to intake forebay if sampling is to be continued for the coming year.

4.6 Impromptu Sampling & Evaluations

4.6.1 Occasionally, Environmental may perform additional studies, which may include evaluations of biocides on Zebra Mussel settlement and mortality. The sampling protocols and schedules will be developed as required by the study.

4.6.2 This procedure does not preclude the detection of other bio-fouling species. **IF** other bio-foulers are detected that could cause problems in piping systems, **THEN** report the results to the Environmental Zebra Mussel Monitoring and Control Program owner.

4.7 Reporting

4.7.1 Environmental technicians develop and maintain all field-sampling records pertaining to these activities and report the results to the Environmental Zebra Mussel Monitoring and Control Program owner.

4.7.2 An annual report is prepared by Environmental, which details the results of the Zebra Mussel Monitoring Program.

4.7.3 Environmental provides a draft for comment and a final copy of the annual report to the Generic Letter 89-13 Program Manager. [Ref. 7.2.1c]

5 CORRECTIVE MEASURES

5.1 None.

6 FINAL CONDITIONS

6.1 An annual report on the methods employed and results of the zebra mussel monitoring has been prepared and submitted to Environmental and the Generic Letter 89-13 Program Manager. [Ref. 7.2.1c]

7 REFERENCES

7.1 Use References:

7.1.1 Standard Protocols for Monitoring and Sampling Zebra Mussels, J. Ellen Marsden, April 1992.

7.2 Writing References:

7.2.1 Source References:

a. NRC IE Bulletin No. 81-03

b. NRC Generic Letter 89-13

c. CR-99-11280

d. NRC Commitments 1199; NRC Generic Letter 89-13, Service Water system problem response.

e. NRC Commitments 1223; NRC Generic Letter 89-13, Service Water system problem response.

f. PMP-2220-001-001, Foreign Material Exclusion (FME)

7.2.2 General References

a. PMP-2010-PRC-001, Procedure Writing

b. PMP-2010-PRC-002, Procedure Alteration, Review, and Approvals

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REVISION SUMMARY

Number: **12-EA-6090-ENV-101** Rev. 3

Title: **Zebra Mussel Sampling and Analysis**

Alteration	Justification
As a result of a procedure periodic review, (00800020-02), the changes listed below were made. The changes involved removing the reference to using a concrete block to weight the artificial substrate sampler, and using the FME Task Plan established for the Environmental sampling activities for FME concerns.	Periodic review of procedure.
10 CFR 50.59 Applicability	This procedure qualifies as a "Maintenance Activity" as described in Section 4.2.2 of the 10 CFR 50.59 Resource Manual. It is a procedure for "implementing surveillances and inspections", thus it is not subject to review under 10 CFR 50.59. There are no manipulations to SSCs in this procedure.
Step 2.2 – "Concrete blocks" were revised out of the list of sampling and analytical tools available for evaluating zebra mussel densities.	The use of a concrete block as a weight for the rope that holds the PVC artificial substrate sampler in the intake forebay has been discontinued. The block disintegrates over time and can become an FME issue. It has since been replaced by a stainless steel weight. (CR-05259060) Change
NOTE Before Step 3.4 – Mention of a concrete block being used as a weight was revised out of the NOTE.	A concrete block that was formerly used as a weight for the rope has been replaced by a more robust stainless steel weight. Change
Step 3.4 – Mention of "FME Area Standard" and "PMAL sheet" were removed from the step.	The FME Task Plan directs what FME Area Standard applies and if a PMAL sheet is needed per PMP-2220-001-001, Foreign Material Exclusion. (FME) Change
Reference 7.2.2b for PMP-2010-PRC-002 title changed from "Procedure Correction, Change and Review" to "Procedure Alteration, Review, and Approvals".	Updated reference with correct procedure title. Editorial Correction Criteria n.

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APPENDIX 3

GLEC

Great Lakes Environmental Center

Applied Environmental Sciences
www.glec-online.com

Traverse City Operations
739 Hastings St.
Traverse City
MI 49686

231 941-2230
231 941-2240 fax

Columbus Operations
1295 King Ave.
Columbus
OH 43212

614 487-1040
614 487-1920 fax

December 15, 2006

Mr. Eric Mallen
American Electric Power
Donald C. Cook Nuclear Plant
One Cook Place
Bridgman, MI 49106

RE: ACUTE TOXICITY TEST REPORTS FOR SAMPLES COLLECTED FROM AMERICAN ELECTRIC POWER, COOK NUCLEAR PLANT ON NOVEMBER 29/30, 2006

Dear Mr. Mallen:

Great Lakes Environmental Center (GLEC) has completed our analyses of the 48-hour *Daphnia magna* and 96-hour fathead minnow acute toxicity tests performed on two different samples collected by American Electric Power (AEP) personnel on November 29/30, 2006. The two samples analyzed were; a 24-hour composite sample that included a 30-minute Mexel dose at 4 mg/L (GLC Number: 7010) and a 30-minute sample collected in conjunction with a 30-minute dose at 4 mg/L of Mexel (GLC Number: 7009). Lake Michigan water collected by AEP personnel was used as the dilution water for the *D. magna* and fathead minnow tests.

The 24-hour composite sample was not acutely toxic to *D. magna* or fathead minnows. There was 100 percent survival of both *D. magna* and fathead minnow in this sample. The 48-hour *D. magna* LC_{50} (median lethal toxicant concentration) and EC_{50} (median effect concentration) estimates were both greater than 100 percent sample. The 96-hour fathead minnow LC_{50} was also greater than 100 percent sample.

The 30-minute sample, which had an estimated residual Mexel concentration of 2.5 mg/L, was acutely toxic to both *D. magna* and fathead minnows. The acute toxicity tests that were initiated with the 30-minute sample had an estimated LC_{50} of 35.4 percent sample in the *D. magna* test and 27.7 percent sample in the fathead minnow test. If we assume an estimated concentration of 2.5 mg Mexel/L in that sample, these LC_{50} estimates equate to LC_{50} estimates of 0.88 mg Mexel/L and 0.69 mg Mexel/L, respectively.

As a comparison, in 2004 GLEC measured a *D. magna* LC_{50} of 0.20 mg Mexel/L and a fathead minnow LC_{50} of 0.45 mg Mexel/L in laboratory toxicity tests. The difference between the current and 2004 LC_{50} estimates may be explained by the difference in dilution water used for the tests and that we have no way of knowing the true concentration of Mexel in these samples. However, we do know from the toxicity database for Mexel that the LC_{50} for *D. magna* ranges between 0.120 mg/L and 0.595 mg/L, and between 0.360 mg/L and 0.66 mg/L for the fathead minnows. Consequently, the differences observed between the laboratory measured LC_{50} estimates and the field based measurements reported here are not that great or unreasonable.

The 24-hour composite toxicity test data demonstrate that at this level of treatment, a resulting 24-hour composite sample used in whole effluent toxicity testing following a Mexel treatment would not be toxic.

A summary of the test conditions for the toxicity tests are included in Tables 1 through 4. The 48-hour and 96-hour LC_{50} and EC_{50} estimates and toxicity test results are included in Report Forms 1 through 4. The raw data are included in Appendix A.

If you have any questions or comments concerning the results of these toxicity tests, please contact either me or Dennis McCauley at (231) 941-2230. Thank you for the opportunity to provide this service to American Electric Power- Donald C. Cook Nuclear Plant.

Sincerely,

Mailee W. Garton
Mailee W. Garton
Laboratory Coordinator

Dennis J McCauley
Dennis J. McCauley
Principal Research Scientist/
Senior Operations Manager

MWG:mg
Enclosures

TABLE 1

FATHEAD MINNOW TOXICITY TEST CONDITIONS
24 Hour Composite Lake Michigan sample dosed with 4 mg/L Mexel in one 30-minute Interval

Summary of Toxicity Test Conditions	
1. Test Species and Age:	*Pimephales promelas*, (Fathead minnow) 6 days-November 25, 2006
2. Test Type and Duration:	96-hour Static, with renewal at 48 hours
3. Test Dates:	December 01-05, 2006
4. Test Temperature (°C):	25 ± 1
5. Light Quality:	Ambient Laboratory, 10-20 $\mu E/m^2/s$
6. Photoperiod:	16 h light, 8 h darkness
7. Feeding Regime:	None
8. Size of Test Vessel:	250 mL glass beaker
9. Volume and Depth of Test Solutions:	200 mL, 65 mm
10. No. of Test Organisms per Test Vessel:	10
11. No. of Test Vessels per Test Solution:	2
12. Total No. of Test Organisms per Test Solution:	20
13. Test Concentrations (percent):	100, 50, 25, 12.5, and 6.25
14. Renewal of Test Solutions:	48-hour renewal
15. Dilution and Primary Control Water:	Lake Michigan GLC# 7008
16. Secondary Control Water:	Synthetic Laboratory (ModeratelyHard)
17. Aeration:	None
18. Endpoints Measured:	Mortality (LC_{50})

REPORTING FORM 1

FATHEAD MINNOW ACUTE TOXICITY TEST

24 Hour Composite Lake Michigan sample dosed with 4 mg/L Mexel in one 30-minute Interval

Facility Name: AEP Cook Nuclear Plant

NPDES Permit No.: ____________

Receiving Water: Lake Michigan

Outfall: ____________

RWC: N/A

Test Dates: 12/01/06 - 12/05/06

Test Species: Fathead minnows

Age Range: 6 days old

Test Laboratory: Great Lakes Environmental Center (GLEC)

Report Date: December 15, 2006

BULK SAMPLE INFORMATION

	SAMPLE COLLECTION DATES	DATE RECEIVED	ARRIVAL TEMPERATURE	DATE OF FIRST USE	ARRIVAL TRC	DECHLORINATION?	ARRIVAL pH	ARRIVAL DO	ARRIVAL AMMONIA
1.	11/29-30/06	11/30/06	0.9°C	12/01/06	NM	No	8.07	12.0	NM

What test methods were used: EPA/600/4-90/027 and EPA-821-R-02-012

Describe any deviations from test methods: None

Source of test organisms: In house lot # 11/25/06

TEST DESCRIPTION

Fed/Un-fed: Fed

Food/Feeding Frequency: *Artemia nauplii*, 2 hours prior to 48-hour renewal

No. Replicates per Concentration: 2

No. Organisms per Replicate: 10

Effluent Filtered? No

Effluent Sample Type: Sample 1: Composite

Sample 2: ________

Diluent (0_1): Lake Michigan Water (GLC# 7008)

Secondary Control (0_2): Synthetic Laboratory Water (Moderately Hard) MH# 1479

SUMMARY OF RESULTS*

48-hour LC_{50}: >100%

96-hour LC_{50}: >100%

Percent Mortality per Concentration
(Percent Effected per Concentration)

Day	--Controls--		--Effluent Concentrations--					
	0_1	0_2	6.25 Percent	12.5 Percent	25 Percent	50 Percent	100 Percent	Percent
1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
3	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	

*Raw data sheets are included in Appendix A.
0_2: Synthetic Laboratory Water (Moderately Hard)

Investigator: Mailee W. Garton

Contact: Dennis McCauley

Phone No.: (231) 941-2230

Signature

Principal Research Scientist/Manager of Operations
Title

12/15/06
Date

TABLE 2

DAPHNIA MAGNA TOXICITY TEST CONDITIONS
24 Hour Composite Lake Michigan sample dosed with 4 mg/L Mexel in one 30-minute Interval

Summary of Toxicity Test Conditions	
1. Test Species and Age:	*Daphnia magna*, <24 hours old
2. Test Type and Duration:	Static, 48 hours
3. Test Dates:	December 01-03, 2006
4. Test Temperature (°C):	25 ± 1
5. Light Quality:	Ambient Laboratory, 10-20 $\mu E/m^2/s$
6. Photoperiod:	16 h light, 8 h darkness
7. Feeding Regime:	None
8. Size of Test Vessel:	30 mL plastic cup
9. Volume and Depth of Test Solutions:	15 mL, 20 mm
10. No. of Test Organisms per Test Vessel:	5
11. No. of Test Vessels per Test Solution:	4
12. Total No. of Test Organisms per Test Solution:	20
13. Test Concentrations (percent):	100, 50, 25, 12.5, and 6.25
14. Renewal of Test Solutions:	None
15. Dilution and Primary Control Water:	Lake Michigan GLC# 7008
16. Secondary Control Water:	Synthetic Laboratory (Moderately Hard)
17. Aeration:	None
18. Endpoints Measured:	Mortality (LC_{50}) and Effect (EC_{50})

REPORTING FORM 2

DAPHNIA MAGNA ACUTE TOXICITY TEST

24 Hour Composite Lake Michigan sample dosed with 4 mg/L Mexel in one 30-minute Interval

Facility Name: AEP Cook Nuclear Plant

NPDES Permit No.:

Receiving Water: Lake Michigan

Outfall:

RWC: N/A

Test Dates: 12/01/06 - 12/03/06

Test Species: *Daphnia magna*

Age Range: <24 hours

Test Laboratory: Great Lakes Environmental Center (GLEC)

Report Date: December 15, 2006

BULK SAMPLE INFORMATION

SAMPLE COLLECTION DATES	DATE RECEIVED	ARRIVAL TEMPERATURE	DATE OF FIRST USE	ARRIVAL TRC	DECHLORINATION?	ARRIVAL pH	ARRIVAL DO	ARRIVAL AMMONIA
1. 11/29-30/06	11/30/06	0.9°C	12/01/06	NM	No	8.07	12.0	NM

ND: Not Detected

What test methods were used: EPA/600/4-90/027 and EPA-821-R-02-012

Describe any deviations from test methods: None

Source of test organisms: In House: BD 11-20-06

TEST DESCRIPTION

Fed/Un-fed: Un- Fed

Food/Feeding Frequency: None

No. Replicates per Concentration: 4

No. Organisms per Replicate: 5

Effluent Filtered? No

Effluent Sample Type: Sample 1: Composite

Sample 2:

Diluent (0_1): Lake Michigan Water (GLC# 7008)

Secondary Control (0_2): Synthetic Laboratory Water (Moderately Hard) MH# 1479

SUMMARY OF RESULTS[*]

48-hour LC_{50}: >100

48-hour EC_{50}: >100

Percent Mortality per Concentration

(Percent Effected per Concentration)

Day	--Controls--		--Effluent Concentrations--					
	0_1	0_2	6.25 Percent	12.5 Percent	25 Percent	50 Percent	100 Percent	Percent
1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
2	0 (0)	0(0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	

[*] Raw data sheets are included in Appendix A.

0_2: Synthetic Laboratory Water (Moderately Hard)

Investigator: Mailee W. Garton

Contact: Dennis McCauley

Phone No.: (231) 941-2230

Signature

Principal Research Scientist/Manager of Operations

Title

12/15/06

Date

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TABLE 3

FATHEAD MINNOW TOXICITY TEST CONDITIONS
30 Minute Lake Michigan sample dosed at 4 mg/L Mexel (2.5 mg/L residual concentration)

Summary of Toxicity Test Conditions	
1. Test Species and Age:	*Pimephales promelas*, (Fathead minnow) 6 days-November 25, 2006
2. Test Type and Duration:	96-hour Static, with renewal at 48 hours
3. Test Dates:	December 01-05, 2006
4. Test Temperature (°C):	25 ± 1
5. Light Quality:	Ambient Laboratory, 10-20 µE/m^2/s
6. Photoperiod:	16 h light, 8 h darkness
7. Feeding Regime:	None
8. Size of Test Vessel:	250 mL glass beaker
9. Volume and Depth of Test Solutions:	200 mL, 65 mm
10. No. of Test Organisms per Test Vessel:	10
11. No. of Test Vessels per Test Solution:	2
12. Total No. of Test Organisms per Test Solution:	20
13. Test Concentrations (mg/L):	100, 50, 25, 12.5, and 6.25
14. Renewal of Test Solutions:	48-hour renewal
15. Dilution and Primary Control Water:	Lake Michigan GLC# 7008
16. Secondary Control Water:	Synthetic Laboratory (ModeratelyHard)
17. Aeration:	None
18. Endpoints Measured:	Mortality (LC_{50})

REPORTING FORM 3

FATHEAD MINNOW ACUTE TOXICITY TEST

30 Minute Lake Michigan sample dosed at 4 mg/L Mexel (2.5 mg/L residual concentration)

Facility Name: AEP Cook Nuclear Plant

NPDES Permit No.:

Receiving Water: Lake Michigan

Outfall:

RWC: N/A

Test Dates: 12/01/06 - 12/05/06

Test Species: Fathead minnows

Age Range: 6 days old

Test Laboratory: Great Lakes Environmental Center (GLEC)

Report Date: December 15, 2006

BULK SAMPLE INFORMATION

SAMPLE COLLECTION DATES	DATE RECEIVED	ARRIVAL TEMPERATURE	DATE OF FIRST USE	ARRIVAL TRC	DECHLORINATION?	ARRIVAL pH	ARRIVAL DO	ARRIVAL AMMONIA
1. 11/30/06	11/30/06	1.0°C	12/01/06	NM	No	8.12	12.2	NM

What test methods were used: EPA/600/4-90/027 and EPA-821-R-02-012

Describe any deviations from test methods: None

Source of test organisms: In house lot # 11/25/06

TEST DESCRIPTION

Fed/Un-fed: Fed

Food/Feeding Frequency: *Artemia nauplii*, 2 hours prior to 48-hour renewal

No. Replicates per Concentration: 2

No. Organisms per Replicate: 10

Effluent Filtered? No

Effluent Sample Type: Sample 1: Composite

Sample 2:

Diluent (0_1): Lake Michigan Water (GLC# 7008)

Secondary Control (0_2): Synthetic Laboratory Water (Moderately Hard) MH# 1479

SUMMARY OF RESULTS*

48-hour LC$_{50}$: 28.72%
96-hour LC$_{50}$: 27.74%
LC$_{50}$ 95% Lower Confidence: 23.93%
LC$_{50}$ 95% Upper Confidence: 32.16 %

Percent Mortality per Concentration
(Percent Effected per Concentration)

Day	--Controls--		--Effluent Concentrations--					
	0_1	0_2	6.25 Percent	12.5 Percent	25 Percent	50 Percent	100 Percent	Percent
1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	100 (100)	100 (100)	
2	0 (0)	0 (0)	0 (0)	0 (0)	30 (35)	100 (100)	100 (100)	
3	0 (0)	0 (0)	0 (0)	0 (0)	35 (35)	100 (100)	100 (100)	
4	0 (0)	0 (0)	0 (0)	0 (0)	35 (50)	100 (100)	100 (100)	

*Raw data sheets are included in Appendix A.
0_2: Synthetic Laboratory Water (Moderately Hard)

Investigator: Mailee W. Garton

Contact: Dennis McCauley

Phone No.: (231) 941-2230

Signature

Principal Research Scientist/Manager of Operations
Title

12/15/06
Date

TABLE 4

DAPHNIA MAGNA TOXICITY TEST CONDITIONS

30 Minute Lake Michigan sample dosed at 4 mg/L Mexel (2.5 mg/L residual concentration)

Summary of Toxicity Test Conditions	
1. Test Species and Age:	*Daphnia magna*, <24 hours old
2. Test Type and Duration:	Static, 48 hours
3. Test Dates:	December 01-03, 2006
4. Test Temperature (°C):	25 ± 1
5. Light Quality:	Ambient Laboratory, 10-20 µE/m²/s
6. Photoperiod:	16 h light, 8 h darkness
7. Feeding Regime:	None
8. Size of Test Vessel:	30 mL plastic cup
9. Volume and Depth of Test Solutions:	15 mL, 20 mm
10. No. of Test Organisms per Test Vessel:	5
11. No. of Test Vessels per Test Solution:	4
12. Total No. of Test Organisms per Test Solution:	20
13. Test Concentrations (mg/L):	100, 50, 25, 12.5, and 6.25
14. Renewal of Test Solutions:	None
15. Dilution and Primary Control Water:	Lake Michigan GLC# 7008
16. Secondary Control Water:	Synthetic Laboratory (ModeratelyHard)
17. Aeration:	None
18. Endpoints Measured:	Mortality (LC_{50}) and Effect (EC_{50})

REPORTING FORM 4

DAPHNIA MAGNA ACUTE TOXICITY TEST
30 Minute Lake Michigan sample dosed at 4 mg/L Mexel (2.5 mg/L residual concentration)

Facility Name: AEP Cook Nuclear Plant

NPDES Permit No.:

Receiving Water: Lake Michigan

Outfall:

RWC: N/A

Test Dates: 12/01/06 - 12/03/06

Test Species: *Daphnia magna*

Age Range: <24 hours

Test Laboratory: Great Lakes Environmental Center (GLEC)

Report Date: December 15, 2006

BULK SAMPLE INFORMATION

SAMPLE COLLECTION DATES	DATE RECEIVED	ARRIVAL TEMPERATURE	DATE OF FIRST USE	ARRIVAL TRC[2]	DECHLORINATION?	ARRIVAL pH	ARRIVAL DO	ARRIVAL AMMONIA
1. 11/29-30/06	11/30/06	0.9°C	12/01/06	NM	No	8.07	12.0	NM

ND: Not Detected

What test methods were used: EPA/600/4-90/027 and EPA-821-R-02-012

Describe any deviations from test methods: None

Source of test organisms: In House: BD 11-20-06

TEST DESCRIPTION

Fed/Un-fed: Un- Fed

Food/Feeding Frequency: None

No. Replicates per Concentration: 4

No. Organisms per Replicate: 5

Effluent Filtered? No

Effluent Sample Type: Sample 1: Composite

Sample 2:

Diluent (0_1): Lake Michigan Water (GLC# 7008)

Secondary Control (0_2): Synthetic Laboratory Water (Moderately Hard) MH# 1479

SUMMARY OF RESULTS*

48-hour LC_{50}: 35.36 %

48-hour EC_{50}: 35.36 %

LC_{50} 95% Lower Confidence: Not reliable

LC_{50} 95% Upper Confidence: Not reliable

Percent Mortality per Concentration
(Percent Effected per Concentration)

Day	--Controls--		--Effluent Concentrations--					
	0_1	0_2	6.25 Percent	12.5 Percent	25 Percent	50 Percent	100 Percent	Percent
1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	20 (20)	100 (100)	
2	0 (0)	0(0)	0 (0)	0 (0)	0 (0)	100 (100)	100 (100)	

*Raw data sheets are included in Appendix A.
0_2: Synthetic Laboratory Water (Moderately Hard)

Investigator: Mailee W. Garton

Contact: Dennis McCauley

Phone No.: (231) 941-2230

Signature

Principal Research Scientist/Manager of Operations
Title

12/15/06
Date

Appendix A

Raw Data Sheets

GLEC

Great Lakes Environmental Center

GLEC

CHAIN OF CUSTODY RECORD
(TO BE COMPLETED ONSITE AND SUBMITTED WITH SAMPLES)

739 Hastings Street
Traverse City, MI 49686
Phone: (231) 941-2230
Fax: (231) 941-2240

Facility: Cook Nuclear Plant
Location: Screen House
Contact Person: Eric Mallen
Phone Number: 269-465-5901 #1540

Collector: Darius K. Barkauskas
Date: November 30, 2006
Witness: Eric Mallen
Date: November 30, 2006

GLC NUMBER (Lab ID)	SAMPLE ID	DATE/TIME OF SAMPLE*	VOLUME COLLECTED	SAMPLE CONTAINER	DESCRIPTION (Type of sample, source, physical characteristics)	PRESERVATION	ANALYSES REQUIRED	Additional Parameters Measured at Collection	
								Ammonia mg/L	Chlorine mg/L
7008	Control	11/30 9:05	2 Gallons	2 (1) gallon	untreated lAKE Michigan water	—	WET Test	✓ in	Temp 0.6°
7009	30" Acute	11/30 10:00	2 Gallon	2 Cubitainer	lAKE Michigan water Dosed → 4 Mg/L Mexel		WET TEST	✓ in	temp 1.0°
7010	24' Composite	11/29 → 11/30 9:45 → 9:45	2 Gallon	2 cubitainer	lAKE Michigan Composite Dosed once w/Mexel		WET TEST	✓ in	temp 0.9°
		Start End							

* For 24-Hour Composite samples, please indicate times and dates the sampling started and ended.

TRANSFER OF SAMPLES:
(First signature is sampler, last signature is authorized laboratory representative.)

	SHIPPER	RECEIVER	DATE	TIME	TEMPERATURE
1.					0.6 - control
2.					

9 Condition of Sample Upon Receipt: good Marlee W. Horton 11/30/06 1515

☒ Received on Ice

Great Lakes Environmental Center

EFFLUENT AND RECEIVING WATER CHECK-IN FORM

CLIENT: Cook Nuclear AEP PROJECT NUMBER: 1861-00

INVESTIGATORS:

INITIAL WATER CHEMISTRY (UPON RECEIPT)

DATE RECEIVED: 11/30/06	INITIALS MWG	Lake Mich H2O Control	30 minute Dosed w/ 4mg/L Mexel	24 hour Composite Dosed 1 w/ mexel
GLC NUMBER:	↓	7008	7009	7010
COLLECTION DATE: (Time Interval)		11/30/06 905	11/30/06 1000	11/29-30 945-945
TEMPERATURE:		0.6	1.0	0.9
EFFLUENT DESCRIPTION:	↓	Clear odorless	Clear odorless	Clear odorless

WATER CHEMISTRY AT TEST TEMPERATURES

DATE RECEIVED: 11/30/06	INITIALS MWG	Lake Mich Water Control	30 minute	24 hour Composite
GLC NUMBER:	MWG	7008	7009	7010
TEMPERATURE	MWG	25.0	25.0	25.0
pH	MWG	8.10	8.12	8.07
DISSOLVED OXYGEN (mg/L)	MWG	13.0	12.2	12.0
CONDUCTIVITY (μmhos/cm)	MWG	316	312	309
HARDNESS (mg/L)	MWG	160	144	136
ALKALINITY (mg/L)	MWG	108	112	112
TOTAL CHLORINE (mg/L)*	/	/	/	/
TOTAL AMMONIA (mg/L)*	/	/	/	/

* Check with project manager to see if necessary.

Hardness:

7008
End mL: 43.0
Start mL: 39.0
Sample Volume: 25

7009
End mL: 46.6
Start mL: 43.0
Sample Volume: 25

7010
E: 50.0
S: 46.6

Alkalinity:

7008
End mL: 35.4
Start mL: 30.0
Sample Volume: 50

7009
End mL: 41.0
Start mL: 35.4
Sample Volume: 50

7010
E: 46.6
S: 41.0
Volume 50

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GLEC

24 hour Composite

FISH 96-HOUR STATIC ACUTE TOXICITY TEST
WITH 48-HOUR RENEWAL

TEST MATERIAL: Cook Nuclear 7010
PROJECT NUMBER: 1861-00
TEST SPECIES: FHM

NO. FRY/CHAMBER: 10
AGE/SOURCE OF FRY: 11/25/06 6 days
DILUTION WATER: Rec H2O GLEC 7008

PHOTOPERIOD (L:D): 16:8
LIGHT INTENSITY (lux): ambient
TEST TEMPERATURE (°C): 25+/-1°C

DATE / TIME	TEST DAY	TECH. INITIALS	TREATMENT LEVEL	CON Rec H2O		A 6.25%		B 12.5%		C 25%		D 50%		E 100%		~~2° Con MH~~	
			REPLICATE NUMBER	1	2	1	2	1	2	1	2	1	2	1	2	1	2
1210 12/1/06	0	mwb	DO (mg/L)	9.5		9.6		9.6		9.6		9.6		9.5			
			Temperature (°C)	25.0		25.0		25.0		25.0		25.0		25.0			
			pH	8.08		8.09		8.09		8.08		8.08		8.08			
			Sp. Cond. (µmhos/cm)	316		308		310		312		312		310			
12/2/06	1	mwb	Number Live	10	10	10	10	10	10	10	10	10	10	10	10		
			Observations														
			DO (mg/L)	9.0		9.0		8.9		8.9		8.9		8.9			
			Temperature (°C)	25.6		25.6		25.6		25.6		25.6		25.5			
			pH	7.99		8.01		8.05		8.09		8.13		8.14			
48-Hour Renewal New Chemistries ~~MH~~		mwb	DO (mg/L)	9.3		9.4		9.4		9.4		9.4		9.4			
			Temperature (°C)	25.0		25.0		25.0		25.0		25.0		26.0			
			pH	8.03		8.13		8.14		8.16		8.11		7.97			
			Special Con. (µmhos/cm)	mwb ~~331~~ 313		312		313		318		321		322			
12/3/06	2	mwb	Number Live	10	10	10	10	10	10	10	10	10	10	10	10		
			Observations														
			DO (mg/L)	9.0		9.0		9.0		9.0		9.0		9.0			
			Temperature (°C)	25.4		25.4		25.4		25.4		25.3		25.3			
			pH	7.89		8.00		8.09		8.15		8.16		8.21			
12/4/06	3	mwb	Number Live	10	10	10	10	10	10	10	10	10	10	10	10		
			Observations														
			DO (mg/L)	8.4		8.4		8.4		8.4		8.4		8.2			
			Temperature (°C)	25.2		25.2		25.2		25.3		25.2		25.2			
			pH	7.84		7.94		8.03		8.09		8.13		8.16			
12/5/06 1145	4	mwb	Number Live	10	10	10	10	10	10	10	10	10	10	10	10		
			Observations														
			DO (mg/L)	8.3		8.4		8.4		8.2		8.2		8.2			
			Temperature (°C)	25.1		25.1		25.1		25.2		25.2		25.2			
			pH	8.00		8.06		8.08		8.11		8.12		8.15			

Observation Key:
N - Normal
ERR - Erratic Swimming

PM - Particulate Matter
FS - Film on Surface

I - Immobilized

Date: 12/5/06
Reviewed By: Marilu W. Horton

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DAPHNID 48-HOUR STATIC ACUTE TOXICITY TEST

TEST MATERIAL: Cook nuclear 24hour Composit
PROJECT NUMBER: 1861-00
TEST SPECIES: D magna
INVESTIGATORS:

TYPE OF TEST: regulatory
NUMBER OF DAPHNIDS/CHAMBER: 5
NUMBER OF CHAMBERS: 4+1 for chems
AGE OF DAPHNIDS: Bd 11/20/06

DILUTION WATER: Rec H_2O 7008
GLC AND/OR BATCH NUMBER: 7010
TEST TEMPERATURE: 25+/-1°C
INCUBATOR #: 9 PHOTOPERIOD: 16:8

MH

DATE	TEST DAY	TECH. INITIALS	TREATMENT LEVEL	CONTROL				A 6.25%				B 12.5%				C 25%				D 50%				E 100%				2° Con			
TIME			REPLICATE NUMBER	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1230 12/1/06	0		TEMPERATURE (°C)	25.0																				25.0				25.0			
			pH	8.08				8.09				8.09				8.08				8.08				8.08				7.84			
			DO (mg/L)	9.5				9.6				9.6				9.6				9.6				9.5				8.4			
			SP. CONDUCTANCE (µmhos/cm)	316				308				310				312				312				310				323			
12/2/06	1		NUMBER LIVE	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
			OBSERVATIONS																												
			pH	8.15				8.21				8.24				8.26				8.30				8.33				7.93			
			DO (mg/L)	9.6				9.6				9.5				9.5				9.5				9.5				9.0			
			TEMPERATURE (°C)	25.5				25.6				25.6				25.6				25.6				25.5				25.5			
1230 12/3/06	2		NUMBER LIVE	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
			OBSERVATIONS																												
			pH	8.39				8.40				8.41				8.41				8.41				8.43				8.01			
			DO (mg/L)	9.4				9.4				9.4				9.4				9.4				9.4				9.0			
			SP. CONDUCTANCE	297				298				297				299				299				304				318			
			TEMPERATURE (°C)	25.2				25.2				25.2				25.2				25.3				25.3				25.3			

Observation Key:

DOB - Dried Out on Beaker
ERR - Erratic Swimming
F - Floater
PM - Particulate Matter
FS - Film on Surface
IMM - Immobile

REVIEWED BY:
DATE: 12/3/06

GLEC
Great Lakes Environmental Center

30' minute

FISH 96-HOUR STATIC ACUTE TOXICITY TEST WITH 48-HOUR RENEWAL

TEST MATERIAL: Cook Nuclear 7009
PROJECT NUMBER: 1861-00
TEST SPECIES: FHM

NO. FRY/CHAMBER: 10
AGE/SOURCE OF FRY: 11/25/06 6days
DILUTION WATER: Rec H2O 7008

PHOTOPERIOD (L:D): 16:8
LIGHT INTENSITY (lux): ambient
TEST TEMPERATURE (°C): 25+/-1°C

DATE TIME	TEST DAY	TECH. INITIALS	TREATMENT LEVEL	CON	Rec H2O	A 6.25% 0.156mg/L		B 12.5% 0.313mg/L		C 25% 0.625mg/L		D 50% 1.25mg/L		E 100% 2.5mg/L		2°Con MH	
			REPLICATE NUMBER	1	2	1	2	1	2	1	2	1	2	1	2	1	2
1200 12/1/06	0	mwb	DO (mg/L)	9.5		9.5		9.5		9.5		9.5		9.7		8.4	
			Temperature (°C)	25.0		25.0		25.0		25.0		25.0		25.0		25.0	
			pH	8.08		8.09		8.11		8.12		8.08		8.09		7.84	
			Sp. Cond. (umhos/cm)	316		305		310		311		310		312		323	
12/2/06	1	mwb	Number Live	10	10	10	10	10	10	10	10	0	0	0	0	10	10
			Observations														
			DO (mg/L)	9.0		9.0		9.0		9.0		8.2		8.0		8.9	
			Temperature (°C)	25.4		25.5		25.5		25.5		25.5		25.5		25.5	
			pH	8.01		8.05		8.07		8.09		8.01		8.00		7.93	
48-Hour Renewal New Chemistries		mwb	DO (mg/L)	9.4		9.4		9.5		9.5						8.4	
			Temperature (°C)	25.0		25.0		25.0		25.0						25.0	
			pH	8.03		8.09		8.07		8.13						7.87	
			Special Con. (umhos/cm)	313		308		314		316						323	
12/3/06	2	mwb	Number Live	10	10	10	10	10	10	7	7						
			Observations							1 Imm							
			DO (mg/L)	9.2		9.2		8.9		8.8						8.9	
			Temperature (°C)	25.3		25.3		25.3		25.4						25.4	
			pH	8.03		7.99		8.07		8.09						7.81	
12/4/06	3	mwb	Number Live	10	10	10	10	10	10	7	6					10	10
			Observations							1 ERR							
			DO (mg/L)	9.2		9.2		9.4		9.5						8.5	
			Temperature (°C)	25.4		25.4		25.2		25.2						25.2	
			pH	7.98		8.05		8.07		8.16						7.74	
1145 12/5/06	4	mwb	Number Live	10	10	10	10	10	10	7	6					10	10
			Observations							2I	1I						
			DO (mg/L)	8.3		8.4		8.4		8.4						8.4	
			Temperature (°C)	25.2		25.2		25.2		25.2						25.2	
			pH	8.13		8.14		8.19		8.22						7.84	

Observation Key:
N - Normal
ERR - Erratic Swimming

PM - Particulate Matter
FS - Film on Surface

I - Immobilized

LC50 = 27.74

Date: 12/5/06
Reviewed By: Maile W. Barton

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TRIMMED SPEARMAN-KARBER METHOD.  MONTANA STATE UNIV

 FOR REFERENCE, CITE:
 HAMILTON, M.A., R.C. RUSSO, AND R.V. THURSTON, 1977.
 TRIMMED SPEARMAN-KARBER METHOD FOR ESTIMATING MEDIAN
 LETHAL CONCENTRATIONS IN TOXICITY BIOASSAYS.
 ENVIRON. SCI. TECHNOL. 11(7): 714-719;
 CORRECTION 12(4):417  (1978).


 DATE:   12/1/06          TEST NUMBER: 1861-00          DURATION:   48 HOURS
 CHEMICAL:  30 MINUTE MEXEL 4 MG/l glc7009              SPECIES:   FHM

 RAW DATA:
   CONCENTRATION(PERCENT)      6.25  12.50  25.00  50.00 100.00
   NUMBER EXPOSED:               20     20     20     20     20
   MORTALITIES:                   0      0      6     20     20
   SPEARMAN-KARBER TRIM:               .00%

  SPEARMAN-KARBER ESTIMATES:      LC50:          28.72
                 95% LOWER CONFIDENCE:           24.91
                 95% UPPER CONFIDENCE:           33.10
------------------------------------------------------------------------------
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TRIMMED SPEARMAN-KARBER METHOD.  MONTANA STATE UNIV

 FOR REFERENCE, CITE:
 HAMILTON, M.A., R.C. RUSSO, AND R.V. THURSTON, 1977.
 TRIMMED SPEARMAN-KARBER METHOD FOR ESTIMATING MEDIAN
 LETHAL CONCENTRATIONS IN TOXICITY BIOASSAYS.
 ENVIRON. SCI. TECHNOL. 11(7): 714-719;
 CORRECTION 12(4):417  (1978).


 DATE:   12/1/06             TEST NUMBER: 1861-00            DURATION:  96 HOURS
 CHEMICAL:  COOK NUCLEAR 30 MINUTE SAMPLE                    SPECIES:  FHM

                                 0.165  0.33   0.625  1.25   2.5 mg/L
 RAW DATA:
   CONCENTRATION(PERCENT)         6.25  12.50  25.00  50.00 100.00
   NUMBER EXPOSED:                 20     20     20     20     20
   MORTALITIES:                     0      0      7     20     20
   SPEARMAN-KARBER TRIM:                 .00%

  SPEARMAN-KARBER ESTIMATES:     LC50:           27.74  0.694 mg/L
               95% LOWER CONFIDENCE:             23.93
               95% UPPER CONFIDENCE:             32.16
-------------------------------------------------------------------------------
```

We measure at 0.2

.12 - .59

FHM measured @ .45

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TRIMMED SPEARMAN-KARBER METHOD.  MONTANA STATE UNIV

 FOR REFERENCE, CITE:
 HAMILTON, M.A., R.C. RUSSO, AND R.V. THURSTON, 1977.
 TRIMMED SPEARMAN-KARBER METHOD FOR ESTIMATING MEDIAN
 LETHAL CONCENTRATIONS IN TOXICITY BIOASSAYS.
 ENVIRON. SCI. TECHNOL. 11(7): 714-719;
 CORRECTION 12(4):417  (1978).


 DATE:   12/1/06            TEST NUMBER: 1861-00            DURATION:   96 HOURS
 CHEMICAL:  COOK NUCLEAR GLC#7009 2.5 MG/1                  SPECIES:  FHM

 RAW DATA:
   CONCENTRATION(MG/L)             .16    .31    .63   1.25   2.50
   NUMBER EXPOSED:                  20     20     20     20     20
   MORTALITIES:                      0      0      7     20     20
   SPEARMAN-KARBER TRIM:                  .00%

  SPEARMAN-KARBER ESTIMATES:      LC50:             .69
               95% LOWER CONFIDENCE:             .60
               95% UPPER CONFIDENCE:             .80
--------------------------------------------------------------------------------
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GLEC
Great Lakes Environmental Center

DAPHNID 48-HOUR STATIC ACUTE TOXICITY TEST

TEST MATERIAL: Cook nuclear 30min
PROJECT NUMBER: 1861-00
TEST SPECIES: D magna
INVESTIGATORS:

TYPE OF TEST: regulatory
NUMBER OF DAPHNIDS/CHAMBER: 5
NUMBER OF CHAMBERS: 4+1 for chems
AGE OF DAPHNIDS: Bd 11-20-06

DILUTION WATER: Rec H_2O 7008
GLC AND/OR BATCH NUMBER: 7009
TEST TEMPERATURE: 25+/-1°C
INCUBATOR #: 9 PHOTOPERIOD: 16:8

0 0.156mg/L 0.313mg/L 0.625mg/L 1.25mg/L 2.5mg/L

DATE TIME	TEST DAY	TECH. INITIALS	TREATMENT LEVEL	CONTROL				A 6.25%				B 12.5%				C 25%				D 50%				E 100%				2° Con			
			REPLICATE NUMBER	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1220 12/1/06	0	mwb	TEMPERATURE (°C)	25.0				25.0				25.0				25.0				25.0				25.0							
			pH	8.08				8.09				8.11				8.12				8.08				8.09							
			DO (mg/L)	9.5				9.5				9.5				9.5				9.5				9.7							
			SP. CONDUCTANCE (µmhos/cm)	316				305				310				311				310				312							
12/2/06	1	mwb	NUMBER LIVE	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	3	4	0	0	0	0				
			OBSERVATIONS																												
			pH	8.18				8.25				8.22				8.21				8.24				8.30							
			DO (mg/L)	9.5				9.5				9.6				9.4				9.4				9.4							
			TEMPERATURE (°C)	25.5				25.5				25.5				25.5				25.6				25.6							
1230 12/3/06	2	mwb	NUMBER LIVE	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0	0	0	0								
			OBSERVATIONS																												
			pH	8.36				8.38				8.39				8.39				8.40											
			DO (mg/L)	9.4				9.5				9.5				9.5				9.5											
			SP. CONDUCTANCE	301				302				300				304				304											
			TEMPERATURE (°C)	25.1				25.2				25.2				25.2				251											

Observation Key:

DOB - Dried Out on Beaker
ERR - Erratic Swimming
F - Floater

PM - Particulate Matter
FS - Film on Surface
IMM - Immobile

REVIEWED BY: Marlee W. Barton
DATE: 12/3/06

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```
TRIMMED SPEARMAN-KARBER METHOD.  MONTANA STATE UNIV

 FOR REFERENCE, CITE:
 HAMILTON, M.A., R.C. RUSSO, AND R.V. THURSTON, 1977.
 TRIMMED SPEARMAN-KARBER METHOD FOR ESTIMATING MEDIAN
 LETHAL CONCENTRATIONS IN TOXICITY BIOASSAYS.
 ENVIRON. SCI. TECHNOL. 11(7): 714-719;
 CORRECTION 12(4):417  (1978).


 DATE:   12/1/06              TEST NUMBER: D MAGNA            DURATION:   48 48
 CHEMICAL:  COOK NUCLEAR 30 MINUTE                             SPECIES:  D MAGNA

 RAW DATA:
   CONCENTRATION(PERCENT)          6.25   12.50   25.00   50.00 100.00
   NUMBER EXPOSED:                   20      20      20      20     20
   MORTALITIES:                       0       0       0      20     20
   SPEARMAN-KARBER TRIM:                    .00%

  SPEARMAN-KARBER ESTIMATES:      LC50:          35.36   0.884 mg/L
                                           95% CONFIDENCE LIMITS
                                           ARE NOT RELIABLE.
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TRIMMED SPEARMAN-KARBER METHOD.  MONTANA STATE UNIV

 FOR REFERENCE, CITE:
 HAMILTON, M.A., R.C. RUSSO, AND R.V. THURSTON, 1977.
 TRIMMED SPEARMAN-KARBER METHOD FOR ESTIMATING MEDIAN
 LETHAL CONCENTRATIONS IN TOXICITY BIOASSAYS.
 ENVIRON. SCI. TECHNOL. 11(7): 714-719;
 CORRECTION 12(4):417  (1978).


 DATE:    12/1/06           TEST NUMBER: 1861-00           DURATION:   48 HOURS
 CHEMICAL:   COOK NUCLEAR 2.5 MG/L glc#7009                SPECIES:   D. MAGNA

 RAW DATA:
   CONCENTRATION(MG/L)             .16     .31     .63    1.25    2.50
   NUMBER EXPOSED:                  20      20      20      20      20
   MORTALITIES:                      0       0       0      20      20
   SPEARMAN-KARBER TRIM:                   .00%

  SPEARMAN-KARBER ESTIMATES:      LC50:                .88
                                              95% CONFIDENCE LIMITS
                                              ARE NOT RELIABLE.
--------------------------------------------------------------------------------
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GLEC

Great Lakes Environmental Center

Applied
Environmental
Sciences
www.glec-online.com

Traverse City Operations
739 Hastings St.
Traverse City
MI 49686

231 941-2230
231 941-2240 fax

Columbus Operations
1295 King Ave.
Columbus
OH 43212

614 487-1040
614 487-1920 fax

September 17, 2007

Mr. Eric Mallen
American Electric Power
Donald C. Cook Nuclear Plant
One Cook Place
Bridgman, MI 49106

RE: ACUTE TOXICITY TEST REPORT FOR A SAMPLE COLLECTED FROM AMERICAN ELECTRIC POWER, COOK NUCLEAR PLANT ON AUGUST 28, 2007

Dear Mr. Mallen:

Great Lakes Environmental Center (GLEC) has completed our analyses of the 48-hour *Daphnia magna* and 96-hour fathead minnow acute toxicity test performed on a sample collected by American Electric Power (AEP) personnel on August 28, 2007. The toxicity tests were initiated on August 29, 2007. The sample analyzed was a Mexel treated effluent sample that was diluted 3:1 (GLC Number: 7160) at the AEP Cook Nuclear Plant. Lake Michigan water (GLC Number 7161) collected by AEP personnel was used as the dilution water for the *D. magna* and fathead minnow tests.

The diluted Mexel treated effluent sample was acutely toxic to both *D. magna* and fathead minnows. The 48-hour *D. magna* and 96-hour fathead minnow LC_{50} (median lethal toxicant concentration) and *D. magna* 48-hour EC_{50} (median effect concentration) estimates were all 65.9 percent effluent, or 1.5 TU_a (acute toxic units).

A summary of the test conditions for the toxicity tests are included in Tables 1 and 2. The 48-hour and 96-hour LC_{50} and EC_{50} estimates and toxicity test results are included in Report Forms 1 and 2. The raw data are included in Appendix A.

If you have any questions or comments concerning the results of these toxicity tests, please contact either me or Dennis McCauley at (231) 941-2230. Thank you for the opportunity to provide this service to American Electric Power - Donald C. Cook Nuclear Plant.

Sincerely,

Mailee W Garton

Mailee W. Garton
Laboratory Coordinator

Dennis J McCauley

Dennis J. McCauley
Principal Research Scientist/
Senior Operations Manager

MWG:mg
Enclosures

TABLE 1

FATHEAD MINNOW TOXICITY TEST CONDITIONS
Mexel treated effluent diluted 3:1

Summary of Toxicity Test Conditions	
1. Test Species and Age:	*Pimephales promelas*, (Fathead minnow), 4 days-August 25, 2007
2. Test Type and Duration:	96-hour Static, with renewal at 48 hours
3. Test Dates:	August 29-September 02, 2007
4. Test Temperature (°C):	25 ± 1
5. Light Quality:	Ambient Laboratory, 10-20 $\mu E/m^2/s$
6. Photoperiod:	16 h light, 8 h darkness
7. Feeding Regime:	48 hours
8. Size of Test Vessel:	250 mL glass beaker
9. Volume and Depth of Test Solutions:	200 mL, 65 mm
10. No. of Test Organisms per Test Vessel:	10
11. No. of Test Vessels per Test Solution:	2
12. Total No. of Test Organisms per Test Solution:	20
13. Test Concentrations (percent):	100, 50, 25, 12.5, and 6.25
14. Renewal of Test Solutions:	48-hour renewal
15. Dilution and Primary Control Water:	Lake Michigan GLC# 7161
16. Secondary Control Water:	Synthetic Laboratory (Moderately Hard MH# 1543)
17. Aeration:	None
18. Endpoints Measured:	Mortality (LC_{50})

REPORTING FORM 1

FATHEAD MINNOW ACUTE TOXICITY TEST
Mexel treated effluent diluted 3:1

Facility Name: AEP Cook Nuclear Plant
NPDES Permit No.:
Receiving Water: Lake Michigan
Outfall:
RWC: N/A
Test Dates: 08/29/07 - 09/02/07
Test Species: Fathead minnows
Age Range: 4 days old
Test Laboratory: Great Lakes Environmental Center (GLEC)
Report Date: September 18, 2007

BULK SAMPLE INFORMATION

	SAMPLE COLLECTION DATES:	DATE RECEIVED	ARRIVAL TEMPERATURE	DATE OF FIRST USE	ARRIVAL TRC	DECHLORINATION?	ARRIVAL pH	ARRIVAL DO	ARRIVAL AMMONIA
1.	08/28/07	08/28/07	0.6°C	08/29/07	NM	No	8.35	10.1	NM

What test methods were used: EPA/600/4-90/027 and EPA-821-R-02-012

Describe any deviations from test methods: None

Source of test organisms: In house lot # 08/25/07

TEST DESCRIPTION

Fed/Un-fed: Fed
Food/Feeding Frequency: *Artemia nauplii*, 2 hours prior to 48-hour renewal
No. Replicates per Concentration: 2
No. Organisms per Replicate: 10
Effluent Filtered? No
Effluent Sample Type: Sample 1: Composite
Sample 2:
Diluent (0_1): Lake Michigan Water (GLC# 7161)
Secondary Control (0_2): Synthetic Laboratory Water (Moderately Hard) MH# 1543

SUMMARY OF RESULTS*

48-hour LC$_{50}$: 68.3%
96-hour LC$_{50}$: 65.9%

Percent Mortality per Concentration
(Percent Effected per Concentration)

Day	--Controls--		--Effluent Concentrations--					
	0_1	0_2	6.25 Percent	12.5 Percent	25 Percent	50 Percent	100 Percent	___ Percent
1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)	100 (100)	
2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)	100 (100)	
3	0 (0)	0 (0)	0 (0)	5 (5)	0 (0)	5 (5)	100 (100)	
4	0 (0)	0 (0)	0 (0)	5 (5)	0 (0)	5 (5)	100 (100)	

*Raw data sheets are included in Appendix A.
0_2: Synthetic Laboratory Water (Moderately Hard)

Investigator: Mailee W. Garton
Contact: Dennis McCauley
Phone No.: (231) 941-2230

Signature
Principal Research Scientist/Manager of Operations
Title
Date

TABLE 2

DAPHNIA MAGNA TOXICITY TEST CONDITIONS
Mexel treated effluent diluted 3:1

Summary of Toxicity Test Conditions	
1. Test Species and Age:	*Daphnia magna*, <24 hours old
2. Test Type and Duration:	Static, 48 hours
3. Test Dates:	August 29-31, 2007
4. Test Temperature (°C):	25 ± 1
5. Light Quality:	Ambient Laboratory, 10-20 $\mu E/m^2/s$
6. Photoperiod:	16 h light, 8 h darkness
7. Feeding Regime:	None
8. Size of Test Vessel:	30 mL plastic cup
9. Volume and Depth of Test Solutions:	15 mL, 20 mm
10. No. of Test Organisms per Test Vessel:	5
11. No. of Test Vessels per Test Solution:	4
12. Total No. of Test Organisms per Test Solution:	20
13. Test Concentrations (percent):	100, 50, 25, 12.5, and 6.25
14. Renewal of Test Solutions:	None
15. Dilution and Primary Control Water:	Lake Michigan GLC# 7161
16. Secondary Control Water:	Synthetic Laboratory (Moderately Hard MH# 1543)
17. Aeration:	None
18. Endpoints Measured:	Mortality (LC_{50}) and Effect (EC_{50})

REPORTING FORM 2

DAPHNIA MAGNA ACUTE TOXICITY TEST
Mexel treated effluent diluted 3:1

Facility Name: AEP Cook Nuclear Plant

NPDES Permit No.:

Receiving Water: Lake Michigan

Outfall:

RWC: N/A

Test Dates: 08/29/07 - 08/31/07

Test Species: *Daphnia magna*

Age Range: <24 hours

Test Laboratory: Great Lakes Environmental Center (GLEC)

Report Date: September 18, 2007

BULK SAMPLE INFORMATION

SAMPLE COLLECTION DATES	DATE RECEIVED	ARRIVAL TEMPERATURE	DATE OF FIRST USE	ARRIVAL TRC	DECHLORINATION?	ARRIVAL pH	ARRIVAL DO	ARRIVAL AMMONIA
1. 08/28/07	08/28/07	0.6°C	08/29/07	NM	No	8.35	10.1	NM

ND: Not Detected

What test methods were used: EPA/600/4-90/027 and EPA-821-R-02-012

Describe any deviations from test methods: None

Source of test organisms: In House: MH 08-17-07

TEST DESCRIPTION

Fed/Un-fed: Un- Fed

Food/Feeding Frequency: None

No. Replicates per Concentration: 4

No. Organisms per Replicate: 5

Effluent Filtered? No

Effluent Sample Type: Sample 1: Composite

Sample 2:

Diluent (0_1): Lake Michigan Water (GLC# 7161)

Secondary Control (0_2): Synthetic Laboratory Water (Moderately Hard) MH# 1543

SUMMARY OF RESULTS*

48-hour LC_{50}: 65.9%
48-hour EC_{50}: 65.9%

Percent Mortality per Concentration
(Percent Effected per Concentration)

Day	--Controls--		--Effluent Concentrations--					
	0_1	0_2	6.25 Percent	12.5 Percent	25 Percent	50 Percent	100 Percent	Percent
1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	95 (95)	
2	0 (0)	0(0)	0 (0)	0 (0)	0 (0)	10 (10)	100 (100)	

*Raw data sheets are included in Appendix A.
0_2: Synthetic Laboratory Water (Moderately Hard)

Investigator: Mailee W. Garton

Contact: Dennis McCauley

Phone No.: (231) 941-2230

Signature

Principal Research Scientist/Manager of Operations
Title

Date

Appendix A

Raw Data Sheets

GLEC

Great Lakes Environmental Center

Great Lakes Environmental Center

CHAIN OF CUSTODY RECORD
(TO BE COMPLETED ONSITE AND SUBMITTED WITH SAMPLES)

739 Hastings Street
Traverse City, MI 49686
Phone: (231) 941-2230
Fax: (231) 941-2240

Facility: Cook Nuclear Plant
Location: One Cook Place, Bridgman, MI 49106
Contact Person: Eric Mallen
Phone Number: 269-465-5901 X1540

Collector: ~~Eric Mallen~~ / Darius Backauskas 8/28/07
Date: 8/28/07
Witness: Eric Mallen
Date: 8/28/07

GLC NUMBER (Lab ID) 8/28/07	SAMPLE ID	DATE/TIME OF SAMPLE*	VOLUME COLLECTED	SAMPLE CONTAINER	DESCRIPTION (Type of sample, source, physical characteristics)	PRESERVATION	ANALYSES REQUIRED	Additional Parameters Measured at Collection	
								Ammonia mg/L	Chlorine mg/L
7160 ~~07-01~~	07-01	8/28/07/10:05 am	1 gallon	Cubitainer	Mixed treated effluent diluted 3:1	none	WET Test	NA	NA
‘	07-02	8/28/07/10:12 am	1 gallon	Cubitainer	Lake water	none	Lab dilutions	NA	NA
7161	07-03	8/28/07 10:12 am	1 gallon	Cubitainer	Lake water	none	Lab dilutions	NA	NA

* For 24-Hour Composite samples, please indicate times and dates the sampling started and ended.

TRANSFER OF SAMPLES:
(First signature is sampler, last signature is authorized laboratory representative.)

	SHIPPER	RECEIVER	DATE	TIME 8/28/07	TEMPERATURE
1.	Cook Nuclear Plant	Adam Reitz	8/28/07	~~[illegible]~~	7161: 0.0 Re H2O
2.	Eric Mallen			10:56	7160: 0.6 F.Effluent

Condition of Sample Upon Receipt: Good Samples 8/28/07 16:30

☑ Received on Ice

GLEC
Great Lakes Environmental Center

EFFLUENT AND RECEIVING WATER CHECK-IN FORM

CLIENT: Cook Nuclear PROJECT NUMBER: 1861.00

INVESTIGATORS: SReitz

INITIAL WATER CHEMISTRY (UPON RECEIPT)

DATE RECEIVED: 8/28/07	INITIALS SR	Final Effluent	Rec H2O	
GLC NUMBER:		7160	7161	
COLLECTION DATE: (Time Interval)		8/28/07	8/28/07	
TEMPERATURE:		0.6	0.0	
EFFLUENT DESCRIPTION:		Clear NO ODOR	Clear NO ODOR	

WATER CHEMISTRY AT TEST TEMPERATURES

DATE RECEIVED: 8/28/07 CHECK IN DATE: 8/29/07	INITIALS SR	Final Effluent	Rec H2O	
GLC NUMBER:		7160	7161	
TEMPERATURE		25.0	25.0	
pH	SR	8.35	8.33	
DISSOLVED OXYGEN (mg/L)		10.1	10.0	
CONDUCTIVITY (µmhos/cm)		307	309	
HARDNESS (mg/L)		128	152	
ALKALINITY (mg/L)		104	108	
TOTAL CHLORINE (mg/L)*		NM	NM	
TOTAL AMMONIA (mg/L)*		NM	NM	

*Check with project manager to see if necessary.

Hardness:

7160
End mL: 38.7
Start mL: 35.5
Sample Volume: 25mL

7161
End mL: 35.5
Start mL: 31.7
Sample Volume: 25mL

Alkalinity:

7160
End mL: 41.2
Start mL: 36.0
Sample Volume: 50mL

7161
End mL: 35.9
Start mL: 30.5
Sample Volume: 50mL

76

GLEC
Great Lakes Environmental Center

DAPHNID 48-HOUR STATIC ACUTE TOXICITY TEST

[redacted]

TEST MATERIAL: Cook Nuclear
PROJECT NUMBER: 1861-00
TEST SPECIES: D. magna
INVESTIGATORS: S Reitz

TYPE OF TEST: Regulatory
NUMBER OF DAPHNIDS/CHAMBER: 5
NUMBER OF CHAMBERS: 4 +1 for chems
AGE OF DAPHNIDS: ~~>~~24 hrs MH 8/17/07

DILUTION WATER: ~~Mod Hard~~ Rec H2O
GLC AND/OR BATCH NUMBER:
TEST TEMPERATURE: 25±1°C
INCUBATOR #: 9 PHOTOPERIOD: 16:8

#1453

DATE			TREATMENT LEVEL	Rec H2O CONTROL				A 6.25%				B 12.5%				C 25%				D 50%				E 100%				2° Con MH			
TIME	TEST DAY	TECH. INITIALS	REPLICATE NUMBER	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
8/29/07 1235	0	SR	TEMPERATURE (°C)	25.0				25.0				25.0				25.0				25.0				25.0				25.0			
			pH	8.33				8.31				8.31				8.33				8.33				8.35				8.11			
			DO (mg/L)	10.0				9.7				9.5				9.5				9.4				10.0				8.8			
			SP. CONDUCTANCE (μmhos/cm)	309				307				309				314				314				307				320			
8/30/07 JK	1	JK	NUMBER LIVE	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	~~5~~ 1 JK	~~5~~ 0 JK	0	0	5	5	5	5
			OBSERVATIONS		3F	3F				1F	3F		1F	1F		2F		2F						2F					3F		
			pH	7.94				8.04				8.11				8.14				8.16				8.24				7.74			
			DO (mg/L)	8.3				8.3				8.4				8.4				8.4				8.4				8.4			
			TEMPERATURE (°C)	24.9				25.1				24.9				24.9				24.9				24.8				24.7			
8/31/07 1200	2	MWG	NUMBER LIVE	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	4	0	/	/	/	5	5	5	5
			OBSERVATIONS																												
			pH	8.23				8.26				8.28				8.29				8.31				8.31				7.94			
			DO (mg/L)	8.5				8.5				8.5				8.5				8.5				8.5				8.5			
			SP. CONDUCTANCE	317				318				321				323				322				296				322			
			TEMPERATURE (°C)	24.7				24.7				24.7				24.8				24.8				24.7				24.8			

Observation Key:

DOB - Dried Out on Beaker
ERR - Erratic Swimming
F - Floater

PM - Particulate Matter
FS - Film on Surface
IMM - Immobile

REVIEWED BY: Marlee W
DATE: 8/31/07

```
TRIMMED SPEARMAN-KARBER METHOD.  MONTANA STATE UNIV

 FOR REFERENCE, CITE:
 HAMILTON, M.A., R.C. RUSSO, AND R.V. THURSTON, 1977.
 TRIMMED SPEARMAN-KARBER METHOD FOR ESTIMATING MEDIAN
 LETHAL CONCENTRATIONS IN TOXICITY BIOASSAYS.
 ENVIRON. SCI. TECHNOL. 11(7): 714-719;
 CORRECTION 12(4):417  (1978).


 DATE:   8/29/07                                       TEST NUMBER: 1861-00
 CHEMICAL: COOK NUCLEAR-AEP                            SPECIES: D. MAGNA

 RAW DATA:
   CONCENTRATION(PERCENT )      6.25  12.50  25.00  50.00 100.00
   NUMBER EXPOSED:                20     20     20     20     20

 DURATION (HOURS   )        LC50     LOWER 95% LIMIT    UPPER 95% LIMIT   PERCENT
TRIM

         48                65.98          60.12              72.41
.00
```

FISH 96-HOUR STATIC ACUTE TOXICITY TEST
WITH 48-HOUR RENEWAL

TEST MATERIAL: Cook Nuclear
PROJECT NUMBER: 1861-00 GLC# 7160
TEST SPECIES: FHM

NO. FRY/CHAMBER: 10
AGE/SOURCE OF FRY: 72 hrs 8/25/07 10:00
DILUTION WATER: ~~ModHard~~ Rec H2O #7161

PHOTOPERIOD (L:D): 16:8
LIGHT INTENSITY (lux): Ambient
TEST TEMPERATURE (°C): 25° ± 1°C

DATE	TEST DAY	TECH. INITIALS	TREATMENT LEVEL	Control Rec H2O		A 6.25%		B 12.5%		C 25%		D 50%		E 100%		Con MH #1403	
TIME			REPLICATE NUMBER	1	2	1	2	1	2	1	2	1	2	1	2	1	2
8/29/07 11:15	0	SR	Temperature (°C)	25.0		25.0		25.0		25.0		25.0		25.0		25.0	
			pH	8.33		8.31		8.31		8.33		8.33		8.35		8.11	
			DO (mg/L)	10.0		9.7		9.5		9.5		9.4		10.0		8.8	
			Sp. Cond. (µmhos/cm)	309		307		309		SR 314		314		307		320	
8/30/07	1	JK	Number Live	10	10	10	10	10	10	~~9~~ 10	10	9	10	0	0	10	10
			Observations														JK
			Temperature (°C)	24.8	~~24.8~~	25.2		25.2		24.6		24.7		24.7		24.9	
			pH	~~8.15~~ 7.79		8.16		8.16		8.17		8.15		7.96		~~8.15~~ 7.77	
			DO (mg/L)	7.8	7.6	7.6	7.6	7.6		7.6		7.6		7.0		7.9	8.0
48-Hour Renewal New Chemistries GLC# 7160 ~~MH~~ 7161 Rec H2O		MWS	Temperature (°C)	25.0		25.0		25.0		25.0		25.0		25.0		25.0	
			pH	8.32		8.33		8.33		8.33		8.34		8.34		8.28	
			DO (mg/L)	9.4		9.6		9.5		9.5		9.8		9.8		8.5	
			Special Con. (µmhos/cm)	310		312		313		313		315		309		326	
8/31/07	2	MWS	Number Live	10	10	10	10	10	10	10	10	9	10			10	10
			Observations														
			Temperature (°C)	24.7		24.9		24.9		25.1		25.1				24.7	
			pH	7.99		8.10		8.13		8.15		8.15				7.81	
			DO (mg/L)	8.0		8.0		8.0		8.0		8.0				7.8	
9/1/07	3	SR	Number Live	10	10	10	10	10	9	10	10	9	10			10	10
			Observations														
			Temperature (°C)	24.8		24.8		24.7		24.8		24.9				24.8	
			pH	8.23		8.26		8.26		8.27		8.29				7.92	
			DO (mg/L)	7.8		7.9		7.8		8.0		8.0				7.8	
9/2/07 11:25	4	SR	Number Live	10	10	10	10	10	9	10	10	9	10			10	10
			Observations														
			Temperature (°C)	24.1		24.7		24.7		24.5		24.4				24.5	
			pH	8.35		8.31		8.33		8.30		8.24				7.95	
			DO (mg/L)	7.9		7.9		8.0		8.0		8.0				8.0	

Observation Key:
N - Normal
ERR - Erratic Swimming

PM - Particulate Matter
FS - Film on Surface

I - Immobilized

Date: 9/4/07
Reviewed By:

```
 TRIMMED SPEARMAN-KARBER METHOD.  MONTANA STATE UNIV

  FOR REFERENCE, CITE:
  HAMILTON, M.A., R.C. RUSSO, AND R.V. THURSTON, 1977.
  TRIMMED SPEARMAN-KARBER METHOD FOR ESTIMATING MEDIAN
  LETHAL CONCENTRATIONS IN TOXICITY BIOASSAYS.
  ENVIRON. SCI. TECHNOL. 11(7): 714-719;
  CORRECTION 12(4):417  (1978).


  DATE:   8/29/07                                       TEST NUMBER: 1861-00
  CHEMICAL: COOK NUCLEAR GLC7160                        SPECIES: FHM

  RAW DATA:
    CONCENTRATION(PERCENT )      6.25  12.50  25.00  50.00 100.00
    NUMBER EXPOSED:                20     20     20     20     20

  DURATION (H       )        LC50    LOWER 95% LIMIT   UPPER 95% LIMIT   PERCENT
TRIM

        48                  68.30           63.84              73.08
.00
```

```
TRIMMED SPEARMAN-KARBER METHOD.  MONTANA STATE UNIV

 FOR REFERENCE, CITE:
 HAMILTON, M.A., R.C. RUSSO, AND R.V. THURSTON, 1977.
 TRIMMED SPEARMAN-KARBER METHOD FOR ESTIMATING MEDIAN
 LETHAL CONCENTRATIONS IN TOXICITY BIOASSAYS.
 ENVIRON. SCI. TECHNOL. 11(7): 714-719;
 CORRECTION 12(4):417  (1978).


 DATE:    9/4/07                                    TEST NUMBER: 1861-00
 CHEMICAL: COOK NUCLEAR-AEP                         SPECIES: FHM

 RAW DATA:
   CONCENTRATION(PERCENT )      6.25   12.50   25.00   50.00 100.00
   NUMBER EXPOSED:                20      20      20      20     20

 DURATION (HOURS   )         LC50    LOWER 95% LIMIT    UPPER 95% LIMIT   PERCENT
TRIM

         96                65.98            59.93              72.64
.00
```

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D. C. COOK PLANT ZEBRA MUSSEL MONITORING PROGRAM WORKSHEET

Mexel Test - Art. Sub. Size and Density Calculation Sheet

Date: 9/13/2006

Sample Veliger Number	Mexel - Untreated		Mexel - Treated	
	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)
1	2	78	2	78
2	16	627	2.5	98
3	3	118	4	157
4	4	157	2	78
5			2	78
6			6	235
7			9	353
8			3	118
9			2	78
10			3	118
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
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34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				
Avg.		245		103
Min.		78		78
Max.		627		353
Dens.		427		1067

Mexel - Untreated		Mexel - Treated	
	# of veligers per slide		# of veligers per slide
Slide #		Subsample	3
1	1	1	1
2		2	1
3		3	2
4	3	4	3
5		5	
6		6	
7		7	
8		8	
9		9	
10		10	
Avg. # / slide	0.8	Avg. # / slide	2

E. Scott Rose / 9-16-06
Analyzed by Date

Corrected/8k 9-19-06

CeMiller 9/22/06
Reviewed by Date

D. C. COOK PLANT ZEBRA MUSSEL MONITORING PROGRAM WORKSHEET

Mexel Test - Art. Sub. Size and Density Calculation Sheet

Date: 9/28/06

Sample Veliger	**Mexel - Untreated**		**Mexel - Treated**	
Number	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)
1	12	470	10	392
2	6	235	8	314
3	11	431	8	314
4	10	392	13	510
5	14	549	2.5	98
6	9	353	2.5	98
7	2.5	98	6	235
8	8	314	8	314
9	2	78	11	431
10	2	78	3	118
11	8	314	7	274
12			8	314
13			2	78
14			7	274
15			9	353
16			3	118
17			9	353
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				
Avg.		301		270
Min.		78		78
Max.		549		510
Dens.		1173		1813

Mexel - Untreated	
	# of veligers per slide
Slide #	
1	5
2	
3	2
4	1
5	3
6	
7	
8	
9	
10	
Avg. # / slide	2.2

Mexel - Treated	
	# of veligers per slide
Slide #	
1	1
2	5
3	9
4	2
5	
6	
7	
8	
9	
10	
Avg. # / slide	3.4

Samples pulled from Mexel test equipment on 9-28-06.

E. [illegible] 9.28.06

Analyzed by Date

[illegible] 9/28/06

Reviewed by Date

D. C. COOK PLANT ZEBRA MUSSEL MONITORING PROGRAM WORKSHEET

Mexel Test - Art. Sub. Size and Density Calculation Sheet

Date: 10/12/06

Sample Veliger	Mexel - Untreated		Mexel - Treated	
Number	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)
1	9	353	8	314
2	13	510	7	274
3	6.5	255	10	392
4	10	392	2	78
5	21	823	2	78
6	8	314	2.5	98
7	2	78	9	353
8	3	118	11	431
9	28	1098	9	353
10	20	784	2.5	98
11	30	1176	18	706
12	57	2234	12	470
13	14	549	9	353
14	8	314	8	314
15	2.5	98	21	823
16	3	118	8	314
17	2.5	98	12	470
18	2.5	98	2	78
19	3	118	2.5	98
20			10	392
21			19	745
22			12	470
23			14	549
24			8	314
25			15	588
26			2.5	98
27			2	78
28			3.5	137
29			6	235
30			9	353
31			2	78
32			2	78
33			2.5	98
34			2	78
35			8	314
36			9	353
37			2	78
38			10	392
39			11	431
40			2	78
41			2.5	98
42			3	118
43			3.5	137
44			2.5	98
45				
46				
47				
48				
49				
50				
Avg.		501		284
Min.		78		78
Max.		2234		823
Dens.		2560		14933

Mexel-Untreated	
	# veligers per slide
Slide #	
1	4
2	1
3	2
4	2
5	15
6	
7	
8	
9	
10	
Avg. # / slide	4.8

Mexel-Treated		
	# veligers per slide	
Slide #		
1	7	
2	94	A
3	7	
4	15	B
5	17	
6		
7		
8		
9		
10		
Avg. # / slide	28	

A

Found 2 "clumps" of veligers. One with 65-75 individuals ranging in size from ~80-160um and the other with 8-10 individuals in the same size range. This total of 94 includes 70 and 9 from the "clumps" as well as 16 others found on the slide

B

This total of 15 includes 2 smaller "clumps" of 5 veligers plus 5 others found on the slide

Mexel Carbon Steel Samples

One Test and one control carbon steel coupons were removed from the treatment system and analyzed. The coupons are 1/2" wide X ~6" long. 3 @ 1/2' sections (.75 in^2 total area) were viewed under the scope. Settled veligers on these 3 sec tions were counted and measured

	Untreated Coupon			Treated Coupon		
	Section 1	Section 2	Section 3	Section 1	Section 2	Section 3
# post-veligers	71	14	30	18	3	5
Randomly chosen post veliger size measurements(um)	1,497	1,449	725	725	676	290
	483	676	531	242	290	290
	386	821	966	483	290	193
	386	580	869	386		386
	1,449	628	386	290		242
	725		918			
	628		435			
	580		531			
	676		773			
	918		580			
Avg. Size (um)	773	831	671	425	419	280
Density (#/M^2)	440,200	86,800	186,000	111,600	18,600	31,000
Avg density (#/M^2)	237,667			53,733		

Densities based on 1550in^2/M^2

E. Scott Rose / 10-12-06	10/18/06
Analyzed by Date	Reviewed by Date

D. C. COOK PLANT ZEBRA MUSSEL MONITORING PROGRAM WORKSHEET

Mexel Test - Art. Sub. Size and Density Calculation Sheet

Date: 10/25/06

Sample Veliger Number	Mexel - Untreated Micrometer Reading	Mexel - Untreated Size (u)	Mexel - Treated Micrometer Reading	Mexel - Treated Size (u)
1	11.5	555	2	97
2	22	1063	15	725
3	7	338	2	97
4	32	1546	8	386
5	21	1014	1.5	72
6	19	918	3	145
7	8	386	2	97
8	11	531	2	97
9	23	1111	2.5	121
10	17	821	1.5	72
11	15	725	13	628
12	46	2222	11	531
13	13	628	6	290
14	2	97	5	242
15	8	386	7	338
16	21	1014	19	918
17	15	725	14	676
18	14	676	16	773
19	19	918	6	290
20	15	725	16	773
21	8	386	14	676
22	17	821	16	773
23	19	918	11	531
24	13	628	17	821
25	9	435	18	869
26	12	580	22	1063
27	93	4492	18	869
28	15	725	11	531
29	21	1014	11	531
30	9	435	22	1063
31	26	1256	15	725
32	7	338	8	386
33	11	531	25	1208
34	18	869	5	242
35	14	676	2.5	121
36	5	242	29	1401
37	45	2174	8	386
38	20	966	18	869
39	6	290	56	2705
40	14	676	15	725
41	51	2463	10	483
42	21	1014	11	531
43	19	918	22	1063
44	21	1014	25	1208
45	16	773	2.5	121
46	39	1884	2	97
47	37	1787		
48	35	1691		
49	20	966		
50	22	1063		
Avg.		968		595
Min.		97		72
Max.		4492		2705
Dens.	org/m^2	8960		13653

Mexel - Untreated

Slide #	# of veligers per slide
1	10
2	31
3	17
4	12
5	14
6	
7	
8	
9	
10	
Avg. # / slide	16.8

Mexel - Treated
(all organisms)

Slide #	# of veligers per slide
1	58
2	12
3	20
4	6
5	32
6	
7	
8	
9	
10	
Avg. # / slide	25.6

Mexel Test slides collected 10/25/06/jf

Mexel - Treated
(settled organisms)

Slide #	# of veligers per slide
1	10
2	12
3	19
4	5
5	11
6	
7	
8	
9	
10	
Avg. # / slide	11.4

Density 6080

>half of the organisms on the treated slides were less than 170um in length, i.e. still considered trans-locators

Additionally, 2 "clumps" of translocator-sized veligers were found on one slide-one "clump" of 14 (72-145um length) and another of 31 (72-170um length).

Analyzed by 10/25/06 Date

Reviewed by 10/25/06 Date

D. C. COOK PLANT ZEBRA MUSSEL MONITORING PROGRAM WORKSHEET

Mexel Test - Art. Sub. Size and Density Calculation Sheet

Date: 11/9/06

Sample Veliger Number	Mexel - Untreated		Mexel - Treated	
	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)
1	45	2174	18	869
2	8	386	16	773
3	7	338	9	435
4	7	338	5	242
5	8	386	19	918
6	5	242	6	290
7	6	290	15	725
8	7	338	6	290
9	7	338	7	338
10	6	290	8	386
11	9	435	40	1932
12	36	1739	12	580
13	9	435	8	386
14	5	242	25	1208
15	6	290	10	483
16	10	483	10	483
17	15	725	8	386
18	10	483	18	869
19	11	531	15	725
20	8	386	14	676
21	5	242	15	725
22	7	338	17	821
23	6	290	26	1256
24	5	242	25	1208
25	4	193	18	869
26	7	338	10	483
27	16	773	23	1111
28	11	531	11	531
29	5	242	14	676
30	10	483	6	290
31	7	338	21	1014
32	6	290	11	531
33	7	338	23	1111
34	7	338	16	773
35	6	290	9	435
36	6	290	44	2125
37	6	290	1	48
38	6	290	15	725
39	5	242	9	435
40	48	2318	11	531
41	33	1594	12	580
42	19	918	8	386
43	6	290	20	966
44	6	290	12	580
45	7	338	12	580
46	7	338	16	773
47	6	290	6	290
48	5	242	10	483
49	5	242	10	483
50	6	290	7	338
Avg.		488		683
Min.		193		48
Max.		2318		2125
Dens.		40,107		28,907

Mexel - Untreated	
	# of veligers per slide
Slide #	
1	72
2	87
3	55
4	69
5	93
6	
7	
8	
9	
10	
Avg. # / slide	75.2

Mexel - Treated		
	# of veligers per slide	
Slide #		
1	36	
2	39	
3	116	A
4	48	
5	32	
6		
7		
8		
9		
10		
Avg. # / slide	54.2	

A
2 "clumps" of translocator-sized veligers were found on one slide- one "clump" of 45 (97-170um length) and another of 12 (97-145um length).

Mexel - Treated (settled organisms)	
	# of veligers per slide
Slide #	
1	36
2	39
3	59
4	48
5	32
6	
7	
8	
9	
10	
Avg. # / slide	42.8

Density 22826.6667

E. Scott Rose / / 11-9-06
Analyzed by Date

Miller 11/14/06
Reviewed by Date

D. C. COOK PLANT ZEBRA MUSSEL MONITORING PROGRAM WORKSHEET

Mexel Test - Art. Sub. Size and Density Calculation Sheet

Date: 12/7/06

Sample Veliger	**Mexel - Untreated**		**Mexel - Treated**	
Number	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)
1	25	980	14	549
2	22	862	10	392
3	9	353	20	784
4	20	784	9	353
5	8	314	31	1215
6	25	980	15	588
7	22	862	29	1137
8	63	2470	30	1176
9	13	510	27	1058
10	14	549	15	588
11	13	510	13	510
12	10	392	18	706
13	28	1098	16	627
14	83	3254	16	627
15	81	3175	8	314
16	56	2195	9	353
17	13	510	43	1686
18	7	274	37	1450
19	8	314	16	627
20	7	274	7	274
21	7	274	27	1058
22	26	1019	29	1137
23	31	1215	9	353
24	31	1215	10	392
25	21	823	12	470
26	8	314	10	392
27	14	549	10	392
28	8	314	13	510
29	19	745	13	510
30	9	353	12	470
31	8	314	6	235
32	7	274	22	862
33	7	274	15	588
34	57	2234	12	470
35	9	353	17	666
36	8	314	17	666
37	35	1372	15	588
38	12	470	14	549
39	14	549	14	549
40	27	1058	10	392
41	60	2352	80	3136
42	8	314	37	1450
43	6	235	30	1176
44	12	470	24	941
45	19	745	8	314
46	6	235	27	1058
47	9	353	57	2234
48	15	588	9	353
49	6	235	15	588
50	8	314	16	627
Avg.		1073		749
Min.		274		235
Max.		3254		3136
Dens.		85440		60800

Mexel-Untreated	
	# veligers per slide
Slide #	
1	75
2	214
3	202
4	228
5	82
6	
7	
8	
9	
10	
Avg. # / slide	160.2

Mexel-Treated	
	# veligers per slide
Slide #	
1	134
2	94
3	114
4	141
5	87
6	
7	
8	
9	
10	
Avg. # / slide	114

There was, for the first time, no evidence of "clumping" on the Mexel-treated slides.

Mexel Carbon Steel Samples

One Test and one control carbon steel coupons were removed from the treatment system and analyzed. The coupons are 1/2" wide X ~6" long. 3 @ 1" sections (1.50 in^2 total area) were viewed under the scope. Settled veligers on these 3 sections were counted and measured

	Untreated Coupon			Treated Coupon		
	Section 1	Section 2	Section 3	Section 1	Section 2	Section 3
# post-veligers	90	87	134	40	14	15
Randomly chosen post veliger size measurements(um)	3,719	918	242	2174	1063	1014
	2,463	1352	338	1014	1159	435
	676	1159	290	725	821	580
	1,256	869	531	1256	1546	1401
	1,063	1546	628	531	1063	531
	918	580	242	580	918	580
	1,014	1014	1,787	483	676	1449
	1,304	725	531	580	869	966
	2,029	1063	1,401	1111	531	1739
	483	918	386	966	725	725
Avg. Size (um)	1,492	1,169	638	942	937	942
Density (#/M^2)	279,000	269,700	415,400	124,000	43,400	46,500
Avg density (#/M^2)	321,367			71,300		

Densities based on 1550in^2/M^2

E. Scott Rose / 12-7-06
Analyzed by Date

12/11/06
Reviewed by Date

Date: 6-7-2007

Sample Veliger	CONTROL				TREATED			
	2007 Mexel		2006 Mexel		2007 Mexel		2006 Mexel	
Number	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)
1	2.5	121	20	966	2	97	38	1835
2	7	338	30	1449	3	145	73	3526
3	2	97	39	1884	2	97	28	1352
4	2.5	121	35	1691	4	193	30	1449
5	2	97	112	5410	2	97	44	2125
6	1.5	72	54	2608	3	145	84	4057
7	4	193	30	1449	4	193	28	1352
8	2	97	59	2850	31	1497	53	2560
9	1.5	72	41	1980	2	97	37	1787
10	2	97	30	1449	2	97	58	2801
11	2	97	342	16519	10	483	31	1497
12	2	97	44	2125	2.5	121	25	1208
13	3	145	25	1208	2	97	28	1352
14	3	145	30	1449	1.5	72	63	3043
15	3	145	72	3478	2.5	121	30	1449
16	2	97	31	1497	2.5	121	13	628
17	2.5	121	52	2512	3.5	169	70	3381
18	3	145	40	1932	2	97	52	2512
19	3	145	31	1497	2	97	61	2946
20	2.5	121	97	4685	2	97	17	821
21	3	145	87	4202	3	145	55	2657
22	3	145	30	1449	2	97	40	1932
23	3.5	169	50	2415	2	97	22	1063
24	2	97	74	3574	3	145	35	1691
25	2	97	39	1884	2	97	21	1014
26	2	97	55	2657	2	97	17	821
27	2.5	121	28	1352	3	145	77	3719
28	2	97	40	1932	2	97	31	1497
29	2	97	21	1014	2	97	11	531
30	3	145	25	1208	2	97	43	2077
31	4	193			2	97		
32	2.5	121			2	97		
33	3	145			2.5	121		
34	3	145			3	145		
35	3	145			2	97		
36	5	242			4	193		
37	2	97			2	97		
38	2	97			2	97		
39	3	145			2	97		
40	2.5	121			2	97		
41	2	97			2	97		
42	4	193			2	97		
43	4	193			2	97		
44	2	97			2	97		
45	2	97						
46	2	97						
47	2	97						
48								
49								
50								
Avg.		129		2677		154		1956
Min.		72		966		72		531
Max.		338		16519		1497		4057
Dens.		~~51520~~ 6-8-07		#REF!		#REF!		#REF!

See here

2007 Mexel Control Density (#/m²)	
Subsample	# of veligers/ml
1	11
2	22
3	7
4	15
5	45
6	
7	
8	
9	
10	

20.0

2007 Mexel Control Density (#/m3)
10,667

2006 Mexel Control Density (#/m²)	
Subsample	# of veligers/ml
1	166
2	227
3	220
4	
5	
6	
7	
8	
9	
10	

204.3

2006 Mexel Control Density (#/m3)
108,973

2007 Mexel Treated Density (#/m²)	
Subsample	# of veligers/ml
1	23
2	14
3	14
4	6
5	8
6	
7	
8	
9	
10	

13.0

2007 Mexel Treated Density (#/m3)
6,933

2006 Mexel Treated Density (#/m²)	
Subsample	# of veligers/ml
1	78
2	64
3	79
4	
5	
6	
7	
8	
9	
10	

73.7

2006 Mexel Treated Density (#/m3)
39,289

Date: 8/23/07

Sample Veliger	MEXEL-CONTROL				MEXEL-TREATED			
	2007 Mexel		2006 Mexel		2007 Mexel		2006 Mexel	
Number	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)
1			5	267			4	214
2			8	427			163	8704
3			5	267			8	427
4			4	214			17	908
5			6	320			10	534
6			17	908			12	641
7			21	1121			7	374
8			280	14952			7	374
9			157	8384			15	801
10			75	4005			15	801
11			5	267			140	7476
12			7	374			12	641
13			4	214			10	534
14			8	427			10	534
15			6	320			8	427
16			6	320			10	534
17			6	320			41	2189
18			9	481			10	534
19			127	6782			13	694
20			203	10840			12	641
21							166	8864
22							11	587
23							10	534
24							12	641
25							8	427
26							13	694
27							9	481
28							10	534
29							6	320
30							8	427
31							18	961
32							12	641
33							10	534
34							10	534
35							27	1442
36							12	641
37							118	6301
38							9	481
39							11	587
40							9	481
41							14	748
42							19	1015
43							34	1816
44							163	8704
45							17	908
46							6	320
47							14	748
48							13	694
49							12	641
50							46	2456
Avg.				2561				1383
Min.				214				214
Max.				14952				8864
Dens.		#DIV/0!		#REF!		#DIV/0!		#REF!

2007 Mexel Control Density (#/m²)

Subsample	# of veligers/slide	# @ <~100um
1		
2		
3		
4		
5		
6	#DIV/0!	Avg.
7		
8		
9		
10		

2007 Mexel Control Density (#/m3) #DIV/0!

2006 Mexel Control Density (#/m²)

Subsample	# of veligers/slide
1	1204
2	872
3	
4	
5	
6	
7	
8	
9	
10	

1038.0 Avg./slide

Due to heavy and mature settlement, only 2 slides were analyzed. Visually the most- and the least-populated.

2006 Mexel Control Density (#/m3) 553,600

2007 Mexel Treated Density (#/m²)

Subsample	# of veligers/slide	# @ <~100um
1		
2		
3		
4		
5		
6	#DIV/0!	Avg.
7		
8		
9		
10		

2007 Mexel Treated Density (#/m3) #DIV/0!

2006 Mexel Treated Density (#/m²)

Subsample	# of veligers/slide
1	324
2	338
3	174
4	198
5	203
6	
7	
8	
9	
10	

247.4 Avg./slide

2006 Mexel Treated Density (#/m3) 131,947

8/24/07

Analyzed by Date

8/27/07

Reviewed by Date

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Analysis of Mexel Test Bio-box Baffles

Date: 9/6/07

Sample Veliger Number	MEXEL-CONTROL				MEXEL-TREATED			
	Micrometer Reading	Size (u)			Micrometer Reading	Size (u)		
1	5	167			4	193		
2	8	266			8	386		
3	19	633			4	193		
4	7	233			6	290		
5	12	400			5	242		
6	22	733			7	338		
7	13	433			5	242		
8	14	466			8	386		
9	12	400						
10	10	333						
11	304	14683						
12	52	2512						
13	11	531						
14	5	242						
15	7	338						
16	68	3284						
17	9	435						
18	10	483						
19	6	290						
20	9	435						
21								
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44								
45								
46								
47								
48								
49								
50								
Avg.		1365				284		
Min.		167				193		
Max.		14683				386		
Dens.		34,875		#REF!		6,200		#REF!

2 @ 1 in^2 scrapings were taken from each baffle - one from a ~sparsely populated area, one from a ~densely populated area.

2007 Mexel Control Density (#/m^2)	
Subsample	# of veligers/ 1 in^2 scraping
1	16
2	29
3	
4	
5	
6	22.5
7	
8	
9	
10	

Avg.
2007 Mexel Control Density (#/m3)
34,875

2007 Mexel Treated Density (#/m^2)	
Subsample	# of veligers/ 1 in2 scraping
1	7
2	1
3	
4	
5	
6	4.0
7	
8	
9	
10	

Avg.
2007 Mexel Treated Density (#/m3)
6,200

E. Scott Rose / 9-6-07
Analyzed by Date

/ 9/7/07
Reviewed by Date

APPENDIX 4

FINAL REPORT

Mixing Zone Evaluation for the Donald C. Cook Nuclear Plant Discharge Plume in Lake Michigan

Prepared for:

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April 20, 2006

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EXECUTIVE SUMMARY

The Indiana Michigan Power Company's Donald C. Cook Nuclear Plant located on the southeastern shore of Lake Michigan is seeking to modify its NPDES Permit to allow the use of the proprietary molluscicide, Mexel 432, to control the settlement and growth of zebra mussels and quagga mussels on the intake tunnels of the circulating water system.

The Michigan Department of Environmental Quality has calculated a water quality criterion for Mexel. If this criterion is applied to the Cook Nuclear Plant as an end-of-pipe limit, the limit will be exceeded. The objective of the mixing zone evaluation was to summarize the existing data in a report to the Michigan Department of Environmental Quality (MDEQ) to determine whether a mixing zone is acceptable and protective of the designated uses and water quality of the receiving water (Lake Michigan). Ultimately, the goal of the demonstration is to achieve compliance for future Cook Nuclear NPDES discharges with Rule 51 of the Michigan Water Quality Standards, specifically, Rule 323.1082 (Rule 82, Mixing zones); Sub-rule 7.

The State of Michigan water quality standard allows dischargers to meet water quality criteria at the edge of a mixing zone. Michigan's regulation defines mixing zone as, "that portion of a water body allocated by the department where a point source or venting groundwater discharge is mixed with the surface waters of the state." (Water Quality Standards Part 4, R 323.1082(1)) Indiana Michigan Power Company was asked by the MDEQ to determine the dilution ratio of the Mexel discharge concentration with Lake Michigan water. Michigan Surface Water Quality Standards rule defines the edge of the mixing zone as the point where discharge-induced mixing ceases to occur.

A computational fluid dynamics model (FLUENT v6.2) was used to determine the dilution ratio of Mexel in the discharge from Cook Nuclear Plant, at the edge of a mixing zone, using Michigan water quality standards definitions and procedures.

The modeling results demonstrated that the dilution factor at the edge of the near-field mixing zone will be approximately 3.0 at the 2 ft./sec. (fps) isopleth. The modeling results also demonstrated that the two cooling water discharges do not overlap and that the area of the near-field mixing zone for each outfall is relatively small and contained within several hundred square feet.

A review of the potential impact on designated uses of Lake Michigan water concluded that there was no impact on any designated use. Of particular concern, will be the impact of the application of a molluscide Mexel A-432 to the cooling water discharge on Great Lakes fisheries and aquatic life. Cook Nuclear had previously developed a Tier I water quality criterion of 0.1 mg/L (100 µg/L) for Mexel. No other water quality criterion is of concern at this time. The expected maximum concentration of Mexel A-432 at the edge of the near-field mixing zone, with one unit treated at a time is approximately 0.1 mg/L. The expected maximum concentration of Mexel A-432 at the edge of the near-field mixing zone, with two units treated simultaneously is approximately 0.2 mg/L.

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AEP Cook Nuclear Plant
Mixing Zone Evaluation **April 20, 2006**

Introduction

The Indiana Michigan Power Company's Donald C. Cook Nuclear Plant located on the southeastern shore of Lake Michigan is seeking to modify its NPDES Permit to allow the use of the proprietary molluscicide, Mexel 432, to control the settlement and growth of zebra mussels and quagga mussels on the intake tunnels of the circulating water system. Plant operators plan to inject Mexel into the circulating water system at the intake structures out in the lake. The Mexel would be circulated through the plant cooling system and discharged back out into the lake through the cooling water discharge structures.

The objective of this mixing zone evaluation is to summarize the existing data in a report to the Michigan Department of Environmental Quality (MDEQ) to determine whether a mixing zone is acceptable and protective of the designated uses and water quality of the receiving water (Lake Michigan). Ultimately, the goal of the demonstration is to achieve compliance for future Cook Nuclear NPDES discharges with Rule 51 of the Michigan Water Quality Standards, specifically, Rule 323.1082 (Rule 82, Mixing zones); Sub-rule 7.

The MDEQ has calculated a water quality criterion for Mexel. If this criterion is applied to the Cook Nuclear Plant as an end-of-pipe limit, the limit will be exceeded. For the treatments to be effective, Mexel will need to be injected in the intake at concentrations that will not be degraded and diluted to a concentration less than or equal to the water quality criterion by the time the cooling water is discharged to Lake Michigan. In other words, the dosage of Mexel 432 required to control zebra and quagga mussels will result in the discharge of cooling water to Lake Michigan that exceeds the water quality criterion.

The State of Michigan water quality standard allows dischargers to meet water quality criteria at the edge of a mixing zone. Michigan's regulation defines mixing zone as, "that portion of a water body allocated by the department where a point source or venting groundwater discharge is mixed with the surface waters of the state." (Water Quality Standards Part 4, R 323.1082(1)) Indiana Michigan Power Company was asked by the MDEQ to determine the dilution ratio of the Mexel discharge concentration with Lake Michigan water. Michigan Surface Water Quality Standards rule defines the edge of the mixing zone as the point where discharge-induced mixing ceases to occur. According to General Rule, Part 4 R 323.1043 Definitions; A to L:

> "Discharge-induced mixing" means the mixing of a discharge and receiving water that occurs due to discharge momentum and buoyancy up to the point where mixing is controlled by ambient turbulence."

A computational fluid dynamics model (FLUENT v6.2) was used to determine the dilution ratio of Mexel in the discharge from Cook Nuclear Plant, at the edge of a mixing zone, using Michigan water quality standards definitions and procedures. The dilution ratio was applied to the expected maximum end of pipe concentration of Mexel A-432 to determine the expected maximum concentration of Mexel A-432 in Lake Michigan under

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varying operational scenarios. That concentration was compared to the calculated Michigan Tier I water quality criterion for Mexel A-432.

Description of the Study Area and Intake and Discharge Configuration

Lake Bathymetry and Water Currents

The bottom of Lake Michigan off shore of the Cook Nuclear Plant is fairly smooth and featureless. The bottom slopes gradually at a uniform angle from the shoreline out to a depth of 50 feet at approximately one mile off shore. At that point, the slope of the decent decreases and the depth increases only 10 feet, from 50 feet to 60 feet, over the next half-mile off shore. From there the slope becomes shallower and the depth increases only 15 feet, from 60 to 75 feet, over the next two miles off shore.

The major surface water currents in the southern basin of Lake Michigan are generally in a counterclockwise direction, giving the prevailing current past the Cook Nuclear Plant a south to north direction. North to south currents occurs infrequently depending upon the wind pattern. Acoustic current meter data from the National Oceanic and Atmospheric Administration (NOAA)/Great Lakes Environmental Research Laboratory (GLERL) Episodic Events in the Great Lakes Experiment (EEGLE) Project was acquired to characterize current velocities in the vicinity of the plant outfall structures. Water velocities measured in the fall of 1998 at Station C4, moored in 11 meters of water offshore of the power plant outfalls, are presented as an appendix to this report. Positive u-components of velocity (the second line on the data graphs, counting from the top) correspond to south-to-north longshore currents. Examination of this time series shows that current velocities are usually smaller than 10-20 cm/s (0.3-0.6 fps). Current velocities exceeded 40 cm/s (1.3 fps) twice during this period; these high velocities persisted for several hours to about one day. Given that the November-January time period is particularly energetic in terms of wind, waves, and currents in the Great Lakes, ambient current velocities near the power plant outfalls will tend to be smaller in other seasons.

Intake Configuration

The design intake flow is 1,645,000 gallons per minute (gpm) for the condenser cooling water flow, 16,000 gpm for the essential service water, and 9,000 gpm for the nonessential service water system, for a total intake of approximately 1.67 million gallons per minute. All cooling water and service water is drawn into the plant through three intake tunnels that extend about 2,250 feet offshore. Each tunnel begins with an octagonal-shaped steel structure and velocity cap crib that protects the upturned elbow that is connected to the intake tunnel. Each intake tunnel is 16 feet in diameter and the tunnel carries the water from the offshore location into the screen house. The intake cribs are located in 24 feet of water at 579 ft MSL water elevation. Water flows into the cribs through an 8 x 8 inch mesh grid work that is intended to keep large objects out of the intakes. The water velocity through the 8 x 8-in. grid is 1.27 fps and the water velocity through the tunnels is about 6 fps.

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Each intake tunnel is 16 feet in diameter and the tunnel carries the water from the offshore location into the screen house. Inside the screen house the water enters a common forebay (common to both units). The water passes through steel trash racks composed of two designs. The original trash racks are composed of $^3/_8$-in thick by 4-in deep bars on 3-in centers, giving an opening of 2 $^5/_8$-in. These are being replaced over time with trash racks made of bars set on edge to allow a 3 $^3/_{16}$-in clear space between bars (bars are 3 $^9/_{16}$-in. on center and the bar material is $^3/_8$-in thick). From the trash racks, the water flows to optionally installed supplemental trash rack removable inserts placed in the traveling screen stop log slots directly in front of the traveling screens. These inserts are made of $^3/_{16}$-in thick by 2-in deep horizontal bars spaced on 1 $^3/_{16}$-in centers and vertical $^3/_{16}$-in rods on 4-in centers leaving an effective rectangular clear space between the bars and rods of 1-in x 3 $^{13}/_{16}$-in. From there the water flows through the traveling water screens. The original screens were chain belt with $^3/_8$-in mesh screens. The original screens have been replaced with single entry single exit screens (with $^3/_8$-in mesh and $^5/_{16}$-in. mesh screen material) manufactured by Geiger International, Inc.

<u>Discharge Configuration</u>

The cooling water is discharged back to the lake through two tunnels buried beneath Lake Michigan. The discharge structures are located 1,200 feet offshore in 18 feet of water. The total cooling water transit time from intake to discharge is about ten minutes. The Unit 1 discharge tunnel is 16 feet in diameter and the Unit 2 tunnel is 18 feet in diameter. Both tunnels terminate with a 90° elbow that turns the water flow from horizontal to vertical. The water enters the discharge structures from the elbows and is passed horizontally through slots in the discharge structures. The Unit 1 discharge structure has two slot openings, with an overall length of 27 ft. 10 1/8 in. and a height of 2 ft., providing a cross-sectional area of 111.36 ft.^{2}. At a cooling water flow rate of 719,850 gpm (1603.94 ft.^{3}/sec), the discharge velocity from Unit 1 is 14.4 fps. The Unit 2 discharge structure has three slot openings, with an overall length of 19 ft. 7/8 in. and a height of 2 ft. 9 in., providing a cross-sectional area of 157.33 ft.^{2}. At a cooling water flow rate of 950,150 gpm (2117.09 ft.^{3}/sec), the discharge velocity from Unit 2 is 13.5 fps. A conceptual diagram of the cooling water system, including the intake and discharge structures, is provided in Figure 1.

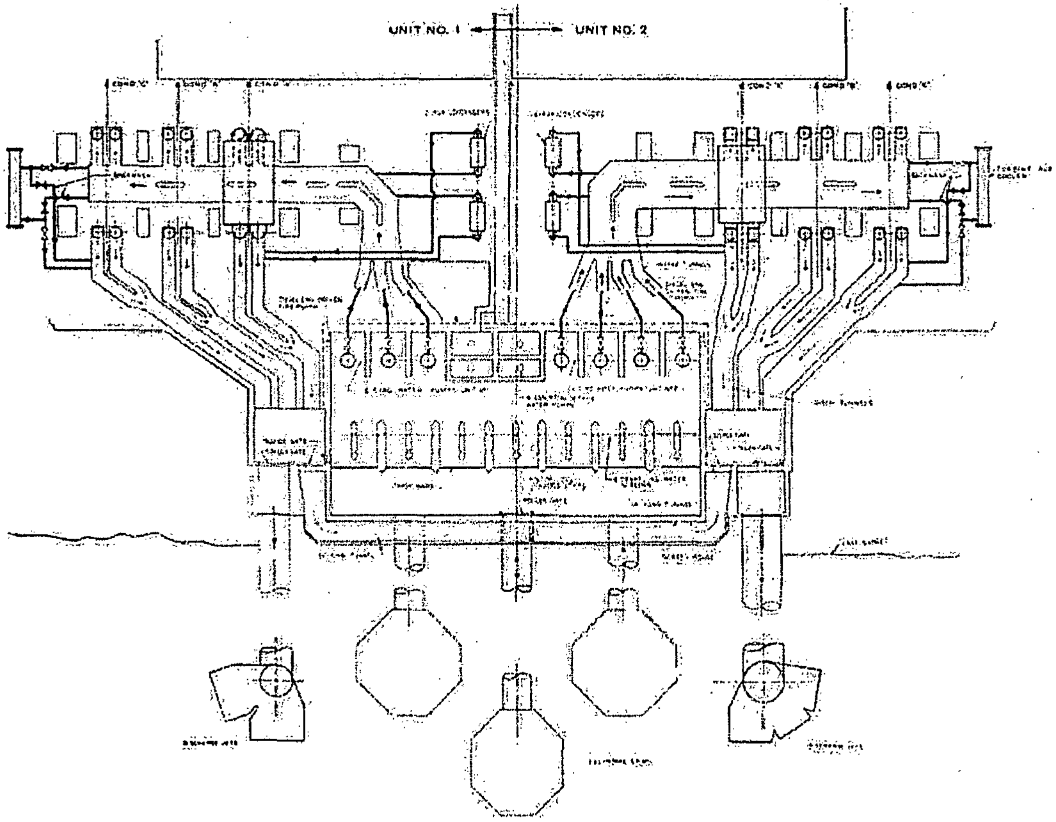

Figure 1. Plan View of D.C. Cook Condenser Cooling Water System

Review of Previous Mixing Zone Studies

LTI conducted a modeling study of the thermal discharge from the D.C. Cook Nuclear Power Plant in 2000 (*Cook Plant Thermal Plume Study*, May 16, 2000). The emphasis of that work was to simulate far-field characteristics of the discharge plume, well beyond the limits of discharge-induced mixing of interest here. However, as part of the LTI study the CORMIX mixing zone model (Jirka et al., 1996) was applied to capture the details of the strong mixing that occurs near the high velocity discharge structures. CORMIX was applied assuming both effluent discharge units were operating, and a long-shore ambient current velocity of 0.03 m/s was used. The CORMIX predictions indicated that (1) the plumes from the two discharge units did not interact with each other (i.e., overlap) in the near-field, (2) the thermal plumes would each reach the lake surface at a distance of 4.85 meters from the respective diffuser structure, and (3) a dilution ratio of 2.2 would be achieved at this distance. The authors of the LTI report did not present the plume velocities predicted by CORMIX, so it is difficult to relate these results to the mixing zone definition being used by the State of Michigan. However, the CORMIX model results can be compared qualitatively to the model predictions made for this mixing zone evaluation.

Modeling Objectives

The object of the numeric modeling was to determine the dilution ratio at the edge of the mixing zone. Michigan Surface Water Quality Standards rule defines the edge of the mixing zone as the point where discharge induced mixing ceases to occur. Theoretically this definition of edge of the mixing zone is reasonable, however, in practice can be difficult to define. A jet discharging into an ambient fluid entrains the ambient fluid. The entrainment is the result of a momentum exchange between the jet and the ambient fluid. Near the source of the jet, the entrainment rate is high, the rate decreases as the jet penetrates the ambient fluid and the jet loses its momentum to the ambient fluid. When the momentum of the jet has been lost to the ambient, further mixing is the result of ambient turbulent mixing and diffusion. Ambient turbulence and diffusion causes mixing at the edge of the plume similar to jet induced mixing but at a much slower rate since there is no relative motion between the jet and the ambient fluid (Davis 1998). The transition from jet induced mixing to ambient mixing is gradual.

Mixing Zone Definition

For the purpose of the DC Cook dilution modeling, the edge of the mixing zone is defined by considering the 3-dimensional velocity distribution for the discharge plumes, predicted by a computational fluid dynamics model. Isopleths (constant velocity surfaces) were constructed and visualized for velocities of 2, 3, 4, and 5 fps. For each iso-surface it was determined if a coherent jet structure was visible. For ambient lake currents of 2 fps it is reasonable to assume that a coherent jet structure is not visible on a 2 fps iso-surface (see Figure 2). Under the same conditions, an iso-surface of 3 fps clearly shows the jet structure (Figure 3). In each figure, the iso-surface has been colored by the inverse of the dilution ratio (i.e., 1/DR). A 100 x 100 ft background grid is shown in each picture. Selecting the appropriate jet surface velocity for defining the edge of discharge induced mixing was somewhat subjective. For this reason, results are provided for a range of velocities.

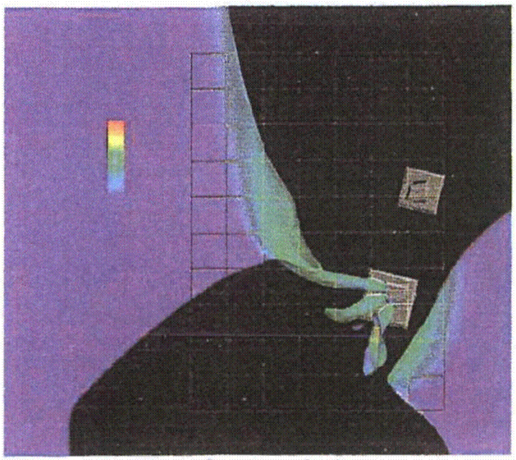

Figure 2. Two fps Isopleth.

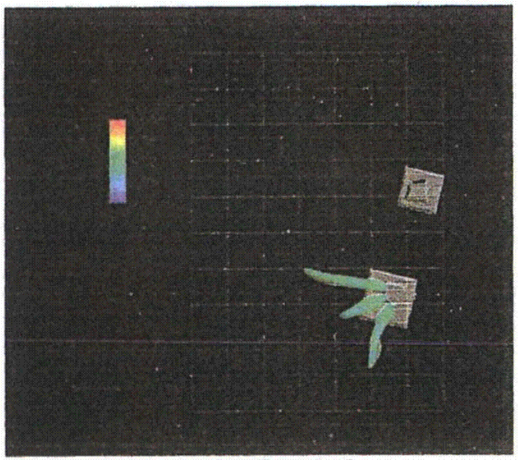

Figure 3. Three fps Isopleth.

FLUENT Model

The commercially available software FLUENT was used for all the simulations. FLUENT is a fully three dimensional computational fluid dynamics (CFD) solving the Navier-Stokes equations on a boundary fitted mesh. A finite volume formulation of the governing equations is solved in FLUENT. Turbulence closure was achieved using the RNG k-epsilon turbulence model (Yakhot and Orszag, 1986). The energy equation was solved in the simulation to account for the difference in the plume temperature and the ambient temperature.

Model Boundary Conditions

Three plant operating conditions were considered; Unit 1 discharge only, Unit 2 discharge only and discharge through Units 1 and 2. Each operating condition was simulated for four lake current conditions; a no current condition, and currents of 0.5, 1, and 2 fps. As illustrated by current meter data (see Appendix A: lake bathymetry and water currents), 2 fps is a relatively extreme high ambient velocity. The lake current was assumed to be from south to north and the nominal current is the depth averaged value. When units 1 and 2 are in operation, the dilution ratio varies considerably if both units are treated simultaneously or individually. Results are given for both conditions in Table 1. The unit 1 discharge in the simulations is 719,850 gpm and unit 2 discharge is 950,150 gpm.

FLUENT Model Results

Michigan DEQ surface water quality standards rule defines the edge of the mixing zone as the point where discharge induced mixing ceases to occur. For the purpose of this study, dilution ratios are reported on surfaces of constant velocity ("isopleths") ranging from 2 to 5 fps in 1 fps intervals. A visual evaluation of the surface was used to estimate if discharge induced mixing occurred at a specific velocity. For ambient lake currents of 0 to 0.5 fps, discharge induced mixing ceases at a plume surface velocity of 1 to 1.5 fps, depending upon the operating and treatment conditions. For an ambient lake current of 1 fps, discharge induced mixing ceases at a plume surface velocity of 1.5 to 3 fps, while at the highest ambient lake current (2 fps), discharge induced mixing ceases at a plume surface velocity of 3 fps.

Visualizations of effluent dilution predicted within the discharge-induced mixing zones are displayed in Figures 4 and 5. Both discharge units are operating in the simulations shown in these figures. In Figure 4, the ambient current velocity is 0 while, in Figure 5, the current velocity is 1 fps. Comparison of Figures 4 and 5 shows that increasing the ambient velocity tends to shrink the extent of the discharge plumes, as well as the entrainment of lake water within the discharge-induced mixing zone. The yellow grid lines in the visualizations are spaced 100 feet apart, to indicate the size of the plumes. The color scale shows the percentage of water from the discharge. Warm colors (red-yellow) indicate less mixing with lake water and cool colors (blue) indicate more mixing

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with lake water. The discharge plumes from the two units do not overlap or interact within the discharge-induced mixing region.

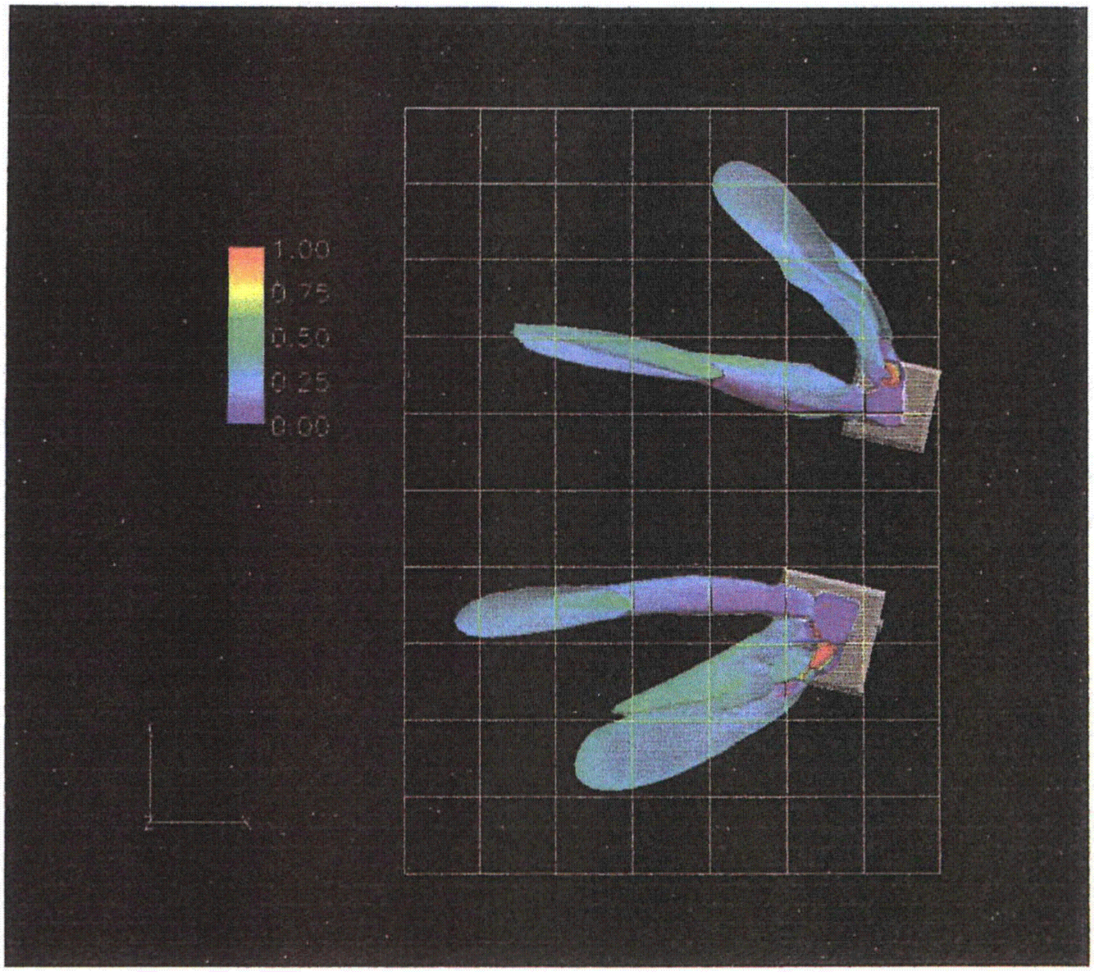

Figure 4. Visualization of effluent dilution within the discharge-induced mixing zone (plan view). FLUENT model prediction of ambient lake water fraction (i.e., 1/DR) on 2 fps plume surface velocity isopleth for zero ambient velocity, 2 discharge units operating and treating simultaneously.

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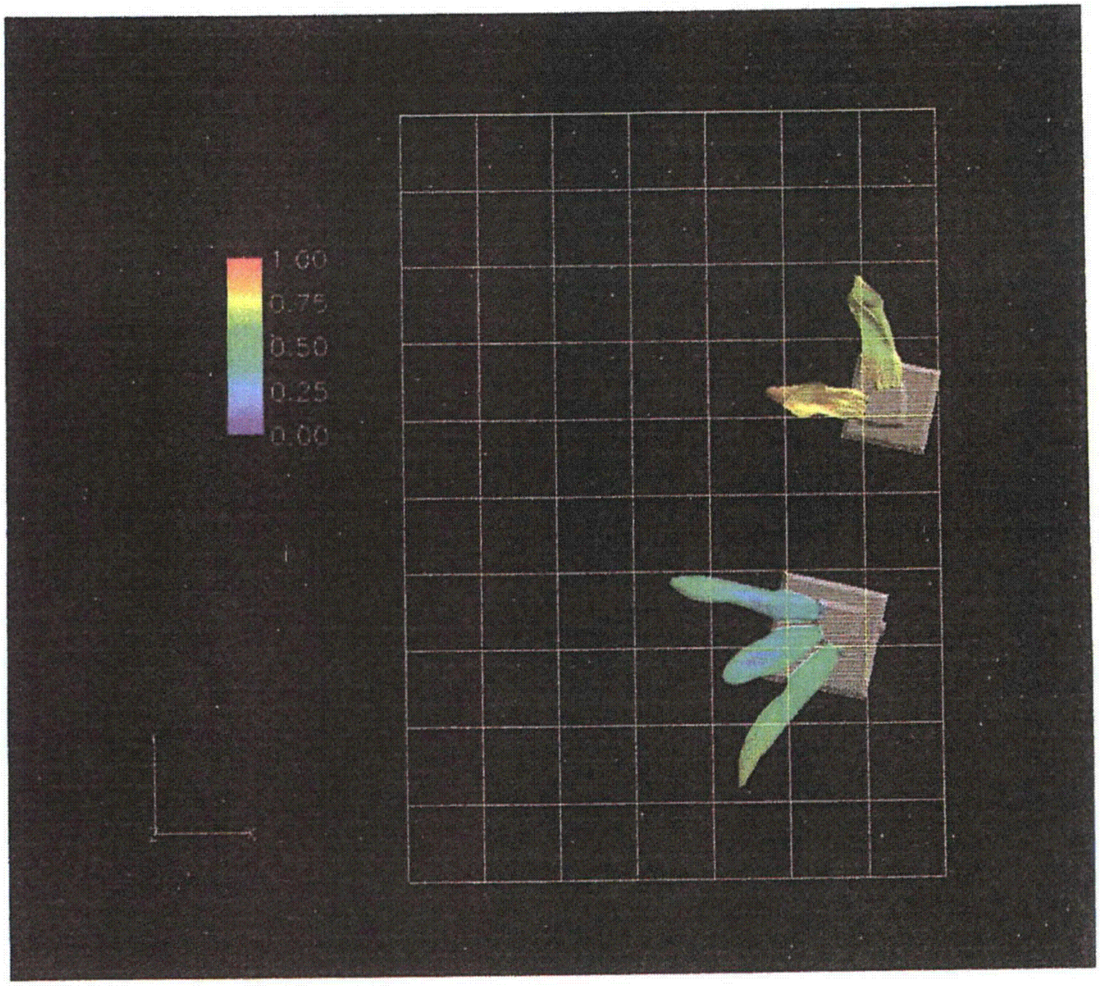

Figure 5. **Visualization of effluent dilution within the discharge-induced mixing zone (plan view). FLUENT model prediction of ambient lake water fraction (i.e., 1/DR) on 3 fps plume surface velocity isopleth for 1 fps ambient velocity, 2 discharge units operating and treating simultaneously.**

Table 1. Predicted Average Dilution Ratios (DRs) For Different Ambient Current Velocities, Plume Boundary Velocities, and Operating/Treatment Conditions.

discharge units operating	1 & 2	1	2	1 & 2	1 & 2
discharge units being treated	1 & 2	1	2	1	2
ambient current velocity (fps): 0					
average DR at 1 fps jet velocity		4.17	7.14	5.88	5.00
average DR at 1.5 fps jet velocity	4.17				
average DR at 2 fps jet velocity	3.23	3.13	3.85	3.23	3.03
average DR at 3 fps jet velocity	2.56	2.50	3.13	2.63	2.50
average DR at 4 fps jet velocity	2.22	2.13	2.56	2.22	2.22
average DR at 5 fps jet velocity	2.00	1.92	2.22	2.00	2.00
ambient current velocity (fps): 0.5					
average DR at 1 fps jet velocity		7.14		4.00	
average DR at 1.5 fps jet velocity			3.13		
average DR at 2 fps jet velocity	2.38	3.03	2.70	2.86	2.38
average DR at 3 fps jet velocity	2.04	2.44	2.13	2.27	2.08
average DR at 4 fps jet velocity	1.85	2.17	1.96	2.00	1.89
average DR at 5 fps jet velocity	1.69	1.96	1.79	1.85	1.67
ambient current velocity (fps): 1.0					
average DR at 1.5 fps jet velocity		4.76			
average DR at 2 fps jet velocity		3.33	2.08		
average DR at 3 fps jet velocity	1.59	2.50	1.92	1.61	1.89
average DR at 4 fps jet velocity	1.47	2.22	1.82	1.47	1.72
average DR at 5 fps jet velocity	1.37	2.00	1.69	1.39	1.59
ambient current velocity (fps): 2.0					
average DR at 3 fps jet velocity	1.72	2.78	1.85	1.64	2.22
average DR at 4 fps jet velocity	1.64	2.44	1.67	1.56	1.92
average DR at 5 fps jet velocity	1.56	2.17	1.52	1.49	1.72

At zero ambient (lake) velocity, all operating/treatment conditions achieve an average dilution factor of greater than 3 (from 3.03 to 7.14) at the 2 fps velocity boundary used to define the plume limits for discharge-induced mixing (Table 1). As ambient velocity is increased, the discharge plume shapes and volumes change in somewhat complex ways that also become more dependent on the operating and treatment conditions. In addition, it becomes more difficult to identify the discharge-induced mixing boundary. Although average dilution ratios in the plume generally decrease (in some cases down to 1.5 to 2.0) as ambient velocity increases, there are instances where the opposite is observed in the modeling results. For example, when discharge unit 1 is being operated and treated, the maximum predicted dilution ratio increases from 4.17 to 7.14 as the ambient velocity is increased from zero to 0.5 fps, but then declines to 4.77 as the ambient velocity is further increased to 1 fps.

Since the ambient velocity in Lake Michigan is usually less than 0.3-0.6 fps, we believe that the model predictions based on an ambient velocity of 0 or 0.5 fps are the most representative for mixing zone determinations. At these ambient velocities, the 1, 1.5 or 2 fps (depending on operating/treatment conditions) discharge plume isopleths can be used to define the discharge induced mixing zone. As indicated in Table 1, dilution ratios are greater than 3.0 for all operating and treatment conditions modeled at zero ambient velocity. At an ambient velocity of 0.5 fps, DRs were predicted to range from 2.4 to 7.1, depending on operating and treatment conditions. Based on these results, we are confident that a dilution ratio of 3.0 will be maintained within the discharge-induced mixing zone under most conditions. Conservatively, a dilution ratio of 2.4 could be selected. However, we believe that using a DR lower than 3.0 is inappropriately conservative because many other safety factors are built into the mixing zone evaluation (see review of Water Quality Standards section).

The model results can also be used to calculate the maximum contact time for a drifting organism that enters the discharge plume. Figure 6 is a visualization of stream paths for particles injected into the plume at the discharge point(s). The color of the stream paths reflects the time of travel as the particles move from the points of discharge to the plume boundaries. As can be seen from this figure, the average contact time of a particle (i.e., a drifting organism) in the plume is about 1 minute, with a maximum contact time of about 2 ½ minutes. The significance of this visualization is the consideration of the potential contact time for aquatic species exposed to the cooling water discharge within the near-field mixing zone and the corresponding water quality criterion concentration.

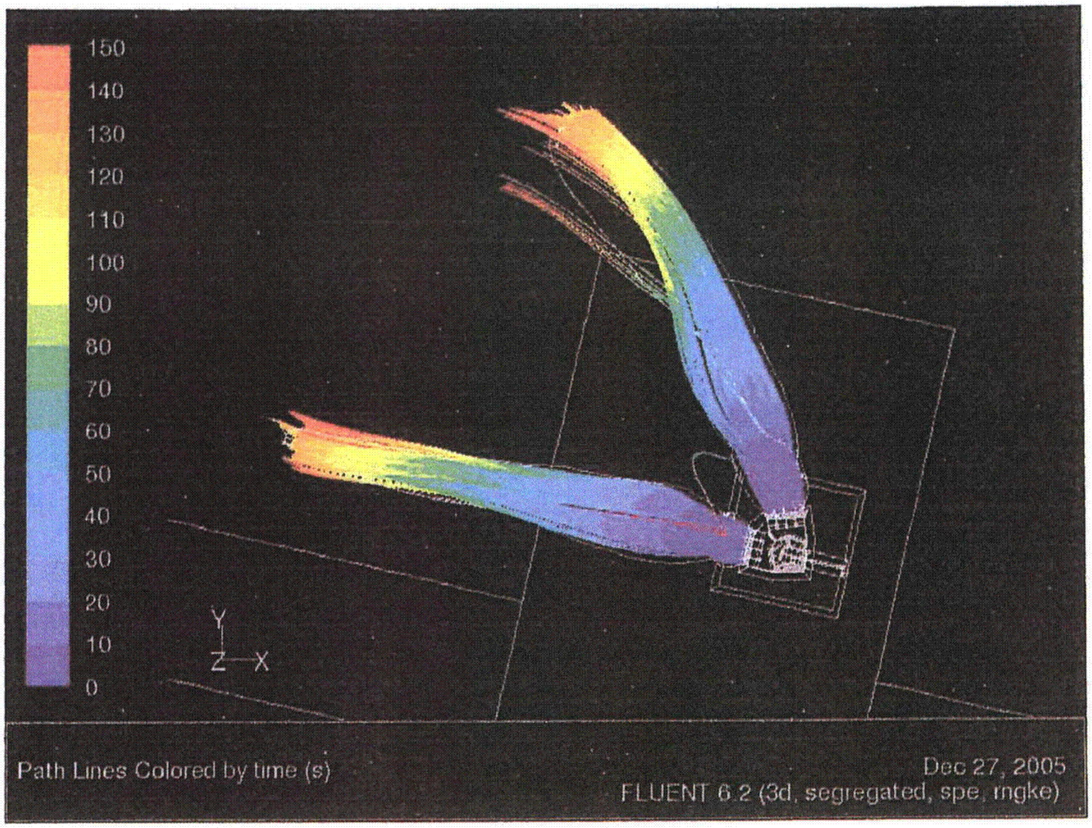

Figure 6. **Visualization of stream paths for particles injected into the plume at the discharge point(s)**

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Impact on Designated Uses

The impact of the cooling water discharge on the designated uses of southern Lake Michigan was evaluated by comparing the observations and results of this study to the seven designated uses of the water body. The designated uses of Lake Michigan, which we evaluated, were:

1. Agriculture
2. Navigation
3. Industrial water supply
4. Public water supply
5. Great Lakes fishery
6. Other indigenous aquatic life and wildlife, and
7. Partial body contact recreation.

Of the seven designated uses outlined for this study, the potential impact to the Great Lakes fishery and other indigenous aquatic life and wildlife may be of greatest concern in this instance. We determined that there was no impact to any designated use in Lake Michigan due to the cooling water discharge. A summary of each use designation, likely impacts and rationale are outlined in Table 2. Additional discussion of the potential impact of the cooling water discharge on Great lakes fisheries, aquatic life and wildlife, and public water supply are discussed below.

Great Lakes Fishery, Aquatic Life and Wildlife

The cooling water discharge at the DC Cook Nuclear Plant is authorized by the State of Michigan via a National Pollutant Discharge Elimination System (NPDES) permit. The conditions of that permit require that Cook routinely monitor the concentration of various water quality constituents and compare those to established water quality based standards that are specifically designed to protect aquatic life and wildlife in the Great Lakes. The DC Cook Nuclear Plant is in complete compliance with their NPDES permit. Consequently, it is reasonable to conclude that the State of Michigan, through the extensive NPDES monitoring, has determined that there is no impact to the Great Lakes fishery, aquatic life and wildlife.

Of particular concern, will be the impact of the application of a molluscide Mexel A-432 to the cooling water discharge. Cook Nuclear Plant is required by their NPDES permit to provide prior notification for the use of any water treatment chemical or change in discharge pursuant to Cook Nuclear Plant's NPDES Permit No. MI0005827, Part I, Section A.6, Request for "Discharge of Water Treatment Additives" and Part II, Section C.10 "Notification of Change in Discharge". Cook Nuclear Plant will be requesting the approval of an intermittent discharge resulting from a daily application of Mexel A-432 to the three circulating water intake tunnels to prevent zebra mussel settlement.

Review of Water Quality Standards and Toxicity Test Data

One principal objective for the DC Cook Nuclear Plant Mixing Zone Evaluation was to evaluate the mixing of the cooling water discharge with Lake Michigan water in the context of the application of the molluscide Mexel A-432 to the cooling water to control zebra mussels. Cook Nuclear had previously developed a Tier I water quality criterion for Mexel. No other water quality criterion is of concern at this time.

We reviewed the water quality information that is specific to Cook Nuclear to determine compliance with State Water Quality Standards, including the toxicity requirements of R323.1057 and R323.1082 of the Michigan Water Quality Standards.

Cook Nuclear Plant's (CNP) intention is to use Mexel 432/0 in an intermittent discharge resulting from a daily application of Mexel 432/0 as A-432 to the three circulating water intake tunnels to prevent zebra mussel settlement. Specifically, CNP's proposal is to treat for up to one 30-minute period per day of discharge of A-432 at a daily average concentration not to exceed the established Final Acute Value (FAV) for Mexel A-432 (0.1 mg/L), with no one sample exceeding a maximum concentration of 1.5 mg/L for each outfall (NPDES Outfalls 001 and/or 002) as measured at each outfall's nearshore sample point during the treatment period and adjusted for the expected concentration at the end of the pipe and mixing zone. CNP in collaboration with Mexel and Great Lakes Environmental Center developed a Tier I FAV for Mexel A-432 following the Michigan DEQ Rule 57 guidelines.

The aquatic toxicity test data generated by CNP and Mexel satisfies the MDEQ Rule 57 requirements for a Tier I FAV calculation (Table 3), and provides intermittent dosage aquatic toxicity test data that demonstrates the reduced toxicity of Mexel A-432 when applied intermittently (Table 4). Table 3 lists the FAV as 0.092 mg/L, which was rounded up to 0.1 mg/L for the purposes of this evaluation.

CNP has used various biocides over the years for shock treatments to the intake tunnels. These treatments have proven to be a very efficient means of removing zebra mussels. An efficacy rate of greater than 95% has been realized by applying a biocide for 12 hours as a shock treatment to the intake tunnels. However, uncontrolled sloughage of shell debris creates a heavy load on the traveling screens and pump strainers downstream from the intake tunnels. The sloughage of shells could possibly overwhelm and block flow in the safety systems required by the NRC at all times for safe operation. In addition, biocides previously used require detoxification with bentonite clay. This process is a potential source of silt intrusion that may clog vital heat exchangers required for safe shutdown of the units.

The CNP proposal to use a daily 30-minute treatment of A-432, targeted at the zebra mussel post-veliger stage will eliminate the uncontrolled release of adult shell debris that potentially affects the safe operation of the plant. A-432 would be applied simultaneously to the tunnels each day during the seasons when zebra mussel veligers and post-veligers are the most abundant (April through November) to remove existing mussel colonies and to prevent further settlement. Mexel A-432 is an aqueous dispersion of linear aliphatic

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amines. It is in the general category of filming amines, differing from other water treatment products in that it treats the wetted surfaces of the system without having to treat the water column. Mexel A-432 functions as a corrosion inhibitor, dispersant, and control agent for cooling system-fouling species such as mussels and hydroids.

The recommended dosage is 4 ppm for 30 minutes per day to strive for an effective concentration in the tunnel. Our calculations for determining effluent concentrations are outlined below. When all three tunnels are dosed at one time, the injected concentration of 4 ppm will be decreased by 1) the demand factor of 0.38 at the tunnel inlet, 2) by a mixing zone factor of 3.0, and 3) by a 0.38 demand factor in the mixing zone. This treatment will result in an expected maximum effluent concentration of 0.51 ppm during the 30 minute treatment period in the effluent (4 ppm x 0.62 x 0.62/3.0).

When one tunnel is dosed at one time, the effluent concentration will depend upon *which* tunnel is dosed, because baffles in the plant intake forebay prevent complete mixing between lake water drawn through the three intake tunnels. The average concentration reductions in each tunnel, based upon measurements (Mallen, 2004), are 9, 61 and 15% for the north, center and south tunnels, respectively. So for Mexel injected into the north intake tunnel, the injected concentration of 4 ppm will be decreased by 1) a demand factor of 0.38 at the tunnel inlet, 2) a concentration reduction of 9% due to forebay dilution, and 3) a demand factor of 38% in the forebay. The mixing zone dilution ratio is 3.0, and there is another 38% demand factor in the mixing zone. For this case, the mixing zone concentration is calculated to be 0.29 ppm [4 ppm × (1-0.38) × (1-0.09) × (1-0.38) × (1-0.38)/3.0 = 0.29 ppm]. For injection into the center intake tunnel, the mixing zone concentration is calculated to be 0.12 ppm [4 ppm × (1-0.38) × (1-0.61) × (1-0.38) × (1-0.38)/3.0 = 0.12 ppm]. And, for injection into the south intake tunnel, the mixing zone concentration is calculated to be 0.27 ppm [4 ppm × (1-0.38) × (1-0.15) × (1-0.38) × (1-0.38)/3.0 = 0.12 ppm]. Once CNP begins dosing, they will be able to corroborate these projections by actual measurement. Measured demands at other locations agreed with these projections.

However, it is important to emphasize that this is a very conservative estimate of the maximum expected concentration during a thirty-minute interval once a day. The final concentration will be much lower because, 1) our degradation estimates are based solely on the water demand and dilution, 2) the demand calculation does not include allowances for surface adsorption or for the demand due to biodegradation, 3) Mexel A-432 is a filming amine, part of the chemical concentration will be lost due to the formation of the film, and 4) our calculations also exclude the demand at the edge of the mixing zone and in the condenser water boxes within the plant due to turbulence. Consequently, we are confident that the actual measured maximum concentration will be much lower than our projections. Once CNP begins dosing, they will be able to corroborate these projections by actual measurement. The final average daily concentration will be far less than the FAV because of the daily intermittent application of the chemical (30 minutes). Mexel's experience with measured demands at other plants has agreed with the projections, and we are confident that they will be able to do the same at Cook.

Consequently, the final average daily concentration that will enter Lake Michigan at the edge of the demonstrated mixing zone as a result of this report will be protective of aquatic life. Our basis for this is that:

1) The maximum expected concentration of Mexel A-432 at the edge of the near-field mixing zone will be equal to or less than the calculated water quality criterion.

2) The expected contact time of a drifting organism potentially drawn into the discharge plume is less than two minutes, whereas the calculated water quality criterion is based on exposures measured in days.

3) Mexel A-432 rapidly biodegrades in water. Its half-life in still water is less than 22 hours, and the half-life can be further reduced to six hours with agitation and aeration.

4) Its toxicity to aquatic life has been well demonstrated (See attached toxicity test information), and the proposed intermittent use and short duration of the dosages further reduce the impact on the environment. In fact, this application provides data that demonstrates that the toxicity of Mexel A-432 is significantly reduced when aquatic organisms are exposed to the chemical on an intermittent daily dosage pattern similar to the typical field application of the product.

5) The degradation products of A-432 consist of water, carbon dioxide, and nitrogen. Product that has not degraded or adhered to the walls of the cooling system will be discharged with the cooling water from the plant.

CNP has also developed intermittent dosage toxicity test data for Mexel A-432 that demonstrates that the toxicity of this substance is less during intermittent exposures than with continuous exposures. That data demonstrates that the median lethal concentration of Mexel A-432 applied as an intermittent dose is more than 44 times less than the demonstrated lethal concentration in continuous exposures (based on a *D. magna* GMAV of 0.197 mg/L and an intermittent dosage LC50 of 8.7 mg/L). This is an important site-specific characteristic because even though we do not expect that the final end of pipe concentration will exceed the FAV, MDEQ can be confident that the final discharge concentration will be much lower than the known toxicity of this compound when it is applied intermittently. Aquatic life toxicity test data using fathead minnow, *Daphnia magna* and rainbow trout in intermittent daily dosage experiments are summarized in Table 4. The fathead minnow and *Daphnia magna* intermittent toxicity test data were generated by the Lake Superior Research Institute at the University of Wisconsin-Superior and the rainbow trout intermittent dose toxicity test data was recently generated at the Great Lakes Environmental Center in Traverse City, Michigan.

Based on the above consideration of the data, it is reasonable to conclude that the application of Mexel A-432 to control zebra mussels will have no impact on Great Lakes fisheries, aquatic life or wildlife.

Public Water Supply

The intake for the Lake Township public water supply (PWS) is located 3,220 ft. southwest of the CNP discharge structure in Lake Michigan (D.C. Cook Condition Report, 1998). The PWS intake and CNP discharge structure are located on a map in Figure 7. As noted in Table 2, the PWS is located well beyond the study area. Fluent model predictions indicate that the maximum extent (length) of the discharge plume is about 2,500 ft from the CNP discharge structures. Thus, under no condition is the cooling water discharge plume predicted to reach the location of the PWS intake. In addition, Mexel does not bioaccumulate or otherwise pose a human health risk at the maximum concentration at the edge of the mixing zone. Based on these considerations, it is reasonable to conclude that the application of Mexel A-432 to control zebra mussels will have no impact on any public water supply.

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Table 2. Summary of the Designated Uses and the Impact of Cooling Water Discharge on Lake Michigan Offshore of the DC Cook Cooling Water Discharge

Designated Use	**Perceived Impact (if any)**	**Rationale**
Agriculture	None	There is no evidence of irrigation water removal.
Navigation	None	The CNP cooling water discharge does not cause any obstructions to recreational navigation in Lake Michigan. The diffuser structure is 18 feet below the surface
Industrial Water Supply	None	There are no other industrial water intakes within the study area.
Public Water Supply	Lake Township public water supply intake is located 3,220 ft southwest of CNP discharge structures in Lake Michigan	This public water supply is located beyond the study area; model predictions indicate that the maximum extent of the discharge plume is about 2,500 ft from the CNP discharge structures. Mexel does not bioaccumulate or pose a human health risk at the maximum concentration at the edge of the mixing zone.
Great Lakes Fishery	None	The expected maximum concentration for Mexel in Lake Michigan at the edge of the mixing zone is similar to the measured criteria for Mexel. The most sensitive species used in the criteria calculation are excluded from the edge of the mixing zone due to discharge velocity. Expected contact time within the mixing plume is less than two minutes for drifting organisms.
Other Aquatic Life and Wildlife	None	The expected maximum concentration for Mexel in Lake Michigan at the edge of the mixing zone is similar to the measured criteria for Mexel The cooling water is neither acutely or chronically toxic to aquatic organisms. The most sensitive species used in the criteria calculation are excluded from the mixing zone due to discharge velocity. Expected contact time within the mixing plume is less than two minutes for drifting organisms.
Recreational Partial Body Contact	None	The water quality of the cooling water discharge would not be detrimental to human health

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Table 3. Summary of Acceptable $^{@}$Mexel Toxicity Test Data (December 2004)

Species	Investigator	LC$_{50}$ (mg/L)	GMAV	FAV
Bluegill Sunfish	GLEC, 2004[1]	**1.71***		
Planaria	GLEC, 2004	2.03		
Hyalella azteca	GLEC, 2004	1.99		
Chironomus tentans	GLEC, 2004	8.82		
Rainbow Trout	GLEC, 2004	0.450		
	Brooke et al, 1997[2]	0.730	**0.5731***	
Lumbriculus	GLEC, 2004	1.86		
Fathead minnow	GLEC, 2004	0.450		
	Brooke et al, 1997	0.360		
	Brooke et al, 1997	0.660	**0.4746***	
Daphnia magna	GLEC, 2004	0.200		
	Brooke et al, 1997	0.121		
	Brooke et al, 1997	0.216		
	Brooke et al, 1997	0.199		
	Brooke et al, 1997	0.178		
	Brooke et al, 1997	0.120		
	Brooke et al, 1997	0.168		
	Brooke et al, 1997	0.198		
	Brooke et al, 1997	0.198		
	Brooke et al, 1997	0.595	**0.197***	
		N = 8 (SMAV)		**0.092 mg/L**

* LC50s used in the Final Acute Value (FAV) calculation.

@ Fathead minnow, *D. magna* and rainbow trout data completed by Brooke, et al was identified as acceptable by MDEQ from the Mexel toxicity data base.

1 Tests conducted by Great Lakes Environmental Center, 2004.

2 Brooke et al. 1997. Tests conducted by the Lake Superior Research Institute.

Table 4. Mexel A-432 Median Lethal Toxicant Concentrations (Lc50) Based on Daily Intermittent Exposures of 20 Minutes Each Day

Species	Water Type	**Daily Exposure Duration** (min. per 24 hrs)	Test Duration	LC_{50} (mg/L)
Fathead minnow (larval) (*Pimephales promelas*)	Lake Superior (USA)	20	96	6.2[1]
Daphnia magna (neonates)	Lake Superior (USA)	20	48	8.7[1]
Rainbow Trout (*Onchorhynchus mykiss*)	Lake Michigan (USA)	20	96	3.2[2]

1 Ghillebaert, F. and L.T. Brooke. 1997. Mexel 432 toxicity to cladorceran and fathead minnow during continuous and daily intermittent exposures. Lake Superior Research Institute, University of Wisconsin-Superior, Groupe d'Embryotoxicologie des Poissons, Universite Paris 7, 12pp.

2 Great Lakes Environmental Center. 2004. LC50 Determination for Mexel A-432 Using Rainbow Trout (*Onchorhynchus mykiss*). Final Report to RTK Technologies, Inc. Baton Rouge, LA. April 23, 2004.

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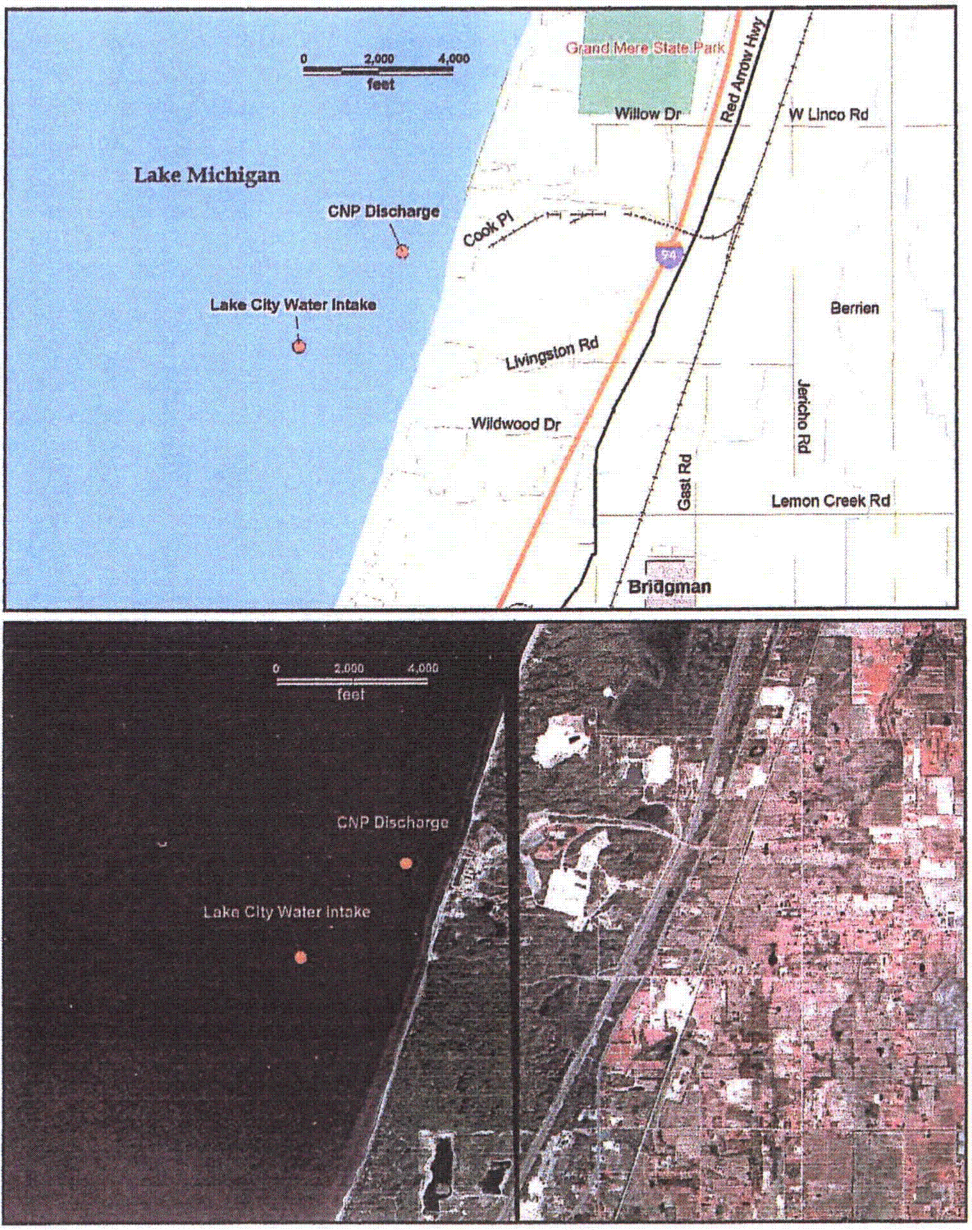

Figure 7. Map Indicating Location of Lake Township Public Water Supply Intake and CNP Discharge Structures in Lake Michigan. The distance between these points was measured as 3,220 feet using survey methods and GPS controls.

SUMMARY AND CONCLUSIONS

The AEP DC Cook Nuclear Plant conducted a mixing zone evaluation to determine the dilution ratio of the plant cooling water with Lake Michigan water at varying velocities and distances. The mixing zone evaluation included a plume modeling study by Alden Laboratories that provided a computational and visual basis for the mixing zone. The mixing zone evaluation also addressed the impact of the cooling water discharge on the designated uses of Lake Michigan and reviewed water quality standards, specifically the toxicity requirements of R323.1057 and R323.1082 of the Michigan Water Quality Standards.

The modeling results demonstrated that the dilution factor at the edge of the near-field mixing zone is approximately 3.0 at the 2 fps isopleth. Conservatively, the dilution factor would increase at ambient currents less than or equal to 0.5 fps. At an ambient velocity of 0.5 fps, DRs were predicted to range from 2.4 to 7.1. The modeling results also demonstrated that the two cooling water discharges do not overlap and that the area of the near-field mixing zone for each outfall is relatively small and contained within several hundred square feet.

A review of the potential impact on designated uses of Lake Michigan water concluded that there was no impact on any designated use. Particular attention was paid to the potential impact on Great Lakes fisheries, aquatic life and wildlife, and public water supplies. A review of Michigan water quality standards, specifically the toxicity requirements of R323.1057 and R323.1082 of the Michigan Water Quality Standards was completed, which also supported the determination of no impact.

Of particular concern, will be the impact of the application of a molluscide Mexel A-432 to the cooling water discharge. One objective for the DC Cook Nuclear Plant Mixing Zone Evaluation was to evaluate the mixing of the cooling water discharge with Lake Michigan water in the context of the application of the molluscide Mexel A-432 to the cooling water to control zebra mussels. Cook Nuclear provided sufficient data to the MDEQ to develop a Tier I water quality criterion for Mexel. No other water quality criterion is of concern at this time. The calculated Tier I water quality criterion for Mexel A-432 is 0.092 mg/L (rounded up to 0.100 mg/L or 100 µg/L for this evaluation). The expected maximum concentration of Mexel A-432 at the edge of the near-field mixing zone, with one unit treated at one time is approximately 0.1 mg/L. The expected maximum concentration of Mexel A-432 at the edge of the near-field mixing zone, with two units treated at one time is approximately 0.5 mg/L.

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The assumptions used for the evaluation of the toxicity of Mexel A-432 within the near-field mixing zone are:

1. The recommended dosage will be 4 ppm (mg/L) for 30 minutes per day to strive for an effective concentration in the tunnel.

2. When all three tunnels are dosed at one time, the injected concentration of 4 ppm will be decreased by: 1) a demand factor of 0.38 at the tunnel inlet, 2) by the mixing zone factor of 3.0, and 3) and by a 0.38 demand factor in the mixing zone. This treatment will result in an expected maximum effluent concentration of 0.51 ppm during the 30 minute treatment period in the effluent [4 ppm × (1-0.38) × (1-0.38)/3.0 = 0.51 ppm].

3. When one tunnel is dosed at one time, the effluent concentration will depend upon *which* tunnel is dosed, because baffles in the plant intake forebay prevent complete mixing between lake water drawn through the three intake tunnels. This is discussed on Page 16 (Review of Water Quality Standards and Toxicity Test Data). The mixing zone concentrations are calculated to be 0.29 ppm, 0.12 ppm, and 0.12 ppm for dosing of the north, center and south intake tunnels, respectively.

Based on the above consideration of the data, it is reasonable to conclude that the proposed application of Mexel A-432 to control zebra mussels will have no impact on Great Lakes fisheries, aquatic life or wildlife, or any other designated use of the Great Lakes.

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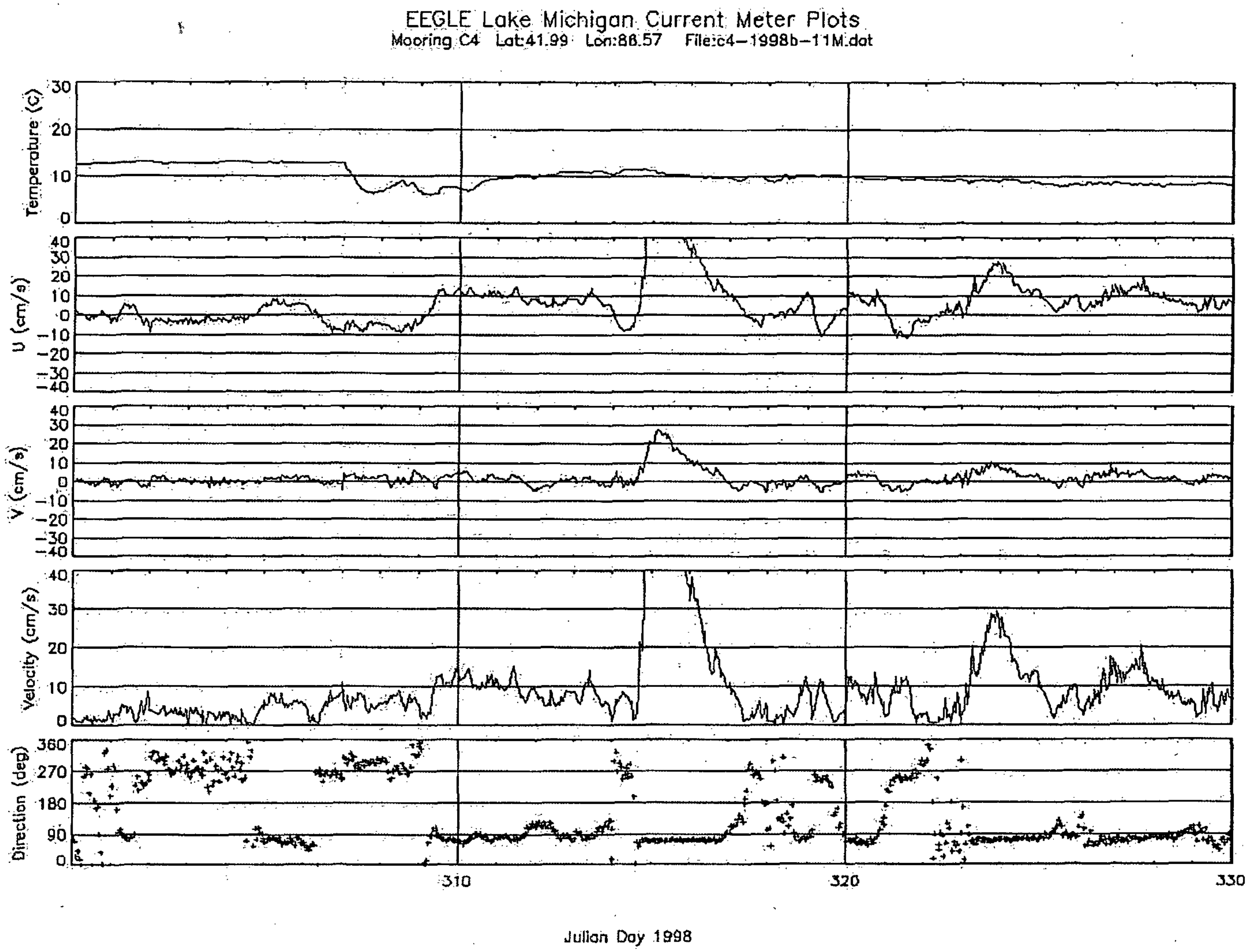
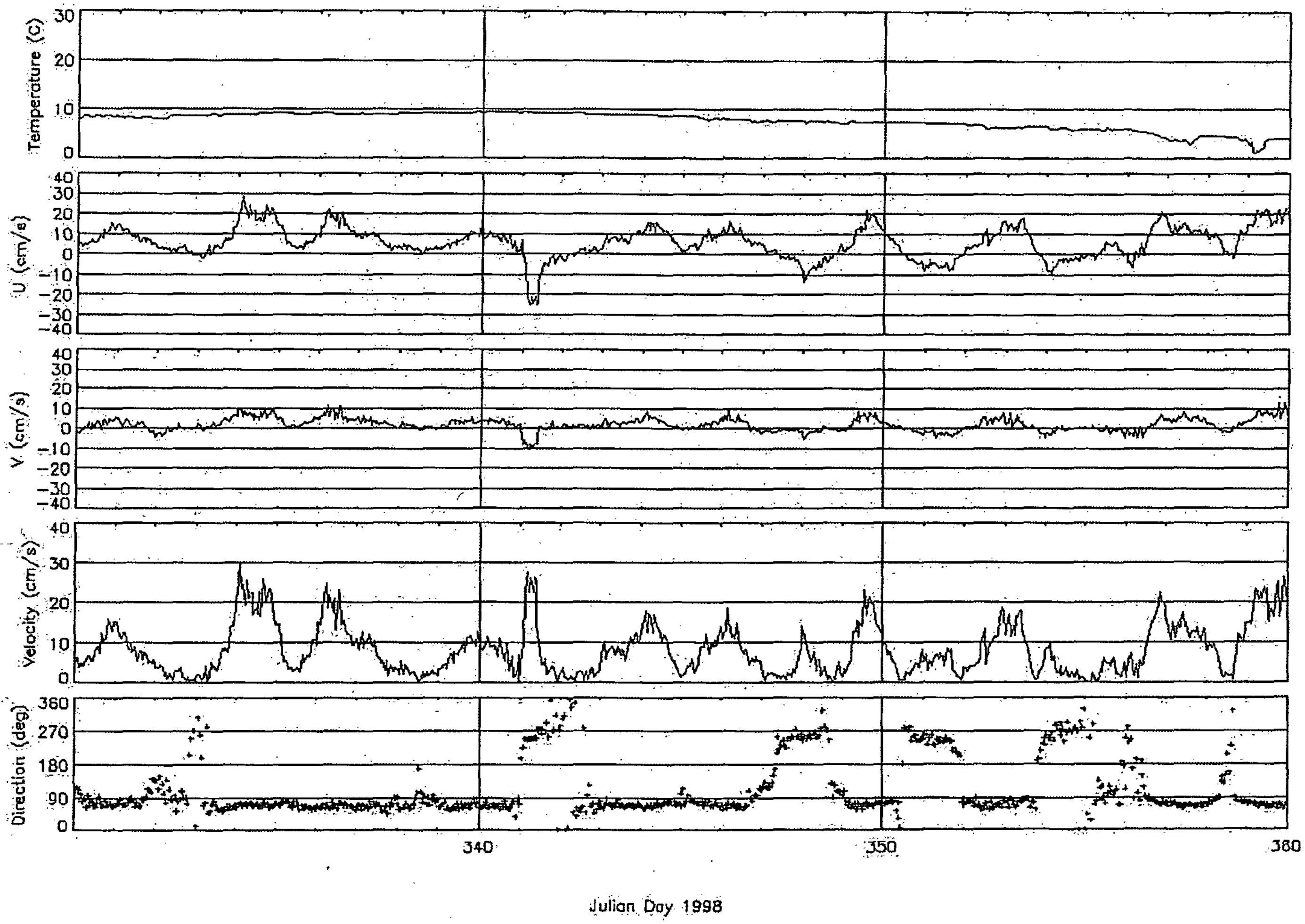
Appendix A. Current Meter Data from NOAA/GLERL EEGLE Project: Data Measured at Station C4, Moored in 11 Meters of Water Offshore of the D.C. Cook Nuclear Power Plant.


EEGLE Lake Michigan Current Meter Plots
Mooring C4 Lat:41.99 Lon:86.57 File:c4-1998b-11M.dat
Temperature (c)
30
20
10
0
U (cm/s)
40
30
20
10
0
-10
-20
-30
-40
V (cm/s)
40
30
20
10
0
-10
-20
-30
-40
Velocity (cm/s)
40
30
20
10
0
Direction (deg)
360
270
180
90
0
310
320
330
Julian Day 1998

EEGLE Lake Michigan Current Meter Plots
Mooring C4 Lat:41.99 Lon:86.57 File:c4-1998b-11M.dat



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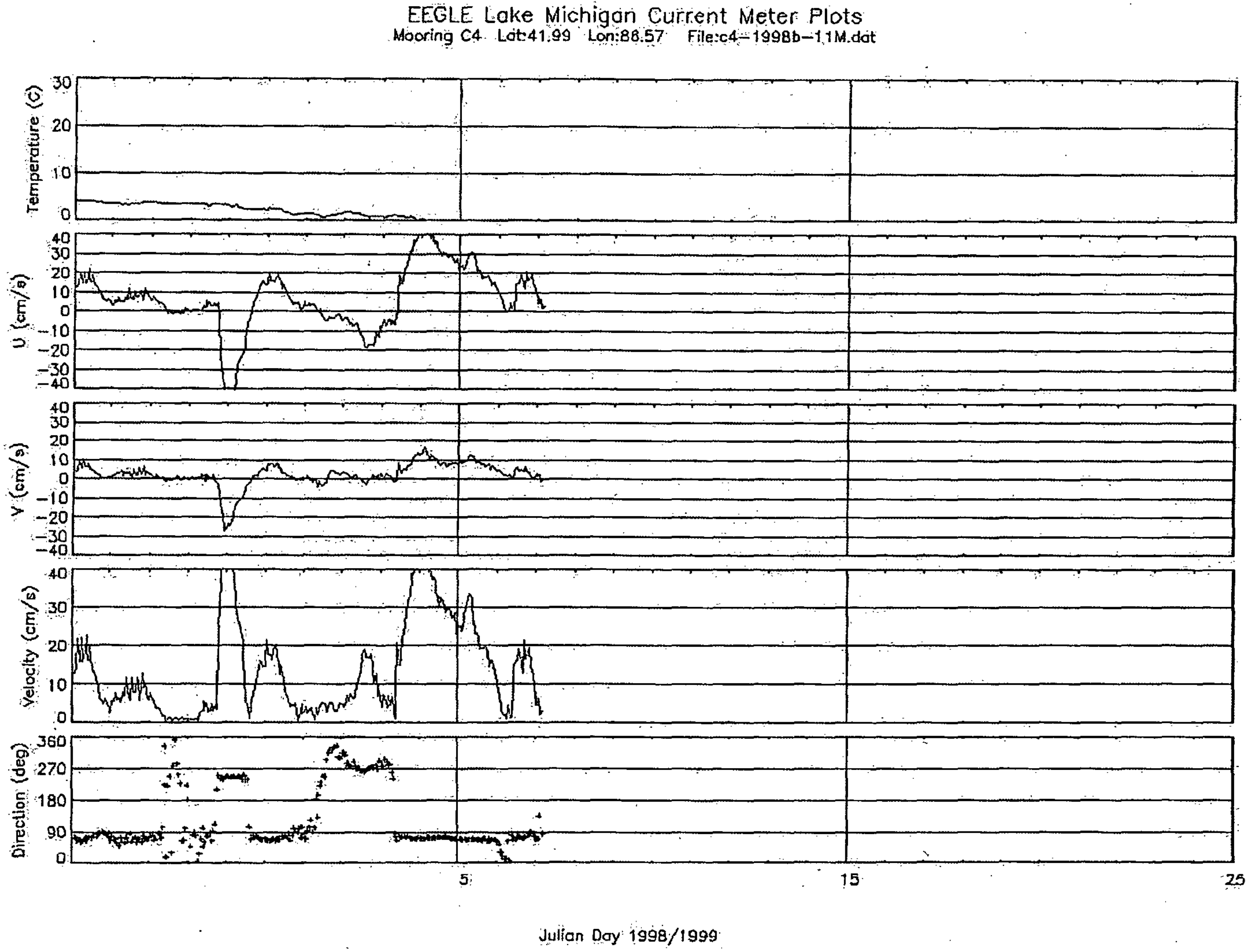
EEGLE Lake Michigan Current Meter Plots
Mooring C4 Lat:41.99 Lon:86.57 File:c4-1998b-11M.dat
Temperature (c)
30
20
10
0
U (cm/s)
40
30
20
10
0
-10
-20
-30
-40
V (cm/s)
40
30
20
10
0
-10
-20
-30
-40
Velocity (cm/s)
40
30
20
10
0
Direction (deg)
360
270
180
90
0
5
15
25
Julian Day 1998/1999

APPENDIX 5

Designation: D 2688 – 94 (Reapproved 1999)$^{\epsilon 1}$

Standard Test Methods for Corrosivity of Water in the Absence of Heat Transfer (Weight Loss Methods)[1]

This standard is issued under the fixed designation D 2688; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] Note—Footnotes were editorially removed in July 1999.

1. Scope

1.1 These test methods cover the determination of the corrosivity of water by evaluating pitting and by measuring the weight loss of metal specimens. Pitting is a form of localized corrosion: weight loss is a measure of the average corrosion rate. The rate of corrosion of a metal immersed in water is a function of the tendency for the metal to corrode and is also a function of the tendency for water and the materials it contains to promote (or inhibit) corrosion.

1.2 The following two test methods are included:

Test Method	Corrosivity Test of	Sections
A	Internal Metallic Pipes (Coupon)	10 to 18
B	City and Building Distribution Water (1, 2, 3, 4, 5)[2]	19 to 30

1.3 *Test Method A* employs flat, rectangular-shaped metal coupons which are mounted on pipe plugs and exposed to the water flowing in metal piping in municipal, building, and industrial water systems.

1.4 *Test Method B* employs removable, tared pipe inserts which are installed in a plastic piping assembly tailored to provide the same surface and flow conditions as in a normal metal piping system. Proper dimensions are provided throughout so that streamline flow (no-flow distortion) results and corrosion and scale formed on the inserts will be the same as that occurring in the metal piping system being tested. Steel, galvanized steel, and soldered copper and copper inserts have been found to provide meaningful corrosion test results by this test method.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific hazard statement, see 26.1.1.

2. Referenced Documents

2.1 *ASTM Standards:*

A 120 Specification for Pipe, Steel, Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless, for Or dinary Use[3]

D 1129 Terminology Relating to Water[4]

D 1193 Specification for Reagent Water[4]

D 2331 Practices for Preparation and Preliminary Testing of Water-Formed Deposits[5]

3. Terminology

3.1 *Definitions:* —For definitions of terms used in these te methods, refer to Terminology D 1129.

4. Significance and Use

4.1 Since the two tendencies are inseparable for a metal corrode and for water and the materials it contains to promot or inhibit corrosion, the corrosiveness of a material or th corrosivity of water must be determined in relative, rather tha absolute, terms. The tendency for a material to corrode i normally determined by measuring its rate of corrosion a comparing it with the corrosion rates of other materials in same water environment. Conversely, the relative corrosivi of water may be determined by comparing the corrosion rate of a material in the water with the corrosion rates of the sa material in other waters. Such tests are useful, for example evaluating the effects of corrosion inhibitors on the corrosi of water. Although these test methods are intended to de mine the corrosivity of water, they are equally useful determining corrosiveness and corrosion rate of materials.

5. Composition of Specimens

5.1 The specimens shall be similar in composition to piping in the system in which the corrosion test is being m Welded or seamless pipe shall be used in Test Method however, butt-welded piping specimens may be used in Method B provided care is taken to pick smooth spec (excluding butt joints).

6. Effect of Cold Working on Corrosion

6.1 Cold working can be important in causing localized corrosion; however, plastic deformation can be minimized in specimen preparation by following proper machining practices (6) (for example, drilling, reaming, and cutting specimens for Test Method A). While the importance of proper preparation and machining is recognized in the other test methods, it is considered important to retain stressed areas in the piping inserts (Test Method B) since these specimens then have the same properties as the piping system being tested.

7. Types of Corrosion

7.1 *General Corrosion* is characterized by uniform attack of the metal over the entire surface.

7.2 *Pitting* is a form of localized corrosion, the depth, number, size, shape, and distribution of pits being pertinent characteristics. It may be evaluated by counting the number, by noting the size, shape, and distribution, and by measuring the depth of pits in representative areas. Both sides of the coupons must be examined in Test Method A. In Test Method B the specimens must be cut longitudinally before internal examination for pitting can be performed.

7.2.1 A system may be devised for grading pitting (7).

7.3 *Crevice Corrosion* is a pertinent factor to consider in corrosion testing, since active corrosion sites may develop in such locations. Crevices may exist at threads and joints and under deposits, as well as in corrosion specimens. In Test Method A, crevice corrosion may be in evidence where the specimen is fastened to the holder and at coupon markings. Providing a large specimen surface area relative to the crevice area reduces this influence on the overall corrosion results. Light sanding is necessary to remove edges of coupon marking. In Test Method B, areas subject to crevice corrosion are coated with paint.

7.4 *Edge Corrosion*— The increased corrosion that occurs at edges of corrosion specimens, where the metal may be of different composition or structure, must be given attention. In Test Method A, specimens of a high ratio of surface area to edge area reduce this effect. In Test Method B, the edges are painted to prevent fluid contact. If an abnormally high degree of edge corrosion is observed in the case of Test Method A, the effect may be evaluated by measurement of the specimen dimensions previous to and following exposure. Use of a specimen of less thickness may also reduce the edge effect in weight loss.

7.5 *Impingement Attack (Erosion-Corrosion)*, associated with turbulent and high-velocity flow, particularly when soft metals and copper are involved, is characterized by continuous [illegible]-type pits and bright metal from which protective films have been scoured away. Some under-cutting also may be present.

8. Water-Formed Deposits

8.1 Water-formed deposits observed on the specimens may be analyzed by the methods listed in Practices D 2331. The most common constituents will be calcium, magnesium, aluminum, zinc, copper, iron, carbonate, phosphate, sulfate, chloride, and silica.

9. Purity of Reagents

9.1 Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[6] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

9.2 *Purity of Water*— Unless otherwise indicated, references to water shall be understood to mean reagent water conforming to Type III of Specification D 1193.

TEST METHOD A—Coupon

10. Summary of Test Method

10.1 Carefully prepared, weighed metal coupons are installed in contact with flowing cooling water for a measured length of time. After removal from the system, these coupons are examined, cleaned, and reweighed. The corrosivity and fouling characteristics of the water are determined from the difference in weight, the depth and distribution of pits, and the weight and characteristics of the foreign matter on the coupons.

11. Interferences

11.1 Deviation in metal composition or surface preparation of the coupons may influence the precision of the results.

11.2 The presence of different metals in close proximity to the coupon, (within 76 mm (3 in.)), even if they are insulated from the coupon, constitutes a source of error in the results.

11.3 Deviations in the velocity and direction of flow past the coupons may influence the precision of the results.

11.4 Results are directly comparable only for the water temperature to which the coupon is exposed.

11.5 Crevices, deposits, or biological growths may affect local corrosivity; results should therefore be interpreted with caution.

12. Apparatus

12.1 *Coupon Specimens*— Prepare coupons in accordance with Section 14.

12.2 *Insulating Washer, Screw, and Nut*—Use for attaching the coupon to the phenolic rod. The insulating washer has a sleeve that fits into the coupon hole and around the screw.[7,8]

12.3 *Phenolic Rod*— Use a 152-mm (6-in.) length of canvas-based 13-mm (0.5-in.) outside diameter phenolic rod,

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[1] These test methods are under the jurisdiction of ASTM Committee D-19 on Water and are the direct responsibility of Subcommittee D19.03 on Sampling of Water and Water-Formed Deposits, and Surveillance of Water.

Current edition approved April 15, 1994. Published June 1994. Originally published as D 2688 – 69. Last previous edition D 2688 – 92.

[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[3] Discontinued 1988 (Replaced by A 53)—See 1988 *Annual Book o Standards*, Vol 01.01.

[4] *Annual Book of ASTM Standards*, Vol 11.01.

[5] *Annual Book of ASTM Standards*, Vol 11.02.

[6] *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

[7] Allied Industrial Electronics, 100 N. Western Ave., Chicago, IL 60680, extruded fiber washer for No. 8 screw, Part No. 26D-3226, manufactured by G. C. Electronics, Rockford, IL (as Part No. 6526C), has been found satisfactory for this purpose. The dimensions are as follows: outside diameter 9.5 mm (3/8 in.), inside diameter of hole 4.0 mm (5/32 in.), total thickness including the raised arc approximately 1.5 mm (1/16 in.), outside diameter of raised arc 6.4 mm (1/4 in.), and thickness of raised arc approximately 0.4 mm (1/64 in.).

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or equivalent, attached at one end to a drilled pipe plug, and having a flat surface and a hole at the other end suitable for attachment of the coupon.[9]

12.4 *Piping Arrangement*, as illustrated in Fig. 1, for installation of coupon specimens. This arrangement has been changed in order that flow passes over the holder end of the specimens first at two locations and over the specimen first at the other two locations. This enables one to determine whether the turbulence provided by the corrosion testers or the elbows influences the results.

12.5 *Dial Depth Gage*— A gage with a knife-edge base, pointed probe, and dial indicator for measurement of pit depth.

12.6 *Emery Paper*, Number 0.

13. Reagents and Materials

13.1 *Benzene.*

13.2 *Chromic Acid-Phosphoric Acid Solution*—Dissolve 30 g of chromic acid (chromium trioxide, CrO_3) in approximately 500 mL of water and add 36 mL of phosphoric acid (H_3PO_4 35 %). Dilute the resulting solution to 1L.

13.3 *Chromium Trioxide* (CrO_3), anhydrous crystals.

13.4 *Corrosion Inhibitor I*, a liquid material having a flash point of 71°F, which contains amino ketones of rosin, surface active agents, alcohols, and less than 10 % by volume of synergists, for hydrochloric acid.

13.5 *Corrosion Inhibitor II*, a nonflammable liquid containing heterocyclic nitrogen bases (usually in the form of salts), surface active agents, and synergists, for sulfuric acid.

13.6 *Hydrochloric Acid* (1 + 4)—Mix 1 volume of concentrated HCl (sp gr 1.19) with 4 volumes of water.

13.7 *Hydrochloric Acid, Inhibited*—Mixed 357 mL of concentrated HCl (sp gr 1.19) and 5.0 g of inhibitor (see 13.4). Then dilute to 1 L with water.

13.8 *Isopropyl Alcohol.*

13.9 *Methyl Orange Indicator Solution* (0.5 g/L)—Dissolve 0.05 g of methyl orange in water and dilute to 100 mL with water.

13.10 *Nitric Acid-Dichromate Solution*—Mix 224 mL of HNO_3 (sp gr 1.42) with twice the volume of water. Add 22.75 g of sodium dichromate ($Na_2Cr_2O_7 \cdot H_2O$) and dissolve. Dilute the resulting solution to 1 L.

13.11 *Sulfuric Acid, Inhibited*—Slowly add 29 mL of H_2SO_4 (sp gr 1.84) to approximately 500 mL of water. Add and dissolve 0.5 g of Inhibitor *II* (see 13.5). Dilute the resulting solution to 1 L with water.

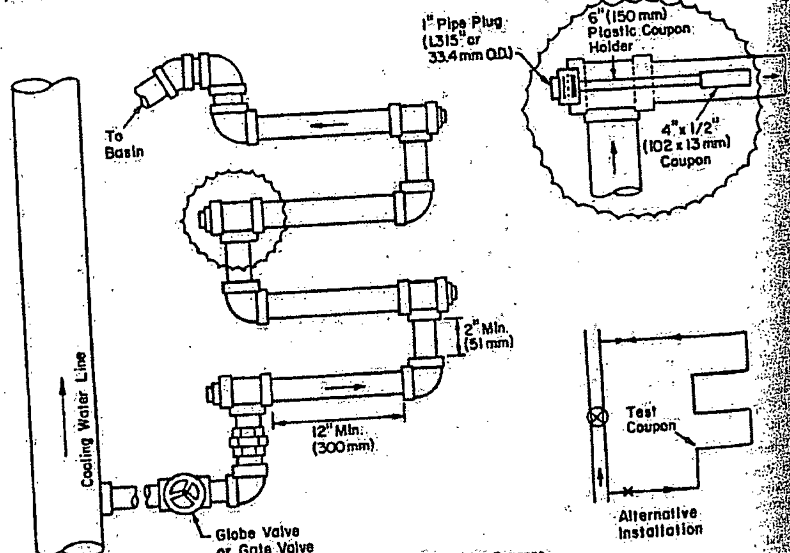

FIG. 1 Installation of Corrosion Coupons

13.12 *Trichloroethylene.*

13.13 *Tripoli*—Finely granulated, porous, siliceous rock; amorphous silica (SiO_2), soft, porous, and free of sharp edges or other suitable erosive-type cleaning agent.

13.14 *Vapor Phase Inhibitor Paper.*.

14. Coupon Preparation

14.1 In this procedure, coupons are to be made principally from sheet metal; however, in a few cases, as with cast iron or cast bronze, it may be necessary to prepare coupons from castings.

14.2 Use a coupon size of 13 by 76 by 1.6 mm (0.5 by 3.0 by 0.0625 in.) for all sheet metals; and a 13 by 76 by 3 mm (0.5 by 3.0 by 0.125 in.) for cast metals. Other sizes are suitable, providing the total area is about 259 mm^2(4 $in.^2$), the principal requirement being to keep the flat area large compared to the edge area.

14.3 *Sheet Metal Coupon Preparation*—Obtain sheet metal of the type desired except for stainless steel; use cold-rolled steel free of rust spots for ferrous metal. Obtain stainless steel with a No. 4 finish.[10]

14.3.1 Shear 14-gage sheet metal material to the dimensions of 13 by 75 mm (0.5 by 3.0 in.).

14.3.2 Drill or punch a 5-mm (0.019-in.) hole with its center about 3 mm (¼ in.) from one end of the coupon.

14.3.3 Deburr all sharp edges on the coupon specimen using a file or emery belt, and deburr the hole with an oversize drill.

14.3.4 Stamp identifying numbers or letters on the coupon area below the mounting hole.

14.4 *Cast Metal Coupon Preparation*—Obtain rough castings of the desired metal, measuring about 19 by 114 by 6 mm (¾ by 4½ by ¼ in.) from a commercial foundry or elsewhere.

14.4.1 Surface grind to the dimensions of 13 by 102 by 3 mm (0.5 by 4.0 by 0.125 in.) and a surface roughness of about 124 μin.

14.4.2 Drill a 7-mm (9/32-in.) hole with its center about 8 mm (5/16 in.) from one end of the coupon.

14.4.3 Deburr all sharp edges on the coupon specimen using a file or emery belt, and deburr the hole with an oversize drill.

14.4.4 Stamp identifying numbers or letters on the small coupon area between the edge and the mounting hole.

14.4.5 The approximate weight of metal coupons, g, is as follows:

Steel	10.35
Cast Iron	11.86
Copper	13.33
Zinc	8.7
Lead	16.80

14.5 *Cleaning Ferrous Metal Coupons*—Remove oil by immersion in benzene. Dry. Immerse in a solution containing HCl (1 + 4) for 30 min at room temperature.

14.5.1 Remove acid from the coupon by three rapid successive rinses in separate water baths; the last rinse water bath shall contain methyl orange solution and must be kept neutral (yellow). The first and second bath must be renewed frequently. Rinse successively in isopropyl alcohol and benzene, and dry with a clean cloth. Store in a desiccator.

14.6 *Cleaning Copper, Brass, and CupraNickel Coupons*—Clean, dry, and store coupons exactly as for ferrous coupons (see 14.5).

14.7 *Cleaning Stainless Steel Coupons*—Degrease with benzene, dry with a clean cloth, and passivate by immersing in nitric acid-dichromate solution (see 13.10) at 43 to 49°C (110 to 120°F) for 15 to 30 min; rinse with water, then benzene, dry with a clean cloth, and store in a desiccator.

14.8 *Cleaning Aluminum Coupons*—Degrease with benzene and dry. Immerse in HNO_3 (sp gr 1.42) for a minimum of 3 min at room temperature. Rinse with water twice, once with isopropyl alcohol; and finally with benzene. Dry with a clean towel and store in a desiccator. If coupon is not visibly clean, repeat the procedure using submerged scrubbing with a fiber bristle brush in the water rinse.

14.9 *Cleaning Zinc or Galvanized Steel Coupons*—If the surface is free of oxide, degrease with benzene, dry with a clean towel, and store in a desiccator. If oxide is present, polish with No. 0 emery paper, scrub in isopropyl alcohol using a stiff fiber brush, and rinse in benzene. Dry and store in a desiccator.

14.10 *Cleaning Lead Coupons*—(Specimens shall be handled gently with plastic-tipped tweezers). First, rinse in deionized water, then immerse in glacial acetic acid for 30 s. Rinse off the acid with flowing deionized water for 30 s; immerse in acetone for 15 s; dry by laying on dry towel; store in a desiccator for 1 h before weighing to 0.1 mg.

15. Procedure

15.1 Weigh the clean, dry specimens on an analytical balance to the nearest 0.1 mg.

15.2 After weighing, store the specimens in a desiccator until ready for use. If storing in a desiccator is inconvenient or impractical, use an alternative method for providing a corrosion-free atmosphere.

15.3 Store ferrous metal coupons in separate envelopes made from vapor phase, inhibitor-impregnated paper. Store nonferrous metal coupons in sealed plastic envelopes or wrapped in plastic film.

15.4 Attach the coupon to the phenolic rod, using an insulating washer to preclude any contact of coupon with the screw and nut assembly (see Specification A 120). For added protection, attach the specimen to the holder using a screw and nut of the same metal composition as the coupon.

15.5 Install the holder and coupon assembly in a suitable line or in a bypass piping arrangement as shown in Fig. 1.

15.6 Adjust the rate of flow of water in the test piping to a rate that gives a flow velocity that corresponds to the normal flow in those parts of the system under prime consideration. Normally, the flow velocity will be in the range from 0.6 to 1.8 m (2 to 6 ft)/s. Check and readjust the flow as necessary to maintain the desired rate.

15.7 Remove specimens from the system at chosen intervals. Since the corrosion will be high initially and then fall to a lower, nearly constant rate, two time series should be chosen.

15.7.1 Use short time intervals for the first time series in order to establish the rate at which passivity occurs. Removal

---

[8] It may be preferred to obtain the complete corrosion tester and coupons from Metal Samples, P.O. Box 8, Mumford, AL 36268, who construct the rod from TFE-fluorocarbon or nylon, include a screw made from this same material and avoid the necessity of including a washer and nut by providing screw threads in the mounting.

[9] Phenolic rod meeting the National Electrical Manufacturers Association (NEMA) Grade CE or LE is satisfactory. The pipe plug is marked externally to permit orientation of the coupon as desired.

[10] *Metals Handbook*, Vol 1, American Society for Metals, Metals Park, OH [illegible], 1961, p. 430.

of three or four sets of coupons at 4- to 7-day intervals is recommended.

15.7.2 Use long time intervals for the second time series in order to establish the mean steady-state corrosion rate. Removal of the first coupons after 1 month and the remaining coupons at 1 to 3-month intervals is recommended.

15.8 Protect the specimen if it cannot be examined, cleaned, and reweighed immediately after removal from the system. Dry between paper towels. Store the ferrous metal coupons in separate envelopes made from vapor phase inhibitor-impregnated paper or wrap carefully in plastic film. For nonferrous metal coupons, wrap carefully in plastic film. The interim period between removal of specimens and reweighing should be kept to a minimum and in no case should it exceed 1 week.

15.9 Examine the specimen and record either by photograph or by description the appearance of the specimen, paying particular attention to the amount and nature of any adherent deposit. Chemical analysis of the deposit may be performed, but this step is optional.

15.10 For ferrous coupons, use one of the following alternative procedures for cleaning the coupon prior to reweighing.

15.10.1 Clean the coupons as well as possible with a plastic knife. Remove oily and greasy deposits by soaking in trichloroethylene. Remove remaining loose corrosion products by brushing with a bristle brush. Immerse the specimens in inhibited acid, using either of the following two techniques.

15.10.1.1 Immerse the specimens in inhibited HCl (1 + 1.8) for 30 s at room temperature.

15.10.1.2 Immerse the specimens in inhibited H_2SO_4 (1 + 34) at 71°C (160°F) with a direct current source imposed on the coupon as an anode, and lead as a cathode. The voltage should be 4 to 5 V and the current density 2.5 to 3.0 A per specimen. Keep the specimens in the bath for 3 to 5 min.

15.10.2 Rinse with water after removing specimens from the inhibited acid bath. Rub specimens with granular Na_3PO_4, then with tripoli. Rinse with water. Rinse with isopropyl alcohol. Dry between paper towels followed by warm air drying.

15.11 For copper to copper alloy coupons, use the following procedure for cleaning prior to reweighing. Clean the coupons as well as possible with a plastic knife. Remove oily or greasy deposits by soaking in trichloroethylene. Immerse the coupons in inhibited HCl (1 + 1.8) for 30 s. Rinse coupons with water, rinse with isopropyl alcohol, and finally, rinse with benzene. Dry coupons between paper towels. Place in a desiccator for 1 h.

15.12 For aluminum or aluminum allow coupons, use the following procedure for cleaning prior to reweighing. Clean the coupons as well as possible with a plastic knife. Remove oily or greasy deposits by soaking in trichloroethylene. Immerse the coupons in chromic acid-phosphoric acid solution (see 13.2) at room temperature for 30 min. Remove and rinse with water, rinse with isopropyl alcohol, and finally, rinse with benzene. Dry between paper towels. Place in a desiccator for 1 h.

15.13 Subject a weighed blank coupon of the same material to the identical cleaning procedure used for the test specimens and reweigh to determine the blank correction factor to be applied to the coupon weight losses.

15.14 Reweigh each coupon to the nearest 0.1 mg.

15.15 If pitting (see 7.2) is apparent on the coupon, measure the depth of the pits in a representative area with the dial depth gage. Record the resultant values as pit depths. The number, size, shape, and distribution of the pits shall also be determined and recorded.

15.16 Record the appearance of the cleaned, weighed coupon as" protected," "moderate localized," "moderate pitting," or" severe pitting," by comparing the coupon with the illustrations given in Fig. 2.

16. Calculation

16.1 Corrosion rates are normally calculated as an average penetration in mils per year or millimetres per year assuming that localized attack or pitting is not present and that the corrosion is general (8).

16.2 *Calculation of the Corrosion Rate:*

16.2.1 To calculate the corrosion rate (8, 9, 10) in mils per year for each coupon, use Eq 1:

$$\text{Corrosion Rate (mils per year, mpy)} = 22.3 \quad W/(dat) \qquad (1)$$

where:

W = weight loss, mg,
d = density of the metal, g/cm^3,
a = exposed area of coupon, in.^{2}, and
t = time, days.

16.2.2 To calculate the corrosion rate in micrometers per year for each coupon, use Eq 2:

$$\text{Corrosion Rate (micrometers per year, μm/y)} = 3650 \ W/(dat) \qquad (2)$$

where:

W = weight loss, mg,
d = density of the metal, g/cm^3,
a = exposed area of coupon, cm ^{2}, and
t = time, days.

16.3 The specific gravities of various metals (g/cm.^{3}) are

Admiralty brass	8.17
Copper	8.9
Yellow brass	8.02
Aluminum	2.70
Low carbon steel	7.85
Lead	11.34

FIG. 2 Recording of Coupon Appearance

16.4 Calculate the pitting rate using Eq 3:

$$\text{Pitting rate, mils (mm) per year} = \text{maximum pit depth} \times 365/t \qquad (3)$$

where:

t = exposure time, days.

16.5 To convert from mils per year to millimetres per year, multiply by 0.0254.

17. Interpretation of Results

17.1 It should be recognized that the following deviations between the coupons and the corresponding material of construction may lead to the following erroneous interpretations:

17.1.1 Deviations in composition or surface preparation,

17.1.2 Deviations in velocity and direction of flow, and

17.1.3 Deviations in crevices, deposits, or biological growths.

18. Precision and Bias

18.1 Precision is a function of each individual system. Therefore, a general statement regarding this property is not practical at this time.

18.2 This is a comparative type test, for which precision cannot be evaluated. There are many variables, such as velocity, temperature, water quality, and the presence of other metals that may influence the rate of corrosion of the coupons. As well, the composition of the test metal and the different forms of corrosion which can occur, such as general corrosion, pitting, and microbiological type, may affect the results appreciably.

TEST METHOD B—Pipe Inserts in Plastic Pipe (1, 2, 3, 4, 5)

INTRODUCTION

This method of corrosion testing in municipal distribution water systems has been used effectively for many years; however the assembly has been cumbersome and costly to prepare. Recently, several papers (1, 2, 3, 4, 5) have been presented which make the technique more practical, accordingly, the test method has been rewritten to include these improvements. Essentially, the change is from exterior metal piping including a plastic sleeve for housing the inserts in a complete plastic (PVC)[11] body. This simplifies the construction and reduces machining costs. The basic unit is now generally a ¾-in. outside diameter (26.7-mm) assembly, rather than 1-in. (33.4-mm). Table 1 provides the dimensions for preparing ½-in. outside diameter (21.3-mm), ¾-in. outside diameter (26.7-mm), and 1-in. outside diameter (33.4-mm) assemblies.

19. Summary of Test Method

19.1 Removable pipe inserts are installed in plastic pipe connected by piping unions and are made part of the pipe system under test. Proper dimensions are provided throughout so that streamline flow (no-flow distortion) is provided in test assemblies in standard steel and galvanized and copper tubing. Interest is now being shown in testing corrosion resistance of other metals, such as lead, for example; however, at present, testing of the corrosion resistance of lead is confined to Test Method A, because the uniform preparation of lead pipe inserts is difficult and may not be reproducible. Soldered copper pipe inserts are presently being tested. Exposed inside surface of the piping is not altered, and the outside surface is painted to prevent corrosive attack since the crevice corrosion occurring there is not indicative of the corrosion desired to be measured. Loss in weight of the insert is a measure of the average corrosion per unit area. Examination of the surface is made to evaluate pitting. This test method may be used to determine the degree of corrosion occurring in a cold or hot distribution water system or cooling water system, to evaluate different methods of chemical treatment, and to determine the proper choice of a corrosion-resistant metal for the system.

20. Apparatus

20.1 *Tester Assembly*— The assembly consists of two inserts, constructed from a representative lot of ¾-in. outside

TABLE 1 Specifications for ISWS Type Corrosion Specimens

	Materials of Construction		Specimen Dimensions			
Pipe size, in.	Class	Metal	Length, in.	Inside diameter, in.	Outside diameter, in.	Area, in.^{2}
½	Schedule 80, pipe	steel	4.00	0.546	0.825	6.86
	Schedule 80, pipe	galvanized	4.00	0.538 [A]	0.825	6.76
	Type L, tube	copper	4.00	0.545	0.625	6.85
¾	Schedule 40, pipe	steel	4.00	0.824	1.050	10.35
	Schedule 40, pipe	galvanized	4.00	0.818 [A]	1.050	10.25
	Type L, tube	copper	4.00	0.824	1.050	10.35
1	Schedule 40, pipe	steel	4.00	1.049	1.125	13.18
	Schedule 40, pipe	galvanized	4.00	1.037 [A]	1.125	13.03
	Type L, tube	copper	4.00	1.025	1.125	12.89

[A] Assumes a zinc coating thickness of 0.004 in.

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[11] PVC piping is specified to be PVC Type I, Grade I, Cell classification-12454-B and CPVC fittings, Type IV, Grade I, Cell classification 23477-B.

diameter (26.7-mm) standard steel or galvanized pipe (Specification A 120) (reduced 0.030-in. (0.8-mm) in outside diameter by machining Schedule 40 galvanized pipe in order to fit desirably in the assembly) or copper piping. The inserts are held in place by ¾-in. outside diameter (26.7-mm) spacers, as shown in Fig. 3 and Fig. 4, in a 1-in. (33.4-mm) PVC union, socket type, installed in a typical ¾-in. (26.7-mm) service line. Recently, ½-in. (21.3-mm), ¾-in. (26.7-mm), and 1-in. (33.4-mm) testers have also been constructed according to Table 1 and Table 2 and installed in these sized lines. The U.S. Army Construction Research Laboratory (CERL) has developed (Fig. 5)[11] a pipe loop system including both Test Methods A and B plus a flow meter and water meter for better measuring the corrosion in a cold and hot water system.

20.2 *Dial Depth Gage*— See 12.5.

20.3 *Ultrasonic Cleaning Equipment*, 150-W, 6-qt (6-L) tank capacity to hold 2-L beaker.

21. Reagents and Materials

21.1 *Acetone.*

21.2 *Alicyclic Abietylamines*, formulated (including ethylene oxide adducts of these amines and nonphenyl and 5 % diethylthiourea in isopropanol solution), liquid corrosion inhibitor for sulfamic acid.

21.3 *Substituted Keto-amine Corrosion Inhibitor*[12], for hydrochloric acid.

21.4 *Hydrochloric Acid* (3 + 8), *Inhibited*—Add 465 mL of concentrated hydrochloric acid (HCl, sp gr 1.19) to 1200 mL of water, then add 4 mL of substituted keto-amine corrosion inhibitor (see 21.3), mix well, and dilute to 2 L.

21.5 *Sulfamic Acid.*

21.6 *Sulfamic Acid* (100 g/L), *Inhibited*—Dissolve 10 g of sulfamic acid (HSO_3NH_2) in 90 mL of water and dilute to 100 mL. Add 5 mL of alicyclic abietylamines (see 21.2) and mix.

21.7 *Trichloroethylene.*

21.8 *Passivating Stock Solution*—Dissolve 40 g of sodium nitrite ($NaNO_2$), 23 g of sodium acid phosphate (NaH_2PO_4), and 20 g of disodium phosphate (Na_2HPO_4) in water, and dilute to 1 L.

21.9 *Passivating Solution, Dilute*—Add 50 mL of passivating stock solution to 350 mL of water.

22. Preparation of Inserts

22.1 After stamping an insert number on the exterior surface with a die, degrease the inserts by immersion in trichloroethylene and air-dry.

22.2 If the inserts show the presence of rust or other coatings that were not removed, clean copper and steel inserts with (1 + 3) hydrochloric acid, inhibited, until free of the coating. Place rubber stoppers in each end of galvanized inserts to prevent attack of internal galvanized surface by the acid. In the case of copper, expose in concentrated HCl for 2 min; however, steel inserts may require a much longer exposure. After cleaning, remove stoppers, rinse inserts with water, and passivate (see Note 1) steel (not copper or galvanized internal surface) surfaces by soaking inserts in dilute passivating solution for at least ½ min. Now air-dry and keep in desiccator until weighed. Record weight and insert number; then inserts are ready to be painted.

NOTE 1—It is not necessary to passivate steel inserts if they are not washed with acetone and then allowed to air dry. For long periods of storage or under moist conditions of storage, passivation may be justified.

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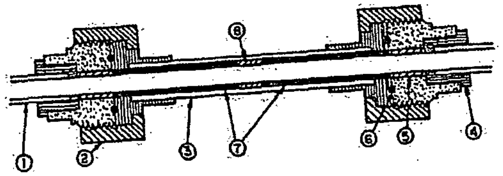
[12] Complex substituted keto-amine (50 to 60 %) corrosion inhibitor as Rodine 213 manufactured by Amchem Products Inc., Ambler, PA 19002 has been found satisfactory for this purpose.



① 3/4"(1.91cm) PVC Service Line
② 1"(2.54 cm) Union, PVC, Socket Type, Sch 80
③ 1"(2.54 cm) x 10"(25.4cm) Pipe Nipple, PVC, Sch 40
④ 1"(2.54 cm) x 3/4"(1.91 cm) Reducing Bushing, PVC, Socket
⑤ 3/4"(1.91cm) PVC Spacer, Sch 40, O.D. Reduced 0.015"(0.038 cm) If Needed, Reducing Union I.D. to Pipe I.D. to Hold Specimen in Place
⑥ O-Ring
⑦ Corrosion Specimens, 3/4" (1.91 cm) O.D. Reduced 0.030"(0.076 cm) Machined from Sch 40 Galvanized Steel or Steel Pipe
⑧ Specimen Separator, 3/4"(1.91 cm) PVC, Sch 40, O.D. Reduced 0.015"(0.038 cm). Length Is Adjusted to Provide Flush Fit with Inner Faces of Union.

FIG. 3 Pipe Specimens (CERL)-¾-in. (1.91-cm)

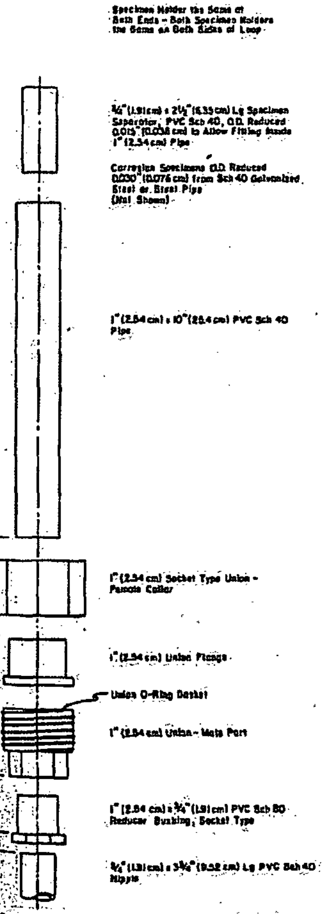


FIG. 4 CERL Pipe Loop System—Specimen Holder Details

TABLE 2 Factors for Converting Weight Loss Measurements into Corrosion Rates

Type of Specimen		Conversion Factors (F) [A]		
		(weight loss (g/d) to corrosion rate)		
Pipe size (in.), Class	Material	mdd [B]	mpy [C]	mmpy [D]
½, Schedule 80	steel pipe	2259	413	10.49
½, Schedule 80	galvanized pipe	2293	462	11.74
½, Type L	copper tube	2263	364	9.24
¾, Schedule 40	steel pipe	1497	274	6.95
¾, Schedule 40	galvanized pipe	1512	305	7.74
¾, Schedule 40	copper pipe	1497	241	6.11
1, Schedule 40	steel pipe	1178	215	5.46
1, Schedule 40	galvanized pipe	1189	240	6.09
1, Type L	copper tube	1203	193	4.91

[A] Corrosion rate = (F) × (weight loss, g/d).
[B] mdd = milligrams per square decimetre per day.
[C] mpy = mils per year.
[D] mmpy = millimetres per year.

22.3 The exterior and ends of the inserts are coated with a polyamide epoxy paint. Blend the epoxy base and epoxy catalyst according to the paint manufacturer's instructions. Place rubber stoppers into the ends of the inserts to protect the interior surfaces during painting. Air spray the inserts to produce a 5 mil dry-film thickness coating. Allow to air dry for 24 h and remove the stoppers.

22.4 Store inserts in a desiccator until installed in the tester assembly (Fig. 3 and Fig. 4).

23. Procedure

23.1 Install the test assembly in a similar-sized pipe line in the system to be observed.

23.1.1 A minimum straight run of 915 mm (3 ft) of piping shall proceed the test assembly to prevent undue flow distortion.

23.1.2 Construct a by-pass valve and piping arrangement in order to allow insert removal while the system is operating.

23.1.3 Install a water meter following the test assembly in order to obtain maximum information concerning the flow rate and total flow.

23.2 The minimum recommended test period is preferably 120 days.

23.2.1 Remove the downstream insert at this time and evaluate.

23.2.2 If feasible, expose the upstream insert preferably for a test period of 12 months.

24. Collateral Data

24.1 Record pertinent information on the physical and chemical characteristics of the environment in which the test is made on the test report sheet (Fig. 6).

24.2 Include also the location of the tester, insert material, insert number, installation data, removal date, and other descriptive information in the test report sheet (Fig. 6).

25. Inspection

25.1 Divert the flow of water from the tester and remove the insert from the test assembly.

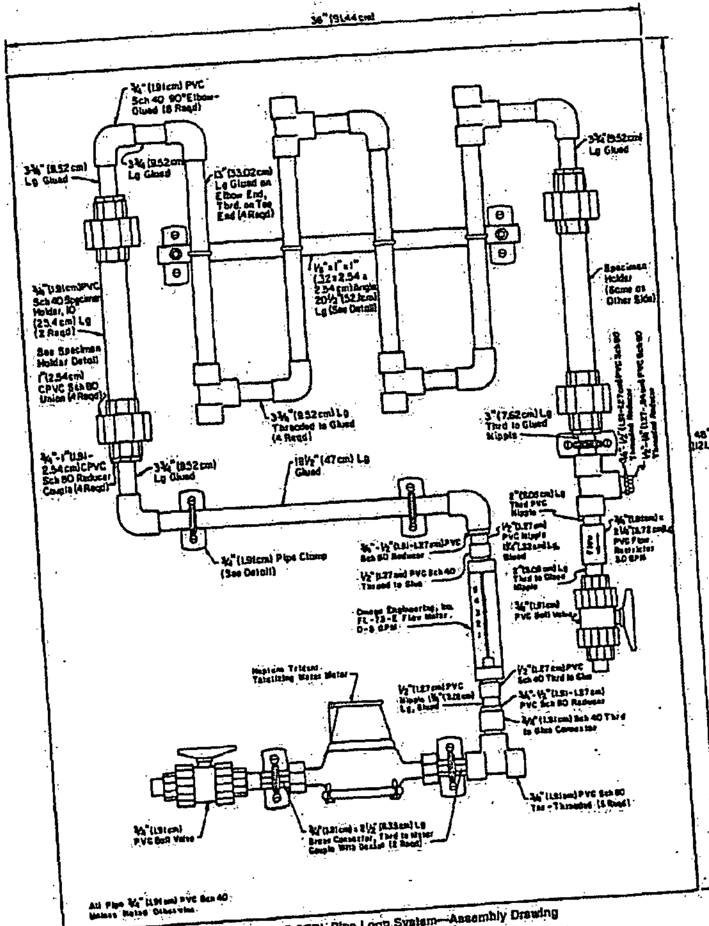
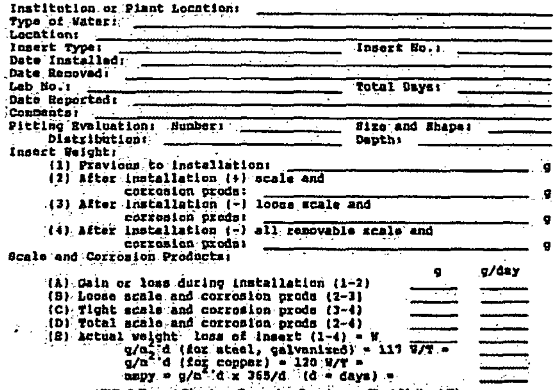


FIG. 5 CERL Pipe Loop System—Assembly Drawing

25.2 Record the corrosion pattern, if any, as uniform or showing evidence of erosion, grooving, roughness, or pitting. Observe and record the appearance of the painted surface (excellent, blistered, peeling, etc.). If the paint has failed to effectively coat the metal surface during the exposu and appreciable corrosion has occurred on the external the accuracy of the corrosion test results may be questioned.



Institution or Plant Location: ______________________

Type of Water: ______________________

Location: ______________________

Insert Type: ______________ Insert No.: ________

Date Installed: ______________________

Date Removed: ______________________

Lab No.: ______________ Total Days: ________

Date Reported: ______________________

Comments: ______________________

Pitting Evaluation: Number: ________ Size and Shape: ________

Distribution: ________ Depth: ________

Insert Weight:

(1) Previous to installation: ______________ g

(2) After installation (+) scale and corrosion prods: ______________ g

(3) After installation (-) loose scale and corrosion prods: ______________ g

(4) After installation (-) all removable scale and corrosion prods: ______________ g

Scale and Corrosion Products:

	g	g/day
(A) Gain or loss during installation (1-2)	____	____
(B) Loose scale and corrosion prods (2-3)	____	____
(C) Tight scale and corrosion prods (3-4)	____	____
(D) Total scale and corrosion prods (2-4)	____	____
(E) Actual weight loss of insert (1-4) = W	____	____
$g/m^2 \cdot d$ (for steel, galvanized) = 117 W/T =		____
$g/m^2 \cdot d$ (for copper) = 120 W/T =		____
mmpy = $g/m^2 \cdot d$ x 365/d (d = days) =		____

FIG. 6 Report Sheet on Corrosion Specimens (Test Method B)

26. Cleaning of Inserts

26.1 After removal from the corroding environment, dry insert in a 105°C oven for 24 h (except for copper inserts which shall be dried in a desiccator for 24 h), close ends of insert with rubber stoppers, immerse insert in an epoxy paint stripper to loosen the paint on the exterior, and remove all the paint film from the insert. After removing the stoppers, dry again in a 105°C oven for 1 h, cool in a desiccator for 1 h (except for copper inserts which shall be dried in a desiccator for 24 h), and weigh to the nearest 0.001 g. Record the weight on line (2) of the report sheet (Fig. 6).

26.1.1 Caution: While removing paint, avoid contact with stripper solution by wearing rubber gloves and working in an exhaust hood.

26.2 Scrape the insert with a spatula to remove loose deposits and wash with a brush and scouring powder. Dry the insert and weigh as previously noted after stripping. Record the weight on line (3) of Fig. 6.

26.3 Immerse steel inserts in a freshly prepared solution of inhibited hydrochloric acid (see 21.4) for several minutes or until all corrosion products are removed. Copper inserts are immersed in concentrated hydrochloric acid for 1 to 2 min to remove deposits, but do not use the copper acid bath to clean steel inserts.

26.3.1 Immerse galvanized inserts in an inhibited sulfamic acid solution (10 %) (see 21.6) for 5 min to loosen the deposits. Remove deposits by brushing and placing in an ultrasonic cleaner if necessary. In this case, place inserts in a 2-L polyethylene beaker containing the inhibited acid and place beaker in ultrasonic equipment containing water.

26.3.2 Rinse all inserts with water and acetone, dry in a 105°C oven for 1 h (except for copper inserts, which shall be dried in a desiccator for 24 h), cool in a desiccator for 1 h, and weigh to the nearest 0.001 g. Record the weight on line (4) of Fig. 6.

26.4 After sawing the inserts lengthwise in a band saw, inspect the interior surfaces for pitting, recording the number, depth, shape, and distribution of pits (see 7.2 and 12.5) in the pitting evaluation column shown in Fig. 6. Also inspect copper inserts using a microscope to determine if striations resulting from erosion-corrosion may have occurred.

27. Calculation

27.1 Calculate the scale and corrosion products in grams and grams per day, as indicated in Fig. 6.

27.2 Express the rates of corrosion either as weight loss per unit area per unit time or the equivalent rate of penetration. The accepted units are grams per square metre per day ($g/m^2/day$) and millimetres penetration per year (mmpy) mils per year (mpy). Calculations in gmd or $g/m^2/day$ may be made using Eq 4:

$$\begin{aligned} g/m^2/\text{day} &= 117\ W/T, \text{ for steel and galvanized specimens,} \\ \text{and } g/m^2/\text{day} &= 120\ W/T, \text{ for copper specimens} \end{aligned} \tag{4}$$

where:

W = actual weight loss of insert, g, and

T = installation time, days.

27.3 The relationship between corrosion rate in gmd, mmpy, and mpy (27.2) is as follows (see Table 2): Multiply gmd by 0.365/density to obtain mmpy, millimetres per year and mmpy/0.0254 to obtain mpy. The densities (g/cm^3) are: steel—7.86; zinc (galvanized)—7.15; copper—8.96; lead—11.34.

28. Interpretation of Results

28.1 This test closely simulates actual piping service conditions and has been observed to yield an accurate measure of corrosion occurring in a piping system.

28.2 Corrosion rates of less than 0.13 mmpy are considered low and are a general indication of satisfactory service life of the metals tested and exposed in the piping system.

28.3 The degree of pitting may be graded (7) and its importance evaluated.

29. Report

29.1 Fig. 6 shall include the observations, weight determinations, and pitting evaluation made in Sections 24 and 25, and the calculations of scale, corrosion products, and corrosion rate in Section 27.

30. Precision and Bias

30.1 Precision is a function of each individual system; therefore, a general statement regarding this property is not practical at this time.

30.2 See 18.2.

31. Keywords

31.1 cooling water corrosion test; coupon corrosion test; distribution water corrosion test method

REFERENCES

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(9) Atkinson, J.T.M., VanDroffelaar, H., "Corrosion and Its Control," National Association of Corrosion Engineers, Houston, TX, 1992.

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APPENDIX 6

CR 03188002

avista

Membrane Autopsy Report
Completed for:
AEP
At Cook Nuclear Plant

July 2003

CONTENTS

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INTRODUCTION

AEP sent a Filmtec BW30-365 element from their Cook Nuclear plant site for autopsy. The Serial Number of that element was A8141661. It was reported that their RO system was exposed to a biocide (Spectus CT1300) that contained a quaternary amine. The system developed signs of fouling shortly after the introduction of this biocide into the feedwater.

The primary Goal of this autopsy was to determine whether Spectrus CT1300 fouled the Filmtec RO membranes.

The element inspection results are summarized below. Please refer to the element drawing in Appendix A for an explanation of the terms used throughout this report.

PROCEDURES AND RESULTS

WET TEST

The element's fiberglass wrapping was badly cracked and deformed. As a result, it could not be wet tested.

ELEMENT WEIGHT

Because element weight is often indicative of the degree of fouling, elements are weighed prior to autopsy. This element weighed 46 pounds. The nominal weight of new elements of this model is approximately 35 pounds.

EXTERNAL INSPECTION

Fiberglass wrap:
The fiberglass wrapping was cracked and deformed.

Telescoping of element leaves:
Both ends of the element were examined for signs of membrane and feed spacer extrusion. This type of damage is termed "telescoping" and is caused by the development of high differential pressure (usually greater than 12 psi) across the element. Moderate telescoping was observed.

Brine seal:
The brine seal prevents bypassing of feedwater around the element. The brine seal was in good condition with no cracks or tears observed.

Anti-telescoping device (ATD):
The ATD's are designed to prevent telescoping of element leaves at normal differential pressures. No cracks were detected.

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Permeate tube:

No scratches or gouges were visible on the ends of the permeate tubes that would allow by-pass of feedwater.

INTERNAL EXAMINATION

Membrane:

Moderate to heavy fouling was seen. The foulant was gray in color and possessed a musty odor. A membrane sample was dyed with crystal violet dye to highlight damaged areas. No significant dye uptake occurred. No significant membrane compaction was observed.

Fujiwara Test

The Fujiwara test is used to determine whether a polyamide (PA) thin-film membrane has been exposed to an oxidizing halogen, such as chlorine, bromine, or iodine. The test determines qualitatively whether halogens have become part of the membrane structure through oxidative attack.

A Fujiwara test was run on a membrane sample, and the test result was positive.

Feed spacer:

The feed spacer is a plastic net material (Vexar) designed to separate membrane leaves to form a flow path and to promote turbulence within feedwater passages. The feed spacer was free of foulant.

Permeate spacer:

The permeate spacer (Tricot) provides a path for permeate flow to minimize permeate-side pressure losses. The spacer was in excellent condition with no signs of chemical attack.

Glue lines:

Membrane leaves are glued on three sides to separate feed and permeate streams. Glue lines showed no signs of leakage.

CELL TEST

Membrane samples were tested in a cell test apparatus to determine membrane performance characteristics.

The permeate flow constant is expressed as the "A" value, and the salt passage constant is expressed by a "B" value. Both constants are functions of the chemical-physical properties of the membrane plus any fouling layer present.

The constants are also independent of operating parameters such as pressure, temperature, and total dissolved solids of the feedstream. "A" value units are cm/sec/atm. "B" value units are cm/sec.

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	A Value	B Value
Serial # A8141661	1.04E-4	1.51E-5
Manufacturer's original specifications	8.00E-4 to 1.08E-4	5.50 to 7.44E-6

FOULANT ANALYSIS

Loss on ignition:

Loss on ignition gives an approximation of the organic content of the foulant. Values in excess of about 35% represent a significant organic content. Loss on ignition was 50.3 percent.

Membrane foulant density:

Membrane foulant density is the weight of dry foulant per area of membrane surface. Foulant densities determined from past autopsies range from 0.04 to 0.6 mg/cm^2 and average 0.203 mg/cm^2. Membrane foulant density for this element was 0.235 mg/cm^2.

Bubble test:

Several drops of dilute hydrochloric acid were placed on the foulant surface. Bubbles indicate the presence of carbonates. No bubbles evolved.

EDX/SEM analysis:

EDX analysis is conducted in conjunction with scanning electron microscopy (SEM) to identify inorganic foulant constituents. The main inorganic components of the foulant were aluminum, silica, and oxygen.

FTIR analysis:

FTIR analysis identifies organic foulant constituents. Fatty acids were detected. Quaternary ammonium compounds were not detected.

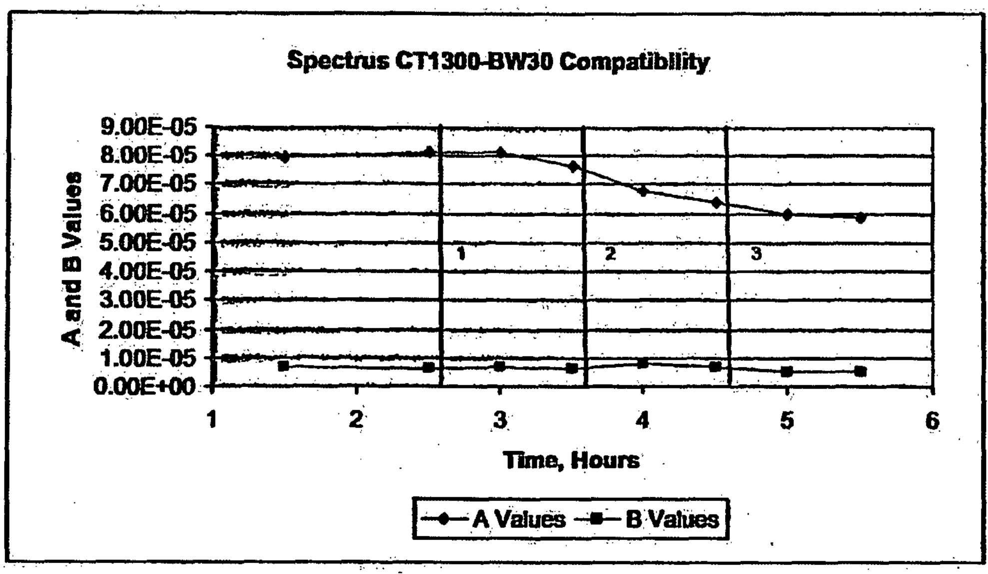
A wet test for quaternary ammonium compounds present in the foulant was also performed. A trace amount (1.94E-4 %) was detected.

Microbiological examination:

A foulant sample was stained and examined with a light microscope. Significant numbers of rod-shaped bacteria (bacilli) were seen.

COMPATIBILITY TEST

A compatibility test was run between the Spectrus CT1300 biocide and new Filmtec BW30 membrane. Tests were run in a cell test apparatus and in a total recycle mode. The results are graphed below.



At point one, 0.1 ppm of Spectrus CT1300 was added. Two ppm was added at point two, and a total of 4 ppm was added at point three.

SUMMARY AND CONCLUSIONS

A wet test to obtain element performance data could not be conducted. However, cell tests of a membrane sample showed permeate flow at the high end of normal. Salt passage was also greater than the upper specification limit for this membrane.

Cleaning the RO system in the reverse direction can sometimes cause longitudinal cracks in the fiberglass wrapping, as seen in this element. However, it was reported that this procedure was never employed. High differential pressures caused by fouling may also result in this type of damage.

The Fujiwara test was positive for chlorine, which may explain the elevated salt passage and permeate flow at the high end of normal.

The foulant consists of clay, possibly some aluminum hydroxide, bacteria, and bacterial slime. A trace of quaternary ammonium compound was detected by a wet test procedure. None was detected by FTIR analysis. The failure to find quaternary amines by FTIR does not necessarily mean that they were absent. It may only mean that they were below detection limits.

The compatibility test showed that Spectrus CT1300 fouls Filmtec BW-30 membrane. Flow declined when as little as 0.1 ppm of biocide was added to the cell test apparatus. A total A value decline of 26 percent was seen after the addition of 4 ppm Spectrus CT1300.

At low concentrations, the effect of foulant on the membrane is expected to be more pronounced in a continuous mode of testing. In a recycle mode, the small quantities of the test substance present in the test loop may be adsorbed onto the membrane surfaces without covering all of the potential attachment sites. In a continuous mode of operation, in which test substance is added to the apparatus continuously, all of the membrane attachment sites will eventually be covered, and a much greater degree of fouling will occur. For practical reasons, our testing was conducted in the recycle mode.

A cleaning test was performed on a fouled membrane sample. Excellent cleaning results were obtained with Avista's RoClean P111 cleaner. However, salt passage did increase significantly following the clean. This is probably due to damaged areas of the membrane being uncovered by the cleaning.

RECOMMENDATIONS

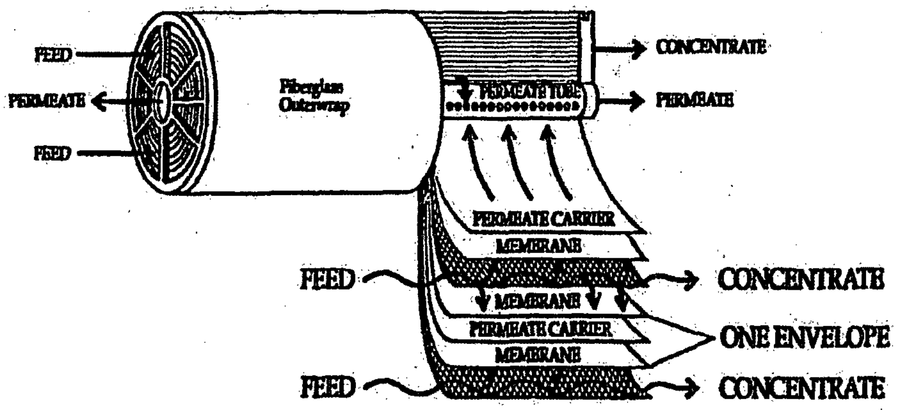
The Spectrus CT 1300 fouls Filmtec BW30 membrane. We recommend that a different material be evaluated. There is a significant risk that continued use of this product will result in irreversible fouling of the RO membranes.

Avista RoClean P111 cleaner should be evaluated. It may be a more cost-effective product for cleaning the RO system than the acid and caustic currently used.

Plant dechlorination procedures should be reviewed.

APPENDIX A

Spiral Wound Membrane Construction



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APPENDIX B

Figure 1 Deformed casing

Figure 2 Fouled membrane leaf

Figure 3 Foulant surface

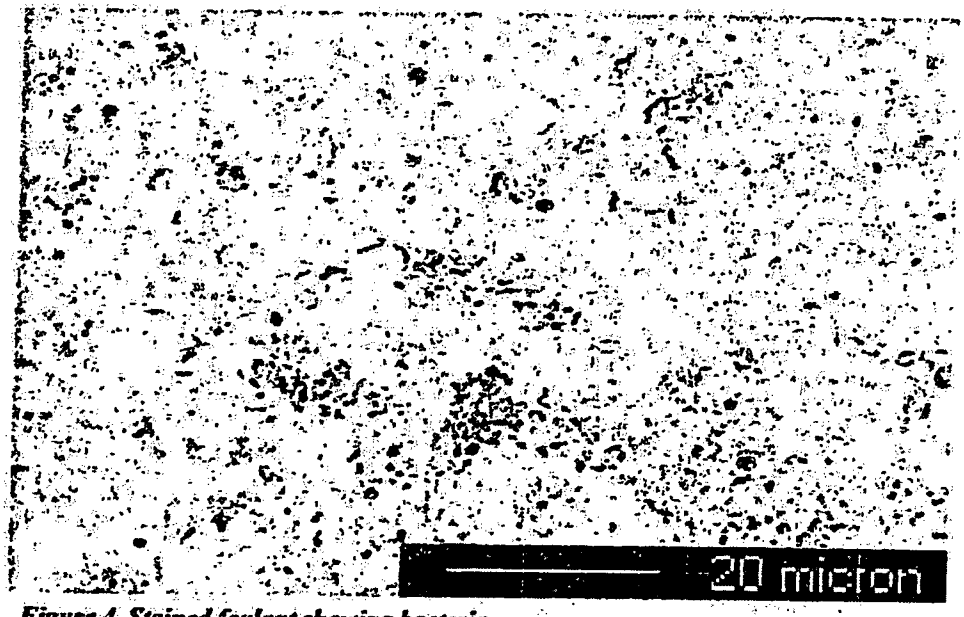

Figure 4 Stained foulant showing bacteria

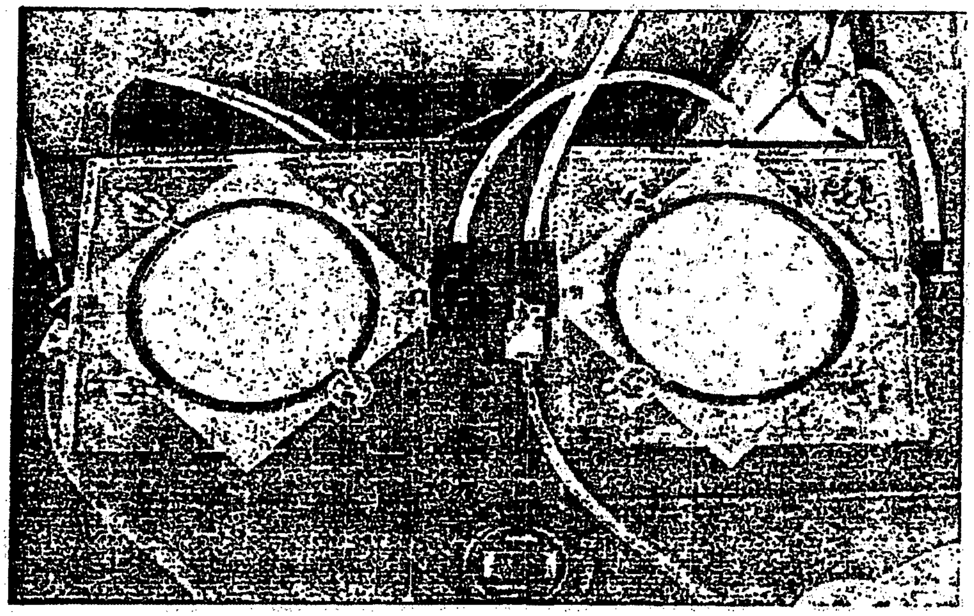

Figure 5 Cleaning results

APPENDIX 7

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400

PALATINE, ILLINOIS 60067
FAX NO. 847/358-7082

DATE: August 28, 2007

TO: Tom Armon

FROM: H. A. Becker

SUBJECT: Indiana and Michigan Power Company
Donald C. Cook Nuclear Plant
Mexel (A-432) Efficiency Study
Compiled Analytical Data August 2006 through August 2007

Dear Tom:

Attached please our laboratory analysis report on the above referenced project. This report is a year long compilation of laboratory and field analyses on water, deposit, and corrosion coupon samples. In addition this report includes the membrane autopsy data from two sets of fouled reverse osmosis membranes.

I hope this information satisfies your requirements. If any further work or discussion is needed, please get back to me.

Very truly yours,

H. A. Becker

HAB:ld
Enclosure

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 9/7/06 (#26723)		Treated 9/7/06 (#26723)		Control 9/14/06 (#26743)		Treated 9/14/06 (#26743)		Control 9/21/06 (#26781)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	10		12		10		4		0	
	2.	Alkalinity ("M")	as $CaCO_3$	120		128		132		128		118	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water Properties	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		5.4		8.6		4.9		8.2		5.9	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		198		198		198		205		191	
	8.	Hardness (Calcium)	as $CaCO_3$	74		74		77		77		79	
	9.	Hardness (Magnesium)	as $CaCO_3$	41		41		42		42		43	
	10.	Hardness (Total)	as $CaCO_3$	116		115		120		119		123	
	11.	pH		8.4		8.5		8.4		8.2		8.0	
	12.	Specific Conductance	µmhos	298		298		298		307		298	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			10.0		7.0		38.5		11.5		
	15.	Aluminum	as Al	0.01	0.09	0.01	0.06	0.01	0.69	0.01	0.14	0.01	0.55
	16.	Barium	as Ba	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01
	17.	Calcium	as Ca	29.8	1.32	29.6	0.48	30.9	5.33	30.7	1.26	31.6	7.20
	18.	Chromium	as Cr	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.01
	19.	Copper	as Cu	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
	20.	Iron	as Fe	0.00	0.14	0.00	0.06	0.00	0.95	0.00	0.20	0.00	1.05
	21.	Lead	as Pb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	9.99	0.38	9.93	0.00	10.3	1.47	10.3	0.28	10.6	1.48
	24.	Manganese	as Mn	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.01	0.00	0.05
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.24		1.30		1.25		1.57		1.28	
	27.	Silver	as Ag	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Cations	28.	Sodium	as Na	6.05		6.24		6.12		6.51		6.22	
	29.	Strontium	as Sr	0.10	0.00	0.10	0.00	0.11	0.01	0.11	0.00	0.11	0.01
	30.	Zinc	as Zn	0.00	0.03	0.00	0.02	0.00	0.03	0.01	0.03	0.01	0.16
	31.	Total Cation Millequivalents		*2.607*		*2.601*		*2.687*		*2.709*		*2.755*	
	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	11.4		11.3		11.0		11.7		11.3	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.07		0.08		0.07		0.08		0.05	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.02		0.01		0.01		0.00		0.00	
	41.	Nitrate	as NO_3	0.73		0.78		0.80		1.03		0.81	
	42.	Nitrite	as NO_2	0.00		0.00		0.00		0.00		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.01		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.10		0.08		0.07	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.00	0.10	0.00	0.10	0.00	0.17	0.00	0.14	0.00	0.09
	49.	Sulfate	as SO_4	21.8		21.7		21.6		22.1		21.7	
	50.	Sulfur (total)	as S	6.59	0.61	6.47	0.25	6.79	0.00	6.69	0.00	6.83	0.82
	51.	Total Anion Millequivalents		*3.218*		*3.378*		*4.119*		*3.975*		*3.182*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.00		0.00		0.00		0.00		0.00	
	55.	Silica	as SiO_2	0.83	1.07	0.95	1.80	21.1	0.00	18.2	0.00	1.02	2.45
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

All data except pH in parts per million or as indicated

Continued on reverse side.

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LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 9/7/06 (#26723)		Treated 9/7/06 (#26723)		Control 9/14/06 (#26743)		Treated 9/14/06 (#26743)		Control 9/21/06 (#26781)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	59.	Bromate	as BrO_3										
Compounds	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon		2.10		2.50		1.90		2.50		1.37	
	84.	Total Organic Nitrogen						0.29		<0.124			
	85.	Mexel (A-432)				3.0				3.0			

Assays 0. All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 9/21/06 (#26781)		Control 9/28/06 (#26813)		Treated 9/28/06 (#26813)		Control 10/5/06 (#26859)		Treated 10/5/06 (#26859)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	0		6		6		0		0	
	2.	Alkalinity ("M")	as $CaCO_3$	118		112		114		114		114	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water Properties	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		4.4		6.4		9.6		8.6		12.7	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		193		195		198		199		206	
	8.	Hardness (Calcium)	as $CaCO_3$	80		81		80		78		78	
	9.	Hardness (Magnesium)	as $CaCO_3$	44		44		44		43		43	
	10.	Hardness (Total)	as $CaCO_3$	124		125		125		122		122	
	11.	pH		8.1		8.2		8.2		8.2		8.1	
	12.	Specific Conductance	µmhos	285		290		295		294		303	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids					47.0		8.0		15.5		12.0
	15.	Aluminum	as Al	0.01	0.05	0.01	0.55	0.01	0.08	0.01	0.25	0.01	0.16
	16.	Barium	as Ba	0.02	0.00	0.02	0.01	0.02	0.00	0.02	0.00	0.02	0.00
	17.	Calcium	as Ca	31.8	0.00	32.2	6.04	32.1	0.02	31.3	0.00	31.3	0.00
	18.	Chromium	as Cr	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
	19.	Copper	as Cu	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.03	0.00	0.00
	20.	Iron	as Fe	0.00	0.09	0.00	1.04	0.00	0.18	0.00	0.30	0.00	0.24
	21.	Lead	as Pb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	10.8	0.00	10.7	2.01	10.8	0.08	10.6	0.17	10.5	0.00
	24.	Manganese	as Mn	0.00	0.00	0.00	0.06	0.00	0.01	0.00	0.01	0.00	0.01
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.39		1.40		1.66		1.22		1.42	
	27.	Silver	as Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cations	28.	Sodium	as Na	6.43		6.49		7.00		6.17		6.57	
	29.	Strontium	as Sr	0.11	0.00	0.11	0.01	0.11	0.00	0.11	0.00	0.11	0.00
	30.	Zinc	as Zn	0.01	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	31.	Total Cation Millequivalents		*2.796*		*2.810*		*2.840*		*2.734*		*2.754*	
	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	11.5		11.3		12.2		11.5		12.1	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.06		0.06		0.06		0.08		0.08	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.00		0.00		0.00		0.00		0.00	
	41.	Nitrate	as NO_3	0.81		0.75		0.79		0.92		0.68	
	42.	Nitrite	as NO_2	0.00		0.04		0.00		0.00		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.00		0.06		0.00	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.00	0.03	0.00	0.04	0.00	0.00	0.02	0.00	0.01	0.00
	49.	Sulfate	as SO_4	21.8		21.8		23.3		22.5		23.3	
	50.	Sulfur (total)	as S	6.90	0.00	6.80	0.11	7.18	0.00	6.80	0.00	6.81	0.00
	51.	Total Anion Millequivalents		*3.185*		*3.094*		*3.175*		*3.122*		*3.148*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.00		1.36		0.95		0.00		0.00	
	55.	Silica	as SiO_2	0.88	0.67	0.94	3.65	0.80	1.24	0.89	2.07	0.78	1.20
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

Analyst

All data except pH in parts per million or as indicated

Continued on reverse side.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 9/21/06 (#26781)		Control 9/28/06 (#26813)		Treated 9/28/06 (#26813)		Control 10/5/06 (#26859)		Treated 10/5/06 (#26859)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	59.	Bromate	as BrO_3										
Compounds	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon		2.42		2.10		7.62		3.00		3.50	
	84.	Total Organic Nitrogen				1.47		1.48		0.38		1.48	
	85.	Mexel (A-432)		3.0				5.0				1.0	

Analyst 0 All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 10/12/06 (#26908)		Treated 10/12/06 (#26908)		Control 10/19/06 (#26957)		Treated 10/19/06 (#26957)		Control 10/26/06 (#27021)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	6		6		10		4		8	
	2.	Alkalinity ("M")	as $CaCO_3$	120		120		120		120		114	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water Properties	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		10.1		9.7		6.6		11.1		7.3	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		198		202		198		205		201	
	8.	Hardness (Calcium)	as $CaCO_3$	76		75		78		78		73	
	9.	Hardness (Magnesium)	as $CaCO_3$	43		42		44		44		41	
	10.	Hardness (Total)	as $CaCO_3$	119		117		122		122		115	
	11.	pH		8.2		8.2		8.2		8.1		8.5	
	12.	Specific Conductance	μmhos	294		295		289		299		296	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			80.0		27.0		7.0		16.0		15.0
	15.	Aluminum	as Al	0.00	0.96	0.00	0.25	0.00	0.10	0.00	0.14	0.01	0.19
	16.	Barium	as Ba	0.02	0.01	0.02	0.00	0.01	0.00	0.02	0.00	0.02	0.00
	17.	Calcium	as Ca	30.5	8.35	30.0	4.22	31.1	0.00	31.3	0.00	29.4	1.49
	18.	Chromium	as Cr	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00
	19.	Copper	as Cu	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	20.	Iron	as Fe	0.04	1.40	0.02	0.44	0.00	0.13	0.00	0.22	0.00	0.31
	21.	Lead	as Pb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	10.4	2.08	10.2	0.92	10.6	0.00	10.6	0.00	9.99	0.34
	24.	Manganese	as Mn	0.00	0.06	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.01
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.38		1.54		1.45		1.68		1.25	
	27.	Silver	as Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cations	28.	Sodium	as Na	6.11		6.31		6.97		7.29		6.09	
	29.	Strontium	as Sr	0.11	0.01	0.11	0.01	0.12	0.00	0.12	0.00	0.10	0.00
	30.	Zinc	as Zn	0.00	0.04	0.00	0.36	0.00	0.12	0.00	0.01	0.00	0.00
	31.	Total Cation Millequivalents		*2.680*		*2.656*		*2.771*		*2.803*		*2.589*	
	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	11.6		12.5		12.3		12.9		11.5	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.06		0.06		0.06		0.06		0.06	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.04		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.02		0.00		0.09		0.00		0.00	
	41.	Nitrate	as NO_3	0.00		0.95		0.77		0.90		0.81	
	42.	Nitrite	as NO_2	0.00		0.00		0.00		0.00		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.00		0.00		0.00	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.00	0.04	0.00	0.03	0.00	0.01	0.01	0.03	0.00	0.00
	49.	Sulfate	as SO_4	22.1		23.7		23.1		23.8		20.7	
	50.	Sulfur (total)	as S	6.61	0.71	6.92	0.64	7.30	0.00	7.64	0.00	7.13	0.00
	51.	Total Anion Millequivalents		*3.218*		*3.291*		*3.274*		*3.308*		*3.088*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.00		0.00		0.00		0.00		0.00	
	55.	Silica	as SiO_2	0.81	4.47	0.78	1.54	0.91	0.88	0.87	0.85	1.11	1.04
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

Analyst All data except pH in parts per million or as indicated.

Continued on reverse side.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 10/12/06 (#26908)		Treated 10/12/06 (#26908)		Control 10/19/06 (#26957)		Treated 10/19/06 (#26957)		Control 10/26/06 (#27021)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	59.	Bromate	as BrO_3										
Compounds	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon		<1.00		2.70		1.79		4.85		4.07	
	84.	Total Organic Nitrogen		<.124		1.06		0.55		0.48		<0.500	
	85.	Mexel (A-432)				6.0				5.0			

Analyst 0 All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding:	Indiana and Michigan Power Company
Location:	Donald C. Cook Nuclear Plant 1 Cook Place Bridgman, MI

Customer No.:	1001392
Report No.:	as indicated
Report Date:	
Analysis Date:	
Sample Date:	as indicated

				Treated 10/26/06 (#27021)		Control 11/2/06 (#27043)		Treated 11/2/06 (#27043)		Control 11/9/06 (#27107)		Treated 11/9/06 (#27107)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	6		0		0		6		6	
	2.	Alkalinity ("M")	as $CaCO_3$	118		134		128		118		116	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water Properties	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		7.5		11.4		9.1		5.2		7.7	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		205		222		212		200		206	
	8.	Hardness (Calcium)	as $CaCO_3$	74		81		80		81		83	
	9.	Hardness (Magnesium)	as $CaCO_3$	41		44		44		44		45	
	10.	Hardness (Total)	as $CaCO_3$	115		125		125		125		128	
	11.	pH		8.5		7.8		7.8		8.4		8.4	
	12.	Specific Conductance	µmhos	300		332		315		301		310	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			5.5		3,023		167		6.0		4.0
	15.	Aluminum	as Al	0.01	0.05	0.01	3.98	0.01	0.94	0.02	0.03	0.02	0.01
	16.	Barium	as Ba	0.02	0.00	0.02	0.03	0.02	0.01	0.02	0.00	0.02	0.00
	17.	Calcium	as Ca	29.5	1.13	32.4	48.9	32.1	10.1	32.3	0.00	33.2	0.00
	18.	Chromium	as Cr	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
	19.	Copper	as Cu	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
	20.	Iron	as Fe	0.00	0.12	0.00	8.01	0.00	1.67	0.00	0.10	0.00	0.05
	21.	Lead	as Pb	0.000	0.001	0.001	0.001	0.002	0.000	0.000	0.000	0.000	0.000
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	10.00	0.23	10.6	17.9	10.7	3.30	10.7	0.00	10.9	0.00
	24.	Manganese	as Mn	0.00	0.00	0.00	0.30	0.00	0.06	0.00	0.00	0.00	0.00
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.33		1.77		1.66		1.39		1.56	
	27.	Silver	as Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cations	28.	Sodium	as Na	6.15		8.30		8.23		6.95		7.30	
	29.	Strontium	as Sr	0.10	0.00	0.11	0.03	0.11	0.00	0.11	0.00	0.11	0.00
	30.	Zinc	as Zn	0.00	0.01	0.01	0.04	0.01	0.01	0.01	0.08	0.01	0.13
	31.	Total Cation Millequivalents		*2.600*		*2.903*		*2.892*		*2.842*		*2.921*	
	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	11.9		13.7		14.0		12.4	—	12.4	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.05		0.06		0.05		0.06		0.05	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.00		0.00		0.00		0.00		0.00	
	41.	Nitrate	as NO_3	0.86		1.20		1.09		1.05		0.91	
	42.	Nitrite	as NO_2	0.00		0.00		0.00		0.00		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.00		0.00		0.00	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.00	0.00	0.00	0.27	0.00	0.04	0.00	0.01	0.00	0.01
	49.	Sulfate	as SO_4	21.4		24.5		24.6		22.9		22.4	
	50.	Sulfur (total)	as S	7.08	0.00	8.31	0.73	8.13	0.00	7.47	0.00	7.63	0.00
	51.	Total Anion Millequivalents		*3.192*		*3.730*		*3.578*		*3.242*		*3.190*	
	52.	Ammonia	as NH_3							0.06		0.08	
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.00		3.80		2.29		0.00		0.00	
	55.	Silica	as SiO_2	1.01	0.59	1.25	14.41	1.16	4.98	1.06	0.36	1.06	0.33
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

All data except pH in parts per million or as indicated

Continued on reverse side.

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LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 10/26/06 (#27021)		Control 11/2/06 (#27043)		Treated 11/2/06 (#27043)		Control 11/9/06 (#27107)		Treated 11/9/06 (#27107)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	59.	Bromate	as BrO_3										
Compounds	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon		4.77		1.67		2.95		<1.00		2.74	
	84.	Total Organic Nitrogen		<0.500		<0.500		0.54		<0.500		<0.500	
	85.	Mexel (A-432)		2.0				1.0				3.0	

Analyst 0 All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 11/16/06 (#27142)		Treated 11/16/06 (#27142)		Control 11/22/06 (#27142)		Treated 11/22/06 (#27142)		Control 11/29/07 (#27177)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	0		0		0		0		0	
	2.	Alkalinity ("M")	as $CaCO_3$	134		136		122		120		122	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water Properties	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		10.0		9.5		3.8		9.2		4.0	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		232		236		207		218		213	
	8.	Hardness (Calcium)	as $CaCO_3$	91		93		82		83		85	
	9.	Hardness (Magnesium)	as $CaCO_3$	49		49		44		44		45	
	10.	Hardness (Total)	as $CaCO_3$	139		142		126		127		130	
	11.	pH		7.8		8.1		8.2		7.9		8.1	
	12.	Specific Conductance	µmhos	347		350		315		325		320	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			106		30.0		51.0		15.8		133
	15.	Aluminum	as Al	0.01	1.42	0.01	0.21	0.00	0.45	0.00	0.19	0.01	0.63
	16.	Barium	as Ba	0.02	0.01	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.01
	17.	Calcium	as Ca	36.2	5.81	37.3	0.00	32.7	3.66	33.0	0.05	34.1	5.75
	18.	Chromium	as Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	19.	Copper	as Cu	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
	20.	Iron	as Fe	0.00	2.21	0.00	0.43	0.00	0.85	0.00	0.31	0.00	1.33
	21.	Lead	as Pb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	11.8	2.36	11.9	0.05	10.7	1.29	10.8	0.13	11.0	2.49
	24.	Manganese	as Mn	0.00	0.09	0.00	0.02	0.00	0.03	0.00	0.01	0.00	0.05
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.48		1.63		1.30		1.49		1.36	
	27.	Silver	as Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cations	28.	Sodium	as Na	7.61		7.89		6.40		6.62		6.95	
	29.	Strontium	as Sr	0.11	0.00	0.11	0.00	0.10	0.00	0.10	0.00	0.11	0.01
	30.	Zinc	as Zn	0.00	0.03	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.03
	31.	Total Cation Millequivalents		*3.153*		*3.230*		*2.831*		*2.865*		*2.945*	
	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	12.7		13.3		11.1		11.3		11.5	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.05		0.03		0.00		0.00		0.04	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.00		0.00		0.00		0.00		0.00	
	41.	Nitrate	as NO_3	1.66		1.38		0.90		0.93		1.08	
	42.	Nitrite	as NO_2	0.00		0.00		0.00		0.00		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.00		0.00		0.00	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.00	0.07	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.21
	49.	Sulfate	as SO_4	22.6		22.8		21.0		24.4		21.4	
	50.	Sulfur (total)	as S	7.93	0.00	8.09	0.00	7.16	0.00	8.39	0.00	8.23	0.00
	51.	Total Anion Millequivalents		*3.602*		*3.652*		*3.244*		*3.281*		*3.291*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.40		0.26		0.18		0.12		0.99	
	55.	Silica	as SiO_2	1.66	5.63	1.56	1.08	1.04	2.03	1.08	1.32	1.16	1.81
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

Aw/a All data except pH in parts per million or as indicated

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LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 11/16/06 (#27142)		Treated 11/16/06 (#27142)		Control 11/22/06 (#27142)		Treated 11/22/06 (#27142)		Control 11/29/07 (#27177)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
Compounds	59.	Bromate	as BrO_3										
	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
Microbiological	69.	Aerobic Plate Count	org's/ml										
	70.	Anaerobic Plate Count	org's/ml.										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon		1.80		3.14		2.26		2.16		4.98	
	84.	Total Organic Nitrogen		<0.500		1.23		1.42		1.09		0.97	
	85.	Mexel (A-432)				3.0				3.0			

[illegible] 0 All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067
847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI.

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 11/29/06 (#27177)		Control 12/7/06 (#27204)		Treated 12/7/06 (#27204)		Control 12/14/06 (#27246)		Treated 12/14/06 (#27246)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	4		0		0		0		0	
	2.	Alkalinity ("M")	as $CaCO_3$	130		134		134		124		130	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water Properties	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		8.0		11.8		22.6		7.9		14.7	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		210		230		237		203		203	
	8.	Hardness (Calcium)	as $CaCO_3$	83		89		89		79		79	
	9.	Hardness (Magnesium)	as $CaCO_3$	45		47		47		43		43	
	10.	Hardness (Total)	as $CaCO_3$	128		136		136		122		122	
	11.	pH		8.2		7.9		7.8		8.0		7.9	
	12.	Specific Conductance	μmhos	314		337		350		306		296	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			6.0		315		78.0		340		21.0
	15.	Aluminum	as Al	0.01	0.03	0.01	3.35	0.01	1.02	0.02	2.34	0.01	0.46
	16.	Barium	as Ba	0.02	0.00	0.02	0.03	0.02	0.01	0.02	0.02	0.02	0.00
	17.	Calcium	as Ca	33.2	0.00	35.5	31.3	35.6	5.75	31.5	25.9	31.4	1.87
	18.	Chromium	as Cr	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00
	19.	Copper	as Cu	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.02	0.00	0.01
	20.	Iron	as Fe	0.00	0.05	0.00	6.03	0.00	1.56	0.00	4.34	0.00	0.54
	21.	Lead	as Pb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	10.8	0.00	11.5	11.0	11.5	1.98	10.5	9.43	10.5	0.71
	24.	Manganese	as Mn	0.00	0.00	0.00	0.22	0.00	0.05	0.00	0.13	0.00	0.01
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.53		1.56		1.65		1.23		1.25	
	27.	Silver	as Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cations	28.	Sodium	as Na	7.02		7.61		7.73		6.60		6.65	
	29.	Strontium	as Sr	0.11	0.00	0.11	0.03	0.11	0.00	0.10	0.03	0.10	0.00
	30.	Zinc	as Zn	0.01	0.02	0.00	0.06	0.00	0.04	0.00	0.04	0.00	0.02
	31.	Total Cation Millequivalents		*2.896*		*3.095*		*3.100*		*2.756*		*2.758*	
	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	11.7		13.4		14.1		11.9		11.7	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.05		0.00		0.04		0.04		0.04	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.00		0.00		0.00		0.00		0.00	
	41.	Nitrate	as NO_3	1.07		2.03		2.13		1.02		1.10	
	42.	Nitrite	as NO_2	0.00		0.00		0.00		0.00		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.00		0.00		0.00	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.00	0.14	1.01	0.00	0.45	0.00	0.00	0.15	0.00	0.03
	49.	Sulfate	as SO_4	21.5		23.3		28.4		22.3		21.9	
	50.	Sulfur (total)	as S	7.69	0.00	7.97	1.19	9.31	0.56	7.02	1.14	7.02	0.00
	51.	Total Anion Millequivalents		*3.446*		*3.685*		*3.795*		*3.342*		*3.451*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.59		0.05		0.01		0.00		0.00	
	55.	Silica	as SiO_2	1.06	0.26	2.25	11.02	2.26	3.69	1.37	8.42	1.35	2.05
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

All data except pH in parts per million or as indicated

Continued on reverse side.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 11/29/06 (#27177)		Control 12/7/06 (#27204)		Treated 12/7/06 (#27204)		Control 12/14/06 (#27246)		Treated 12/14/06 (#27246)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	59.	Bromate	as BrO_3										
Compounds	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon		3.94		5.14		13.80		5.36		4.39	
	84.	Total Organic Nitrogen		1.23		<0.500		1.01		<0.812		<0.800	
	85.	Mexel (A-432)		2.5				5.0				4.5	

Analyst 0 All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 12/21/06 (#27294)		Treated 12/21/06 (#27294)		Control 12/28/06 (#27323)		Treated 12/28/06 (#27323)		Control 1/4/07 (#27352)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	0		0		0		8		0	
	2.	Alkalinity ("M")	as $CaCO_3$	116		116		116		104		118	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water Properties	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		7.5		16.0		6.4		29.4		14.3	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		208		198		196		191		199	
	8.	Hardness (Calcium)	as $CaCO_3$	81		79		79		79		80	
	9.	Hardness (Magnesium)	as $CaCO_3$	43		43		44		44		43	
	10.	Hardness (Total)	as $CaCO_3$	124		123		123		123		123	
	11.	pH		7.7		8.0		8.2		8.4		8.0	
	12.	Specific Conductance	μmhos	308		293		295		293		295	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			106		3.0		13.0		13.0		305
	15.	Aluminum	as Al	0.02	1.07	0.02	0.03	0.02	0.80	0.02	0.12	0.01	3.11
	16.	Barium	as Ba	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.01	0.02
	17.	Calcium	as Ca	32.3	7.13	31.8	0.00	31.6	3.27	31.8	0.00	31.8	31.9
	18.	Chromium	as Cr	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
	19.	Copper	as Cu	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.08
	20.	Iron	as Fe	0.00	1.84	0.00	0.05	0.00	1.17	0.00	0.18	0.00	6.12
	21.	Lead	as Pb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	10.5	2.91	10.6	0.00	10.6	1.45	10.7	0.00	10.6	12.7
	24.	Manganese	as Mn	0.00	0.05	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.20
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.43		1.38		1.43		1.37		1.26	
	27.	Silver	as Ag	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Cations	28.	Sodium	as Na	5.89		6.12		6.70		6.65		6.34	
	29.	Strontium	as Sr	0.11	0.00	0.11	0.00	0.10	0.00	0.11	0.00	0.10	0.02
	30.	Zinc	as Zn	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.06
	31.	Total Cation Millequivalents		2.776		2.762		2.779		2.792		2.769	
	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	8.74		8.93		10.3		10.5		11.0	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.01		0.00		0.02		0.00		0.03	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.00		0.00		0.00		0.00		0.00	
	41.	Nitrate	as NO_3	1.28		0.60		0.85		1.03		0.98	
	42.	Nitrite	as NO_2	0.00		0.00		0.00		0.00		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.00		0.00		0.00	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.09	0.06	0.00	0.02	0.04	0.04	0.00	0.02	0.00	0.19
	49.	Sulfate	as SO_4	20.4		19.8		21.4		21.6		21.4	
	50.	Sulfur (total)	as S	6.54	0.94	6.59	0.88	6.80	0.75	6.78	0.62	7.32	1.99
	51.	Total Anion Millequivalents		3.064		3.029		3.142		2.900		3.132	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.00		0.00		1.45		0.82		0.00	
	55.	Silica	as SiO_2	1.44	1.88	1.08	0.00	1.15	2.15	1.12	0.00	0.00	9.75
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

All data except pH in parts per million or as indicated

Continued on reverse side.

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LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 12/21/06 (#27294)		Treated 12/21/06 (#27294)		Control 12/28/06 (#27323)		Treated 12/28/06 (#27323)		Control 1/4/07 (#27352)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	59.	Bromate	as BrO_3										
Compounds	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0:00	
	83.	Total Organic Carbon		1.94		4.29		3:09		7.78		5.63	
	84.	Total Organic Nitrogen		<0.500		0.51		<0.500		0.93		<0.500	
	85.	Mexel (A-432)				8.0				8.0			

All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

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LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding:	Indiana and Michigan Power Company
Location:	Donald C. Cook Nuclear Plant 1 Cook Place Bridgman, MI
Customer No.:	1001392
Report No.:	as indicated
Report Date:	
Analysis Date:	
Sample Date:	as indicated

				Treated 1/4/07 (#27352)		Control 1/11/07 (#27369		Treated 1/11/07 (#27369)		Control 1/18/07 (#27436)		Treated 1/18/07 (#27436)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
Water Properties	1.	Alkalinity ("P")	as $CaCO_3$	10		0		0		12		6	
	2.	Alkalinity ("M")	as $CaCO_3$	120		126		126		126		124	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		33.8		17.9		18.9		6.4		15.1	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		200		214		215		201		204	
	8.	Hardness (Calcium)	as $CaCO_3$	80		81		82		82		82	
	9.	Hardness (Magnesium)	as $CaCO_3$	44		43		44		44		44	
	10.	Hardness (Total)	as $CaCO_3$	123		124		127		126		126	
	11.	pH		8.5		8.0		8.0		8.4		8.2	
	12.	Specific Conductance	µmhos	298		319		323		303		307	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			25.0		195		34.0		38.0		26.0
Cations	15.	Aluminum	as Al	0.01	0.30	0.02	2.55	0.01	0.36	0.01	0.59	0.00	0.13
	16.	Barium	as Ba	0.01	0.01	0.02	0.02	0.02	0.00	0.01	0.01	0.01	0.01
	17.	Calcium	as Ca	31.8	1.40	32.3	18.0	32.9	5.42	32.7	4.18	32.7	1.76
	18.	Chromium	as Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	19.	Copper	as Cu	0.00	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	20.	Iron	as Fe	0.00	0.61	0.00	4.43	0.00	0.72	0.00	0.91	0.00	0.26
	21.	Lead	as Pb	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	10.6	0.75	10.6	5.60	10.8	0.95	10.7	0.90	10.7	0.03
	24.	Manganese	as Mn	0.00	0.02	0.00	0.16	0.00	0.03	0.00	0.03	0.00	0.01
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.27		1.40		1.65		1.29		1.32	
	27.	Silver	as Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
	28.	Sodium	as Na	6.43		6.70		7.34		6.83		6.89	
	29.	Strontium	as Sr	0.10	0.00	0.10	0.02	0.10	0.00	0.10	0.01	0.11	0.00
	30.	Zinc	as Zn	0.00	0.02	0.01	0.27	0.01	0.18	0.00	0.04	0.00	0.02
	31.	Total Cation Millequivalents		*2.775*		*2.810*		*2.891*		*2.845*		*2.852*	
Anions	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	11.0		12.7		12.5		11.3		11.1	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.03		0.00		0.00		0.00		0.00	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.00		0.00		0.00		0.00		0.00	
	41.	Nitrate	as NO_3	0.95		1.51		1.24		1.23		1.29	
	42.	Nitrite	as NO_2	0.00		0.00		0.00		1.00		0.34	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.00		0.00		0.00	
	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.00	0.02	0.00	0.06	0.00	0.00	0.00	0.02	0.00	0.00
	49.	Sulfate	as SO_4	21.1		23.3		22.7		21.3		20.8	
	50.	Sulfur (total)	as S	7.33	0.54	7.52	0.76	7.77	0.31	7.33	0.87	7.38	0.63
	51.	Total Anion Millequivalents		*3.167*		*3.388*		*3.365*		*3.325*		*3.254*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.00		0.00		0.00		0.00		0.00	
	55.	Silica	as SiO_2	0.00	0.83	0.00	7.75	0.00	0.00	0.00	0.00	0.00	0.00
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

All data except pH in parts per million or as indicated

Continued on reverse side.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 1/4/07 (#27352)		Control 1/11/07 (#27369		Treated 1/11/07 (#27369)		Control 1/18/07 (#27436)		Treated 1/18/07 (#27436)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	59.	Bromate	as BrO_3										
Compounds	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon		10.20		6.22		9.07					
	84.	Total Organic Nitrogen		0.86		<0.500		<0.500					
	85.	Mexel (A-432)		10.0				4.0				4.0	

Analyst 0 All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067
847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 1/25/07 (#27429)		Treated 1/25/07 (#27429)		Control 2/1/07 (#27466)		Treated 2/1/07 (#27466)		Control 2/8/07 (#27502)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	0		0		8		6		10	
	2.	Alkalinity ("M")	as $CaCO_3$	120		120		122		120		126	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water Properties	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		3.9		7.1		11.8		7.0		7.4	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		212		214		211		208		209	
	8.	Hardness (Calcium)	as $CaCO_3$	82		82		81		80		80	
	9.	Hardness (Magnesium)	as $CaCO_3$	45		45		43		44		45	
	10.	Hardness (Total)	as $CaCO_3$	127		127		124		125		125	
	11.	pH		8.2		8.2		8.2		8.2		8.1	
	12.	Specific Conductance	µmhos	317		318		310		309		310	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			427		37.0		10.0		11.0		234
	15.	Aluminum	as Al	0.01	2.09	0.01	0.50	0.01	0.19	0.01	0.13	0.01	1.98
	16.	Barium	as Ba	0.02	0.01	0.01	0.00	0.02	0.00	0.02	0.00	0.02	0.01
	17.	Calcium	as Ca	32.8	16.2	32.8	1.05	32.3	0.00	32.2	0.00	31.9	13.5
	18.	Chromium	as Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	19.	Copper	as Cu	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
	20.	Iron	as Fe	0.00	3.57	0.00	0.75	0.00	0.24	0.00	0.20	0.00	3.38
	21.	Lead	as Pb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	10.9	5.84	10.8	0.57	10.5	0.54	10.7	0.35	11.0	4.56
	24.	Manganese	as Mn	0.00	0.11	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.09
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.46		1.63		1.29		1.34		1.06	
	27.	Silver	as Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cations	28.	Sodium	as Na	7.37		7.70		6.74		6.74		6.44	
	29.	Strontium	as Sr	0.10	0.02	0.10	0.00	0.11	0.00	0.11	0.00	0.11	0.01
	30.	Zinc	as Zn	0.00	0.02	0.00	0.01	0.01	0.02	0.00	0.05	0.00	0.05
	31.	Total Cation Millequivalents		*2.896*		*2.908*		*2.811*		*2.817*		*2.807*	
	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	12.2		12.0		10.2		10.3		9.34	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.00		0.00		0.00		0.00		0.00	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.10		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.00		0.00		0.00		0.00		0.01	
	41.	Nitrate	as NO_3	1.13		1.08		0.00		0.00		1.05	
	42.	Nitrite	as NO_2					0.00		0.00		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4					0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4					0.00		0.00		0.00	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P					0.00	0.00	0.00	0.00	0.00	0.10
	49.	Sulfate	as SO_4					22.0		22.1		22.4	
	50.	Sulfur (total)	as S					7.66	0.75	7.60	0.52	7.55	0.50
	51.	Total Anion Millequivalents		*#VALUE!*		*#VALUE!*		*3.206*		*3.165*		*3.267*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B					0.92		0.63		0.00	
	55.	Silica	as SiO_2					0.00	0.00	0.00	0.00	0.00	0.00
	56.	Sodium Nitrite	as $NaNO_2$	#VALUE!		#VALUE!							
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

All data except pH in parts per million or as indicated

Continued on reverse side.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 1/25/07 (#27429)		Treated 1/25/07 (#27429)		Control 2/1/07 (#27466)		Treated 2/1/07 (#27466)		Control 2/8/07 (#27502)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	59.	Bromate	as BrO_3										
Compounds	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$										
	83.	Total Organic Carbon											
	84.	Total Organic Nitrogen											
	85.	Mexel (A-432)								1.50			

Analyst 0 All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 2/8/07 (#27502)		Control 2/15/07 (#27541)		Treated 2/15/07 (#27541)		Control 3/1/07 (#27631)		Treated 3/1/07 (#27631)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	12		6		8		0		0	
	2.	Alkalinity ("M")	as $CaCO_3$	128		144		144		122		120	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water Properties	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		16.6		8.6		7.7		5.4		6.1	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		210		232		235		208		208	
	8.	Hardness (Calcium)	as $CaCO_3$	79		95		95		87		86	
	9.	Hardness (Magnesium)	as $CaCO_3$	45		49		50		46		46	
	10.	Hardness (Total)	as $CaCO_3$	125		145		145		133		132	
	11.	pH		8.3		8.1		8.1		8.0		8.2	
	12.	Specific Conductance	µmhos	312		346		350		311		304	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			4.5		7.0		7.0		83.0		3.0
	15.	Aluminum	as Al	0.01	0.08	0.00	0.09	0.01	0.08	0.01	0.63	0.01	0.03
	16.	Barium	as Ba	0.02	0.00	0.02	0.01	0.02	0.01	0.02	0.00	0.02	0.00
	17.	Calcium	as Ca	31.8	0.00	38.1	0.00	38.1	0.00	34.6	4.75	34.4	0.00
	18.	Chromium	as Cr	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00
	19.	Copper	as Cu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.03
	20.	Iron	as Fe	0.00	0.10	0.00	0.15	0.00	0.14	0.00	1.46	0.00	0.06
	21.	Lead	as Pb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	11.0	0.00	12.0	0.17	12.1	0.24	11.3	1.58	11.3	0.00
	24.	Manganese	as Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.09		1.53		1.49		1.42		1.31	
	27.	Silver	as Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cations	28.	Sodium	as Na	6.45		7.51		7.31		6.56		6.49	
	29.	Strontium	as Sr	0.11	0.00	0.10	0.00	0.10	0.00	0.11	0.00	0.11	0.00
	30.	Zinc	as Zn	0.00	0.03	0.00	0.02	0.00	0.02	0.01	0.02	0.01	0.00
	31.	Total Cation Millequivalents		*2.800*		*3.255*		*3.261*		*2.982*		*2.963*	
	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	9.78		13.5		13.8		11.4		11.3	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.00		0.10		0.11		0.10		0.10	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.00		0.00		0.00		0.01		0.00	
	41.	Nitrate	as NO_3	0.96		1.84		1.90		1.45		1.29	
	42.	Nitrite	as NO_2	0.00		0.01		0.00		0.00		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.12		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.49		0.00		0.00		0.00	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.05	0.00	0.00
	49.	Sulfate	as SO_4	22.3		24.4		24.7		21.2		21.6	
	50.	Sulfur (total)	as S	7.52	0.00	8.08	0.00	8.25	0.00	7.44	0.25	7.51	0.00
	51.	Total Anion Millequivalents		*3.316*		*3.808*		*3.821*		*3.290*		*3.262*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.00		0.16		0.10		0.00		0.00	
	55.	Silica	as SiO_2	0.00	0.00	0.00	0.00	0.00	0.00	1.65	2.38	1.99	0.06
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

Analyst: All data except pH in parts per million or as indicated.

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LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 2/8/07 (#27502)		Control 2/15/07 (#27541)		Treated 2/15/07 (#27541)		Control 3/1/07 (#27631)		Treated 3/1/07 (#27631)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
Compounds	59.	Bromate	as BrO_3										
	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
Microbiological	69.	Aerobic Plate Count	org's/ml										
	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon											
	84.	Total Organic Nitrogen											
	85.	Mexel (A-432)		2.5				1.0				2.5	

Analys 0 All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

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LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 3/8/07 (#27631)		Treated 3/8/07 (#27631)		Control 3/15/07 (#27677)		Treated 3/15/07 (#27677)		Control 3/22/07 (#27694)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	0		0		10		10		10	
	2.	Alkalinity ("M")	as $CaCO_3$	132		134		126		126		138	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water Properties	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		2.7		4.4		20.7		5.2		14.6	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		237		241		209		200		226	
	8.	Hardness (Calcium)	as $CaCO_3$	99		99		80		79		86	
	9.	Hardness (Magnesium)	as $CaCO_3$	52		52		44		43		46	
	10.	Hardness (Total)	as $CaCO_3$	151		151		124		123		133	
	11.	pH		8.2		8.2		8.2		8.3		8.2	
	12.	Specific Conductance	μmhos	358		359		316		308		338	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			20.0		54.0		543		19.0		280
	15.	Aluminum	as Al	0.01	0.19	0.01	0.32	0.01	5.30	0.01	0.29	0.01	2.44
	16.	Barium	as Ba	0.02	0.00	0.02	0.00	0.02	0.03	0.02	0.00	0.02	0.02
	17.	Calcium	as Ca	39.4	0.00	39.5	1.47	32.0	42.7	31.8	0.85	34.6	25.3
	18.	Chromium	as Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	19.	Copper	as Cu	0.00	0.02	0.00	0.03	0.00	0.01	0.00	0.00	0.00	0.00
	20.	Iron	as Fe	0.00	0.34	0.00	0.78	0.00	9.31	0.00	0.50	0.00	5.39
	21.	Lead	as Pb	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.003	0.000	0.005
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	12.6	0.00	12.6	0.97	10.6	17.0	10.6	0.08	11.2	9.27
	24.	Manganese	as Mn	0.00	0.01	0.00	0.03	0.00	0.33	0.00	0.02	0.00	0.24
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	26.	Potassium	as K	1.56		1.58		1.34		1.30		1.44	
	27.	Silver	as Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cations	28.	Sodium	as Na	8.44		8.52		6.61		6.57		6.81	
	29.	Strontium	as Sr	0.12	0.00	0.11	0.00	0.11	0.04	0.11	0.00	0.10	0.03
	30.	Zinc	as Zn	0.01	0.01	0.01	0.01	0.01	0.04	0.00	0.01	0.01	0.05
	31.	Total Cation Milliequivalents		*3.415*		*3.424*		*2.792*		*2.776*		*2.984*	
	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	14.7		15.1		11.7		11.6		12.9	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.11		0.11		0.11		0.11		0.11	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.03	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.00		0.00		0.00		0.00		0.00	
	41.	Nitrate	as NO_3	2.24		2.32		1.27		1.16		1.94	
	42.	Nitrite	as NO_2	0.00		0.00		0.00		0.00		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.00		0.00		0.00	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.01	0.12
	49.	Sulfate	as SO_4	24.2		24.6		21.3		21.2		22.6	
	50.	Sulfur (total)	as S	8.39	0.00	8.42	0.00	7.01	1.02	6.79	0.00	7.51	0.91
	51.	Total Anion Milliequivalents		*3.683*		*3.740*		*3.364*		*3.358*		*3.689*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.00		0.00		0.00		0.00		0.01	
	55.	Silica	as SiO_2	2.41	0.67	2.40	1.60	1.34	22.43	1.32	2.16	1.68	11.77
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

All data except pH in parts per million or as indicated

Continued on reverse side.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 3/8/07 (#27631)		Treated 3/8/07 (#27631)		Control 3/15/07 (#27677)		Treated 3/15/07 (#27677)		Control 3/22/07 (#27694)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
Compounds	59.	Bromate	as BrO_3										
	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{16}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
Microbiological	69.	Aerobic Plate Count	org's/ml										
	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon											
	84.	Total Organic Nitrogen											
	85.	Mexel (A-432)				<1.0				1.5			

Analyst 0 All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 3/22/07 (#27694)		Control 3/28/07 (#27725)		Treated 3/28/07 (#27725)		Control 4/10/07 (#27790)		Treated 4/10/07 (#27790)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	10		8		8		0		0	
	2.	Alkalinity ("M")	as $CaCO_3$	136		126		126		132		132	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water Properties	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		8.2		16.2		7.6		6.6		7.5	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		222		209		209		211		222	
	8.	Hardness (Calcium)	as $CaCO_3$	86		82		82		88		89	
	9.	Hardness (Magnesium)	as $CaCO_3$	46		45		45		48		48	
	10.	Hardness (Total)	as $CaCO_3$	132		128		127		136		137	
	11.	pH		8.2		8.2		8.2		8.1		8.0	
	12.	Specific Conductance	µmhos	335		312		312		332		323	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			21.5		154		1.0		2.5		1.5
	15.	Aluminum	as Al	0.01	0.26	0.01	1.27	0.01	0.04	0.01	0.06	0.01	0.06
	16.	Barium	as Ba	0.02	0.00	0.02	0.01	0.02	0.00	0.02	0.00	0.02	0.00
	17.	Calcium	as Ca	34.4	1.97	32.8	12.2	32.9	0.00	35.4	0.00	35.8	0.00
	18.	Chromium	as Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	19.	Copper	as Cu	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00
	20.	Iron	as Fe	0.00	0.48	0.00	3.14	0.00	0.20	0.00	0.08	0.00	0.06
	21.	Lead	as Pb	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	11.1	0.59	11.0	4.05	11.0	0.00	11.5	0.00	11.6	0.00
	24.	Manganese	as Mn	0.00	0.02	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.35		1.31		1.29		1.56		1.45	
	27.	Silver	as Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cations	28.	Sodium	as Na	6.57		7.09		6.95		9.04		8.29	
	29.	Strontium	as Sr	0.10	0.00	0.11	0.01	0.11	0.00	0.12	0.00	0.11	0.00
	30.	Zinc	as Zn	0.01	0.03	0.00	0.05	0.01	0.01	0.01	0.08	0.01	0.01
	31.	Total Cation Millequivalents		*2.952*		*2.893*		*2.884*		*3.153*		*3.140*	
	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	12.6		11.6		12.1		13.4		13.7	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.10		0.10		0.10		0.11		0.11	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.00		0.01		0.00		0.00		0.00	
	41.	Nitrate	as NO_3	1.79		1.22		1.13		1.44		1.32	
	42.	Nitrite	as NO_2	0.00		0.08		0.00		0.00		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.00		0.00		0.00	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.00	0.00	0.00	0.09	0.00	0.01	0.01	0.00	0.02	0.00
	49.	Sulfate	as SO_4	22.4		21.0		21.8		22.2		22.7	
	50.	Sulfur (total)	as S	7.57	0.00	6.93	0.80	6.97	0.00	7.70	0.00	7.76	0.00
	51.	Total Anion Millequivalents		*3.632*		*3.357*		*3.384*		*3.546*		*3.561*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.00		0.00		0.00		0.00		0.00	
	55.	Silica	as SiO_2	1.64	2.01	1.37	5.67	1.35	0.49	1.05	0.00	1.05	0.10
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

All data except pH in parts per million or as indicated

Continued on reverse side.

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LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company	Customer No.: 1001392
Location: Donald C. Cook Nuclear Plant	Report No.: as indicated
1 Cook Place	Report Date:
Bridgman, MI	Analysis Date:
	Sample Date: as indicated

				Treated 3/22/07 (#27694)		Control 3/28/07 (#27725)		Treated 3/28/07 (#27725)		Control 4/10/07 (#27790)		Treated 4/10/07 (#27790)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	59.	Bromate	as BrO_3										
Compounds	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon											
	84.	Total Organic Nitrogen											
	85.	Mexel (A-432)		2.5				1.5				1.5	

0 All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

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LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company	Customer No.: 1001392
Location: Donald C. Cook Nuclear Plant	Report No.: as indicated
1 Cook Place	Report Da
	Analysis [
Bridgman, MI	Sample Date: as indicated

				Control 4/19/07 (#27817)		Treated 4/19/07 (#27817)		Control 5/3/07 (#27972)		Treated 5/3/07 (#27972)		Control 5/10/07 (#27972)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	0		10		10		10		10	
	2.	Alkalinity ("M")	as $CaCO_3$	162		162		134		144		138	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		15.4		9.0		6.1		6.5		6.5	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		263		263		218		227		229	
	8.	Hardness (Calcium)	as $CaCO_3$	118		109		88		93		92	
	9.	Hardness (Magnesium)	as $CaCO_3$	62		57		47		51		51	
Properties	10.	Hardness (Total)	as $CaCO_3$	180		166		134		144		143	
	11.	pH		8.0		8.3		8.2		8.2		8.3	
	12.	Specific Conductance	µmhos	399		392		327		341		343	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			175		8.0		1.0		1.0		1.0
	15.	Aluminum	as Al	0.02	1.79	0.02	0.15	0.01	0.02	0.01	0.01	0.01	0.01
	16.	Barium	as Ba	0.03	0.01	0.03	0.00	0.02	0.00	0.02	0.00	0.02	0.00
	17.	Calcium	as Ca	47.3	6.85	43.5	0.00	35.0	0.00	37.3	0.00	36.8	0.00
	18.	Chromium	as Cr	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	19.	Copper	as Cu	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	20.	Iron	as Fe	0.00	3.68	0.00	2.83	0.00	0.09	0.00	0.02	0.00	0.02
	21.	Lead	as Pb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	15.0	2.51	13.9	0.00	11.4	0.00	12.4	0.00	12.3	0.00
	24.	Manganese	as Mn	0.00	0.15	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.85		1.58		1.35		1.32		1.28	
	27.	Silver	as Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cations	28.	Sodium	as Na	9.19		8.68		6.87		7.19		7.13	
	29.	Strontium	as Sr	0.13	0.00	0.11	0.00	0.11	0.00	0.11	0.00	0.11	0.00
	30.	Zinc	as Zn	0.01	0.09	0.01	0.00	0.00	0.23	0.00	0.06	0.00	0.05
	31.	Total Cation Millequivalents		*4.045*		*3.735*		*3.019*		*3.232*		*3.197*	
	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	15.7		15.8		11.9		13.3		13.1	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.10		0.10		0.09		0.08		0.09	
	38.	Formate	as CHO_2	0.05		0.00		0.04		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.07		0.02		0.02		0.01		0.00	
	41.	Nitrate	as NO_3	2.58		2.52		1.40		1.68		1.68	
	42.	Nitrite	as NO_2	0.06		0.00		1.06		0.24		0.32	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.00		0.00		0.00	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	49.	Sulfate	as SO_4	24.8		25.1		21.8		23.4		22.8	
	50.	Sulfur (total)	as S	8.60	0.00	8.04	0.00	6.99	0.00	7.47	0.00	7.28	0.00
	51.	Total Anion Millequivalents		*4.460*		*4.397*		*3.624*		*3.888*		*3.731*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	5.84		3.24		0.09		0.08		0.02	
	55.	Silica	as SiO_2	2.26	6.12	2.00	0.82	3.04	0.00	3.18	0.00	2.64	0.00
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

All data except pH in parts per million or as indicated

Continued on reverse side.

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LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date: 1/0/00
Analysis Date: 1/0/00
Sample Date: as indicated

				Control 4/19/07 (#27817)		Treated 4/19/07 (#27817)		Control 5/3/07 (#27972)		Treated 5/3/07 (#27972)		Control 5/10/07 (#27972)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	59.	Bromate	as BrO_3										
Compounds	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon											
	84.	Total Organic Nitrogen											
	85.	Mexel (A-432)				1.5				2.5			

All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

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LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 5/10/07 (#27972)		Control 5/17/07 (#27958)		Treated 5/17/07 (#27958)		Control 5/24/07 (#27999)		Treated 5/24/07 (#27999)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	10		0		0		0		0	
	2.	Alkalinity ("M")	as $CaCO_3$	134		152		154		122		124	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water Properties	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		7.1		16.0		16.3		5.9		6.3	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		216		231		236		214		210	
	8.	Hardness (Calcium)	as $CaCO_3$	88		86		86		68		68	
	9.	Hardness (Magnesium)	as $CaCO_3$	49		46		47		40		40	
	10.	Hardness (Total)	as $CaCO_3$	136		132		134		108		108	
	11.	pH		8.2		7.8		8.0		7.8		8.1	
	12.	Specific Conductance	µmhos	327		346		346		319		320	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			1.0		160		8.0		7.0		2.0
	15.	Aluminum	as Al	0.01	0.04	0.01	1.43	0.01	0.15	0.01	0.08	0.00	0.02
	16.	Barium	as Ba	0.02	0.00	0.02	0.01	0.02	0.00	0.02	0.00	0.02	0.00
	17.	Calcium	as Ca	35.1	0.00	34.2	15.2	34.6	3.80	27.3	1.44	27.3	0.00
	18.	Chromium	as Cr	0.00	0.00	0.00	0.01	0.00	0.01	0.03	0.02	0.03	0.01
	19.	Copper	as Cu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	20.	Iron	as Fe	0.00	0.10	0.01	2.76	0.01	0.32	0.01	0.22	0.00	0.02
	21.	Lead	as Pb	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	11.8	0.00	11.2	4.98	11.5	0.76	9.69	0.17	9.63	0.00
	24.	Manganese	as Mn	0.00	0.00	0.00	0.12	0.00	0.01	0.00	0.01	0.00	0.00
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.22		1.38		1.43		2.07		1.90	
	27.	Silver	as Ag	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Cations	28.	Sodium	as Na	6.63		7.39		7.72		8.47		8.35	
	29.	Strontium	as Sr	0.11	0.00	0.11	0.02	0.11	0.01	0.12	0.00	0.13	0.00
	30.	Zinc	as Zn	0.00	0.05	0.00	0.17	0.00	0.13	0.01	0.45	0.00	0.30
	31.	Total Cation Millequivalents		*3.044*		*2.993*		*3.045*		*2.583*		*2.570*	
	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	11.9		12.7		13.1		12.7		12.0	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.09		0.00		0.11		0.09		0.10	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.49		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.00		0.00		0.00		0.01		0.01	
	41.	Nitrate	as NO_3	1.35		1.74		1.69		0.91		0.81	
	42.	Nitrite	as NO_2	0.00		0.06		0.00		0.00		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.00		0.00		0.00	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.00	0.00	0.00	0.06	0.00	0.01	0.00	0.00	0.00	0.00
	49.	Sulfate	as SO_4	21.6		23.6		24.7		21.5		20.9	
	50.	Sulfur (total)	as S	7.05	0.00	7.71	0.00	7.67	0.00	6.40	0.21	6.19	0.00
	51.	Total Anion Millequivalents		*3.566*		*3.991*		*4.061*		*3.317*		*3.365*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.00		0.00		0.00		0.00		0.00	
	55.	Silica	as SiO_2	2.23	0.00	2.00	5.15	1.91	1.27	1.47	0.61	2.69	0.00
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_8N_3$										

Analyst

All data except pH in parts per million or as indicated

Continued on reverse side.

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LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 5/10/07 (#27972)		Control 5/17/07 (#27958)		Treated 5/17/07 (#27958)		Control 5/24/07 (#27999)		Treated 5/24/07 (#27999)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	59.	Bromate	as BrO_3										
Compounds	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon											
	84.	Total Organic Nitrogen											
	85.	Mexel (A-432)		2.5				2.5				2.5	

0. All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 5/31/07 (#27999)		Treated 5/31/07 (#27999)		Control 6/21/07 (#28100)		Treated 6/21/07 (#28100)		Control 6/28/07 (#28129)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	0		6		0		10		0	
	2.	Alkalinity ("M")	as $CaCO_3$	118		120		154		150		130	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water Properties	4.	*Free Mineral Acidity*	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		12.6		13.0		8.9		7.3		23.4	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		210		211		213		210		224	
	8.	Hardness (Calcium)	as $CaCO_3$	70		68		82		81		86	
	9.	Hardness (Magnesium)	as $CaCO_3$	41		40		46		45		46	
	10.	Hardness (Total)	as $CaCO_3$	111		108		128		127		132	
	11.	pH		8.1		8.4		7.9		8.2		7.7	
	12.	Specific Conductance	µmhos	317		315		318		314		338	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			73.0		7.0		144		6.5		213
	15.	Aluminum	as Al	0.00	0.59	0.00	0.05	0.01	1.16	0.01	0.03	0.01	0.87
	16.	Barium	as Ba	0.02	0.01	0.02	0.00	0.02	0.01	0.02	0.00	0.02	0.01
	17.	Calcium	as Ca	28.0	3.37	27.1	0.99	32.6	8.78	32.5	0.00	34.5	19.4
	18.	Chromium	as Cr	0.04	0.01	0.03	0.01	0.01	0.01	0.01	0.00	0.00	0.02
	19.	Copper	as Cu	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.02	0.00	0.02
	20.	Iron	as Fe	0.00	0.93	0.00	0.12	0.03	2.39	0.03	0.06	0.00	2.51
	21.	Lead	as Pb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	9.93	0.00	9.62	0.02	11.1	3.03	11.0	0.00	11.1	5.22
	24.	Manganese	as Mn	0.00	0.05	0.00	0.00	0.00	0.11	0.00	0.00	0.03	0.14
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
	26.	Potassium	as K	2.01		1.83		1.46		1.41		1.51	
	27.	Silver	as Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
Cations	28.	Sodium	as Na	8.36		8.08		7.69		7.49		7.51	
	29.	Strontium	as Sr	0.12	0.00	0.12	0.00	0.11	0.00	0.11	0.00	0.11	0.01
	30.	Zinc	as Zn	0.00	0.29	0.00	0.24	0.01	0.02	0.01	0.01	0.00	0.04
	31.	Total Cation Millequivalents		*2.631*		*2.546*		*2.924*		*2.896*		*3.009*	
	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	12.5		12.4		12.0		12.8		12.2	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.10		0.09		0.08		0.08		0.07	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.01		0.01		0.00		0.00		0.00	
	41.	Nitrate	as NO_3	0.92		0.87		0.00		0.00		0.71	
	42.	Nitrite	as NO_2	0.00		0.00		0.00		0.00		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.50		0.52		0.00	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.07	0.00	0.16
	49.	Sulfate	as SO_4	20.9		21.2		20.2		21.4		21.9	
	50.	Sulfur (total)	as S	6.43	0.36	6.23	0.50	7.03	1.56	7.01	0.89	7.02	0.96
	51.	Total Anion Millequivalents		*3.223*		*3.252*		*3.948*		*3.889*		*3.502*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.00		0.00		0.00		0.00		0.00	
	55.	Silica	as SiO_2	1.58	3.13	1.18	0.38	3.13	5.22	2.34	0.73	2.60	4.39
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

All data except pH in parts per million or as indicated

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LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 5/31/07 (#27999)		Treated 5/31/07 (#27999)		Control 6/21/07 (#28100)		Treated 6/21/07 (#28100)		Control 6/28/07 (#28129)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
Compounds	59.	Bromate	as BrO_3										
	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon											
	84.	Total Organic Nitrogen											
	85.	Mexel (A-432)				2.5				2.5			

Analyst 0: All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 6/28/07 (#28129)		Control 7/5/07 (#27190)		Treated 7/5/07 (#27190)		Control 7/12/07 (#27190)		Treated 7/12/07 (#27190)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	0		0		0		0		10	
	2.	Alkalinity ("M")	as $CaCO_3$	126		134		134		134		130	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
W	4.	Free Mineral Acidity	as $CaCO_3$										
a	5.	Chemical Oxygen Demand (C.O.D.)		15.6		7.8		7.5		6.9		6.6	
t	6.	Chloroform Extractables											
e	7.	Dissolved Solids		214		219		206		214		206	
r	8.	Hardness (Calcium)	as $CaCO_3$	84		84		81		83		81	
	9.	Hardness (Magnesium)	as $CaCO_3$	46		44		44		44		45	
P	10.	Hardness (Total)	as $CaCO_3$	131		128		125		127		126	
r	11.	pH		8.1		7.8		8.1		7.8		8.2	
o	12.	Specific Conductance	µmhos	318		327		310		318		307	
p	13.	Specific Gravity	g/ml										
e	14.	Suspended Solids			0.0		174		2.0		245		8.0
r	15.	Aluminum	as Al	0.01	0.02	0.01	1.78	0.02	0.03	0.01	2.00	0.01	0.09
t	16.	Barium	as Ba	0.02	0.00	0.02	0.01	0.02	0.00	0.02	0.02	0.02	0.00
i	17.	Calcium	as Ca	33.7	0.96	33.4	12.4	32.3	0.97	33.1	20.8	32.4	1.52
e	18.	Chromium	as Cr	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.02	0.00	0.01
s	19.	Copper	as Cu	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.03
	20.	Iron	as Fe	0.00	0.12	0.00	2.73	0.00	0.09	0.01	3.55	0.00	0.30
	21.	Lead	as Pb	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.004	0.000	0.001
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	11.2	0.00	10.8	3.87	10.8	0.00	10.7	5.75	10.8	0.12
	24.	Manganese	as Mn	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.19	0.00	0.01
	25.	Nickel	as Ni	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.42		1.43		1.31		1.34		1.31	
	27.	Silver	as Ag	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C	28.	Sodium	as Na	7.23		7.12		6.80		6.82		6.79	
a	29.	Strontium	as Sr	0.11	0.00	0.11	0.01	0.11	0.00	0.11	0.02	0.11	0.00
t i	30.	Zinc	as Zn	0.01	0.34	0.01	0.05	0.01	0.01	0.01	0.05	0.01	0.09
o	31.	Total Cation Millequivalents		*2.960*		*2.904*		*2.829*		*2.871*		*2.839*	
n	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
s	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	12.1		11.9		12.0		12.0		12.2	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.06		0.07		0.08		0.07		0.07	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.00		0.00		0.00		0.00		0.00	
	41.	Nitrate	as NO_3	1.09		2.66		1.10		1.35		1.12	
	42.	Nitrite	as NO_2	0.00		0.00		0.00		0.06		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.00		0.00		0.00	
	46.	Phosphate (poly)	as PO_4										
A	47.	Phosphate (organo)	as PO_4										
n i	48.	Phosphorus (total)	as P	0.00	0.05	0.02	0.11	0.00	0.02	0.00	0.15	0.00	0.03
o	49.	Sulfate	as SO_4	22.7		21.8		22.3		22.3		22.7	
n	50.	Sulfur (total)	as S	7.03	0.60	6.91	1.08	6.84	0.84	6.80	1.23	6.83	0.82
s	51.	Total Anion Millequivalents		*3.426*		*3.737*		*3.586*		*3.653*		*3.509*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.00		0.00		0.00		0.00		0.00	
	55.	Silica	as SiO_2	2.14	0.99	6.62	7.54	2.55	1.99	4.33	8.27	2.14	0.98
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

Anys. All data except pH in parts per million or as indicated

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LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 6/28/07 (#28129)		Control 7/5/07 (#27190)		Treated 7/5/07 (#27190)		Control 7/12/07 (#27190)		Treated 7/12/07 (#27190)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	59.	Bromate	as BrO_3										
Compounds	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon											
	84.	Total Organic Nitrogen											
	85.	Mexel (A-432)		3.0				2.5				2.5	

Anays 0 All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 7/19/07 (#28250)		Treated 7/19/07 (#28250)		Control 7/25/07 (#28250)		Treated 7/25/07 (#28250)		Control 8/2/07 (#28301)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	0		12		0		12		0	
	2.	Alkalinity ("M")	as $CaCO_3$	130		128		132		128		130	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water Properties	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		6.0		8.1		5.5		6.4		10.2	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		204		210		210		208		208	
	8.	Hardness (Calcium)	as $CaCO_3$	80		79		81		80		80	
	9.	Hardness (Magnesium)	as $CaCO_3$	43		43		43		44		44	
	10.	Hardness (Total)	as $CaCO_3$	123		122		124		123		124	
	11.	pH		8.1		8.4		8.0		8.4		8.0	
	12.	Specific Conductance	µmhos	305		312		311		309		309	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			66.0		4.0		109		2.0		66.0
	15.	Aluminum	as Al	0.01	0.66	0.01	0.05	0.01	1.10	0.02	0.04	0.01	0.84
	16.	Barium	as Ba	0.02	0.01	0.02	0.00	0.02	0.01	0.02	0.00	0.02	0.01
	17.	Calcium	as Ca	31.9	6.22	31.5	0.00	32.5	8.06	31.8	0.00	32.0	5.39
	18.	Chromium	as Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	19.	Copper	as Cu	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
	20.	Iron	as Fe	0.00	1.05	0.00	0.05	0.07	1.70	0.00	0.07	0.00	1.33
	21.	Lead	as Pb	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	10.4	1.55	10.4	0.00	10.4	2.34	10.6	0.00	10.7	1.33
	24.	Manganese	as Mn	0.00	0.06	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.09
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.34		1.30		1.26		1.23		1.30	
	27.	Silver	as Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
Cations	28.	Sodium	as Na	7.09		6.80		6.53		6.50		6.50	
	29.	Strontium	as Sr	0.11	0.01	0.10	0.00	0.10	0.01	0.10	0.00	0.11	0.00
	30.	Zinc	as Zn	0.02	0.04	0.01	0.01	0.01	0.03	0.01	0.02	0.00	0.01
	31.	Total Cation Millequivalents		*2.796*		*2.762*		*2.806*		*2.782*		*2.795*	
	32.	Acetate	as $C_2H_3O_2$	0.50		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	11.4		10.8		11.1		11.4		10.3	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.05		0.05		0.05		0.05		0.07	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.00		0.00		0.00		0.00		0.00	
	41.	Nitrate	as NO_3	1.69		0.93		1.25		0.93		1.17	
	42.	Nitrite	as NO_2	0.00		0.00		0.00		0.00		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.00		0.00		0.00	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.00	0.03	0.00	0.00	0.01	0.05	0.01	0.00	0.00	0.03
	49.	Sulfate	as SO_4	20.4		19.5		20.0		20.8		20.0	
	50.	Sulfur (total)	as S	7.41	0.00	7.20	0.00	7.32	0.00	7.33	0.00	6.79	0.17
	51.	Total Anion Millequivalents		*3.504*		*3.345*		*3.518*		*3.410*		*3.494*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.00		0.00		0.00		0.00		0.00	
	55.	Silica	as SiO_2	3.59	3.53	1.67	0.99	3.71	5.34	2.36	0.84	4.88	3.42
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

Analyst

All data except pH in parts per million or as indicated

Continued on reverse side.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067
847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Control 7/19/07 (#28250)		Treated 7/19/07 (#28250)		Control 7/25/07 (#28250)		Treated 7/25/07 (#28250)		Control 8/2/07 (#28301)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
Compounds	59.	Bromate	as BrO_3										
	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon											
	84.	Total Organic Nitrogen											
	85.	Mexel (A-432)				2.5				2.5			

0 All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 8/2/07 (#28301)		Control 8/8/07 (#28301)		Treated 8/8/07 (#28301)		Control 8/15/07 (#28332)		Treated 8/15/07 (#28332)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	1.	Alkalinity ("P")	as $CaCO_3$	16		0		14		0		8	
	2.	Alkalinity ("M")	as $CaCO_3$	134		128		128		134		130	
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
Water Properties	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		7.0		29.8		7.0		6.7		7.2	
	6.	Chloroform Extractables											
	7.	Dissolved Solids		204		205		202		212		206	
	8.	Hardness (Calcium)	as $CaCO_3$	79		80		78		85		83	
	9.	Hardness (Magnesium)	as $CaCO_3$	43		43		42		45		45	
	10.	Hardness (Total)	as $CaCO_3$	122		123		120		130		128	
	11.	pH		8.4		8.0		8.4		7.9		8.3	
	12.	Specific Conductance	µmhos	303		308		300		315		308	
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			3.5		213		8.0		166		7.0
	15.	Aluminum	as Al	0.02	0.04	0.01	2.55	0.01	0.08	0.01	2.05	0.02	0.08
	16.	Barium	as Ba	0.02	0.00	0.02	0.02	0.02	0.00	0.02	0.02	0.02	0.00
	17.	Calcium	as Ca	31.5	0.46	31.9	17.5	31.1	0.00	33.9	12.2	33.1	0.00
	18.	Chromium	as Cr	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	19.	Copper	as Cu	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
	20.	Iron	as Fe	0.00	0.06	0.00	4.04	0.00	0.13	0.00	3.41	0.00	0.20
	21.	Lead	as Pb	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.004	0.000	0.000
	22.	Lithium	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium	as Mg	10.5	0.00	10.4	4.64	10.2	0.00	10.9	3.04	10.9	0.00
	24.	Manganese	as Mn	0.00	0.00	0.00	0.24	0.00	0.01	0.00	0.22	0.00	0.01
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.	Potassium	as K	1.25		1.25		1.27		1.32		1.26	
	27.	Silver	as Ag	0.00	0.08	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Cations	28.	Sodium	as Na	6.36		6.27		6.27		6.73		6.37	
	29.	Strontium	as Sr	0.11	0.00	0.10	0.02	0.10	0.00	0.11	0.01	0.11	0.00
	30.	Zinc	as Zn	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.06	0.00	0.18
	31.	Total Cation Millequivalents		*2.753*		*2.756*		*2.701*		*2.920*		*2.860*	
	32.	Acetate	as $C_2H_3O_2$	0.00		0.00		0.00		0.00		0.00	
	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00	
	34.	Chloride	as Cl	10.3		9.99		10.3		10.4		10.6	
	35.	Chlorate	as ClO_3	0.00		0.00		0.00		0.00		0.00	
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.05		0.06		0.05		0.00		0.05	
	38.	Formate	as CHO_2	0.00		0.00		0.00		0.00		0.00	
	39.	Glycolate	as $C_2H_3O_3$	0.00		0.00		0.00		0.00		0.00	
	40.	Molybdate	as MoO_4	0.00		0.00		0.00		0.00		0.00	
	41.	Nitrate	as NO_3	0.72		0.83		0.73		0.85		0.79	
	42.	Nitrite	as NO_2	0.00		0.00		0.00		0.00		0.00	
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00		0.00		0.00		0.00	
	45.	Phosphate (ortho)	as PO_4	0.00		0.00		0.00		0.00		0.00	
Anions	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.12	0.00	0.00
	49.	Sulfate	as SO_4	21.3		20.2		20.8		20.5		21.5	
	50.	Sulfur (total)	as S	6.74	0.07	6.72	0.86	6.57	0.00	7.21	0.51	7.11	0.00
	51.	Total Anion Millequivalents		*3.505*		*3.373*		*3.333*		*3.533*		*3.407*	
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.00		0.00		0.00		0.00		0.00	
	55.	Silica	as SiO_2	2.31	0.21	2.79	10.67	1.04	0.62	3.62	10.58	1.35	1.72
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

All data except pH in parts per million or as indicated

Continued on reverse side.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 8/2/07 (#28301)		Control 8/8/07 (#28301)		Treated 8/8/07 (#28301)		Control 8/15/07 (#28332)		Treated 8/15/07 (#28332)	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	59.	Bromate	as BrO_3										
Compounds	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon											
	84.	Total Organic Nitrogen											
	85.	Mexel (A-432)		2.5				2.5				2.5	

All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 8/23/07 (#28436)		Control 8/23/07 (#28436)							
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
Water Properties	1.	Alkalinity ("P")	as $CaCO_3$	0		0							
	2.	Alkalinity ("M")	as $CaCO_3$	122		118							
	3.	Alkalinity ("OH") (calculated)	as $CaCO_3$										
	4.	Free Mineral Acidity	as $CaCO_3$										
	5.	Chemical Oxygen Demand (C.O.D.)		8.5		11.3							
	6.	Chloroform Extractables											
	7.	Dissolved Solids		222		200							
	8.	Hardness (Calcium)	as $CaCO_3$	92		82							
	9.	Hardness (Magnesium)	as $CaCO_3$	47		46							
	10.	Hardness (Total)	as $CaCO_3$	139		128							
	11.	pH		7.9		8.1							
	12.	Specific Conductance	μmhos	332		307							
	13.	Specific Gravity	g/ml										
	14.	Suspended Solids			177		0.0						
Cations	15.	Aluminum	as Al	0.01	1.88	0.02	0.03						
	16.	Barium	as Ba	0.02	0.01	0.02	0.00						
	17.	Calcium	as Ca	36.7	8.91	32.8	0.00						
	18.	Chromium	as Cr	0.00	0.00	0.00	0.00						
	19.	Copper	as Cu	0.00	0.01	0.00	0.00						
	20.	Iron	as Fe	0.02	3.01	0.02	0.07						
	21.	Lead	as Pb	0.000	0.006	0.000	0.002						
	22.	Lithium	as Li	0.00	0.00	0.00	0.00						
	23.	Magnesium	as Mg	11.4	2.34	11.2	0.00						
	24.	Manganese	as Mn	0.00	0.16	0.00	0.00						
	25.	Nickel	as Ni	0.00	0.00	0.00	0.00						
	26.	Potassium	as K	1.27		1.29							
	27.	Silver	as Ag	0.00	0.00	0.00	0.00						
	28.	Sodium	as Na	6.82		6.74							
	29.	Strontium	as Sr	0.11	0.00	0.11	0.00						
	30.	Zinc	as Zn	0.02	0.04	0.01	0.00						
	31.	Total Cation Millequivalents		*3.108*		*2.888*							
Anions	32.	Acetate	as $C_2H_3O_2$	0.00		0.00							
	33.	Bromide	as Br	0.00		0.00							
	34.	Chloride	as Cl	10.8		10.3							
	35.	Chlorate	as ClO_3	0.00		0.00							
	36.	Chromate	as CrO_4										
	37.	Fluoride	as F	0.10		0.09							
	38.	Formate	as CHO_2	0.03		0.00							
	39.	Glycolate	as $C_2H_3O_3$	0.08		0.00							
	40.	Molybdate	as MoO_4	0.00		0.01							
	41.	Nitrate	as NO_3	2.23		0.75							
	42.	Nitrite	as NO_2	0.00		0.00							
	43.	Nitrogen (total)	as N										
	44.	Oxalate	as C_2O_4	0.00		0.00							
	45.	Phosphate (ortho)	as PO_4	0.09		0.00							
	46.	Phosphate (poly)	as PO_4										
	47.	Phosphate (organo)	as PO_4										
	48.	Phosphorus (total)	as P	0.05	0.07	0.00	0.00						
	49.	Sulfate	as SO_4	21.0		19.4							
	50.	Sulfur (total)	as S	7.52	7.41	7.03	6.88						
	51.	Total Anion Millequivalents		*3.568*		*3.183*							
	52.	Ammonia	as NH_3										
	53.	Benzotriazole	as $C_6H_5N_3$										
	54.	Boron	as B	0.04		0.09							
	55.	Silica	as SiO_2	10.2	8.35	3.34	0.40						
	56.	Sodium Nitrite	as $NaNO_2$										
	57.	Sodium Sulfite	as Na_2SO_3										
	58.	Tolyltriazole	as $C_7H_6N_3$										

All data except pH in parts per million or as indicated

Continued on reverse side.

LABORATORY REPORT - WATER ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: as indicated
Report Date:
Analysis Date:
Sample Date: as indicated

				Treated 8/23/07 (#28436)		Control 8/23/07 (#28436)							
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	59.	Bromate	as BrO_3										
Compounds	60.	Chlorite	as ClO_2										
	61.	Cyclohexylamine*	as $C_6H_{13}N$										
	62.	Diethylamine*	as $C_4H_{11}N$										
	63.	Diethylaminoethanol*	as $C_6H_{15}NO$										
	64.	Ethylamine*	as C_2H_7N										
	65.	Morpholine*	as C_4H_9NO										
	66.	Diethylene Glycol*	% by weight										
	67.	Ethylene Glycol*	% by weight										
	68.	Propylene Glycol*	% by weight										
	69.	Aerobic Plate Count	org's/ml										
Microbiological	70.	Anaerobic Plate Count	org's/ml										
	71.	Fecal Coliform	org's/100ml										
	72.	Iron Bacteria											
	73.	Mold	org's/ml										
	74.	Nitrate Reducers	org's/ml										
	75.	Slime Formers	org's/ml										
	76.	Sulfate Reducers	org's/ml										
	77.	Total Coliform	org's/100ml										
	78.	Yeast	org's/ml										
	79.	Residue by Evaporation											
	80.	Volatile Solids											
	81.	System Capacity	gal.										
	82.	Propionate	as $C_3H_5O_2$	0.00		0.00							
	83.	Total Organic Carbon											
	84.	Total Organic Nitrogen											
	85.	Mexel (A-432)		2.5									

Analyst :0 All data except pH in parts per million or as indicated

*Analysis by Gas Chromatography.

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400

PALATINE, ILLINOIS 60067
FAX NO: 847/358-7082

DATE: November 7, 2006

TO: Tom Armon

FROM: H. A. Becker

SUBJECT: American Electric Power
Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI
Analysis of reverse osmosis membrane.

Dear Tom:

Attached you will find our laboratory analysis reports pertaining to the above referenced deposit sample(s), our laboratory number 26782.

I hope this information satisfies your requirements. If any further work or discussion is needed, please get back to me.

Very truly yours,

H. A. Becker

HAB:ld
Enclosure
cc: Darius Barkauskas

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LABORATORY REPORT - DEPOSIT ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: American Electric Power
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.:	1001392
Report No.:	26782
Report Date:	11/7/06
Analysis Date:	9/25/06
Sample Date:	9/21/06

			Fouled Reverse Osmosis Membrane		New Reverse Osmosis Membrane		A-432					
			Percent	Equivalents	Percent	Equivalents	Percent	Equivalents	Percent	Equivalents	Percent	Equivalents
1.	Aluminum	as Al_2O_3	0.20	0.012	0.31	0.019						
2.	Barium	as BaO	0.03	0.000	0.01	0.000						
3.	Calcium	as CaO	51.70	1.844	2.22	0.079						
4.	Chromium	as Cr_2O_3	0.01	0.000	0.02	0.001						
5.	Copper	as CuO	0.14	0.003	0.06	0.002						
6.	Iron	as Fe_2O_3	0.29	0.011	0.34	0.013						
7.	Lead	as PbO	0.02	0.000	0.00	0.000						
8.	Lithium	as Li_2O	0.00		0.00	0.000						
9.	Magnesium	as MgO	4.44	0.220	0.15	0.007						
10.	Manganese	as MnO	0.01	0.000	0.04	0.001						
11.	Nickel	as Ni	0.07	0.002	0.02	0.001						
12.	Potassium	as K_2O	0.07	0.002	0.26	0.006						
13.	Silica	as SiO_2	0.22	0.007	1.81	0.060						
14.	Silver	as Ag_2O	0.00		0.00	0.000						
15.	Sodium	as Na_2O	0.25	0.008	32.30	1.042						
16.	Strontium	as SrO	0.13	0.002	0.00	0.000						
17.	Tin	as SnO	0.00		0.00	0.000						
18.	Zinc	as ZnO	0.48	0.012	1.11	0.027						
19.												
20.	Boron	as B_4O_6	0.00		0.00	0.000						
21.	Carbonate	as CO_2	39.24	1.784	0.00							
22.	Chloride	as Cl			0.00							
23.	Molybdenum	as MoO_3	0.00	0.000	0.05	0.000						
24.	Nitrate	as NO_2										
25.	Nitrite	as NO										
26.	Phosphate	as P_2O_5	0.14	0.006	1.72	0.073						
27.	Sulfate	as SO_3	2.57	0.064	59.58	1.488						
28.	Tolyltriazole	as $C_7H_6N_3$										
29.												
30.	Ignition Loss											
31.	Undetermined											
32.	Total		100.00		100.00							
33.	Chloroform Extractable		2.66		1.86		2.40					

Physical Properties and Appearance:

Analyst:

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400

PALATINE, ILLINOIS 60067
FAX NO. 847/358-7082

DATE: August 30, 2007

TO: Tom Armon

FROM: H. A. Becker

SUBJECT: Indiana and Michigan Power Company
Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI
Analysis of reverse osmosis membrane.

Dear Tom:

Attached you will find our laboratory analysis reports pertaining to the above referenced deposit sample(s), our laboratory number 28351.

I hope this information satisfies your requirements. If any further work or discussion is needed, please get back to me.

Very truly yours,

H. A. Becker

HAB:ld
Enclosure
cc: Darius Barkauskas

LABORATORY REPORT - DEPOSIT ANALYSIS

H-O-H Chemicals, Inc.
500 S. Vermont St.
Palatine, IL 60067

847/358-7400
Fax: 847/358-7082

Regarding: Indiana and Michigan Power Company
Location: Donald C. Cook Nuclear Plant
1 Cook Place
Bridgman, MI

Customer No.: 1001392
Report No.: 28351
Report Date: 8/30/07
Analysis Date: 8/24/07
Sample Date: 8/23/07

			Reverse Osmosis from Treated Stream of Test Mexel Rig									
			Percent	Equivalents	Percent	Equivalents	Percent	Equivalents	Percent	Equivalents	Percent	Equivalents
1.	Aluminum	as Al_2O_3	0.09	0.005								
2.	Barium	as BaO	0.00	0.000								
3.	Calcium	as CaO	53.16	1.899								
4.	Chromium	as Cr_2O_3	0.01	0.000								
5.	Copper	as CuO	0.10	0.002								
6.	Iron	as Fe_2O_3	0.13	0.005								
7.	Lead	as PbO	0.02	0.000								
8.	Lithium	as Li_2O	0.00	0.000								
9.	Magnesium	as MgO	2.42	0.120								
10.	Manganese	as MnO	0.01	0.000								
11.	Nickel	as Ni	0.02	0.001								
12.	Potassium	as K_2O	0.03	0.001								
13.	Silica	as SiO_2	0.19	0.006								
14.	Silver	as Ag_2O	0.00	0.000								
15.	Sodium	as Na_2O	0.12	0.004								
16.	Strontium	as SrO	0.14	0.003								
17.	Tin	as SnO	0.00	0.000								
18.	Zinc	as ZnO	0.03	0.001								
19.												
20.	Boron	as B_4O_6	0.00	0.000								
21.	Carbonate	as CO_2	40.11	1.823								
22.	Chloride	as Cl										
23.	Molybdenum	as MoO_3	0.00	0.000								
24.	Nitrate	as NO_2										
25.	Nitrite	as NO										
26.	Phosphate	as P_2O_5	0.14	0.006								
27.	Sulfate	as SO_3	3.01	0.075								
28.	Tolyltriazole	as C_7H_6N										
29.												
30.	Ignition Loss											
31.	Undetermined		0.27									
32.	Total		100.00									
33.	Chloroform Extractable											

Physical Properties and Appearance:	1" wide cross-section.				

Analyst: .con

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water technology

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400

PALATINE, ILLINOIS 60067
FAX NO. 847/358-7082

TO: Tom Armon

DATE: October 19, 2006

1001392

FROM: H. A. Becker

SUBJECT: American Electric Power
Donald C. Cook Nuclear Plant
1 Cook Place Bridgman, MI
Evaluation of corrosion test coupon data

Dear Tom:

Attached you will find our laboratory report pertaining to the above referenced corrosion coupons, our laboratory reference number 26910.

The rate of corrosion experienced by a corrosion coupon is derived through a very precise determination of any weight loss that may have occurred as a result of exposure of the coupon to system conditions for a period of at least 30 days. Given the dimensions of the test coupon, its material of construction, and the time of exposure, weight loss data may be equated to an average thinning of the coupon over its entire surface. Coupon corrosion rate data should be evaluated according to the following criteria.

Evaluation	Steel	Stainless	Galvanized	Aluminum	Copper	Brass
Excellent	0.00-0.99	0.00-0.24	0.00-0.49	0.00-0.49	0.00-0.24	0.00-0.24
Good	1.00-2.99	0.25-0.49	0.50-0.99	0.50-0.99	0.25-0.49	0.25-0.49
Fair	3.00-4.99	0.50-0.74	1.00-1.99	1.00-1.99	0.50-0.74	0.50-0.74
Poor	5.00-6.99	0.75-1.24	2.00-3.99	2.00-3.99	0.75-1.24	0.75-1.24
Unacceptable	7.00-Over	1.25-Over	4.00-Over	4.00-Over	1.25-Over	1.25-Over

Corrosion coupon data pertaining to this evaluation may be summarized as follows:

	Coupon No.	Material	Days Exposed	Treatment	System Type	Weight Loss (gm)	Corrosion Rate (MPY)	Evaluation
1.	T-75I	Steel	43	None	Once Through	0.6537	8.51	Unacceptable
2.	T-75K	Steel	43	A-432	Once Through	0.2989	3.89	Fair

I hope that this information satisfies your requirements. If any further laboratory work or discussion is needed, please get back to me.

Very truly yours,

H.A. Becker

HAB/ld

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400

PALATINE, ILLINOIS 60067
FAX NO. 847/358-7082

CORROSION TEST - STRIP TYPE

Please complete the important information below, being sure to include your full company name and address, and the name of your H-O-H representative. Return completed form with the exposed test strip to our laboratory for determination of corrosion rate. Laboratory data will be relayed to you through your sales representative upon completion.

CUSTOMER IDENTIFICATION / INFORMATION

Company: American Electric Power

Address: Donald C. Cook Nuclear Plant
1 Cook Place Bridgman, MI

Your H-O-H Sales Representative: Tom Armon

Water Type:

	Condensate		Open Recirculating
	Cooling Water		Closed
x	Once Through		Other

Treatment: None

Location in System: Coupon rack on Mexel test rig

Installation Date: 8/30/06

Removal Date: 10/12/06

H - O - H LABORATORY DATA

Test Strip No.: T-751

Metal: Steel

Days Exposed: 43

Laboratory No.: 26910

WEIGHTS (in grams)

Original: 16.9772
Final: 16.3235
Loss: 0.6537

Mils Penetration per Year (MPY): 8.51

CORROSION DESCRIPTION:

x	Severe		Moderate		Slight		Negligible
x	Even		Uneven		General		Localized

4.0 Maximum Pit Depth (mils)

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400

PALATINE, ILLINOIS 60067
FAX NO. 847/358-7082

CORROSION TEST - STRIP TYPE

Please complete the important information below, being sure to include your full company name and address, and the name of your H-O-H representative. Return completed form with the exposed test strip to our laboratory for determination of corrosion rate. Laboratory data will be relayed to you through your sales representative upon completion.

CUSTOMER IDENTIFICATION / INFORMATION

Company: American Electric Power
Address: Donald C. Cook Nuclear Plant
1 Cook Place, Bridgman, MI

Your H-O-H Sales Representative: Tom Armon

Water Type:
_____ Condensate _____ Open Recirculating
_____ Cooling Water _____ Closed
x Once Through _____ Other _____

Treatment: A-432

Location in System: Coupon rack on Mexel test rig

Installation Date: 8/30/06 Removal Date: 10/12/06

H - O - H LABORATORY DATA

Test Strip No.: T-75K Metal: Steel

Days Exposed: 43 Laboratory No.: 26910

WEIGHTS (in grams)
Original: 16.6354
Final: 16.3365
Loss: 0.2989

Mils Penetration per Year (MPY): 3.89

CORROSION DESCRIPTION:

_____ Severe x Moderate _____ Slight _____ Negligible
_____ Even x Uneven _____ General _____ Localized

4.0 Maximum Pit Depth (mils)

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400

PALATINE, ILLINOIS 60067
FAX NO. 847/358-7082

TO: Tom Armon

DATE: November 7, 2006

1001392

FROM: H. A. Becker

SUBJECT: American Electric Power
Donald C. Cook Nuclear Plant
1 Cook Place Bridgman, MI
Evaluation of corrosion test coupon data

Dear Tom:

Attached you will find our laboratory report pertaining to the above referenced corrosion coupons, our laboratory reference number 27022.

The rate of corrosion experienced by a corrosion coupon is derived through a very precise determination of any weight loss that may have occurred as a result of exposure of the coupon to system conditions for a period of at least 30 days. Given the dimensions of the test coupon, its material of construction, and the time of exposure; weight loss data may be equated to an average thinning of the coupon over its entire surface. Coupon corrosion rate data should be evaluated according to the following criteria.

Evaluation	Steel	Stainless	Galvanized	Aluminum	Copper	Brass
Excellent	0.00-0.99	0.00-0.24	0.00-0.49	0.00-0.49	0.00-0.24	0.00-0.24
Good	1.00-2.99	0.25-0.49	0.50-0.99	0.50-0.99	0.25-0.49	0.25-0.49
Fair	3.00-4.99	0.50-0.74	1.00-1.99	1.00-1.99	0.50-0.74	0.50-0.74
Poor	5.00-6.99	0.75-1.24	2.00-3.99	2.00-3.99	0.75-1.24	0.75-1.24
Unacceptable	7.00-Over	1.25-Over	4.00-Over	4.00-Over	1.25-Over	1.25-Over

Corrosion coupon data pertaining to this evaluation may be summarized as follows:

	Coupon No.	Material	Days Exposed	Treatment	System Type	Weight Loss (gm)	Corrosion Rate (MPY)	Evaluation
1.	T-75J	Steel	43	A-432	Once Through	0.2947	3.84	Fair
2.	T-75L	Steel	43	None	Once Through	0.6093	7.94	Unacceptable

I hope that this information satisfies your requirements. If any further laboratory work or discussion is needed, please get back to me.

Very truly yours,

H.A. Becker

HAB/ld

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400

PALATINE, ILLINOIS 60067
FAX NO. 847/358-7082

CORROSION TEST - STRIP TYPE

Please complete the important information below, being sure to include your full company name and address, and the name of your H-O-H representative. Return completed form with the exposed test strip to our laboratory for determination of corrosion rate. Laboratory data will be relayed to you through your sales representative upon completion.

CUSTOMER IDENTIFICATION / INFORMATION

Company: American Electric Power

Address: Donald C. Cook Nuclear Plant
1 Cook Place Bridgman, MI

Your H-O-H Sales Representative: Tom Armon

Water Type:

	Condensate		Open Recirculating
	Cooling Water		Closed
x	Once Through		Other

Treatment: A-432

Location in System:

Installation Date: 8/30/06

Removal Date: 10/12/06

H - O - H LABORATORY DATA

Test Strip No.: T-75J

Metal: Steel

Days Exposed: 43

Laboratory No.: 27022

WEIGHTS (in grams)

Original: 17.1817
Final: 16.8870
Loss: 0.2947

Mils Penetration per Year (MPY): 3.84

CORROSION DESCRIPTION:

	Severe	x	Moderate		Slight		Negligible
	Even	x	Uneven		General		Localized

5.0 Maximum Pit Depth (mils)

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400

PALATINE, ILLINOIS 60067
FAX NO. 847/358-7082

CORROSION TEST - STRIP TYPE

Please complete the important information below, being sure to include your full company name and address, and the name of your H-O-H representative. Return completed form with the exposed test strip to our laboratory for determination of corrosion rate. Laboratory data will be relayed to you through your sales representative upon completion.

CUSTOMER IDENTIFICATION / INFORMATION

Company: American Electric Power
Address: Donald C. Cook Nuclear Plant
1 Cook Place Bridgman, MI

Your H-O-H Sales Representative: Tom Armon

Water Type:	Condensate		Open Recirculating
	Cooling Water		Closed
	x Once Through		Other

Treatment: None

Location in System:

Installation Date: 8/30/06

Removal Date: 10/12/06

H - O - H LABORATORY DATA

Test Strip No.: T-75L

Metal: Steel

Days Exposed: 43

Laboratory No.: 27022

WEIGHTS (in grams)
Original: 16.8973
Final: 16.2880
Loss: 0.6093

Mils Penetration per Year (MPY): 7.94

CORROSION DESCRIPTION:

Severe	x Moderate	Slight	Negligible
x Even	Uneven	General	Localized

8.0 Maximum Pit Depth (mils)

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400

PALATINE, ILLINOIS 60067
FAX NO. 847/358-7082

TO: Tom Armon DATE: January 8, 2007 1001392

FROM: H. A. Becker

SUBJECT: American Electric Power
Donald C. Cook Nuclear Plant
1 Cook Place Bridgman, MI
Evaluation of corrosion test coupon data

Dear Tom:

Attached you will find our laboratory report pertaining to the above referenced corrosion coupons, our laboratory reference number 27212.

The rate of corrosion experienced by a corrosion coupon is derived through a very precise determination of any weight loss that may have occurred as a result of exposure of the coupon to system conditions for a period of at least 30 days. Given the dimensions of the test coupon, its material of construction, and the time of exposure; weight loss data may be equated to an average thinning of the coupon over its entire surface. Coupon corrosion rate data should be evaluated according to the following criteria.

Evaluation	Steel	Stainless	Galvanized	Aluminum	Copper	Brass
Excellent	0.00-0.99	0.00-0.24	0.00-0.49	0.00-0.49	0.00-0.24	0.00-0.24
Good	1.00-2.99	0.25-0.49	0.50-0.99	0.50-0.99	0.25-0.49	0.25-0.49
Fair	3.00-4.99	0.50-0.74	1.00-1.99	1.00-1.99	0.50-0.74	0.50-0.74
Poor	5.00-6.99	0.75-1.24	2.00-3.99	2.00-3.99	0.75-1.24	0.75-1.24
Unacceptable	7.00-Over	1.25-Over	4.00-Over	4.00-Over	1.25-Over	1.25-Over

Corrosion coupon data pertaining to this evaluation may be summarized as follows:

	Coupon No.	Material	Days Exposed	Treatment	System Type	Weight Loss (gm)	Corrosion Rate (MPY)	Evaluation
1.	T-80P	Steel	56	A-432	Once Through	0.4109	4.11	Fair
2.	T-80Q	Steel	56	None	Once Through	0.3446	3.45	Fair
3.	T-80R	Steel	56	A-432	Once Through	0.6190	6.19	Poor
4.	T-80S	Steel	56	None	Once Through	0.3594	3.59	Fair

I hope that this information satisfies your requirements. If any further laboratory work or discussion is needed, please get back to me.

Very truly yours,

H.A. Becker

HAB/ld

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400

PALATINE, ILLINOIS 60067
FAX NO. 847/358-7082

CORROSION TEST - STRIP TYPE

Please complete the important information below, being sure to include your full company name and address, and the name of your H-O-H representative. Return completed form with the exposed test strip to our laboratory for determination of corrosion rate. Laboratory data will be relayed to you through your sales representative upon completion.

CUSTOMER IDENTIFICATION / INFORMATION

Company: American Electric Power
Address: Donald C. Cook Nuclear Plant
1 Cook Place Bridgman, MI

Your H-O-H Sales Representative: Tom Armon

Water Type:
____ Condensate
____ Cooling Water
__x__ Once Through
____ Open Recirculating
____ Closed
____ Other ____

Treatment: A-432

Location in System: Test rig over unit 2 discharge platform

Installation Date: 10/12/06
Removal Date: 12/7/06

H - O - H LABORATORY DATA

Test Strip No.: T-80P
Metal: Steel

Days Exposed: 56
Laboratory No.: 27212

WEIGHTS (in grams)
Original: 17.1763
Final: 16.7654
Loss: 0.4109

Mils Penetration per Year (MPY): 4.11

CORROSION DESCRIPTION:

____ Severe __x__ Moderate ____ Slight ____ Negligible
____ Even __x__ Uneven ____ General ____ Localized

0.5 Maximum Pit Depth (mils)

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400

PALATINE, ILLINOIS 60067
FAX NO. 847/358-7082

CORROSION TEST - STRIP TYPE

Please complete the important information below, being sure to include your full company name and address, and the name of your H-O-H representative. Return completed form with the exposed test strip to our laboratory for determination of corrosion rate. Laboratory data will be relayed to you through your sales representative upon completion.

CUSTOMER IDENTIFICATION / INFORMATION

Company: American Electric Power
Address: Donald C. Cook Nuclear Plant
1 Cook Place Bridgman, MI

Your H-O-H Sales Representative: Tom Armon

Water Type:
____ Condensate
____ Cooling Water
x Once Through
____ Open Recirculating
____ Closed
____ Other ____

Treatment: None

Location in System: Test rig over unit 2 discharge platform

Installation Date: 10/12/06
Removal Date: 12/7/06

H - O - H LABORATORY DATA

Test Strip No.: T-80Q
Metal: Steel

Days Exposed: 56
Laboratory No.: 27212

WEIGHTS (in grams)
Original: 17.2254
Final: 16.8808
Loss: 0.3446

Mils Penetration per Year (MPY): 3.45

CORROSION DESCRIPTION:

____ Severe
x Moderate
____ Slight
____ Negligible
____ Even
x Uneven
____ General
____ Localized

2.0 Maximum Pit Depth (mils)

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400

PALATINE, ILLINOIS 60067
FAX NO: 847/358-7082

CORROSION TEST - STRIP TYPE

Please complete the important information below, being sure to include your full company name and address, and the name of your H-O-H representative. Return completed form with the exposed test strip to our laboratory for determination of corrosion rate. Laboratory data will be relayed to you through your sales representative upon completion.

CUSTOMER IDENTIFICATION / INFORMATION

Company: American Electric Power
Address: Donald C. Cook Nuclear Plant
1 Cook Place Bridgman, MI

Your H-O-H Sales Representative: Tom Armon

Water Type:
____ Condensate
____ Cooling Water
x Once Through
____ Open Recirculating
____ Closed
____ Other ____

Treatment: A-432

Location in System: Test rig over unit 2 discharge platform

Installation Date: 10/12/06
Removal Date: 12/7/06

H - O - H LABORATORY DATA

Test Strip No.: T-80R
Metal: Steel

Days Exposed: 56
Laboratory No.: 27212

WEIGHTS (in grams)
Original: 17.3501
Final: 16.7311
Loss: 0.6190

Mils Penetration per Year (MPY): 6.19

CORROSION DESCRIPTION:

x Severe
x Even
____ Moderate
____ Uneven
____ Slight
____ General
____ Negligible
____ Localized

1.5 Maximum Pit Depth (mils)

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400
PALATINE, ILLINOIS 60067
FAX NO. 847/358-7082

CORROSION TEST - STRIP TYPE

Please complete the important information below, being sure to include your full company name and address, and the name of your H-O-H representative. Return completed form with the exposed test strip to our laboratory for determination of corrosion rate. Laboratory data will be relayed to you through your sales representative upon completion.

CUSTOMER IDENTIFICATION / INFORMATION

Company: American Electric Power
Address: Donald C. Cook Nuclear Plant
1 Cook Place Bridgman, MI

Your H-O-H Sales Representative: Tom Armon

Water Type:
Condensate
Cooling Water
[✓ Once Through]
Open Recirculating
Closed
Other

Treatment: None

Location in System: Test rig over unit 2 discharge platform

Installation Date: 10/12/06
Removal Date: 12/7/06

H - O - H LABORATORY DATA

Test Strip No.: T-80S
Metal: Steel

Days Exposed: 56
Laboratory No.: 27212

WEIGHTS (in grams)
Original: 16.9964
Final: 16.6370
Loss: 0.3594

Mils Penetration per Year (MPY): 3.59

CORROSION DESCRIPTION:

Severe
[✓ Moderate]
Slight
Negligible

Even
[✓ Uneven]
General
Localized

0.5 Maximum Pit Depth (mils)

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400

PALATINE, ILLINOIS 60067
FAX NO. 847/358-7082

TO: Tom Armon/Darius Barkauskas

DATE: September 12, 2007

1001392

FROM: H. A. Becker

SUBJECT: Indiana and Michigan Power Company
Donald C. Cook Nuclear Plant
1 Cook Place Bridgman, MI
Evaluation of corrosion test coupon data

Dear Tom/Darius:

Attached you will find our laboratory report pertaining to the above referenced corrosion coupons, our laboratory reference number 28856.

The rate of corrosion experienced by a corrosion coupon is derived through a very precise determination of any weight loss that may have occurred as a result of exposure of the coupon to system conditions for a period of at least 30 days. Given the dimensions of the test coupon, its material of construction, and the time of exposure, weight loss data may be equated to an average thinning of the coupon over its entire surface. Coupon corrosion rate data should be evaluated according to the following criteria:

Evaluation	Steel	Stainless	Galvanized	Aluminum	Copper	Brass
Excellent	0.00-0.99	0.00-0.24	0.00-0.49	0.00-0.49	0.00-0.24	0.00-0.24
Good	1.00-2.99	0.25-0.49	0.50-0.99	0.50-0.99	0.25-0.49	0.25-0.49
Fair	3.00-4.99	0.50-0.74	1.00-1.99	1.00-1.99	0.50-0.74	0.50-0.74
Poor	5.00-6.99	0.75-1.24	2.00-3.99	2.00-3.99	0.75-1.24	0.75-1.24
Unacceptable	7.00-Over	1.25-Over	4.00-Over	4.00-Over	1.25-Over	1.25-Over

Corrosion coupon data pertaining to this evaluation may be summarized as follows:

	Coupon No.	Material	Days Exposed	Treatment	System Type	Weight Loss (gm)	Corrosion Rate (MPY)	Evaluation
1.	T-83K	Steel	200	Mexel	Once Through	0.4594	1.29	Good
2.	T-83L	Steel	200	None	Once Through	0.4761	1.33	Good

I hope that this information satisfies your requirements. If any further laboratory work or discussion is needed, please get back to me.

Very truly yours,

H.A. Becker

HAB/ld

H-O-H CHEMICALS, INC.

500 SOUTH VERMONT STREET
847/358-7400

PALATINE, ILLINOIS 60067
FAX NO. 847/358-7082

CORROSION TEST - STRIP TYPE

Please complete the important information below, being sure to include your full company name and address, and the name of your H-O-H representative. Return completed form with the exposed test strip to our laboratory for determination of corrosion rate. Laboratory data will be relayed to you through your sales representative upon completion.

CUSTOMER IDENTIFICATION / INFORMATION

Company: Indiana and Michigan Power Company
Address: Donald C. Cook Nuclear Plant
1 Cook Place Bridgman, MI

Your H-O-H Sales Representative: Tom Armon/Darius Barkauskas

Water Type:
Condensate
Cooling Water
[✓ Once Through]
Open Recirculating
Closed
Other

Treatment: Mexel

Location in System: Test rig over unit 2 discharge platform

Installation Date: 2/4/07
Removal Date: 8/23/07

H - O - H LABORATORY DATA

Test Strip No.: T-83K
Metal: Steel

Days Exposed: 200
Laboratory No.: 28856

WEIGHTS (in grams)
Original: 17.3728
Final: 16.9134
Loss: 0.4594

Mils Penetration per Year (MPY): 1.29

CORROSION DESCRIPTION:

Severe
[✓ Moderate]
Slight
Negligible

Even
[✓ Uneven]
General
Localized

0.5 Maximum Pit Depth (mils)

200

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Company: Indiana and Michigan Power Company
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Your H-O-H Sales Representative: Tom Armon/Darius Barkauskas

Water Type:

______	Condensate	______	Open Recirculating
______	Cooling Water	______	Closed
x	Once Through	______	Other ______

Treatment: None

Location in System: Test rig over unit 2 discharge platform

Installation Date: 2/4/07 Removal Date: 8/23/07

H - O - H LABORATORY DATA

Test Strip No.: T-83L Metal: Steel

Days Exposed: 200 Laboratory No.: 28856

WEIGHTS (in grams)
Original: 17.2034
Final: 16.7273
Loss: 0.4761

Mils Penetration per Year (MPY): 0.50

CORROSION DESCRIPTION:

______	Severe	______	Moderate	______	Slight	______	Negligible
______	Even	______	Uneven	______	General	______	Localized

______ Maximum Pit Depth (mils)

APPENDIX 8

Assessment Number: SA-2003-REA-003-QH **Assessment Dates:** 12/15/03 to 01/25/04,
Condition Report: CR-03344013

Assessment Topic: Zebra Mussel Monitoring and Control Program

Lead Assessor: Eric Mallen

Peer Evaluator: Richard F. Green, Nine Mile Point Nuclear Station

Reviewed By 1/26/04
Lead Assessor / Date

Approval: 1/26/04
Responsible Management/Date

Executive Summary

Introduction

The Zebra Mussel Monitoring and Control program is dictated by the requirements described within AEP: NRC: 1104, Generic Letter 89-13, Service Water System Problem Response Action Item I: Control of Service Water System Biofouling. The plant requirements currently exist as commitments within the NRC Commitment Database and are implemented by ENVI-8913 Rev. 3, Zebra Mussel Monitoring and Control Program. This program document satisfies the objectives of Generic Letter 89-13.

One critical attribute of the program document was reviewed in this self-assessment. This attribute being, maintaining the intake tunnel zebra mussel infestations to ≤2 inches to minimize clumps breaking off and challenging the traveling screens and systems downstream. A preventive treatment strategy using a daily biocide application specified in Step 4.7.1, Chemical Control Methods, of ENVI-8913, Zebra Mussel Monitoring and Control Program was employed in 2003 to control zebra mussel infestation in the intake tunnels. The self-assessment will determine the efficacy of the preventive treatment strategy in its being able to control zebra mussel infestations in the intake tunnels.

Results in general terms

The objectives of the self-assessment were achieved. Mr. Richard Green, a peer evaluator from the Constellation Energy Nine Mile Point Nuclear Plant in charge of their zebra mussel monitoring and control program assisted in the self-assessment. Interviews were held with Ms. Carol Grandholm, a contract zebra mussel monitoring technician, and Mr. William Jung, a contract chemical applications engineer for GEBetz. Reviews of Request for Proposals and chemical vendor responses, letters of request for biocide approval and responses from the MDEQ, the application procedure, settlement monitoring system and data, chemical residual bio-box and unit discharge data, and personnel interviews were valuable in assessing the critical attribute.

Primary Challenges

Results of diving inspections of the North and Center Intake tunnels revealed that zebra mussel infestations were ≤2 inches on the tunnel walls. From review of the bio-box settlement data and discussions, this infestation level was kept in check for the most part via tunnel flow (6-7 ft./sec) as opposed to the chemical treatment. Results from the preventive biocide treatments were not as favorable as expected due to; 1) Very restrictive MDEQ discharge limits (70 ppb), 2) Low system demand that was available to reduce the discharge concentration in the unit discharges, and 3) Inadequate dilution flow due to the intake forebay design not providing a perfect 2/3 reduction in concentration before the effluents are discharged. Despite these restrictions to the preventive treatment regime, zebra mussel sloughage from the intake tunnels in 2003 was

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managed by the traveling screens without impacts to components downstream. The plant should continue to maintain an aggressive posture in controlling zebra mussels in the intake tunnels to prevent under-deposit corrosion of the tunnel walls, and prevent an event that occurred at the Palisades Plant (OE #11308, 6/16/2000) where an unexplained die-off of mussels from the plant's intake tunnels occurred resulting in large clumps of mussels being swept into the intake bay and challenging the traveling screens.

Assessment Strengths

None

Assessment Findings and Prescribed Corrective Actions

None

Recommendations and Proposed Actions

1) The preventive treatment program was implemented as designed. There are no findings but a recommendation to review this assessment with peers and vendors to develop a more effective chemical preventive treatment program, mechanical cleaning, or revisit targeted shock treatments to the intake tunnels.

2) The peer evaluator noted that the biocide application procedure could be enhanced including more contingencies into the procedure such as strainer pluggage, power reductions etc. The biocide application procedure 12-EA-6090-ENV-109, Intake Tunnel Molluscicide Treatment should be revised to include these contingencies.

3) Investigate the possibility of installing a In-Situform™ sock as a means of making the tunnel walls smooth. This technology is employed often in the repair to sewer lines.

4) Investigate a non-chemical means of controlling zebra mussels in the intake tunnels via hypoxia. The tunnels could be shut for a period of time to deplete the dissolved oxygen level to the point where the mussels suffocate. The use of sodium bisulfite could be used to hasten the oxygen depletion process and minimize the time period that the tunnel was removed from service.

Areas Found Acceptable

1) No spill events or chemical discharge exceedences occurred during the application period. The vendor and plant proved that the preventive biocide application could be controlled within its MDEQ permitted conditions. This is the first known zebra mussel preventive biocide application of this grand a scale performed in the U. S.

2) The settlement monitoring system was able to provide feedback as to whether the settlement goal was being achieved. An upgraded bio-box pumping system was used for the first time during this project. This design was able to perform reliably for four months as opposed to one month as in the past.

3) Many lessons were learned. A better knowledge of our intake tunnel corrugated pipe design being conducive to zebra mussel settlement due to the eddying effect of the pipe corrugations is better understood. The demand and dilution characteristics of the lake water and intake forebay are better understood.

Objectives and Scope

The objective of this self-assessment was to assess the effectiveness of the preventive treatment strategy using a daily or other periodic biocide application in implementing the required action specified in Step 4.7.1 Chemical Control Methods, of ENVI-8913, Zebra Mussel Monitoring and Control Program. This attribute being:

- Maintaining intake tunnel zebra mussel infestations ≤2 inches to minimize clumps breaking off and challenging the traveling screens. These requirements are:

a) Requests for proposals and responses were adequate for successful treatment.

- Chemical feed and lab analysis.
- Performance monitoring.
- Training and qualifications.
- Procedure development.
- Material and system compatibility.
- Compliance with regulations.

b) Letters requesting approval of the biocide that were sent to the state requested applications in a manner that would achieve a successful treatment.

- Review state authorization letter and compliance with the letter.

c) Procedure 12-EA-6090-ENV-109, Intake Tunnel Molluscicide Treatment, was revised to incorporate the new treatment procedure and met the requirements of ENVI-8913.

d) The settlement monitoring system was able to provide feedback as to whether the settlement goal was being achieved. This goal being that no more than 10% of the post-veligers measured on the slides would exceed 500 microns.

e) Chemical residuals were monitored in the bio-boxes and unit discharges. No spill events or chemical discharge exceedences occurred during the application period. The chemical residuals specified by the vendor were achieved in the intake tunnel bio-boxes.

Attribute evaluation was performed by:

1) Review of Request for Proposals and responses from Chemical Vendors.

2) Review of letters of request for biocide approval and responses from the MDEQ.

3) Review of procedure 12-EA-6090-ENV-109, Intake Tunnel Molluscicide Treatment.

4) Review of settlement monitoring system and data.

5) Review of chemical residual bio-box and unit discharge data.

6) Personnel interviews.

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Assessment

Methodology

Mr. Richard Green, a peer evaluator from the Constellation Energy Nine Mile Point Nuclear Plant in charge of their zebra mussel monitoring and control program assisted in the self-assessment. Interviews were held with Ms. Carol Grandholm, a contract zebra mussel monitoring technician, and Mr. William Jung, a contract chemical applications engineer for GEBetz. Reviews of Request for Proposals and chemical vendor responses, letters of request for biocide approval and responses from the MDEQ, the application procedure, settlement monitoring system and data, chemical residual bio-box and unit discharge data, Performance Observation Program (POP) observations, condition reports, Operating Experiences (OEs), and personnel interviews were performed. A site tour was given to the peer evaluator for him to gain familiarity with the plant systems and lay-out, and equipment used for the project. The peer evaluator also had the opportunity of observing Ms. Grandholm performing standard method zebra mussel counts on artificial substrates during his visit.

Self-Assessment Team

Mr. Richard Green, a peer evaluator from the Constellation Energy Nine Mile Point Nuclear Plant in charge of their zebra mussel monitoring and control program assisted in the self-assessment. Jon Hamer, a Cook Nuclear Plant Environmental Supervisor assisted in developing the scope and objectives of the self-assessment and reviewed applicable condition reports and Operating Experience events. Eric Mallen, a Cook Nuclear Plant Environmental Specialist and Zebra Mussel Monitoring & Control Program owner, was responsible for the overall planning, recruiting of self-assessment team members, developing scope and objectives, scheduling, coordination, and writing the self-assessment report. All self-assessment team members reviewed the self-assessment report and comments were incorporated herein.

Assessment of Critical Attributes

1. **Maintaining intake tunnel zebra mussel infestations to ≤2 inches to minimize clumps breaking off and challenging the traveling screens via a preventive treatment strategy using a daily or other periodic biocide application.**

   a) Requests for proposals and responses were adequate for successful treatment.

Request for proposal RFP23525 was sent out to three vendors for bids on December 20, 2002. A pre-bid meeting was held on Jan. 14, 2003 and proposals were received on February 7, 2003. The RFP requested vendors to provide a proposal to furnish materials, equipment, and management oversight to provide a non-oxidizing chemical treatment to prevent zebra mussel colonization in the circulating water intake tunnels. The treatment strategy was to be structured so that the accumulation of zebra mussels in the tunnels did not impair plant operation. The treatment season was to run from April 1 thru November 30th subject to the vendor's recommendations. The tunnels were to be treated sequentially as to take advantage of the dilution water supplied by the two untreated tunnels during the treatment. Chemical detoxification was not desired for the project. Plant labor was originally envisioned to operate the system and perform the lab analyses; however in addition, the plant requested that an option be provided for the vendor to provide this service of which we opted to take.

The plant was to perform a cumulative settlement study during the treatment season with their zebra mussel monitoring vendor. A goal was set that no more than 10% of the post-veligers measured on the slides during the treatment season would exceed 500 microns.

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The vendor was to work with the plant to develop a site application procedure and supply the plant with analytical procedures for determining both process and discharge effluent chemical residual concentrations. The vendor was to evaluate the treatment chemical for materials compatibility to ensure there would be no impact to plant seals, gaskets, structures, and piping components. The vendor was to also determine and report impacts if any that the chemical might have on the Plant's Make-up Plant and the chemical being used simultaneously with continuous chlorination of the service water systems. In addition to meeting the above criteria, award of the contract was contingent upon approval by the MDEQ to use the vendor's chemical at the Cook Plant.

Bids were evaluated on their technical merit, the chemical's ability to be approved by the MDEQ for use at the Cook Plant in the manner being proposed by the vendor, and cost.
The three chemicals that were evaluated were GEBetz Spectrus CT1300, Ondeo-Nalco EVAC, and HOH Chemicals A-432 (Mexel).

The A-432 (Mexel) would have required longer lead times for delivery due to its being produced in France. The proposed method for delivery to the on-site bulk tank utilized plant compressed air to pressurize the delivery tank. This method is unlike methods used at the plant, as the delivery trucks are equipped with their own chemical off-loading system. Static mixers were also proposed to be located between the dilution water supply header and the screenhouse connection points to the 3-inch PVC chemical feed lines which route to the intake cribs. This arrangement would have possibly needed additional supports, and would have taken up additional screenhouse floor space. The CT1300 and EVAC products are produced in the U.S. and have been used successfully in the past at Cook Plant.

The proposed treatment regimes for CT1300 and A-432 were quite compelling due to their relatively short durations. The proposed application rate for the CT1300 was 1.5 ppm for 2 hr./day per tunnel and the A-432 was 2-2.25 ppm for 20-30 minutes per day per tunnel. The EVAC treatment regime was less desirable at 0.25 ppm for 4 hrs./day per tunnel. The CT1300 and A-432 were the most competitive as far as cost was concerned. CT1300 was selected for the project based on technical, cost, and MDEQ discharge suitability, the last of which will be addressed later in this report.

All three vendors evaluated their products for compatibility with the Plant's Make-up Plant, component materials, and continuous chlorination of the service water systems. None anticipated any problems posed by their products in the concentrations and durations being applied. None anticipated problems with the Make-up Plant provided the pre-treatment system was working as designed. A problem with the Make-up Plant R/O membranes being plugged by colloidal material was had during the daily CT1300 applications. A consultant from Water & Power Technologies, Inc. hypothesized that the R/O element failure was due to the addition of the CT1300, which is a very surface-active cationic surfactant. He thought that CT1300 modified the negative surface charge of the colloids in the water and/or the negative charge characteristics of the poly-amide R/O membrane surface. This allowed the colloidal material to come out of suspension and grow larger and plate out on the R/O membrane. It was the opinion of the consultant that neither the vendor staff, Cook Nuclear Plant, nor himself, could have foreseen the occurrence of this situation in advance. The application procedure needed to be revised to use the Lake Township water supply during periods when the CT1300 was being applied.

During the first few applications, Chemistry reported that they were seeing an increase in circulating water system demand and having to raise chlorine residuals during the period of biocide injection. It is surmised that the biocide was stripping off bio-mass causing an increase in demand during the period of biocide addition. As such, the intermittent chlorination of the circulating water system was scheduled and completed before the 6-hr. biocide application each day.

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b) Letters requesting approval of the biocide that were sent to the state requested applications in a manner that would achieve a successful treatment.

Letters of request for the two most competitive products, A-432 and CT1300 were sent to the MDEQ for review.

A letter requesting the use of A-432 was sent to the MDEQ, Surface Water Quality Division on May 22, 2003 (2003-690). The request was in accordance with the vendor's bid proposal to apply the biocide independently to each tunnel up to a maximum concentration of 3.75 ppm for up to 30 minutes each day during the veliger spawning season to remove existing mussel colonies and to prevent further settlement. This would result in three 30-minute discharges of A-432 out each unit's outfall (001 & 002) averaging 0.5 ppm with no one sample exceeding 0.75 ppm. as measured at each outfall's near shore sample point. The MDEQ replied in a letter dated May 29, 2003 (2003-744), that based on the toxicity information available for A-432, a discharge concentration of 0.5 ppm will exceed the daily maximum discharge concentration of 0.021 ppm that had been established for the product. They in turn disapproved the application under the conditions set forth in our May 22, 2003 request letter. The vendor has since run additional toxicity testing on A-432 and is engaging the services of a Michigan water quality lab versed in the state procedures to develop a higher discharge limit for the product.

A letter requesting the use of CT1300 was sent to the MDEQ, Surface Water Quality Division on May 6, 2003 (2003-596). The request was in accordance with the vendor's bid proposal to apply the biocide independently to each tunnel at a concentration of 1.5 ppm for up to 2 hours each day during the veliger spawning season from April thru November. The request described that there would be imperfect mixing due to the preference of effluents from the North intake tunnel to be discharged out the Unit 1 Discharge tunnel (Outfall 001) and the effluents from the South intake tunnel to be discharged out the Unit 2 Discharge tunnel (Outfall 002) and approval was sought for a 1 ppm discharge concentration as measured at each outfall's sample point with a 10:1 mixing zone.

Discussions were had with the MDEQ and Environmental management and it became apparent that the MDEQ was not going to apply a mixing zone to the proposed discharge concentration without further demonstration. Subsequently, the CT1300 vendor was able to present toxicity data to the MDEQ to support raising the discharge limit from 0.038 ppm to 0.070 ppm. In a letter to the MDEQ on June 12, 2003 (2003-803), the Plant modified its request to apply the biocide independently to each tunnel for 2 hours per day with the resulting discharge concentration as measured from each outfall's sample point not to exceed 0.070 ppm. The plant also stated that there was a possibility of increasing the mixing zone to 1.5 based on studies by Alden Labs. In a letter dated June 13, 2003 (2003-839), the MDEQ granted permission to discharge up to 0.070 ppm of CT1300 from each outfall for 2 hours per tunnel per day with no changes to the mixing zone.

It is important to note, and will be discussed further in this report, that the final discharge concentration that was granted by the MDEQ was much lower (by a factor of 14X) than what was requested by the plant. Therefore, the possibility of a successful treatment outcome was jeopardized by the restrictive discharge limits granted by the MDEQ. It was thought that even at this low concentration, there would be some effect on the zebra mussel larvae in that the tunnels would exhibit an environment not conducive to settlement and an effect on the slime layer underneath the adult mussels that would cause them to release over time.

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c) **Procedure 12-EA-6090-ENV-109, Intake Tunnel Molluscicide Treatment, was revised to incorporate the new treatment procedure and met the requirements of ENVI-8913.**

Revision 4 of 12-EA-6090-ENV-109, Intake Tunnel Molluscicide Treatment was issued on June 20, 2003. The revision incorporated a method to perform preventive treatments to the intake tunnels on a routine basis that are targeted at the microscopic settlement stage of the zebra mussel. It was expected that applying a biocide on a daily or other routine schedule does not necessarily kill the zebra mussel, but provides an unsuitable environmental for it to settle and colonize a system. The scope of this procedure revision is consistent with para. 4.7.1a. of ENVI-8913 Rev. 3, Zebra Mussel Monitoring and Control Program, that states; "A preventive treatment strategy using daily or other periodic biocide applications is under evaluation". Revision 5 of 12-EA-6090-ENV-109 was issued on July 29, 2003 to provide a method for switching the water supply for the Make-up Plant from the NESW to Lake Township water during the period of biocide treatments so that the NESW treated water did not enter the Make-up Plant and cause fouling of the R/O membranes. Both procedure revisions performed as expected.

The Peer evaluator commented that in reviewing the site biocide procedure 12-EA-6090-ENV-109, Intake Tunnel Molluscicide Treatment, that the MDEQ limits for preventive treatments were not mentioned in the procedure. We explained that the MDEQ granted permission to perform preventive treatments late in the spring of 2003. Because of this late approval, we purposely did not state the type of biocide to be used or the actual discharge limit values, but referred the user to the limits as specified in the MDEQ's approval letter.

The Peer evaluator also commented that more contingencies are written into their site biocide procedure than were included in ours e.g. loss of power, loss of heat exchangers, etc.

A condition report search for the years' 2002 and 2003 was performed on the key word search, "Detailed Condition Description" = mussels or clams or CT1300 or molluscicide. The search produced four condition reports (CRs 02159030 of 6/8/02, 02290055 of 10/17/02, 03079007 of 3/20/03 & 03326033 of 11/22/03) related to traveling screen carryover of mussels and debris due to spray nozzles being plugged or misaligned. One of the screen panels on 2-OME-43-4 (CR-02159030 had broken screen mesh due possibly to corrosion. It is important to note that this degraded mesh condition due to corrosion was identified later as a failure mechanism in the fish intrusion event of April 2003 (CR 03114044). All condition reports were classified "OR" (Operations Review) at the 0900 Plant Managers meetings and concluded "that the Work Control Process is adequate to resolve this issue and no further evaluations are needed in this CR". New multi-disk design traveling screens (12-RPA-5191) made of materials that are corrosion resistant and result in zero carryover, have been tested and are planned for installation in 2004. The 2003 preventive biocide treatment had no noticeable effect on traveling screen carryover.

The original treatment schedule of April 1 thru November 30 subject to the vendors' recommendations could not be met. This was due to the late MDEQ approval of the chemical discharge received on 6/13/03 which impacted an earlier start, and WMO-17 needing to be closed to support intake forebay diving operations in November during the Unit 1 Refueling Outage which cut off two weeks toward the end. Even if the biocide had been deemed effective, this reduced schedule window would have had little impact, as the first zebra mussel peak spawn of 186,500 veligers per cubic meter (Attachment 2) did not occur until 6/19/03 and we started the daily biocide treatments shortly thereafter on 6/25/03. When it was confirmed by diving inspections of the Center and North intake tunnels during the Unit 1 Refueling Outage that the biocide applications were having little effect, it was decided that continuing the biocide applications would be of little value. Instead, we opted to concentrate our efforts into ensuring that all needed screen house diver cleaning activities of the intake forebay were completed during the Unit 1 Refueling Outage. Should preventive treatments be considered in the future, a biocide application schedule of May 1 thru November 30th schedule should be considered similar to the schedule for service water system continuous chlorination.

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d) The settlement monitoring system was able to provide feedback as to whether the settlement goal was being achieved. This goal being that no more than 10% of the post-veligers measured on the slides would exceed 500 microns.

The plant had prior experience with a sampling system that consisted of placing 8 gpm well-pumps down the intake tunnel manways and feeding extension cords and tygon tubing through the plant perimeter fence to direct the water flow to bio-boxes placed on a table on the west wall of the screenhouse. These bio-boxes would then drain to the intake forebay. In previous shock treatments, the bio-boxes were seeded with live adult zebra mussels and left exposed to the treated water from the intake tunnels during the treatment. The efficacy of the treatment could be assessed by counting the number of live and dead zebra mussels in the bio-boxes in the days that followed the treatment. Within two weeks following the treatments, the count was completed. The bio-box and well pump arrangement also served as a sampling system for the treated water to determine the biocide residual. This system worked quite well for the approximate 4-week period it was called upon to pump water for chemical shock treatments.

The challenge was to either find a new pumping system or upgrade the existing system to pump 24/7 for 8 months in a 6-7 ft/sec. intake tunnel flow. Our previous experience was that the well pumps would typically give out after one month of continuous operation. This short running life was difficult to accept, as well pumps in a home can last in excess of 20 years. After an evaluation, an air operated diaphragm pump was tested. It would not lift the 14 ft. head from the water surface to the screenhouse grade and the idea was discarded. An Environmental Technician explained the problem with the well pumps to our well pump supplier and he was able to recommend fitting out our well pumps with a PVC sleeve and a wire reinforced tubing length with a screen at the end. This assembly allowed the well pump to remain submerged in the water that rose into the manway, but out of the swift flow of the intake tunnel. The wire reinforced tubing and screen extended down into the intake tunnel flow. The flow of water rushing past the pump motor and into the pump inlet cooled the motor and greatly enhanced its running life. This configuration is similar to how a well pump is situated within a well casing.

For the settlement study, test tube racks filled with microscope slides were placed into the bio-boxes to serve as artificial substrates to monitor settlement in each of the North, Center, and South intake tunnel manway bio-boxes. For a control, microscope slides placed in test tube racks surrounded by metal cages were attached to a weighted rope and deployed in the center of the intake forebay west of the trash racks.

The system was set up in mid-June and operated continuously until early October when flow was observed to be diminishing on the North intake manway bio-box. About a week later, flow was observed to be diminishing on the South intake manway bio-box. The North and South pumps were replaced with new pumps and the intake screens and wire reinforced tubing was cleaned and backflushed. From this experience it can be concluded that the pumps have a pumping life of about 4 months before they wear out. In the future, we'll be able to anticipate this diminished performance, and schedule a pump change-out before it occurs.

The settlement monitoring system did provide feedback as to whether the goal of no more than 10% of the settled post-veligers were greater than 500 microns was being met. Referring to the chart (Attachment 1), with the exception of the 10/30 sample on the North Intake Tunnel Manway bio-box, the average size range and individual average size increased in all bio-boxes. Within about a month (7/23) after commencing the daily treatments, the South Intake Tunnel Manway bio-box showed that 14% of the settled post-veligers counted were greater than 500 microns. By the next sample date on 8/7 all of the test bio-boxes showed more than 10% of the settled post-veligers greater than 500 microns. The Control slides did not show more than 10% of the settled post veligers greater than 500 microns until 10/2. This could have been due to the fact that these slides were getting a longer duration though lower concentration exposure being that these slides were positioned downstream of the intake tunnels, or that they were suspended in a flow as opposed to the slides in the bio-boxes where the flow was virtually stagnant. At any rate, the sampling system was able to determine whether the goal of no more than 10% of the settled post-veligers were greater than 500 microns was being met. The sampling results showed that the goal was not being met.

During the monitoring season, discussions were had as to whether the bio-boxes simulated the conditions in the intake tunnels, being that the flow rate through the tunnels was 6-7 ft/sec. and the flow rate through the bio-boxes was virtually stagnant. Running the sample stream through a small-scale corrugated pipe was discussed, however the volume of water pumped by the sample pumps would have had to be much greater to simulate the 6-7 ft./sec. flow rate. This was discussed with the peer evaluator during the self-assessment who explained that our pipe corrugation design creates small eddies or low flow areas on the downstream side of the corrugation which causes zebra mussel settlement. This being the case, the bio-boxes do simulate the eddies or low flow areas in the pipe where zebra mussel settlement occurs. It was surmised by the evaluation team that if our intake tunnels were smooth, there would be little if any settlement in the tunnels at a flow rate of 6-7 ft./sec. This is the case with the Nine Mile Point 2 intake concrete tunnel. The peer evaluator reported that they only see settlement at the joint gaps where eddies occur in the concrete tunnel.

Video diving inspection tapes were reviewed with the Peer Evaluator from the Center and North Intake tunnels performed in the fall of 2003. These were compared with the diving inspection performed on the North Intake tunnel in the spring of 2002. The 2003 inspection results show that there are two layers of 3/8" zebra mussels growing on the downstream side of the corrugations and beginning to fill the invert of the corrugation. From these tapes, the Peer Evaluator was able to develop a theory as to how mussels infest the intake tunnel in the presence of a high flow velocity (6-7 ft./sec) through the tunnel. He stated that mussels settle due to the pipe being made of corrugated steel. Flow velocity is much lower along the tunnel walls, probably on the order of 1-2 ft./sec. Eddies are created on the downstream side of the corrugation that allows larval and juvenile mussels to settle and accumulate on the downstream side of the corrugation. These settled mussels in turn move the eddy further downstream and allow mussels to settle and eventually fill in the entire inverted corrugation. This eddying effect could be mitigated by making the tunnel walls smooth. He mention the possibility of installing a In-Situform™ sock as a means of making the tunnel walls smooth. This is done by introducing an epoxy sock at one end of the tunnel and allowing it to expand out to the tunnel walls and harden in place. The result is a smooth piping surface. He reported that this technology is employed often in the repair to sewer lines.

Twenty (20) Performance Observation Program observations (POPs) were made in 2002 and 2003 on the zebra mussel monitoring and chemical applications vendors. This POPs entailed observing these persons performing tasks on various aspects of zebra mussel monitoring and biocide treatments. No performance deficiencies were determined from the review of the POPs.

A site tour was given to the peer evaluator for him to gain familiarity with the plant systems and lay-out, and equipment used for the project. The peer evaluator also had the opportunity of observing Ms. Grandholm performing standard method zebra mussel counts on artificial substrates during his visit. The peer evaluator concluded that the equipment used for the project was consistent with industry practices for performing zebra mussel monitoring and control. It was also concluded that Ms. Grandholm was using the standard protocols for determining zebra mussel counts and sizes on artificial substrates.

e) **Chemical residuals were monitored in the bio-boxes and unit discharges. No spill events or chemical discharge exceedences occurred during the application period. The chemical residuals specified by the vendor were achieved in the intake tunnel bio-boxes.**

Attachment 2 shows the daily chemical residual data collected in the intake tunnel manway bio-boxes. This data was taken from Data Sheet 1 of procedure 12-EA-6090-ENV-109, Intake Tunnel Molluscicide Treatment. The daily biocide treatments were performed on the intake tunnels from June 25, 2003 until October 28, 2003. Daily treatments were stopped after this date as the emergency service water gate WMO-17 needed to be closed to accommodate outage diving and MOV maintenance work during the Unit 1 Refueling Outage. Daily treatments were resumed on November 19, 2003 to deplete the chemical that remained in the semi-bulk container and flush the system. The tunnels were treated daily for 113 days.

The MDEQ discharge limit of 0.070 ppm (70 ppb) was never exceeded. Chemical residuals within the tunnels had to be kept low during the beginning of the season, but could be raised as circulating water system demand increased as warmer lake water temperatures led to plankton blooms, and in the fall, turbulent lake conditions resulted in more material in suspension. The highest chemical residual obtained during the treatment season was 298 ppb in the Center Intake tunnel on October 13, 2003. The average chemical residual concentration for the 113 day period measured in the North Intake Tunnel Manway bio-box was 66 ppb, for the Center Intake Tunnel Manway bio-box it was 102 ppb and for the South Intake Tunnel Manway bio-box it was 64 ppb. In their proposal, the chemical vendor recommended that 1.5 ppm (1500 ppb) be applied for 2 hours per tunnel per day. At best we were able to deliver an average residual of 102 ppb for 2 hours per day in the Center tunnel. Therefore, the chemical residual specified by the vendor was not achieved as measured in the intake tunnel bio-boxes.

The biocide vendor believes that flow in the tunnel at a velocity of 6-7 ft./sec is turbulent. Therefore, the biocide distribution in the tunnel is homogeneous. The velocity profile is disturbed by the tunnel corrugations. The low concentration of chemical being applied during preventive treatments is either not getting down in the lower dips in the corrugations due to the eddy effect or existing mussel populations remove the available chemical residual and recover from the exposure. The chemical never reaches the slime layer between the mussels and the tunnel wall, thus mussels do not release from the tunnel walls.

Upon his return to Nine Mile Point Nuclear Plant, the Peer Evaluator discussed our corrugated steel intake pipe design with their system engineers and developed the following theory. Regardless of pipe construction, the normal velocity profile would be lower at the tunnel wall. The pipe corrugations magnify this effect resulting in stratification of the boundary layer of water at the tunnel wall with the bulk flow. Any chemical residual in this low velocity boundary layer would be quickly consumed by the chemical demand from mussels, slime, and sediments residing on the pipe walls and not replenished by the chemical residual in the bulk water flow. This has been experienced in the past while doing shock treatments. When we brought the chemical residual up slowly in a swiftly flowing intake tunnel it would take a long time to overcome the chemical demand. Conversely, where we've brought the chemical residual concentration up quickly, the chemical demand is quickly overcome, and we can easily maintain a residual concentration in the tunnel.

In contrast, good results can be achieved when performing shock treatments in water temperatures ≥68 degrees F by slowing the intake tunnel flow using a stoplog or having fewer circulating water pumps in run during outage periods. This allows the higher concentration (4-6 ppm) biocide better contact with the mussels residing in the tunnel corrugations and results in a

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better kill. Decreasing flow velocity in the intake tunnel may decrease the eddy effect at the tunnel walls and result in a chemical "soak type" environment.

During the self-assessment, the Peer Evaluator mentioned a non-chemical means of controlling zebra mussels in the intake tunnels via hypoxia. The tunnels could be shut for a period of time to deplete the dissolved oxygen level to the point where the mussels suffocate. The use of sodium bisulfite could be used to hasten the oxygen depletion process and minimize the time period that the tunnel was removed from service.

A restrictive MDEQ discharge limit of 0.070 ppm, a low circulating water system demand especially early in the season, and an inadequate dilution of the intake tunnel effluent before being discharged to the lake impacted our ability to achieve the vendor's recommended residual concentrations within the intake tunnels.

A discussion of this inadequate dilution phenomenon is worthy for purposes of planning future treatment strategies of this kind. Intake tunnel residual data was compared with the corresponding Unit 1 and Unit 2 discharge data from October 1-17, 2003. Both units were in operation during this time period and the circulating water system was in its normal alignment with all three tunnels open and tunnel flow rates in the 6-7 ft./sec. velocity range. Under perfect mixing conditions, one would expect a 2/3 (67% reduction) dilution of the intake tunnel effluent when it mixes with the two untreated tunnels before being discharged to the lake. However, due to the plant's intake forebay design, this is not the case. Because of the baffle wall configuration in the intake forebay and the uneven number of circulating water pumps (3 for U1 & 4 for U2), effluents from the North Intake tunnel have a preference for being discharged out the Unit 1 Discharge and effluents from the South Intake tunnel have a preference for being discharged out the Unit 2 Discharge tunnel. Due to the additional circulating water pump on Unit 2, effluents from the Center Intake tunnel have a tendency to be drawn toward the Unit 2 side of the intake forebay and be discharged out the Unit 2 Discharge. A percent reduction of the intake tunnel residuals due to mixing and system demand was determined for this data and is presented below:

Tunnel Treated	% Reduction in Effluent Concentration Discharged from Unit 1	% Reduction in Effluent Concentration Discharged from Unit 2	Average Reduction in Effluent Concentration Discharged from Both Units
North	3	15	9
Center	60	61	61
South	18	12	15

The best percent reduction in effluent concentration in the plant discharges occurs when treating the Center Intake tunnel (61%). Very little reduction in effluent concentration occurs when treating the North (9%) or the South (15%) intake tunnels. One should be cognizant of these percent reductions in effluent concentrations when planning future preventive treatment applications.

Summary

Site Request for Proposal and Contracting procedures were used to obtain a chemical vendor to supply chemical, equipment, and labor for the project. The CT1300 treatment was selected for the project based on technical, cost, and MDEQ discharge suitability. Two unforeseen issues arose as a result of using the product. A problem with the Make-up Plant's R/O membranes being plugged by colloidal material was had during the daily CT1300 applications. It was the opinion of an independent make-up plant consultant that "neither the vendor staff, Cook Nuclear Plant, nor himself, could have foreseen the occurrence of this situation in advance". The application procedure needed to be revised to use the Lake Township water supply during periods when the CT1300 was being applied. Also, during the first few applications, Chemistry reported that they were seeing an increase in circulating water system demand and having to

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raise chlorine residuals during the period of biocide injection. This was remedied by scheduling the daily biocide treatments after the daily intermittent chlorination treatment to the circulating water system.

Letters of request for the two most competitive products, A-432 and CT1300 were sent to the MDEQ for review. The letters requested use of the products in accordance with the vendors' recommendations described in their proposals. The MDEQ would not approve discharge of the products as recommended. The plant elected to submit a request to the MDEQ and obtained approval to discharge the CT1300 product at a much lower concentration (0.070 ppm) than specified in the vendor's proposal. It was thought that even at this low concentration, there would be some effect on the zebra mussel larvae in that the tunnel would exhibit an environment not conducive to settlement and have an effect on the slime layer underneath the adult mussels that would cause them to release over time. The low concentrations applied to the intake tunnels did not have this expected effect.

Plant procedure 12-EA-6090-ENV-109, Intake Tunnel Molluscicide Treatment, was revised to incorporate the new treatment procedure and met the requirement of ENVI-8913. The procedure had to be revised again to provide a method for switching the water supply for the Make-up Plant from the NESW to Lake Township water during the period of biocide treatments so that the NESW treated water did not enter the Make-up Plant and cause fouling of the R/O membranes. Both procedure revisions performed as expected. The peer evaluator commented that more contingencies could be written into our biocide addition procedure e.g. loss of power, loss of heat exchangers, etc.

The settlement monitoring system was able to provide feedback as to whether the settlement goal was being achieved. This goal being that no more than 10% of the post-veligers measured on the slides would exceed 500 microns. An upgraded bio-box pumping system was used for the first time during this project. This design was able to perform reliably for four months as opposed to one month as in the past. The sampling results showed that the goal was not being met.

Chemical residuals were monitored in the bio-boxes and unit discharges. No spill events or chemical discharge exceedences occurred during the application period. The vendor and plant proved that the preventive biocide application could be controlled within its MDEQ permitted conditions. Save for spent analytical reagents, there were no waste application products to dispose of at the end of the project. The chemical residuals specified by the vendor were not achieved in the intake tunnel bio-boxes, because of the MDEQ discharge limits being too low, low circulating water system demand, and inadequate dilution due to the flow characteristics in the intake forebay.

Strengths

None

Areas Found Acceptable

1) No spill events or chemical discharge exceedences occurred during the application period. The vendor and plant proved that the preventive biocide application could be controlled within its MDEQ permitted conditions. This is the first known zebra mussel preventive biocide application of this grand a scale performed in the U. S.

2) The settlement monitoring system was able to provide feedback as to whether the settlement goal was being achieved. An upgraded bio-box pumping system was used for the first time during this project. This design was able to perform reliably for four months as opposed to one month as in the past.

3) Many lessons were learned. A better knowledge of our intake tunnel corrugated pipe design being conducive to zebra mussel settlement due to the eddying effect of the pipe corrugations is better understood. The demand and dilution characteristics of the lake water and intake forebay are better understood.

Findings

None

Recommendations

1) Review this assessment with peers and vendors to develop a more effective chemical preventive treatment program, mechanical cleaning, or revisit targeted shock treatments to the intake tunnels.

2) The peer evaluator noted that the biocide application procedure could be enhanced including more contingencies into the procedure such as strainer plugging, power reductions etc. The biocide application procedure 12-EA-6090-ENV-109, Intake Tunnel Molluscicide Treatment should be revised to include these contingencies.

3) Investigate the possibility of installing a In-Situform™ sock as a means of making the tunnel walls smooth. This technology is employed often in the repair to sewer lines.

4) Investigate a non-chemical means of controlling zebra mussels in the intake tunnels via hypoxia. The tunnels could be shut for a period of time to deplete the dissolved oxygen level to the point where the mussels suffocate. The use of sodium bisulfite could be used to hasten the oxygen depletion process and minimize the time period that the tunnel was removed from service.

ZEBRA MUSSEL SETTLEMENT MONITORING
RESULTS 2003
PREVENTIVE TREATMENT

North Intake Tunnel Manway

DATES	7/10/2003	7/17/2003	7/23/2003	8/7/2003	8/21/2003	9/4/2003	9/18/2003	10/2/2003	10/16/2003	10/30/2003
Density	15,467	74,311	108,800	782,933	249,493	958,720	>9/4	TNTC	(1)	130,844
Size Range (µ)	200-330	200-460	160-630	200-1490	200-1190	230-3300	200-4290	230-4030	260-1600	300-1190
Avg Size (µ)	246	304	352	472	357	611	941	1026	752	522
# >500 µ	0	0	3	10	8	13	13	34	36	23
% >500 µ	0	0	6	20	16	26	26	68	72	46

Center Intake Tunnel Manway

DATES	7/10/2003	7/17/2003	7/23/2003	8/7/2003	8/21/2003	9/4/2003	9/18/2003	10/2/2003	10/16/2003	10/30/2003
Density	4,000	25,244	41,600	300,267	TNTC	1,040,000	>9/4	TNTC	(1)	228,267
Size Range (µ)	200-400	160-600	160-700	200-1160	200-1490	200-1550	200-3130	200-3070	230-2110	230-4290
Avg Size (µ)	242	264	301	446	400	403	550	678	674	852
# >500 µ	0	3	2	14	8	4	8	19	24	28
% >500 µ	0	6	4	28	16	8	16	38	48	56

South Intake Tunnel Manway

DATES	7/10/2003	7/17/2003	7/23/2003	8/7/2003	8/21/2003	9/4/2003	9/18/2003	10/2/2003	10/16/2003	10/30/2003
Density	23,467	79,289	98,667	509,333	TNTC	702,933	>9/4	TNTC	168,533	172,089
Size Range (µ)	160-360	160-600	160-830	230-1420	200-3140	200-660	200-1190	200-1980	230-2400	300-2145
Avg Size (µ)	244	321	362	436	499	385	396	422	557	880
# >500 µ	0	3	7	9	8	5	9	11	25	32
% >500 µ	0	6	14	18	16	10	18	22	50	64

Control Forebay

DATES	7/10/2003	7/17/2003	7/23/2003	8/7/2003	8/21/2003	9/4/2003	9/18/2003	10/2/2003	10/16/2003	10/30/2003
Density	ND	159,467	149,333	358,400	2,363,200	1,553,600	1,888,500	1,565,300	406,933	404,000
Size Range (µ)	ND	200-460	160-400	200-430	200-530	230-500	230-600	230-730	330-930	300-1680
Avg Size (µ)	ND	273	288	315	357	355	384	376	547	623
# >500 µ	ND	0	0	0	1	0	1	8	17	23
% >500 µ	ND	0	0	0	2	0	2	16	34	46

ND - No Data
TNTC - Too Numerous To Count
(1) - Too Much Detritus

Attachment 2

2003 Preventive Treatment
Biocide Residual & Zebra Mussel Whole Water
Monitoring Results

Date	North	Center	South	
	CT-1300 ug/l	CT-1300 ug/l	CT-1300 ug/l	Whole-Water
5/1/2003	-	-	-	75
5/8/2003	-	-	-	50
5/22/2003	-	-	-	2,075
5/29/2003	-	-	-	10,275
6/5/2003	-	-	-	16,975
6/19/2003	-	-	-	186,500
6/25/2003	55	<50	60	ND
6/26/2003	50	<50	55	10,725
6/27/2003	55	<50	50	ND
6/28/2003	70	70	70	ND
6/29/2003	50	50	50	ND
6/30/2003	90	80	90	ND
7/1/2003	65	65	50	ND
7/2/2003	70	85	95	ND
7/3/2003	105	80	110	120,750
7/4/2003	95	110	100	ND
7/5/2003	65	<50	ND	ND
7/6/2003	<50	<50	<50	ND
7/7/2003	<50	<50	<50	ND
7/8/2003	80	<50	50	ND
7/9/2003	-	-	-	ND
7/10/2003	-	-	-	107,600
7/11/2003	-	-	-	ND
7/12/2003	85	120	90	ND
7/13/2003	82	70	86	ND
7/14/2003	70	80	80	ND
7/15/2003	68	87	63	ND
7/16/2003	62	80	59	ND
7/17/2003	54	65	55	60,500
7/18/2003	67	99	69	ND
7/19/2003	-	-	-	ND
7/20/2003	-	-	-	ND
7/21/2003	-	-	-	ND
7/22/2003	-	-	-	ND
7/23/2003	-	-	-	331,750
7/24/2003	72	128	72	ND
7/25/2003	-	-	-	ND
7/26/2003	-	-	-	ND
7/27/2003	-	-	-	ND
7/28/2003	-	-	-	ND
7/29/2003	60	99	56	ND
7/30/2003	52	131	66	ND

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7/31/2003	77	52	57	331,000
8/1/2003	65	81	65	ND
8/2/2003	53	98	55	ND
8/3/2003	54	86	52	ND
8/4/2003	<50	76	<50	ND
8/5/2003	<50	70	<50	ND
8/6/2003	53	73	56	ND
8/7/2003	<50	89	55	184,650
8/8/2003	51	89	<50	ND
8/9/2003	56	76	<50	ND
8/10/2003	53	94	56	ND
8/11/2003	51	89	<50	ND
8/12/2003	<50	67	<50	ND
8/13/2003	61	83	58	ND
8/14/2003	60	90	<50	450,000
8/15/2003	57	74	50	ND
8/16/2003	58	127	62	ND
8/17/2003	82	72	89	ND
8/18/2003	76	119	74	ND
8/19/2003	74	84	80	ND
8/20/2003	68	68	56	ND
8/21/2003	76	139	68	126,400
8/22/2003	81	113	84	ND
8/23/2003	76	167	54	ND
8/24/2003	64	95	72	ND
8/25/2003	64	92	80	ND
8/26/2003	60	102	56	ND
8/27/2003	67	163	66	ND
8/28/2003	87	169	62	88,100
8/29/2003	57	182	57	ND
8/30/2003	93	180	75	ND
8/31/2003	72	159	91	ND
9/1/2003	75	110	67	ND
9/2/2003	<50	86	<50	ND
9/3/2003	88	138	77	ND
9/4/2003	<50	60	51	13,950
9/5/2003	<50	118	63	ND
9/6/2003	55	60	<50	ND
9/7/2003	55	56	53	ND
9/8/2003	55	75	53	ND
9/9/2003	<50	132	<50	ND
9/10/2003	60	<50	63	50,925
9/11/2003	80	102	81	ND
9/12/2003	56	80	55	ND
9/13/2003	57	110	75	ND
9/14/2003	<50	60	<50	ND
9/15/2003	<50	60	<50	ND
9/16/2003	51	89	55	ND

9/17/2003	58	149	53	ND
9/18/2003	79	125	59	37,650
9/19/2003	70	134	70	ND
9/20/2003	72	120	61	ND
9/21/2003	50	128	<50	ND
9/22/2003	100	106	<50	ND
9/23/2003	50	103	55	ND
9/24/2003	95	105	75	ND
9/25/2003	<50	134	<50	21,025
9/26/2003	52	90	52	ND
9/27/2003	55	105	<50	ND
9/28/2003	<50	130	54	ND
9/29/2003	<50	<50	<50	ND
9/30/2003	<50	70	52	ND
10/1/2003	82	73	67	ND
10/2/2003	<50	<50	<50	33,300
10/3/2003	58	98	63	ND
10/4/2003	50	204	<50	ND
10/5/2003	<50	110	57	ND
10/6/2003	75	70	100	ND
10/7/2003	75	72	100	ND
10/8/2003	63	89	50	21,625
10/9/2003	65	265	91	ND
10/10/2003	<50	112	<50	ND
10/11/2003	67	193	72	ND
10/12/2003	50	192	<50	ND
10/13/2003	69	298	64	ND
10/14/2003	51	117	<50	ND
10/15/2003	<50	93	<50	ND
10/16/2003	62	89	71	36,425
10/17/2003	50	130	57	ND
10/18/2003	<50	130	<50	ND
10/19/2003	-	-	-	ND
10/20/2003	<50	<50	<50	ND
10/21/2003	<50	<50	<50	ND
10/22/2003	<50	141	<50	ND
10/23/2003	ND	96	82	ND
10/24/2003	ND	166	75	ND
10/25/2003	104	166	161	ND
10/26/2003	209	183	131	ND
10/27/2003	190	73	83	ND
10/28/2003	94	89	90	ND

Attachment 2

	North	Center	South	
Max.	209	298	161	
Avg.	66	102	64	
Min.	<50	<50	<50	

- No Treatment
ND No Data

Self Assessment Plan

Assessment Number: SA-2003-REA-003-QH
Assessment Topic: Zebra Mussel Monitoring and Control Program

1. Scope of Assessment:

- Evaluate the effectiveness of the preventive treatment strategy using a daily or other periodic biocide application in implementing the required action specified in Step 4.7.1 Chemical Control Methods, of ENVI-8913, Zebra Mussel Monitoring and Control Program. This action being maintaining intake tunnel infestations ≤ 2 inches to minimize clumps breaking off and challenging the traveling screens and systems downstream. ENVI-8913, Zebra Mussel Monitoring and Control Program satisfies one of the objectives of NRC Generic Letter 89-13, that being Action 1- Flow Blockage and Biofouling Monitoring/Control.

2. Expectations of the Assessment:

- A review of contracting activities, obtaining an MDEQ discharge permit, procedure revision, equipment mobilization and operation, and chemical residual and settlement results monitoring, will reveal any program weaknesses in the goal to maintain intake tunnel infestations ≤ 2 inches to minimize clumps breaking off and challenging the traveling screens and systems downstream.

3. Critical Attributes:

I. The Plant intake tunnels were treated daily with a biocide to control zebra growth in the intake tunnels to ≤ 2 inches.

a) Requests for proposals and responses were adequate for successful treatment.

- Chemical feed and lab analysis.
- Performance monitoring.
- Training and qualifications.
- Procedure development.
- Material and system compatibility.
- Compliance with regulations.

b) Letters requesting approval of the biocide that were sent to the state requested applications in a manner that would achieve a successful treatment.

- Review state authorization letter and compliance with the letter.

c) Procedure 12-EA-6090-ENV-109, Intake Tunnel Molluscicide Treatment, was revised to incorporate the new treatment procedure and met the requirements of ENVI-8913.

d) The settlement monitoring system was able to provide feedback as to whether the settlement goal was being achieved. This goal being that no more than 10% of the post-veligers measured on the slides would exceed 500 microns.

e) Chemical residuals were monitored in the bio-boxes and unit discharges. No spill events or chemical discharge exceedences occurred during the application period. The chemical residuals specified by the vendor were achieved in the intake tunnel bio-boxes.

Attribute evaluation will be performed by:

1) Review of Request for Proposal and responses from Chemical Vendors.
2) Review of letters of request for biocide approval and responses from the MDEQ.
3) Review of procedure 12-EA-6090-ENV-109, Intake Tunnel Molluscicide Treatment.

4) Review of settlement monitoring system and data.

5) Review of chemical residual bio-box and unit discharge data.

6) Personnel interviews.

4. Organizations to be Notified:

1. Environmental and contractors

5. Assessment Schedule:

Start: 12/10/2003
Completion: 01/30/2004

Milestones:

12/3/03 – Arrange for a peer evaluator
12/5/03 – Collect data and send out familiarization packet to peer evaluator
12/10- Peer Evaluator Arrives from New York, Introductions, Site Tour, Review of Data
12/11 – Interview with Carol Grandholm
12/11-Interview with William Jung, Complete data collection.
1/16/04 – Draft Assessment Report Complete.
1/30/04 – Final Assessment Report Complete.

6. Assessment Checklist:

1. Perform introductions with peer evaluator and familiarization with Cook Nuclear Plant.
2. Tour of screenhouse and vicinity for understanding of equipment placement and sampling activities.
3. Review of Request for Proposal and responses from chemical vendors.
4. Review of letters of request for biocide approval and responses from the MDEQ.
5. Review of procedure 12-EA-6090-ENV-109, Intake Tunnel Molluscicide Treatment.
6. Review of settlement monitoring data.
7. Review of bio-box and unit discharge chemical residual data.
8. Interview with Chemical Vendor – William Jung
9. Interview with Settlement Monitoring Technician –Carol Grandholm
10. Discuss concluding remarks with Peer Evaluator.

Lead Assessor: Eric Mallen
Team Assessor: Jon Harner
Peer Evaluator: Richard Green, Nine Mile Point Nuclear Station

Reviewed By: 12/4/03
Lead Assessor/ Date

ApprovedBy: 11/25-03
Responsible Management/Date

APPENDIX 9

CR03188002

TECHNICAL ANALYSIS REPORT

Indiana Michigan Power Company

Donald C. Cook Nuclear Plant
One Cook Place
Bridgman, MI 49106

July 28, 2003

Water & Power Technologies, Inc., Job# 7574
Earth Tech Contract Number A-19484
3740 West 1987 South
Salt Lake City, Utah 84104
Phone: (801) 974-5500
Fax: (801) 973-9733
www.wpt.com

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TECHNICAL ANALYSIS REPORT

July 28, 2003

INTRODUCTION

This report summarizes the findings and recommendations from the consulting services conducted by Water & Power Technologies, Inc. (WPT) for Indiana Michigan Power Company (AEP), Donald C. Cook Nuclear Plant in Bridgman, Michigan. Blair Zordell of Indiana Michigan Power Company coordinated the consulting services.

WPT and Norman Norvelle would like to thank Jay Adams, John Carlson Jr., Jonathan Cross, Jon Harner, Eric Mallen, Tom Summers, Jeff Weaver, and Blair Zordell for their time and efforts during this consulting service.

BACKGROUND

Indiana Michigan Power Company (AEP) owns and operates Donald C. Cook Nuclear Plant, an electric generating facility in Bridgman, Michigan. The water at this facility is supplied from Lake Michigan. Water treatment plant feedwater utilizes Lake Michigan water that is provided from the plant's non-essential service water. Supplemental reverse osmosis (RO) system feedwater can be purchased from the Lake Township water supply.

The water treatment plant provides high purity make-up water for the steam generation plant and other plant needs. The water treatment plant is of a standard design using pretreatment, a 2-stage RO system, and a three-bed demineralizer system (cation exchanger, anion exchanger, and mixed bed) with a vacuum degasifier. Overall, the pretreatment system and RO system has provided reliable service and operations.

Environmental regulations and operational conditions necessitated a different water treatment program for zebra mussel control. A biocide from GE Betz (Spectrus CT 1300) was chosen for an evaluation that commenced on June 25, 2003. Within one week the RO system 1st stage feed pressure increased over 100%. The RO elements were chemically cleaned and they returned to original performance. After returning to service they immediately fouled again. Within two-weeks following the addition of the biocide, the RO elements failed due to high differential pressure. Also, salt rejection decreased. A decrease in salt rejection is a failure of the membrane to reject the passage of salt ions. This is observed and measured by an increase in permeate conductivity, which is usually an increase in permeate dissolved solids.

The RO elements were replaced. One of the RO elements was sent to Avista Technologies, Inc for a membrane autopsy. GE Betz performed microbiological analysis of the water. An outside consultant and consulting service (Water & Power

Technologies, Inc) was retained to assist with a recommendation. The purpose of this consulting service was to address the following concerns:

1. Find probable cause of high differential pressure in reverse osmosis (RO) system.
2. Find probably cause of decreased salt rejection (increased permeate conductivity).
3. Provide recommendations to resolve high differential pressures.
4. Provide recommendations to prevent future decrease membrane salt rejection.

INFORMATION & DATA

The following information and data were used to write this report:

1. On-site plant meeting, discussion of water system operation, review of data, and walk down of system on July 15, 2003 with operators, engineers, supervisors, and other technical staff to discuss operational problems and RO system failure.
2. Follow-up meeting and exit meeting report on July 16, 2003.
3. BetzDearborn Material Safety Data Sheet, Effective Date 27-OCT-1988.
4. Ondeo Nalco EVAC© Mollusk Control Treatment Confidential Product Profile.
5. Cook Nuclear Plant Procedure Number: 12-OHP-4021-062-011 Rev.3A, Title: Reverse Osmosis Operations.
6. Cook Nuclear Plant Procedure Number: 12-OHP-4021-062-012 Rev. 1a, Title: Reverse Osmosis Membrane Cleaning.
7. Change of Process Notification for NPDES Permit No. MI0005827 dated October 28, 1996 pertaining to two modifications of RO unit and dry lay-up of boiler.
8. Process printouts of data and charts of RO System for past three weeks.
9. Make-Up Plant Flow for Cook Nuclear Plant H-O-H Chemicals-Dwg # BIO903.
10. Lake Michigan Water Analysis Summary and plant intake water analysis.
11. Cook Nuclear Plant, Information PMP-2291-TRS-001, Rev.2, Data Sheet 1, Troubleshooting Control For Plant, (Pages 25-30).
12. GE Betz Microbiological Analysis, Laboratory ID: 83416, Reported 14-JUL-2003, Cook Nuclear Plant AEP CORP.
13. Avista Membrane Autopsy Report, AEP at Cook Nuclear Plant, July 2003.
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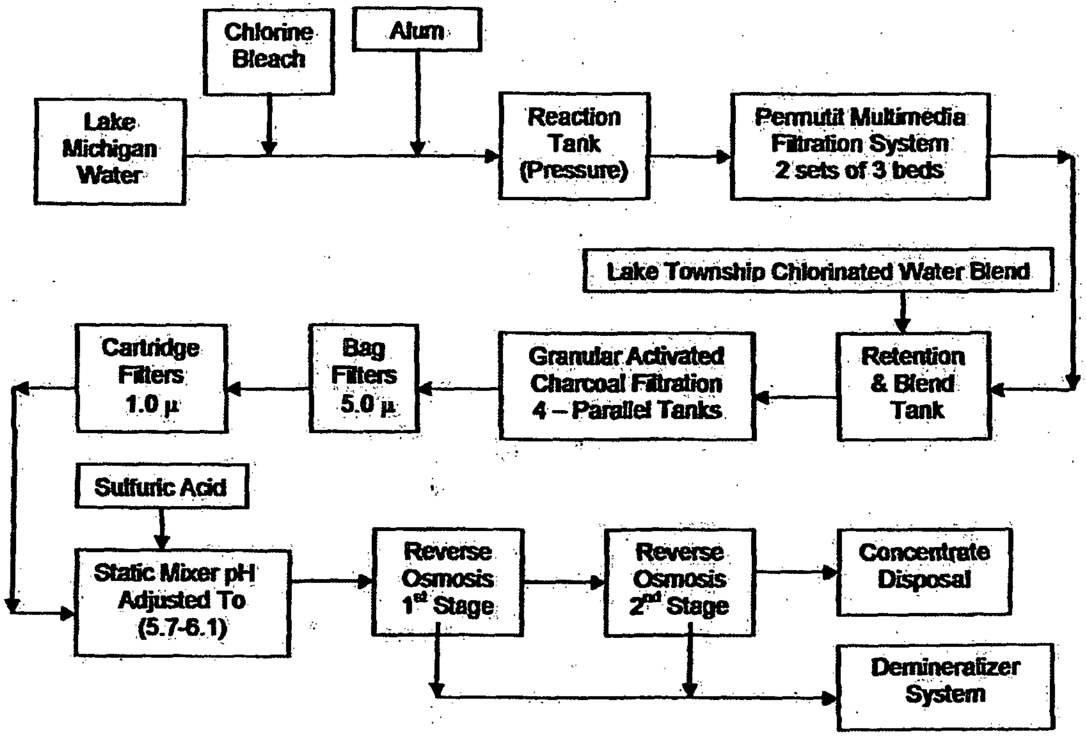
WATER TREATMENT PROCESS



OBSERVATIONS & FINDINGS

1. The existing RO system was designed and built by Ionics, Incorporated.
2. The RO system consists of two separate parallel skids. Each system is a two-stage design consisting of 9 pressure vessels in the first stage and 6 pressure vessels in the second stage. There are 6 elements per pressure vessel.
3. The RO elements are Dow Filmtec membranes (8" BW30-365), which are high surface area brackish water RO elements.
4. Typical RO permeate flow ranges from 250 – 305 gpm and RO reject (concentrate) flow ranges from 90 – 110 gpm.
5. Almost all RO reject water is returned to Lake Michigan and requires a permit.
6. The RO system pretreatment process has been successful operated for many years with few problems.

7. Normal make-up for the water treatment plant is raw water from Lake Michigan with an alternative supply available from the lake township municipal supply.
8. The Lake Michigan raw water quality is very good with an average temperature of 22° C (72° F). The water has a positive L.S.I. and could form calcium carbonate scale without pH adjustment with acid or scale inhibitors.
9. The RO system feedwater pH is adjusted with sulfuric acid to a pH of 5.7 – 6.1 to prevent scaling and overall deposition on the RO element membranes.
10. GE Betz performed a microbiological analysis of the raw lake water (July 14th) and found that overall the water contained only low levels of biota.
11. A new biocide program for zebra mussel control was started on June 25th.
12. The biocide used was GE Betz Spectrus CT1300 (alkyl dimethyl benzyl ammonium chloride). This is also known as an ADBAC quat.
13. About 70 ppb of active biocide is injected for about 6 hours per day. It takes about 15 – 30 minutes for the biocide to clear the forebay.
14. Within several days after the addition of the new biocide there was a rapid increase in 1st stage feed pressure, differential pressure across the 1st stage, and in silt density index (SDI). SDI was greater than 5 in the RO feedwater.
15. The SDI for pretreated raw lake water is typically 1 ½ - 2 and for pretreated municipal water 3 – 3 ½. With the addition of the biocide the SDI was >5.
16. The biocide appeared to require about 4-6 days to migrate through the water treatment system and produce high pressures in the RO system 1st stage.
17. RO system failure resulted from hydraulic rupture and failure of the elements produced from high feed and differential pressures. This pressure resulted from inorganic particles fouling the RO elements. Excessive pressure resulted in elements telescoping, being compressed, and outer fiberglass shells splitting.
18. Avista Technologies performed a membrane autopsy. The primary goal of the autopsy was to determine whether Spectrus CT1300 fouled the membrane. In their recommendations they concluded that CT 1300 fouls Filmtec BW30 membranes and that a different material be evaluated.
19. The autopsy foulant deposit from the membrane consisted of clay, possibly some aluminum hydroxide, bacteria, and bacterial slime.
20. The autopsy revealed a 10-pound gain in the element weight due to particle fouling. This is considered moderate fouling, but would result in very high-pressure drop and pluggage due to the very small size of the particles.
21. The 5.0 µ bag filters are changed weekly.
22. The 1.0 µ cartridge filters are changed every three weeks.
23. Iron levels in the lake make-up water reach up to 0.97 mg/L and an orange precipitate has been noticed on the 1.0 µ cartridge filters.
24. The RO elements were replaced about 2 years ago.
25. The RO elements are chemically cleaned about every 2 years.
26. The RO elements were chemically cleaned after the first fouling and the elements returned to original operating condition prior to the fouling.
27. The water treatment system has no on-line process particle or turbidity analyzers.
28. Operational and Maintenance data are recorded, logged, and can be trended. However, a software program, such as "FTNORM", to normalize and trend

membrane-operating data is not used. Normalization software could not be found to trend water at the cooler Lake Michigan water temperature, which is 22° C.

29. The autopsy also revealed a positive Fujiwara test that is indicative for membranes damaged by chlorine oxidation. Avista recommended that plant dechlorination procedures should be reviewed.
30. A decrease in salt rejection (increase in conductivity) appeared within the same time frame as the fouling. *Note – typical of chlorine oxidation.*
31. Chlorine is injected in front of screens at the forebay for 90 minutes daily, Monday through Friday, for slime control. Also, chlorine is used to disinfect other various plant systems. Chlorine is added as part of the pretreatment system.
32. Chlorine is removed prior to the RO system with granular activated charcoal beds.
33. The granular activated charcoal (GAC) beds are changed out (replaced) yearly and are due for replacement.
34. Lake Township water supply is a supplemental supply to the plant and adds only chlorine and alum to their municipal water treatment process.
35. The Lake Township municipal water supply was used during the past 30 days.
36. The plant treated water is chlorinated to about 0.5 mg/L as free available chlorine (FAC) and the Lake Township municipal water ranges from 2 – 3 mg/L FAC.
37. Lake Township water is added after the GAC beds and is not dechlorinated.
38. The water treatment system has no on-line process chlorine analyzers or oxidation-reduction potential (ORP) analyzers to detect chlorine residuals before the RO system elements.

DISCUSSION

The main objective of this report is to find the probable cause of high differential pressure in the RO system and provide a recommendation to resolve the problem. Other objectives include finding the probable cause of decreased salt rejection and provide recommendations to resolve the problem. Also, provide recommendations to prevent these two reoccurrences and increase RO element longevity.

Based on the information/data identified above and other information, the cause of the element failure was due to high differential pressure. The high differential pressure resulted from mostly inorganic colloidal fouling and sequential plugging of the RO membrane. The probable cause of the colloidal fouling was the addition of a new biocide (GE Betz Spectrus CT 1300) into the water treatment program for zebra mussel control. The cause of the decreased salt rejection was due to oxidation by chlorination. This may have been caused by a failure of the carbon filter (GAC) beds to remove the chlorine. The following will be divided into individual, but related topics to support this conclusion..

Mollusk Control and Quats

Zebra mussel control is difficult and the options are few. Environmental restrictions and treatment costs eliminate many options. Depending on the restrictions and circumstances, the most viable chemical treatment options are chlorination, chlorine dioxide, quaternary ammonium compounds (quats), and other materials combined with

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quats, such as ONDEO Nalco's EVAC mollusk control treatment that is a combination of endothall acid and dimethyl alkylamine.

Cook Nuclear Plant previously utilized chlorination for zebra mussel control. After careful evaluation of several treatment options, the change was made in June to a new program provided by GE Betz (Spectrus CT 1300). Spectrus CT 1300 is a quaternary ammonium compound called alkyldimethylbenzylammonium chloride (ADBAC).

Quaternary Ammonium Compounds (quats)

This general family of cationic wetting agents is sometimes referred to as cationic surfactants or cationic detergents. They are also called quaternary ammonium salts, quaternary amine compounds, quats, and QACs. Quats are a type of organic nitrogen compound in which the molecular structure includes a central nitrogen atom joined to four organic groups as well as to an acid radical. Pentavalent nitrogen ring compounds are also considered quaternary ammonium compounds. They are all cationic surface-active compounds and tend to be adsorbed onto surfaces. There are hundreds of cationic detergents classified as quats. They have the following uses: detergent, disinfectant, cleanser, fungicide, etc. Not all quats are chemically the same or perform the same.

Alkyldimethylbenzylammonium chloride (ADBAC)

ADBAC is an abbreviation and general name for a type of quat. There are many types of quaternary detergents called ADBAC. All are included in the general classification as an ADBAC, but each compound is a little different. An example of a different type of quat that is not an ADBAC is benzalkonium chloride. Spectrus CT 1300 is an ADBAC quat.

Surface Adsorption of ADBAC

A quote from a Betz report states, "ADBAC has a strong affinity for many kinds of suspended solids and substrates which are anionically (negatively) charged." A series of laboratory and field studies conducted by Rohm and Haas Company evaluated the degree and rate that the ADBAC Quat is electrostatically bound to suspended matter and other substrates. Radioactive labeled Quat solutions at concentrations of 0.01 ppm and 0.1ppm were used for studies to determine adsorptive characteristics with different types of materials. These studies appeared to be conducted with natural surface water. With 400-ppm turbidity, and 30 ppm alum concentration the ADBAC was 100 % adsorbed in 30 minutes. However, this is a considerable amount of surface-active adsorptive material for the quat to be adsorbed onto. The average Lake Michigan turbidity is less than 5 ppm and only 5 ppm alum is added to the water treatment system. This may not be enough suspended solids (silt and colloids) and alum to remove the ADBAC quat. Typical, ADBAC and other quats are removed from water by their adsorption onto clay particles.

Filming Tendency of ADBAC and Other Quats

Quats act in a manner very similar to a filming amine. They form a monomolecular film on almost all surfaces (concrete, metal, filter media, GAC, and RO membranes). Some quats are used as filming (barrier) corrosion inhibitors. Most colloids and clays have a negative surface charge. The cationic charge and filming tendency of the quats would allow good removal by adsorption onto clay particles. Due to this filming and adsorption tendency and the low level of ADBAC administrated (70 ppb), several days would probably be required for the ADBAC quat to migrate through the piping, multimedia filters, and GAC beds to reach the RO element membranes and affect them.

Scaling and Fouling of RO Membranes

Deposition of deposits in RO elements is the result of scaling and/or fouling. Scaling occurs when the solubility limit of a salt is exceeded and the salt crystal precipitates near the surface of the element membrane. High feed pressures are produced when a sufficient amount of scale is deposited. Depending on the type of scale that has the potential to be deposited, scaling can usually be controlled by adjustment of the pH with an acid, chemical scale inhibitor, or decreasing RO recover rates (reject concentration). Fouling is more complex. There are two general types of fouling: biofouling and particle fouling. Biofouling results from the growth of living bacteria and/or fungi on the membrane. Particle fouling is where the material deposits on the membrane, but does not grow on the membrane. Particles can be from living (or once living) and nonliving materials. Living (or once living) particles are the bacteria, fungi, algae, protozoa, or their dead components. Nonliving particles are inorganic minerals and organic materials.

Particle Sizes

Inorganic particles can be classified based on their sizes. These sizes are as follows:

- Sand: 50 microns to 2 millimeters (visible to the human eye)
- Silt: 5 – 50 microns (the largest of these may be visible)
- Clay: 1 – 5 microns (not visible to the un-aided eye)
- Colloid: Less than 1 micron (most are too small for a light microscope)

Sand, silt, and clay are particles that will settle. Colloids are very small, finely divided solids (that do not dissolve) that remain dispersed in water due to their small size and electrical charge. Most of the colloidal particles in natural surface water have a negative electrical charge and tend to repel each other. This repulsion prevents the particles from clumping together, becoming heavier, and settling out. A well-designed and operated pretreatment system can typically remove particles 1 micron and greater.

Colloidal fouling of reverse osmosis elements is a common problem. It can seriously impair performance by lowering productivity and sometimes decreasing salt rejection. An early sign of colloidal fouling is often an increased pressure differential across the system. Colloids include mineral clays, insoluble inorganic minerals, colloidal silica, iron corrosion products, and water treatment chemicals such as alum, ferric salts, or cationic polyelectrolytes (polymers).

Clay

The term clay can have two meanings. It can refer to clay as a particle size classification or clay as a mineral. Most inorganic silt and colloids that stay suspended in natural surface water are mineral clays. Clay is a rock term and like most rock it is made up of a number of different minerals in varying proportions. They are a family of hydrous aluminum silicates. Clays may also contain magnesium, iron, potassium, sodium, and are usually mixed with other minerals. Also, they have the ability to adsorb many different materials. Mineral clay could be used to remove phosphate from water, but would not be as efficient as alum and lime. Therefore, X-Ray surface analysis (EDX, XRD, etc.) of a membrane or SDI filter showing aluminum, silica, oxygen, and/or any of the above-mentioned minerals could just be colloidal clay particles and nothing else.

Quantification of Particles

Early quantification of particles was performed by total suspended solids (TSS) analysis. A known volume of water was filtered through a 1.2 micron filter, and then the filter was dried and weighted. The need for lower levels of measurement and in real-time resulted in turbidity measurement becoming popular. Turbidity is an indirect measurement of particles by passing light through a water solution and measuring how much light is reflected by the particles in the liquid. Turbidity is measured in Nephelometric Turbidity Units (NTUs). The lower the NTUs, the fewer particles in the water. Due to recent advances in technology, particle counters using lasers and computers can now measure the exact size and number of particles in a liquid. The higher the TSS or turbidity value of the water, the greater the number of particles and thus the higher the fouling potential.

The best available technology for determining fouling potential of reverse osmosis feed water is the measurement of the Silt Density Index (SDI). This is sometimes referred to as the Fouling Index (FI). An SDI is determined by the initial time it takes to filter water through a 0.45-μ (micron) membrane filter at 30 PSI and fill a 500 ml container. After the water is allowed to flow to drain for 15 minutes, a second 500 ml container is filled and timed. These two timed values are used in a formula to calculate the SDI. A well-operated municipal drinking water treatment system, using surface water as the source water, should be able to remove most particles greater than 0.5 microns, produce a water quality of 0.1-0.2 NTUs, and a SDI of 3 – 4. The feedwater to an RO element should have a <5 SDI and an SDI of < 3 is preferred.

Particle (Colloid) Removal

The best multimedia filters can only remove particles down to about 10 microns. Cartridge filters can effectively remove particles down to 1 micron, but this is only cost effective with nominal filtration. One-micron removal with absolute filtration is usually too expensive. Typically, in a conventional water treatment plant, particles smaller than 10 microns are removed by coagulation, flocculation, sedimentation, and then filtration.

Coagulation is the clumping together of very fine particles (colloids) into larger particles (floc) caused by the use of chemicals (coagulants). Coagulants are usually cationic chemicals, such as alum, ferric chloride, and synthetic organic cationic polyelectrolytes (polymers). The coagulants partially neutralize the negative electrical charges of the fine particles, allowing them to come closer together and to form larger clumps. This clumping together makes it easier to separate the solids from the water by settling and filtering. The gathering together of the fine particles after coagulation to form larger particles by a process of gentle mixing is called flocculation. The sedimentation and filtration of the floc is how the very fine particles (colloids) are removed from the water.

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Usually, the greater the number of colloids present, the better the coagulation and flocculation process.
The process used in a conventional water plant is called conventional filtration. This process uses a clarifier (sedimentation basin). The water treatment plant at Cook does not have a clarifier and this process is called direct filtration. The sedimentation step is omitted and is not required due to the water quality of the lake. In conventional filtration a large floc particle is developed and removed by sedimentation. With direct filtration the floc is not allowed to grow as large and is removed with the media (usually sand). Also, in direct filtration, particles are removed by sticking to media that has a cationic (positive) charge given to the media by the coagulant. The particle attraction to the charged media is weak and the particles are removed by backwashing.

Hypothesis for Why the RO Elements Fouled

The behavior of colloidal particles is of fundamental importance in water treatment processes, especially for reverse osmosis systems. The RO system pretreatment removes all particles greater than 1 micron so that the only particles remaining are colloidal in size. The autopsy revealed the foulant deposit consisted of very fine clays and other colloidal materials. The fouling was principally inorganic in nature and was a result of colloidal clay deposition. The interaction between colloidal particles in suspension and other media surfaces depends on many variables:

- Water chemistry.
- Surface chemistry and charge of particles.
- Surface chemistry and charge of media surfaces.
- Kinetics of the particles, the water, and surfaces each interact with.

Most of these variables are interrelated. Options for altering these variables can include, but are not limited to: addition and/or adjustment of coagulants, pH, polymers, other polyelectrolytes, oxidants, mixing conditions, and biological activity.

Colloids and Cationic Materials

Colloids tend to carry a negative charge on their outer surface. By having this negative common charge they will tend to repel each other. They resist coming into close proximity with each other and do not combine to form larger particles. With this charge neutralized or removed, for example with the addition of a cationic polymer, the colloids are more likely to coagulate into larger particles and fall out of solution. This charge can be neutralized or removed by positively charged (cationic) materials such as aluminum, ferric coagulants, cationic polyelectrolytes (polymers) and other cationic materials. These positively charged materials attach themselves to polyamide RO membranes.

Polyamide (PA) Membranes and Cationic Materials

Most RO membrane elements used today are polyamide (PA) thin-film membranes. This is the RO membrane element that is used at Cook Nuclear Plant. PA membranes are a thin layer of aromatic polyamide extruded onto a less dense polysulfone substrate. The PA thin-film membrane most commonly used in water purification intentionally has a negative surface charge characteristic. The negative charge of the colloids and the negative charge of the membrane surface repel each other and this helps prevent colloidal fouling. Only chemicals that are compatible with this negative charge should be allowed to come into contact with a PA thin-film membrane. For example, only anionic (negative charged) surfactants should be used to clean an anionic (negative charged) PA membrane. Cationic (positive charged) surfactants should not be used.

Conclusion

Based on the above information, I hypothesize that the RO element failure was due to the addition of the GE Betz Spectrus CT 1300 (ADBAC quat), which is a very surface-active cationic surfactant. I think that the Spectrus CT 1300 modified the negative surface charge of the colloids in the water and/or the negative charge characteristics of the PA membrane surface. This allowed the colloids to come out of suspension and grow larger. Additionally, I believe this material could also affect the surface charge of the media in the multimedia sand filter and decrease particulate removal. Also, I believe the GAC beds were affected and chlorine removal efficiency may have been reduced. Also, since it was time to replace the GAC beds, the beds may have been exhausted and unable to remove the chlorine. It is the opinion of this consultant that neither the staff of GE Betz, Cook Nuclear Plant, nor myself could have foreseen the occurrence of this situation in advance.

This hypothesis could probably be proven experimentally by measuring the overall charge characteristics of the water versus the addition of the biocide. The measurement of the overall charge characteristics of colloids in water is called the zeta potential (ZP). However, I recommend using a streaming current detector (SCD) instead of a ZP meter because a more accurate and repeatable measure of charge can be accomplished.

Salt Rejection

Salt rejection is the percentage of dissolved salts (ions) that are rejected (removed) by the RO membrane. An increase in permeate conductivity usually indicates a decrease in salt rejection or leaking o-rings. Decreased salt rejection occurs when the RO membrane is damaged by chemical attack. Generally, three different conditions can produce chemical attack on polyamide (PA) membranes;

- Exposure to organic solvents.
- Exceeding operating and cleaning limits (pH and/or temperature)
- Oxidation by an oxidizing biocide

Organic solvents are improbable in this situation and will not be discussed.

Operating and Cleaning Limits

The Filmtec membrane (8" BW30-365) is an excellent membrane and a good choice for this application. The pH range for continuous operation is 2-11 and the maximum operating temperature is 113°F. These have not been exceeded for normal operation.

Harsh and frequent chemical cleaning will shorten membrane life, typically by increased salt passage, while mild and seldom cleaning will extend the membrane life. For regular cleaning the preferred pH for acid cleaning is no lower than 2.0 and the preferred pH for alkaline (caustic) cleaning is no higher than 12.0. Both of these are at 30°C (86°F). For extended element life, it is best not to exceed this temperature. A 6-hour soak is usually adequate. The pH range for short-term cleaning (30 min. chemical contact) of this membrane is 1 – 12. Adjust and maintain the pH during cleaning if possible. Always, acid clean first and then follow with an alkaline cleaning. Acid cleaning removes inorganic salts and caustic cleaning removes inorganic colloids (silt), silica, biofilms, and organics. Please refer to the Filmtec Technical manual for more information.

Oxidation

Chemical attack on PA membranes usually occurs from oxidation by chlorine. At present, I feel that Filmtec has the most chlorine resistant PA membranes. The Dow Filmtec Membranes Product information sheet has the operating limit for the free available chlorine (FAC) tolerance of the BW30 membranes as < 0.1 ppm, but in reality the chlorine tolerance is more important.

The following is a quote from Dow Tech Facts, "When Filmtec membranes (PA) are used in the reverse osmosis process, the RO feed must be dechlorinated to prevent oxidation of the membrane. Filmtec membranes have some chlorine tolerance before noticeable loss of salt rejection is observed. Eventual degradation may occur after approximate 200 – 1000 hours of exposure to 1 mg/L of free chlorine (FAC). The rate of chlorine attack depends on various feedwater characteristics. Under alkaline pH conditions, chlorine attack is faster than at neutral or acidic pH. An acidic pH is preferred for a better biocidal effect during chlorination. Chlorine attack is also faster at higher temperature and at higher concentrations of heavy metals (e.g. iron), which catalyze membrane degradation. If dechlorination upsets occur in a Filmtec RO system, and if corrected in a timely manner, membrane damage can be minimized."

This means that the PA membrane has 200 – 1000 ppm-h tolerance of free available chlorine (FAC). If the actual tolerance is only 200 ppm-h, then this membrane could operate 200 hours at 1 ppm FAC (8.3 days), or 2000 hours at 0.1 ppm FAC (83.3 days), or 20,000 hours at 0.01 ppm (2.28 years). In other words, polyamide RO membranes are essentially zero chlorine tolerant. The presence of any free chlorine will result in some damage to the membrane. However, this damage might not be noticeable if not severe.

Chlorine Tolerance and pH

Please note that at the exit meeting I was in error about chlorine exposure at low pH being more aggressive than chlorine exposure at high pH. According to Filmtec, chlorine attack is less severe at neutral or acidic pH than alkaline pH. When chlorine is added to water, hypochlorous acid (HOCl) is initially formed. Depending on pH and temperature, hypochlorous acid separates into another component in water, which is the hypochlorite ion (OCl^{-1}). Hypochlorous acid has almost twice the oxidation power and more than 10 times the disinfectant ability of hypochlorite ion. However, hypochlorous acid is a weak acid and because of incomplete disassociation is poorly ionized. Hypochlorite ion, which forms at a higher pH, is more completely dissociated and ionized. This must be the reason that the hypochlorite ion is more damaging to the RO membrane than the hypochlorous acid. At a pH of 6.0 and 20°C, about 95% of the free available chlorine is as hypochlorous acid and about 5% is as hypochlorite ion.

Dechlorination

Free available chlorine, also known as free chorine, is best removed from water by filtering through granular activated carbon (GAC) and/or injecting chemical reducing agents. The GAC system must be properly designed for the amount of chlorine to be removed. The GAC is consumed and exhausted in the removal of chlorine. Also, GAC can be a growth media for biological activity. Therefore, GAC should be replaced on a regular basis. Depending on service conditions, GAC beds are usually replaced every 6 to 12 months.

Chemical reducing agents that can be used to remove chlorine are sodium metabisulfite, sodium bisulfite, sodium sulfite, sodium thiosulfate, and sulfur dioxide. Sodium metabisulfite (SMBS) is the most common agent used and most cost effective. The SMBS should be of food grade quality or better, free of impurities, and not contain activators (catalysts) such as cobalt. Sometimes SMBS is cobalt-activated to shorten reaction time with chlorine and oxygen. Cobalt and iron can catalyze and enhance the effects of chlorine oxidation on PA membranes. Also, do not use sodium thiosulfate because this material, depending on water chemistry, can form colloidal sulfur.

In theory, 1.34 mg of sodium metabisulfite will remove 1.0 mg/L FAC. But, in actual practice, 3.0 mg of SMBS is normally used to remove 1.0 mg/L of FAC. The actual amount required can be better determined with a good on-line process analyzer for free chlorine. Solid SMBS has a shelf life of 4-6 months under cool, dry storage conditions. However, in a day tank the solution can oxidize when exposed to air. The following is a typical solution life in a day tank:

(Wt. %)	Solution Life
10	2-3 days
20	1 month
30	6 months

It may be more cost effective to purchase this material as a 30% aqueous liquid than as a dry solid. Permeate or deionized water should be used for dilution water if the SMBS solution is to be made from the dry material.

Monitoring

In the past, the existing water treatment system monitoring has been adequate. However, due to the recent developments, monitoring for particles and chlorine should be considered. Monitoring can be performed by grab samples (point in time) or process instrumentation (real-time). Monitoring for particles is presently performed with SDI analysis. I do not believe that turbidity monitoring is necessary. However, if the decision is made to add turbidity monitoring I feel that the best turbidity and particle monitoring equipment is manufactured and sold by the HACH Company.

SDI Analysis

SDI analysis is the best indicator of RO fouling. However, this test is time consuming and suffers from accuracy and precision (repeatability). I do not believe an on-line process unit is necessary to perform this test and that a regular grab sample would be adequate. Operations can determine the frequency that SDI analysis is required. The purchase of a portable Simple SDI analyzer from SDI Solutions can increase accuracy and precision of the SDI analysis and save valuable operator time. I have personally used these units and can recommend them. Their phone number is 972-422-1212 and website is www.simplesdi.com. They sell for about $2000.

Chlorine Monitoring

Due to the poor free chlorine tolerance of PA membranes, the low level presence or absence of chlorine should be monitored with on-line instrumentation. On-line process instrumentation can activate an alarm to alert operators and shut down the RO system when free chlorine is detected. There are three general type of chlorine analyzers: ORP, Colorimetric, and Amperometric.

Oxidation-Reduction Potential (ORP) analyzers do not measure free chlorine directly. They measure whether the water is under an oxidative or reductive environment. A disadvantage of ORP is that the readings may be affected by other components in the water. For example, the reading is affected by water pH and combined chlorine.. ORP analyzers are not specific, but due to the low cost, low maintenance, and simplicity, this analyzer has been commonly used in place of chlorine analyzers in industrial processes.

Colorimetric analyzers are primarily used by the drinking water industry. Colorimetric analyzers consist of a photoelectric cell and a light source that detects a variation in color produced in a sample stream with the addition of a reagent specific for chlorine. This analyzer uses consumable reagents that must be refilled each month. While these analyzers are very dependable and accurate, they are made to detect chlorine in the range of 0.5 to 5 mg/L. The low level of detection is not reliable enough for this application.

Amperometric analyzers have gained popularity during the last several years due to new innovations. Typically they consist of two electrodes that are immersed in a continuous water supply. The electrodes are made of two dissimilar metals that measure a change in current flow between them that is directly proportional to the amount of chlorine residual in the water. They can be used to measure free or combined chlorine. There are many variations. For this application I feel that the best chlorine analyzer would be the Hach 9184. Polymetron makes this and Hach Company now owns them. At a of pH <7.5, this unit has a detection limit of 10 ppb for HOCl and 20 ppb for free chlorine. The repeatability is 5 ppb for HOCl and 10 ppb for free chlorine. After the pH is adjusted for your RO system, almost all free available chlorine in the feed water would exist as HOCl. This means that the detection limit would be 10 ppb. Due to an ion selective membrane, the Hach 9184 measures only free chlorine and has almost no interferences from combined chlorines or other materials. The response time is < 90 seconds. Minimal maintenance is required for this unit. The current cost of this analyzer is $3,400.00

Emergency Procedure

In an RO system, fouling usually occurs in the lead element of the 1st stage. If high pressures develop in the 1st stage, consider removing the lead element in each vessel of the 1st stage, pushing the other elements forward in each vessel and then installing a clean element as the tail element (6th) in each vessel. This is good for emergencies.

RECOMMENDATIONS

1. Do not allow ADBAC quat biocides into the make-up water going into the water treatment plant or the RO system feedwater. Use an alternative source, such as the Lake Township municipal water when feeding the biocide to the intakes.

2. Lake Township municipal water must be dechlorinated before entering the RO system. A sodium metabisulfite (SMBS) injection system is recommended. The SMBS should be injected upstream of the retention/blend tank. Adequate mixing should be ensured with a static mixer or adequate downstream pipe lengths after injection. Add only enough SMBS to remove the chlorine and no excess SMBS.

3. Replace the granular activated charcoal (GAC) in the carbon filters at least once a year. Change out more often if this is not adequate.

4. Free available chlorine should be less than 0.020 mg/L (20 ppb) for all water entering the RO system. The greater the exposure of the RO elements to chlorine, the shorter the life of the element.

5. Install a free available chlorine (FAC) analyzer before the RO system. The analyzer should have an alarm to alert the operators and shut down for the RO system should the FAC exceed 20 ppb.

6. Initiate and maintain a trending program for Net Permeate Flow (NPF) and normalized salt content such as Dow Filmtec's FTNORM. This is a free program that is used to normalize membrane-operating data. To effectively evaluate system performance, it is necessary to compare permeate flow and salt passage data at the same conditions. Ask DOW for help and assistance with this program. Their program was developed for their membranes and they will provide technical assistance if you are persistent. Talk to the individuals that sold you the Filmtec RO elements. This is a free support service that they will provide.

7. Stop and chemically clean the RO elements whenever:
   - The normalized permeate flow drops by 10%
   - The normalized salt content of the permeate water increases by 10%
   - The differential pressure (feed pressure-concentrate pressure) increases by 15% from the reference conditions (initial performance established during the first 24-48 hours of operation).

8. Continue to adjust the RO feedwater pH to 5.7-6.1. However, consideration should be given to lower the pH even more to a range of 5.5-5.8. Below a pH of 6.0 the aluminum ions are solubilized and cannot produce any precipitates.

9. The ADBAC quat biocide may have coated the granular media in the multimedia filters. Consider cleaning the filters with high pH water (11) and bleach (5 ppm FAC) with a 6-hour soak. Then backwash and flush the filters several times.

APPENDIX (Exit Meeting Report of Wednesday July 16, 2003)

Date: July 16, 2003
Location: Cook Nuclear Plant, Bridgman, MI.
From: Norman R. Norvelle, Water & Power Technologies (Earth Tech)
Subject: Exit Meeting Report (Wednesday 1:00 pm – RO System Failure Analysis)

Problem Definition

1. The plant RO system is experiencing high differential pressures in the first stage. The system failed due to high differential pressures and the resulting rupture of the RO elements.
2. The RO system is also experiencing a decrease in salt rejection (an increase in conductivity).

Client Expectations

1. Find cause of high differential (Δ delta) pressures and high SDIs.
2. Provide recommendations to resolve.
3. Find cause of decreased salt rejection.
4. Provide recommendations to resolve.

Summary of Observations and Information Gathered

1. Operation and performance of the RO system was good until the addition of biocide.
2. After new biocide was added high SDIs (>5) were found.
3. After new biocide was added high ΔPs were produced in the first stages.
4. After new biocide was added element failures occurred.
5. After new biocide was added salt rejection decreased.
6. The only change in operational and chemical parameters was the addition of biocide.

Hypothesis of Failure

There are two major control methods for mollusks, chlorine and Quaternary ammonia compounds (Quats). Quats are also called quaternary amine compounds and QACs. The term Quat is a general name and refers to over 100 compounds. Quats are cationic surfactants (detergents). They are excellent cleaners and biocides. They are used in many household products, such as 409 Cleaner, Lysol disinfectant, and Odor Ban. Industrially they are used as cleaners, disinfectants, biocides, and corrosion inhibitors. GE Betz Clam-Trol (CT 1300) is a Quat biocide.

They act in a manner very similar to a filming amine. They form a monomolecular film (coating) on all surfaces (concrete, metals, filter media, granular activated charcoal, and RO membranes). Quats can be easily removed from water by being adsorbed on clay particles.

Most colloids, such as clay particles, have a negative charge. RO element membranes also have a negative charge. These negative charges repel each other and prevent colloids from sticking to the membrane surface and producing high differential pressures.

Quats are strong cationic surfactants. I think that the Quat biocide (CT 1300) has coated the colloids and membranes and allowed the colloids to stick on the surface of the membrane. This resulted in a high differential pressure. Also, I believe this has changed the negative charge on the colloids and allowed them to stick together, much like a cationic coagulant polymer. Additionally, I think that the Quat has also coated or filmed the granular activated charcoal (GAC) bed and that the GAC bed is no longer effective for chlorine removal. The available chlorine could possibly be oxidizing and damaging the membrane.

Low-level analysis of Quats may be difficult to detect because Quat decomposes rapidly in the environment, is adsorbed on clay, and is adsorbed on the walls of sample containers. There is also a reaction between alum and Quat.

Recommendations

1. Do not allow any further Quat (CT 1300) to enter the RO pretreatment and system.
2. Replace the GAC media immediately. Rent GAC skids if necessary.
3. Consider cleaning the MMF with high pH water (11) and bleach (5 ppm FAC). Then backwash and flush with clean water.
4. When using CT 1300, obtain make-up water from other inlets or sources, such as city water.
5. If detention time and neutralization time is inadequate for the higher chlorination levels in city water, consider renting or using additional GAC beds only for city water or injecting sodium metabisulfite (SMBS).
6. Consider adding additional process monitoring equipment, such as chlorine analyzers and particle or turbidity monitors.
7. You should consider the addition of sodium metabisulfite to help reduce chlorine residuals before the RO elements, preferably before the retention tank in order to have adequate contact time between the chlorine residual and sulfite.

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