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APPENDIX V

SPECIAL REPORTS

2008

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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 1 5 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,

Mark J. Horwitz.

Chemical Emergency Preparedness and Prevention Section

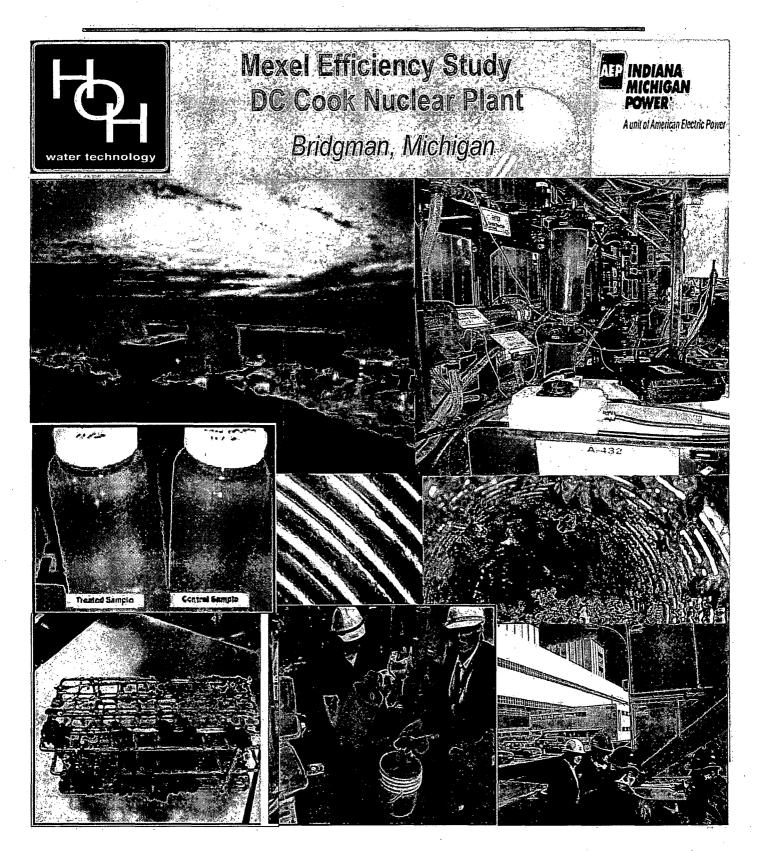
cc: Richard Wagner (C-14J)

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

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February, 2008 Mexel Efficiency Study

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Mexel Efficiency Study DC Cook Nuclear Plant

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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.

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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 blocides 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.

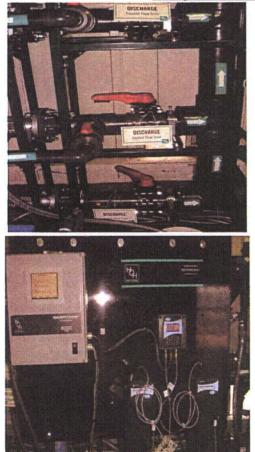
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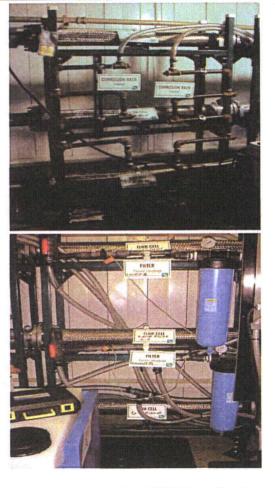
Power plants are complex industrial facilities that contain integrated components constructed of different materials performing a variety of functions. Any chemical product added at the intake must be compatible with all materials of construction that treated water contacts in the plant. For example, 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



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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*.
- 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.
- 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.

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- 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 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

Sample Mean =
$$\mathbf{x} = \frac{1}{N} \sum_{i=1}^{N} \mathbf{x}_{i}$$

Where:

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

Where:

- (σ) is the standard deviation
- (N) is the numbers of samples on the sample date
- (x_i) is the sample value
- (x) is the mean of the sample date

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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.

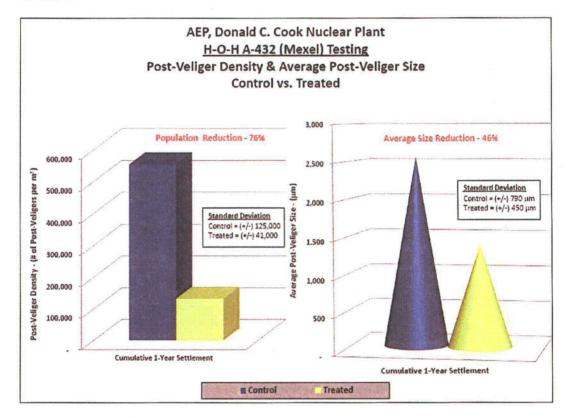


Figure 1 - Post- Veliger Density, Treated vs. Control (Glass Microscope Slides)

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.

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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.

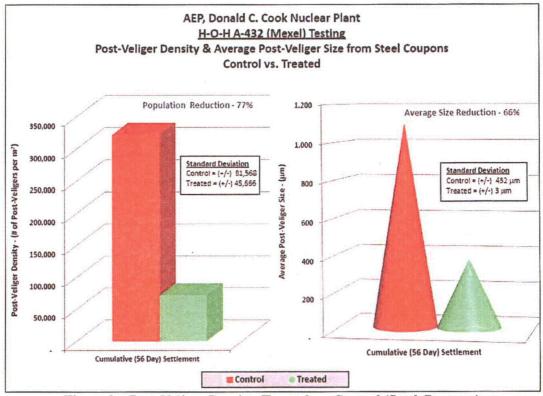


Figure 2 - Post-Veliger Density, Treated vs. Control (Steel Coupons)

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.

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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

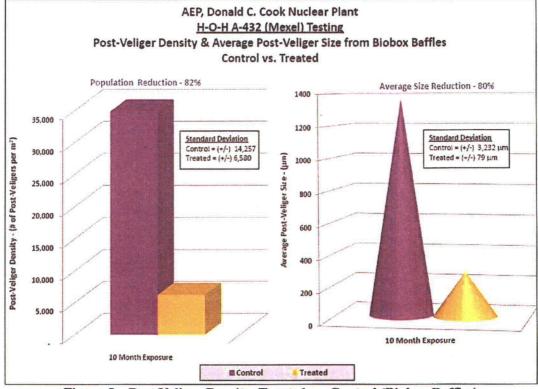


Figure 5 - Post Veliger Density, Treated vs. Control (Biobox Baffles)

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.

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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

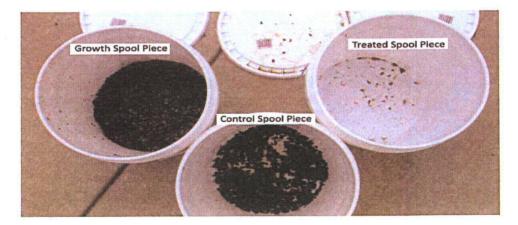


Figure 11 - Final Mussel Debris Collection Amounts

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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.

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 %	

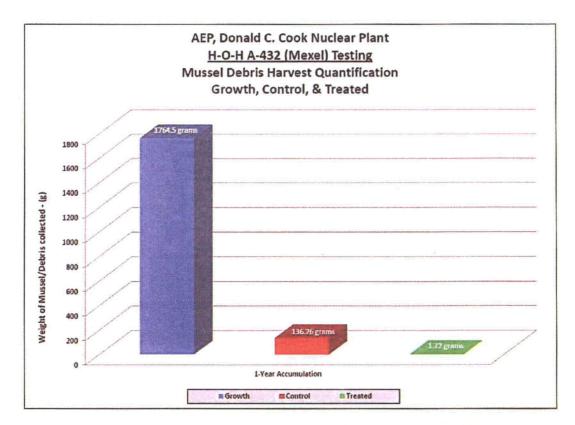


Figure 12 - Mussel Debris Collections Quantification Graph

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	Steël	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
		Contro	l Coupons, Cur	nulative,		
Coupon No:	Material	Days Exposed	Treatment	Weight Loss, (g)	Corrosion Rate, (MPY)	Evaluation
T-751	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		

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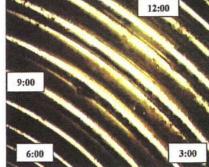
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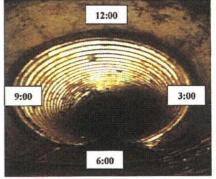
Internal Investigation and Observations

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





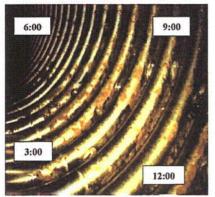
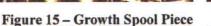
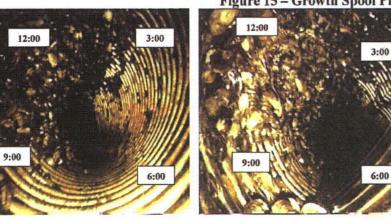
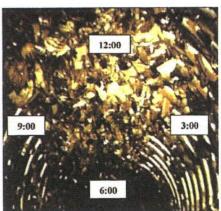


Figure 14 - Control Spool Piece









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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.

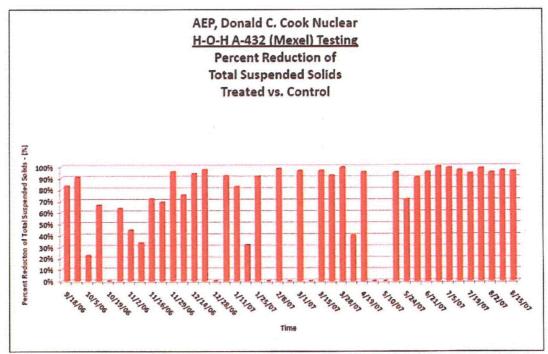


Figure 18 - Total Suspended Solids Reduction

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.

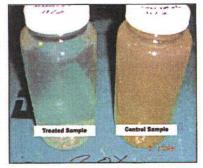


Figure 19 – Water Clarity (Treated vs. Control)

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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 translocators. 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.

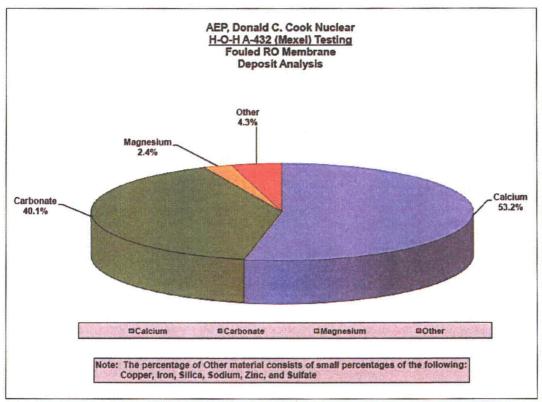


Figure 21 - Fouled Membrane Analysis

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.

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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.

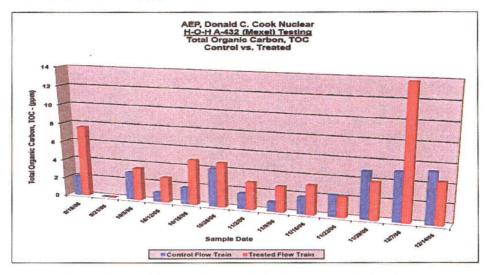


Figure 22 - Total Organic Carbon (TOC) Results from Lab Samples

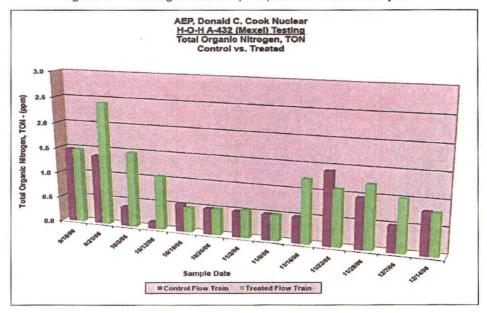


Figure 23 - Total Organic Nitrogen (TON) Results from Lab Samples

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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 24hours 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 30minute 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_1 magna or fathead minnows, (See Figure 25). There was 100 percent survival of both D_1 magna and fathead minnows in this sample. The 48-hour D_1 magna LC₅₀ (median lethal toxicant concentration) and EC₅₀ (median effect concentration) estimates were both greater than 100 percent in that sample. The 96-hour fathead minnow LC₅₀ 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.

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Whole Effluent Toxicity Testing Summary, continued

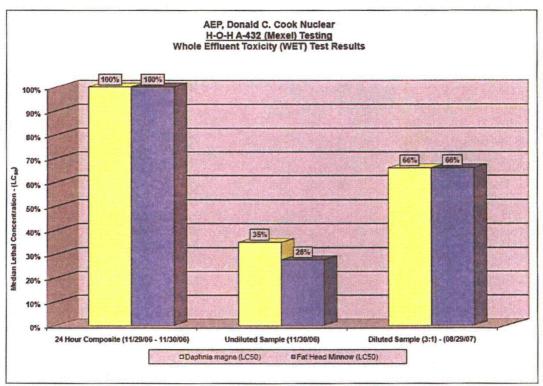


Figure 25 - WET Test Results

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.

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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.

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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 translocators. 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 <u>not</u> 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 LC₅₀ 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.

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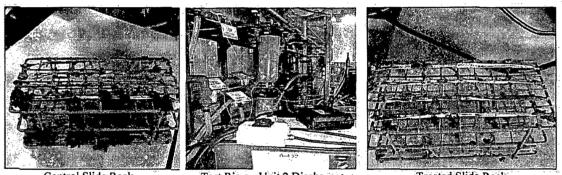
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- 1. <u>American Electric Power (AEP)</u>
 - Eric Mallen Environmental Specialist
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 - > AEP Cook Nuclear Environmental Department Staff
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 - Francois Ghillebaert Aquatic Toxicologist, PhD
- 4. <u>Great Lakes Environmental</u>
 > Dennis McCauley Operations Co-Manager/Principal Research Scientist
- 5. <u>Michigan Department of Environmental Quality (MDEQ)</u>
 > Sylvia Heaton Aquatic Biologist, Senior Level



Control Slide Rack

Test Rig on Unit 2 Discharge Platform Treated Slide Rack

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- 1. Ackerman, J.D., Claudi, R., Spencer, F.S., Sim, B., Evans D., <u>A Continuous Flow</u> <u>Research Facility for Zebra Mussel Research & Control</u> 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 <u>A Novel Molluscicide. Corrosion</u> 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.
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Mexel Efficiency Study DC Cook Nuclear Plant

APPENDIX 1

0.3



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.

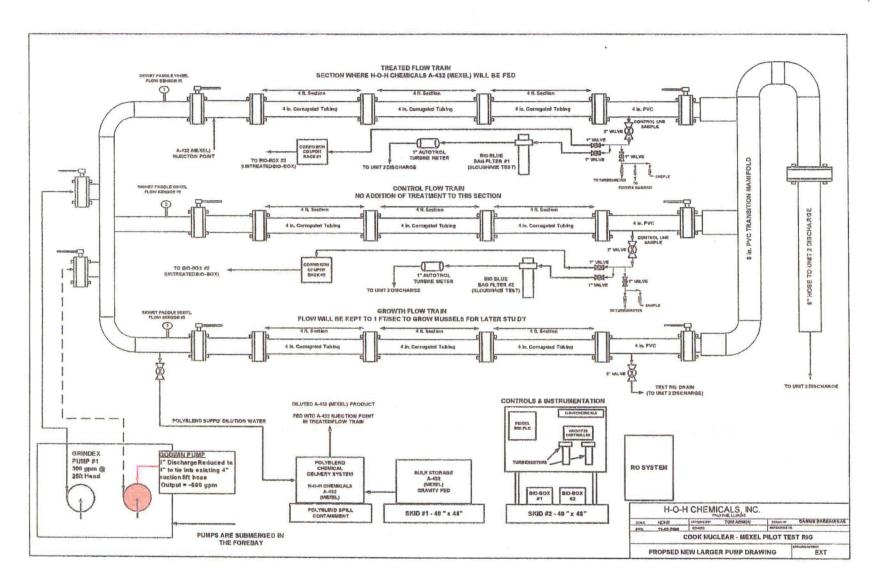
Conclusions will provide plant specific information for continual use of Mexel at Cook Nuclear Facility. Data collected will detail how Mexel should be injected, effects on existing infestation in Cook's intake tunnels, prevention of future growth and effects on pretreatment equipment. Experimental data 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
- Kreuser, R., Vanlaer, A., Damour, A. 1997 <u>A Novel Molluscicide. Corrosion</u> Inhibitor and Dispersant, Corrosion 1997, Paper No. 409

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30

 Ackerman, J.D., Claudi, R., Spencer, F.S., Sim, B., Evans D., <u>A Continuous Flow</u> <u>Research Facility for Zebra Mussel Research & Control</u> presented at the 4th international zebra mussel conference Madison Wisconsin 1994



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	ation	
	perseded by (list sup	erseding procedures):
Minor Revision		
	ocedure (Full Revie	:w)
Section 3 - Temporary Procedure / Revision:		
N/A Temporary Procedure Temporary Revision	AR No.:	<u> </u>
Expiration Date / Ending Activity: N/A		
Section 4 – Associated Configuration Impact Assessments:		
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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 effect	ive date?	🗌 Yes 🛛 No
10 CFR 50.59 Requirements complete? Tracking No .:	<u> </u>	' 🗌 Yes 🛛 N/A
Technical Reviewer: _ Jon A. Harner / Jor H. Harne		Date: 11-5-06
Section 7 - Ready for Approval:	· · · · · · · · · · · · · · · · · · ·	
	N/A CR No	
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Ops Manager Concurrence: N/A ()		Date:
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Commitment Database update requested in actordance with PMP-23		🗌 Yes 🛛 N/A
NDM notified of new records or changes to records that could affec	t record retention?	Yes 🛛 N/A

Only	· · · · · · · · · · · · · · · · · · ·	Office Information For Form Tracking Only – Not Part of Form].
NDM Use		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	

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Marcia Strefling	John Carlson		ironmental
Writer	Document Owner	Cogniza	nt Organization

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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. 7.2.16, 7.2.16, 7.2.16)

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	٠	plastic barrel
		é	pump
•	test tube racks	•	flow meter or bucket and timing device
•	microscope slides	٠	1 liter plastic collection jars
٠	plankton net with cod-end		
	bucket	•	PVC pipe sampler
•	stereo-microscope with		· · · · · · · · · · · · · · · · · · ·
	polarizing filters	•	1 ml Sedgewick-Rafter counting cell
÷	magnetic stirrer	•	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.

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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.

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

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	Zebra Mussel Sampling ar	nd Analysis	•

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.

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4.2.6 Dilute 1-liter sample as needed.

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Zebra Mussel Sampling and Analysis							
NOTE:	Size me	easureme	nts may b	e taken simu	ltaneously v	vith counts.	
4.2.7	Count	t number	of live ve	ligers per 1	ml. sub-san	ple.	
4.2.8		er and A				the Whole V nsity Counti	
4.2. <u>9</u>				dest part) of than 10 from		ligers (chose ample.	en "at
4.2.10				ing on the S or each velig		r Systems V I.	eliger
4.2.11	Remo	ve and c	arefully cl	ean slide an	d cover slip.		. .
4.2.12		appropr				4.2.11 until les have bee	
4.2.13	the W	hole Wa	ter Velige		ial Substrate	Factors Tab Post-Velig	
4.3 Artifici	al Subst	rate Sam	pling	a.		,	

E: 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.

	Informati	ion 12-EA-6090-ENV-101	Rev. 3	Page 6 of 10
		Zebra Mussel Sampling an	d Analysis	
	4.3.2	Artificial substrate samplers, used for t study, may also consist of a section of held together by a hose clamp(s) and at rope or cable that is anchored via a cor	PVC pipe cut in hal ttached in a vertical	f length-wise and orientation to
	4.3.3	Obtain and stage the following pieces of	of equipment:	· ·
		• empty test tube/slide collection rac	k or equivalent	
	4.3.4	Remove the bio-box or cage cover.		
NOI		Handle slides by the edges and transport Mussels are inadvertently damaged or re		nat no Zebra
~	4.3.5	Carefully remove the appropriate numb from installed slide rack.	per of glass slides (t	ypically 5-10)
	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	Artifici	al Substrate Analysis - Microscope Slide		
•	4.4.1	Obtain and stage the following pieces of	of analytical equipment	ent:
		• stereo-microscope with polarizing	filters	•
		• "Standard Protocols for Monitorin Mussels" by J. Ellen Marsden	g and Sampling Zeb	ora
	•.	• single-edge razor blade or similar	scraping device	
	4.4.2	Carefully remove a slide from the colle touch only the edges.	ction rack being car	ceful to
		touch only the edges.	· · ·	
. 8	4.4.3	Carefully scrape clean one side of the s	slide.	

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Zebra Mussel Sampling and Analysis							
4.4.5	IF density is > -60 organisms per Artificial Substrate Density Dilutio Whole Water Veliger and Artificial Density Counting Form for sub-sar number of organisms per slide.	n Table maintained on t l Substrate Post-Veliger	he				
OTE:	Size measurements may be taken sim	ultaneously with counts	· · · · · · · · · · · · · · · · · · ·				
4.4.6	Count number of settled veligers/ac	lults.					
4.4.7	Record counts on the Artificial Sub Calculation Sheet and sizes on the S Size Calculation Sheet.		Veliger				
4.4.8	Measure the breadth (widest part) of "at random") but no more than 10						
4.4.9	Record micrometer reading on the Size Calculation Sheet for each org		Veliger				
4.4.10	Repeat steps 4.4.2 thru 4.4.9 until of) slides have been analyzed.	10 (or an appropriate m	imber				
4.4.11	Enter "Multiplier used" from the M the Whole Water Veliger and Artifi Density Counting Form to auto-calc	icial Substrate Post-Veli					
5 Artific	ial Substrate Analysis – PVC Substra	tes					
4.5.1	Pull PVC sampler from the intake f	orebay.	, · · · ·				
4.5.2	Remove the clamp(s) and open up t	he two halves.					
4.5.3	Scrape a representative one square i S-R-C.	inch section and transfe	rittoa				
4.5.4	IF there is too much settlement that the S-R-C, THEN smaller portions transferred to the S-R-C.	the second of the second se	into				
,							

I	informat	ion	12-EA-6090-ENV-101	Rev. 3	Page 8 of 10					
			Zebra Mussel Sampling an	d Analysis	· · · ·					
NOT	E:	Size me	asurements may be taken simult	neously with count	S.					
				1						
NOTE:		followin	of zebra mussels per square me of formula and is automatically c of the Artificial Substrate Size a	alculated on the PV	C Substrate					
		Density	Density (Zebra Mussels/m ²) = [(#Sample 1 + #Sample2)/2] x 10,000/6.4516							
	4 No. 1 1	Where: $6.4516 \text{ cm}^2 = 1 \text{ inch}^2$								
•	4.5.5	Substr	the number of zebra mussels an ate section of the Artificial Subs lation Sheet.	(a) A set to the term of term o						
,	4.5.6	micro	are breadth of 50 randomly chose meter readings on the PVC Subs sial Substrate Size and Density C	trate Section of the						
	4.5.7	Repea	t steps 4.5.3 thru 4.5.6 for a sec	ond sample.						
	4.5.8	the W	"Multiplier used" from the Mag hole Water Veliger and Artificia ty Counting Form to auto-calcula	I Substrate Post-Ve						
	4.5.9		and return PVC sampler to intal tinued for the coming year.	te forebay if sampl	ing is to					
4. 6	Impro	mptu San	npling & Evaluations							
	4.6.1	includ	ionally, Environmental may perf e evaluations of biocides on Zeb ampling protocols and schedules	ra Mussel settleme	nt and mortality.					
	4.6.2	IF oth system	rocedure does not preclude the over bio-foulers are detected that one, THEN report the results to the oring and Control Program own	ould cause problen ne Environmental 2	ns in piping					

	1.2		
7		a ta alla difficanta	
Ze	bra Mussel Sampling ar	nd Analysis	

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.

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- 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

REVISION SUMMARY

Rev. 3

Number: 12-EA-6090-ENV-101

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.

 Office Information For Form Tracking Only – Not Part of Form

 This is a free-form as called out in PMP-2010-PRC-002, Procedure Alteration, Review, and Approval.
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APPENDIX 3

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December 15, 2006

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

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

Dear Mr. Mallen:

RE:

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 LC₅₀ 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 LC₅₀ estimates equate to LC₅₀ 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.

Great Lakes Environmental Center

Applied Environmental Sciences www.glectonline.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 Mr. Eric Mallen AEP-Cook Nuclear Plant

December 15, 2006

A summary of the test conditions for the toxicity tests are included in Tables 1 through 4. The 48-hour and 96-hour LC_{s0} and EC_{s0} 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,

ston 0 0

Mailee W. Garton Laboratory Coordinator

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 μE/m³/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 Nuclea	<u>ir Plant</u>	<u>·</u> ·			NPDES Pe	ermit No.:	
Receiving Wat	tèr: <u>Lake Michigan</u>	Ou'	utfall:		<u></u>	RWC: <u>N/A</u>	<u> </u>	
Test Dates: 12	2/01/06 - 12/05/06	Ter	st Species: Fat	thead minno	WS	Age Range	e: 6 days old	<u></u>
Test Laborator	y: Great Lakes Er	nvironmental Cente	er (GLEC)			Report Dat	te: December	<u>r 15, 2006</u>
		F	BULK SAMPLE	<u>E INFORMAT</u>				
SAMPLE COLLECTION DATES	DATE N RECEIVED	ARRIVAL TEMPERATURE	DATE OF FIRST USE	ARRIVAL TRC	DECHLORIN ATION?	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
<u></u>						<u></u>		
Source of test on	rganisms: In hous	e <u>lot # 11/25/06</u>		SCRIPTION	- <u></u>	<u></u>		
Fed/Un-fed: Fe	ed	Food/F	eeding Freque	əncy: <u>Artemi</u> r	l <u>a nauplii, 2 hour</u>	rs prior to 48	-hour renewa	<u>1</u>
No. Replicates Concentration:			ganisms per ate: <u>10</u>	а т. •	Effluent Filtered	id? <u>No</u>		
Effluent Sample	le Type: Sample 1	1: Composite			Sample 2:			
Diluent (0 <u>1): La</u>	ake Michigan Wate	<u>r (GLC# 7008)</u>	· ·		Secondary Cor (Moderately Ha	ntrol (0 ₂): <u>Syr</u> ard) MH# 14	<u>thetic Labor</u> 79	atory Water
			SUMMARY	OF RESULTS	S.			e antes
				2			48-hou 96-ho	ur LC ₅₀ : <u>>1009</u> our LC ₅₀ : <u>>100</u>
••			rcent Mortality					
	Controls	-			-Effluent Concentra	ations		
Dav D								4

-		-Ciniberin Concentrations		· · · · · · · · · · · · · · · · · · ·				
Day		,0 ₂	6.25 Percent	12.5 Percent	25 Percent	50 Percent	100 Percent	Percent
1	0 (0)	. o (ô)	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	o (o)	°o (0)	:0.(0) .	0 (0)	0 (0)	0 (0)	ō (ö)	
:		· · ·		•	·	•		÷

Raw data sheets are included in Appendix A. 02: Synthetic Laboratory Water (Moderately Hard)

Investigator: Mailee W. Garton \mathcal{L}

Signature

Contact: Dennis McCauley

Phone No.: (231) 941-2230

Principal Research Scientist/Manager of Operations Title

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 Tox	icity Test Conditions
1. Test Species and A	Age:	Daphnia magna, <24 hours old
2. Test Type and Du	ration:	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 Vesse	4:	30 mL plastic cup
9. Volume and Deptl	of Test Solutions:	15 mL, 20 mm
10. No. of Test Organ	isms per Test Vessel:	5.
11. No. of Test Vessel	s per Test Solution:	
12. Total No. of Test	Organisms per Test Solution:	20
13. Test Concentration	ns (percent):	100, 50, 25, 12,5, and 6,25
14. Renewal of Test S	olutions:	None
15. Dilution and Prim	ary Control Water:	Lake Michigan GLC# 7008
16. Secondary Contro	Water:	Synthetic Laboratory (Moderately Hard)
17. Aeration:		None
18. Endpoints Measur	eđ:	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: AE	P Cook Nuclea	r Plant				NPDES Pe	rmit No.:	• 	
Receiving Water;	Lake Michigan	Oul	fall:		· · · · · · · · · · · · · · · · · · ·	RWC: N/A	<u></u>		
Test Dates: 12/01	/06 - 12/03/06	Tes	t Species: <u>Dar</u>	ohnia magna	3	Age Range	: <u><24 hours</u>		
Test Laboratory:_	<u>Great Lakes Er</u>	nvironmental Cente	er (GLEC)			Report Date	Report Date: December 15, 2006		
		E			TION				
SAMPLE COLLECTION DATES	DATE RECEIVED	ARRIVAL TEMPERATURE	DATE OF FIRST USE	ARRIVAL TRC	DECHLORIN ATION?	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: EP	A/600/4-90/027 ar	d EPA-821-R-	02-012		<u> </u>			
Describe any devia	tions from test	methods: <u>None</u>		· · · · · · · · · · · · · · · · · · ·		<u> </u>	<u> </u>		
Source of test orga	nisms: <u>In Hous</u>	e: BD 11-20-06	· · · · · · · · · · · · · · · · · · ·					· ·	
· .									
				SCRIPTION					
Fed/Un-fed: Un- F	ed	Food/F	eeding Freque	ncy:None					
No. Replicates per Concentration: 4	r		janisms per ite: <u>5</u>	· · · · · · · · · · · · · · · · · · ·	Effluent Filtere	d? <u>No</u>			
Effluent Sample T	ype: Sample 1	: Composite		 ,	Sample 2:				
Diluent (01): Lake	Michigan Wate	er (GLC# 7008)	<u> </u>		Secondary Cor (Modérately'Ha			atory Water	
			SUMMARY (DF RESULT	S		48-ho	our LC ₅₀ : >100	

48-hour EC₅₀; >100

Percent Mortality per Concentration (Percent Effected per Concentration)

	Con	trois			-Effluent Con	centrations		
Day	0 ₁	02	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.	<u>:</u> 0:(0)	0(0)	0 (0)	0 (0)	0 (0)	0`(0)	0 (0)	

'Raw data sheets are included in Appendix A: 02: Synthetic Laboratory Water (Moderately Hard)

Investiga	tor: Mailee W. Gar	ton
N	VIICA 1	
.4	All Carle	4
Signature))
		1

Contact: Dennis McCauley Phone No.: (231) 941-2230. Principal Research Scientist/Manager of Operations Title 15 n 13 Date

TABLE 3

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

······································	
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/m³/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)

raciiny Name	: AEP Cook Nuclea	r Plant				INFUES F	ermit No.:	
Receiving Wa	ater: <u>Lake Michigan</u>	Ou	tfall:	<u>.</u>		RWC: N//	4	·
Test Dates: 1	2/01/06 - 12/05/06	Te	st Species: <u>Fa</u>	thead minnov	VS.	Age Rang	e: <u>6 days old</u>	<u> </u>
Test Laborato	ory: Great Lakes Er	nvironmental Cent	ər (GLEC)		· · · · · · · · · · · · · · · · · · ·	Report Da	te: December	15, 2006
	· <u></u>	E	BULK SAMPLE		10N			
SAMPLE COLLECTIC DATES	DATE DN RECEIVED	ARRIVAL TEMPERATURE	DATE OF FIRST USE	ARRIVAL TRC	DECHLORIN ATION?	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	NŴ
escribe any d	ods were used: EF eviations from test organisms:. In hous	methods: <u>None</u>	· ·	02-012	<u>, </u>			
	ngamana m nous	e <u>100# 11/25/06</u>					<u> </u>	÷
			TEST DE	SCRIPTION	·			
Fed/Un-fed:	Fed	Food/F	eeding Freque	ncy: <u>Artemia</u>	a nauplii, 2 hou	rs prior to 48	-hour renewal	
No. Replicate Concentration		No: Or Replice	ganisms per ate: <u>10</u>		Effluent Filtere	ed? <u>No</u>		
Effluent Samj	ole Type: Sample	1: Composite			Sample 2:			
Diluent (0 ₁):	ake Michigan Wate	er (GLC# 7008)	*		Secondary Co (Moderately H	ntrol (0₂): <u>Sy</u> ard) MH# 14	nthetic Labora 79	tory Water
	(ب		SUMMARY (OF RESULTS	5			
	ر. 	·	SUMMARY	OF RESULTS	5	LC ₅₀ 95% Lo LC ₅₀ 95% U	48-hour 96-hour ower Confiden pper Confiden	LC ₅₀ : <u>27.74</u> ce: <u>23.93%</u>
	ر		SUMMARY (cent Mortality ercent Effected	per Concen	tration	LC ₅₀ 95% Lo LC ₅₀ 95% U	96-hour ower Confiden	LC ₅₀ : <u>28.77</u> LC ₅₀ : <u>27.74</u> ce: <u>23.93%</u> ce: <u>32.16.%</u>
	پ Controis-	(Pe	cent Mortality	per Concen	tration	LC ₅₀ ,95% U	96-hour ower Confiden	LC ₅₀ : <u>27.74</u> ce: <u>23.93%</u>
Day	Controis- 0;	(Pe	cent Mortality arcent Effected	per Concen	tration ration)	LC ₅₀ ,95% U	96-hour ower Confiden	LC ₅₀ : <u>27.74</u> ce: <u>23.93%</u>
Day		(Pe	cent Mortality prcent Effected Percent 12.5	per Concen	tration ration) Effluent Concentr	LC ₅₀ ,95% U	96-hour ower Confiden pper Confiden	LC ₆₀ : <u>27.7</u> / ce: <u>23:93%</u> ce: <u>32.16 %</u>
	0,	(Pe 	Cent Mortality arcent Effected Percent 12.5 (0) 0	Percent	tration ration) Effluent Concenti 25 Percent	LC ₅₀ ,95% U ations 50 Percent	96-hour ower Confiden pper Confiden <u>100 Percent</u>	LC ₆₀ : <u>27.7</u> / ce: <u>23:93%</u> ce: <u>32.16 %</u>
1	0, 0 (0)	(Pe	Cent Mortality Percent Effected (0) 0 (0) 0	Percent (0)	tration ration) Effluent Concentr 25 Percent 0 (0) 30 (35)	LC ₅₀ ,95% U ations <u>50 Percent</u> 00 (100)	96-hour ower Confiden pper Confiden 100 Percent	LC ₆₀ : <u>27.7</u> / ce: <u>23:93%</u> ce: <u>32.16 %</u>

Investigator: Mailee W. Garton; Ĭ Signature

Contact: Dennis McCauley

Phone No.: (231) 941-2230

Date

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Principal Research Scientist/Manager of Operations Title

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 Toxic	ity Test Conditions
1.	Test Species and Age:	<i>Daphnia magna</i> , <24 hours old
2.	Test Type and Duration:	Static, 48 hours
3.	Test Dates:	December 01-03, 2006
4.	Test Temperature (°C):	25 ± 1
<i>.</i> 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: AE	P Cook Nuclea	r Plant				NPDES Pe	rmit No.:	
Receiving Water:	Lake Michigan	Ou	tfall:		<u>_</u>	RWC: <u>N/A</u>		
Test Dates <u>: 12/01</u>	/06 - 12/03/06	Tes	st Species: <u>Dar</u>	ohnia magna	<u>.</u>	Age Range	<pre>: <24 hours</pre>	
Test Laboratory:	Great Lakes Er	nvironmental Cente	er (GLEC)			Report Date	e: <u>December</u>	15, 2006
·		. E	BULK SAMPLE		TION			
SAMPLE COLLECTION DATES	DATE RECEIVED	ARRIVAL TEMPERATURE	DATE OF FIRST USE	ARRIVAL TRC ²	DECHLORIN ATION?	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	ŇM
ND: Not Detected				· · · · · · · · · · · · · · · · · · ·				<u>ji an </u>
What test methods	were used: EP	A/600/4-90/027 ar	nd EPA-821-R-	02-012			·	
Describe any devia								
Source of test orga								· ·
				· · · · · · · · · · · · · · · · · · ·				
			TEST DE	SCRIPTION	•			
Fed/Un-fed: <u>Un-</u> F	ed	Food/F	eeding Freque	ncy: <u>None</u>				
No. Replicates pe Concentration: 4	r	No. Or Replica	ganisms per ate: <u>5</u>	·	Effluent Filtere	d? <u>No</u>		
Effluent Sample T	ype: Sample 1	: Composite			Sample 2:			
Diluent (0;): Lake	e Michigan Wa	ter (GLC# 7008)			Secondary Cor (Moderately Ha	ntrol (0 ₂): <u>Syr</u> (rd) MH# 147	nthetic Labora 19	atory Water
			SUMMARY (OF RESULT	S			
					· · ·	C ₅₀ 95% Lov	48-hour E	LC ₅₀ : <u>35.36 %</u> C ₅₀ : <u>35:36 %</u> ce: <u>Not reliable</u>

LC50 95% Upper Confidence: Not reliable

Percent Mortality per Concentration (Percent Effected per Concentration)

·		Con	trois		Effluent Concentrations						
	Day	0,	02	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. 02: Synthetic Laboratory Water (Moderately Hard)

(Investigator: Mailee W. Garton

Signature:

Contact: Dennis McCauley

Title

Phone No.: (231) 941-2230

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Principal Research Scientist/Manager of Operations

Date

Appendix A

Raw Data Sheets



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 Eax: (231) 941-2240

Facility: Coo	K N	UCLEAT	PIANT
Location:	Freen	House	
Contact Person:	Enic	Mallen	
Phone Number:_	Z69-	465-59	01 #1540

Collector:	
Date:	November 30 2006

Date: November 30, 2006

GLC NUMBER (Lab ID)	SAMPLE	DATE/TIME OF SAMPLE*	VOLUME COLLECTED	SAMPLE CONTAINER	DESCRIPTION (Type of sample, source, physical characteristics)	PRESERVATION	ANALYSES REQUIRED	Additional I Measured a Ammonia mg/L	
7008	Control	11/30 9:05	26011025	2(1)gollard	Nutrepted IAKE Michigowie		WET		Temp 0.6°
7009	35"Awte	11/30 10:00	ZGOMON	2 Cubitainer	LAKE MICHIDON WATEr Dosed + 4	Ma/L Mexel	WET TEST		temp 10°
7010	Zit' Composite	11/29 - 11/30 9:45 - 9:45	2 Goilons	Zeubitainer	LAKE MICHISAN COMPOSITE DOSE	L ONLE W/Mexel	WEITEST	Jint	enp 0.9.
		Stort End			•••••				
			<u> </u>	1	: :				
			د 					······	

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

TRANSFER OF SAMPLES:

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(First signature is sampler, last signature is authorized laboratory representative.)

	SHIPPER .	RECEIVER	DATE	TIME	<u>TEMPERATURE</u> 0.6 - Control
2.	,			· ·	
<u>Condi</u>	tion of Sample Upon Rec	eipt: good Malu w Lw	Shar) Haloula	1515	Received on Ice
		JOOC MINING IN DEN	rAn 11/30/06	10, 0	



EFFLUENT AND RECEIVING WATER CHECK-IN FORM

Great Lakes Environmental Center

ook Duclean CLIENT: INVESTIGATORS

PROJECT NUMBER: 861-00

INITIAL WATER CHEMISTRY (UPON RECEIPT)

AEP

DATE RECEIVED:	INITIALS	Lake Mich Control	30 minute Dosedw/ 4 mg/L Mercel	24 hour Composite Doxed 7 when	Ke Ê
GLC NUMBER:		7008	7009	7010	<i></i>
COLLECTION DATE: (Time Interval)	•	11/30/06 905	11/30/06 1000	11/29-30945	-945
TEMPERATURE:		0.6	1.0	0.9	
EFFLUENT DESCRIPTION:		Clear	clean	Clean	
	V	oderlas	adorliss	odoln	• •

WATER CHEMISTRY AT TEST TEMPERATURES

DATE RECEIVED:	INITIALS	Lake Mich Water Control	30 Minute	24 hour Composite
GLC NUMBER:	nub-	7008	7:009	7010
TEMPÉRATURE	new	25.0	25:0	25.0
рН	Neit	8.10	8112	8.07
DISSOLVED OXYGEN (mg/L)	pueb	13.0	12, 2	12.0
CONDUCTIVITY (µmhos/cm).	mut	316	312	309
HARDNESS (mg/L)	Mutr	160	144	130
ALKALINITY (mg/L)	mub	108	112	112
TOTAL CHLORINE (mg/L)	1	1		/
TOTAL AMMONIA (mg/L)				

Check with project manager to see if necessary.

Ikalinity Hardness 7008 7009 End mL: 40.6 Start mL: 43.0 อเอ 1008 6.50.0 End mL: UI O 430 End mL: 35. 51466 Start mL:35.4 Start mL: 30 O S Sample Volume: 25 Sample Volume: 50 Sample Volume 50 Sample Volume: 25 Volume 50 58

Giric Sinte			Hhow Ce	mposite	FIS			ATIC AC			TEST						
TEST MATERIA PROJECT NUM TEST SPECIES	BER:	<u>- Nuclea</u> 361-00 111	<u>r 7010</u>	AGE/SOURCE OF FRY: 11/25/04 6 deup					LIGHT	PHOTOPERIOD (L:D):							
DATE	TEST. DAY	TECH, INITIALS	TREATNENT LEVEL	CON	HZO	A	p.259	B	12.57	U	257.	DF	50%	EI	009.	2°Cm	MH
THE	<u></u>		REPLICATE NUMBER	9.5	42	9.6	<u></u>	9:0		9.6	2.	9,6	3	9.5		i.	· · · /
0	£ .		DO (mpl) Temperature (*C)	75.0		25.0		30		250	4	250		7.5			
2/1/32	, î 0 - ``	muld	рн	8.08		8.09		8,09		8.08		8-08		8-08			
2/11		1 m	Sp. Cond (umbostem)	316)	3	08		510		312		ià	30	the second se	54 m 1	1
· · ·			Number Live	10	10	10	10	0	10	10	(0)	10	D	10	10	·	
	· •	CUL	Observations			<u> </u>								<u> </u>			
Joly 1	1	as	DD (mg/L)	9,0		9,0		8.9	<u> </u>	8,9		89		89			
3[3134		T.N.	Temperatura (*C):	25-6	- 	05.6		50	· · · · · · · · · · · · · · · · · · ·	35.6		25-6		25.5	<u> </u>		<u> </u>
and we we derive a state	a ka tinati katika kati di	- Cu. 28 Cable of a 20	рн	7.94		8-01		8.05		8.09	A 44 8	8.13		8.14			
44-140	ú,	1	00 (mg/L)	0.3		9.4		9.4	·	9.4		9.4	·	9.4		ļ	ļ
45-He Renn New Chemia	ent. Tries	كلاسم	Temperature (*C).	<u>क्रिल</u> इ.७३		35.0	,	25.0 8.14		250 8116		95:0 8:11		2610 791			ļ
	,		<u>più</u>	Nucle To The	21212		12		13		18	<u>x (1</u> '3c	ـــــــــــــــــــــــــــــــــــــ		322		<u> </u>
HT I F	an ana ana ana ana an	a an	Spickil Con, (umbos/cm)	10	(1)	0	ID:	10	10	10	10	- <u>10</u>	10	10	10		
			Number Live Observations		<u> </u>	<u> </u>	<u> </u>		<u> </u>		<u></u>			1-10-	μ <u>ιν</u>		· · · · · · · · · · · · · · · · · · ·
3/3/3	2	MUUT	00 (mg/L)	90		90		9.0		9.0		9.0		910	 	1	
31		1mm	Temperature (°C)	25.4		75.4		25:4		254		35.3		5.3			· · · · · · · · · · · · · · · · · · ·
			рН	7.89	·	800		8.09		8.15		8.16		8.31			
2			Number Live	10	10	10	10	G	10	10	GI	(0)	10	10	10	1	
1.40			Observations												<u> </u>	$\cdot t$	
aler los	3	Cur	DO (mg/L)	8.4		8.4		8.4		8.4		84		8.2		1	
			Temperature ("C)	98.2		25 x		252		25.3		25:2		25.2		<u>k</u>	
		<u> </u>	рН	7.54		7.94		8.03		8.09		8.13		8.16		<u> </u>	
N and	:	.К	Number Live	- 10	10	10	10	() ()	(0	10	(0	0	10	0	10		· · · · · · · · · · · · · · · · · · ·
1512	tore with	ans	Observations		<u>.</u>					9. 1	<u></u>	v -		18:	<u> </u>		
1816			DO (mg/L)	8.3	- 	84	· · · · · ·	8.4		8.2		8.3	<u>.</u>	82	·····		<u> </u>
1 BUY			Temperatura (*C)	261		25.1		8.08		252 811		25.2		8.15			, <u></u>
<u></u>		<u></u>	рн			ا قال: لا ا		10-10-01		0111		1215		10.12	<u> </u>	L	laine i contantia

Observation Key: N - Normal ERA Erratic Swimming.

PM - Particulate Matter FS - Film on Surface

I - Immobilized

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Reviewed By

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()	FLE(DAPH	NID 48-HO	UR STATIO	C ACUTE 1	ΟΧΙΟΙΤΥ Τ	EST				
Great Lok	TEST MATERIAL: COOK MUCIEUY COMPOSITION TYPE OF TEST: POINT ATOM DILITION WATER ROCH-0 7008												
TEST M	ATERIAL:	rook n	nclear Com	NOSUL TYPE O	FTEST: PUUL	atons		ILUTION WATER: RP	CH-0 7008	r. •			
	CT NUMBER:		-00		R OF DAPHNIDS/CHAM	0 5	µ- · v	LC AND/OR BATCH NU	"AU				
4	PECIES:	Dmag	a de la companya de l		R OF CHAMBERS:	4+1 For chi		EST TEMPERATURE:					
INVEST	GATORS:		<u></u>			11/20/00				,:8			
		•								<u> </u>			
	<u></u>	·		<u>A</u>	10 1:200	0 17 50	0. 257	N MAD		De Auro Att			
DATE	. TEST	TECH.	TREATMENT LEVEL	CONTROL	A 10.2590	B 12.5%		D 50%	E 100%	2° Con			
TIME	DAY	INITIALS	REPLICATE NUMBER	1234	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4		1 2 3 4			
130			TEMPERATURE (*C)	<u>25.0</u>	8.09	8.8	2.2	8.08	25.0	25.0 7.84			
XV .	0	The	pH	9.5	0.01 9.6	9.6	8.08	9.00	8.08 9.5	8.4			
2/120		Vor.						-1-10		<u>O. I</u>			
<u></u>	- -		SP. CONDUCTANCE (µmhos/cm)	316	308	310	312	313	310	323			
		• 2	NUMBER LIVE	5555	5555	5555	5555	5555	5555	5555			
1.21			OBSERVATIONS										
2/2/2	đ.	augus 1	pH	8.15	8.21	8.74	8.26	8.30	833	7.93			
S		6	DO (mg/L)	97.6	C . (g	9.5	9,5	9.5	915	9.0			
;i			TEMPERATURE (*C)	25.5	25.10	35.6		750	25.5	25.5			
30			NUMBER LIVE	5655	5555	6555	5555	5555	5555	6555			
330	1	5	OBSERVATIONS										
3	2 4	3	pH	<u> </u>	8.40	841	8.41	8:41	8.43	8.01 9,0			
Y.			DO (mg/L)	297	9.4 29.8	9.4	<u>914</u> 379	9,4	<u> </u>	318			
			SP. CONDUCTANCE	·····									
		<u> </u>	TEMPERATURE (°C)	25 3	<u> </u>	25.2	5.2	25.3	25.3	253			

Observation Key:

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

REVIEWED BY <u>Эю</u> DATE

DIREservan

Gine			30'minute ar 7009		FIS				UTE TO RENEW		TEST						
TEST MATERI	AL (00)	Nuclea	x 7009	NO. FRY	CHAMBER:	10)				PHOT	DPERIOD (L	·D):	6:8			
PROJECT NUM		361-00)		JRCE OF FR	Y:	11/2=	500	ladur	n		INTENSITY		ambiei	nt		
TEST SPECIES					WATER:	Rer t	1,0'-	TOOX			_			Der LI	0°		······································
[,	<u></u>			HZO HZO				31300	<u>it O</u>	62509		URE ("C):		TYP	1.26.0	- 74.1 3
DATE.	TEST DAY	TECH	TREATWENT LEVEL	CON	1	<u>H</u>	0.25%	12		<u>40</u>	25%	1.2	50%	EI	<u>)0' Iv</u>	2° Cor	MH
TIME			REPLICATE NUVAER	9.5	. 2:	9,5	·	9,5	, ,	9.5		9.5		9,7	2	84	
7200		1	DD (mg/L) Temperature (IC)	25.0		25.0		250		250		250		25.0		25.0	
Alle	0	Run	pH'	808	·	8:09		811	· · ·	812		8.08		8.09		7.84	
(W)		m	So. Cond. (um han/cm)	311	0:	2	05	3	VO	3	11	31	0	31	み	323	
			Number Live	10	0	10	10	0)	10	10	(0	Ø	Ø	Ø	0	10	10
30	н. С		Observations														
0/2/2	. 1	کل ا	DO (mgA)	9,0		9.0		90		9,0		8.3	the second s	80		8.9	
\mathcal{N}		10	Tamperatura (*C)	75.4		25.5		25.5	<u> </u>	25.5		25.5	;	255		25.5	
Section and the sector of the sector	ware see of Albe		pH	8.01		8.05		8.07		8.69		8.01	·	8.00	•••• • • • •	7.93	
- da tindi :Renevial Natur			DO (mp/L)	9,4	-	9,4		9.5	·	9.5						814	
		Juil S	Temperature (TC)	250		250		25.0	: 	25.0			<u> </u>			25:0	
Chemi	let? he t	NUUN	<u></u>	9.03	<u>,</u>	5.09		8.07	<u>.</u>	8:13			<u></u>		· /	7.8.7	
animetra das y de Carros			Special Con, (umhos/cm)	313	·	1. Martin	্য	9 esta 110	14	31	6					32	
Desirability attacks at 1.			Special Con, (umhosicm)	10	ιÖ	ج. 10	D) D	10	10	7	9				1		
1920	2	Lung		10	·	<u>ت</u>		10	.1.*	Trnn	7						2
13/3/00	2	mint	Number Live Observitions .DO (mgA)	10 9.2	·	10 9 >		10 89	.1.*	7 1500 88	9 7					8.9	2
13/3/200	2	Mult	Number Live.	10 9.2 35-3	·	(Ö) G 3 35:3		10 89 25-3	.1.*	7 15mm 88 254						8.9 25-4	2
193200	2	ment	Number Live Observations DO (mpl) Temperature (*C) pit	9.2 35-3 7-03		10 9 x 25:3 7.99		10 X 9 25 3 8 07	10	7 1500 88	7					8.9 25.4 7.81	
	2		Number Live Ob servicitoris DO (mgA) Tamperiature (*C) pH	10 9.2 35-3	·	(Ö) G 3 35:3		10 89 25-3	.1.*	7 15mm 88 254	2 7 2					8.9 25-4 7.81 10	2
	2		Number Live Observeitions D0 (mg4.) Tampere Rure (*C) pH Number Live Observeitions	9.2 35-3 7-03		(O) 9 3 35:3 7.99 10	[D 0	10 8.9 25 3 8.07 10	10	7 1200 88 254 809 7 1E64	7					8.9 25.4 7.81 10 8.5	
	2	Mert	Number Live Ob servicitoris DO (mgA) Tamperiature (*C) pH	(1) (7,2) (35:3) (7:03) (10) (7,2) ((O) 95.3 7.99 10 9 2	10	20 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	10	7 17ma 88 254 809 7	7					8.9 25.4 7.87 10 85 85	
, julio			Number Live Observitions DO (mg/L) Tamperishure (*C) pH Number Live Observitions DO (mg/L)	10 9.3 95.3 7.03 10 9.2		10 53,39 7,99 10 7,99 10 7,99 10 7,99 8,35	10	<u>२</u> २ २ २ २ २ २ २ २ २ २ २ २ २ २	-01 	7 12ma 254 88 254 809 7 1884 9.5	7					8.9 25.4 7.81 10 8.5 8.5 8.5 774	10
stulio	2		Number Live Ob servicions DO (mgA) Temperature (*C) pH Number Live Ob servicions DO (mgA) Temperature (*C)	(1) (7,2) (35:3) (7:03) (10) (7,2) ((① () () () () () () () () () () () () ()	10	20 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	10	7 17ma 254 254 254 254 254 254 1844 95 253 810 7	۲ د: د					8.9 25.4 7.87 10 85 85	
stulio		(nuls	Number Live Observeitons D0 (mgA) Tampershore (*C) pH Number Live Observeitons D0 (mgA) Tempershore (*C) pH Number Live	10 9.2 35.3 7.03 10 9.2 25.4 7.98 10	0 10	10 9,35,33 7,49 0 9,2 35,49 0 9,2 35,49 8,35 0		20 25:3 25:3 20 20 20 20 20 20 20 20 20 20 20 20 20	10	7 1200 88 254 809 7 1824 9.5 252 10 7 25 252 7 25	7 					8.9 25.4 7.87 10 8.5 8.5 8.5 774	10
		(nuls	Number Live Observeitons D0 (mgA) Tampershore (*C) pH Number Live Observeitons D0 (mgA) Tempershore (*C) pH Number Live	10 9.2 35.3 9.03 10 9.2 9.2 25.4 7.98 10 10 83	0 10	10 9353 7.99 20 92 20 25 20 84		20 x en 25 3 25 3 20 2 2 2 2 2 2 2 2 2 2 2 2 2	10	7 1200 254 254 254 254 7 164 955 7 164 7 253 816 7 253 816 7 254 84	۲ د: د					8.9 25.4 7.87 10 85.6 7.77 0 85.777 0 85.4 7.77	10
, julio			Number Live Observeitons D0 (mgA) Tampershore (*C) pH Number Live Observeitons D0 (mgA) Tempershore (*C) pH Number Live	10 9,2 35.3 7,03 10 9,2 25,4 7,93 10 10 8,2 7,93 10 8,3 25,4	0j	10 9,3 35,3 7,99 10 9,2 35,4 8,35 10 8,4 25,2	0	20 8:53 25 25 27 27 27 27 27 27 27 27 27 27 27 27 27	10	7 12 18 18 18 18 18 19 18 19 19 19 19 19 19 19 19 19 19	۲ د: د					8.9 25.4 7.87 70 85.2 7.74 85.2 7.74 20 84 25.2	10
1145 1145 1145		(nuls	Number Live Ob servicitors D0 (mgA) Tamperature (*C) pH Number Live Ob servicitors O0 (mgA) Tamperature (*C) pH Number Live Ob servicitors O0 (mgA) Tamperature (*C) pH Number Live Ob servicitors Ob servicitors Ob servicitors	10 9.2 35.3 9.03 10 9.2 9.2 25.4 7.98 10 10 83	0j	10 9,3 35,3 7,99 10 9,2 35,4 8,35 10 8,4 25,2	0	20 8:53 25 25 27 27 27 27 27 27 27 27 27 27 27 27 27	10	7 1200 254 254 254 254 7 164 955 7 164 7 253 816 7 253 816 7 254 84	7 .0 .0 					8.9 25.4 7.87 10 85.6 7.77 0 85.777 0 85.4 7.77	10
JULION JU	-4:	(nuls	Number Live Ob serveitors D0 (mgA) Tamperature (*C) pH Number Live Ob serveitors Ob serveitors D0 (mgA) Tamperature (*C) pH Number Live Ob serveitors D0 (mgA) Temperature (*C) pH Number Live Ob serveitors D0 (mgA) Temperature (*C) pH PM - Particulate Matter	10 9,2 35.3 7,03 10 9,2 25,4 7,93 10 10 8,2 7,93 10 8,3 25,4	<u>(0)</u>	10 9,3 35,3 7,99 10 9,2 35,4 8,35 10 8,4 25,2	0	20 8:53 25 25 27 27 27 27 27 27 27 27 27 27 27 27 27	10	7 1200 88 254 809 7 184 9.5 25 25 25 25 25 25 25 25 25 25 25 25 25	۲ د: د					8.9 25.4 7.87 70 85.2 7.74 85.2 7.74 20 84 25.2	10
AUD AUD AUD AUD AUD AUD AUD AUD AUD AUD	-4:	(nuls	Number Live Observations DO (mgA) Tampershere (*C) pM Number Live OD servations DO (mgA) Tempershere (*C) pM Number Live Ob servations DO (mgA) Tempershere (*C) pH Number Live Ob servations DO (mgA) Tempershere (*C) pH	10 9.2 35.3 9.03 10 9.2 25.4 7.98 10 10 8.9 25.2 8.3	<u>(0)</u>	10 9,3 35,3 7,99 10 9,2 35,4 8,35 10 8,4 25,2		20 8:53 25 25 27 27 27 27 27 27 27 27 27 27 27 27 27	10	7 1200 88 254 809 7 184 9.5 25 25 25 25 25 25 25 25 25 25 25 25 25	7 .0 .0 					8.9 25.4 7.87 70 85.2 7.74 85.2 7.74 20 84 25.2	10

Observation Key: N • Normal ERR - Erratic Swimming

I - Immobilized

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Reviewed By:

TRIMMED SPEARMAN-KARBER METHOD. MONTANA STATE UNIV

1. 1. 1.

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:12/1/06TEST NUMBER:1861-00DURATION:48 HOURSCHEMICAL:30 MINUTE MEXEL4 MG/1 glc7009SPECIES:FHM

RAW DATA: CONCENTRATION(PERCENT) NUMBER EXPOSED: MORTALITIES: SPEARMAN-KARBER TRIM:	6.25 20 0	12.50 20 0 .00%	25.00 20 6	50.00 20 20	100.00 20 20	
SPEARMAN-KARBER ESTIMATES: 95% LOWER CON 95% UPPER CON	IFIDENCE	6 : 6 :	24 33	10		

ï

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 0.825 1.25 2.5 19/2 RAW DATA: 6.25 12.50 25.00 50.00 100.00 CONCENTRATION (PERCENT) NUMBER EXPOSED: 2`0 20 20 20 20 MORTALITIES: 0 .0 7 20 2.0 .00% SPEARMAN-KARBER TRIM: 27.74 O. 694 Mg/ SPEARMAN-KARBER ESTIMATES: LC50: 95% LOWER CONFIDENCE: 23.93 95% UPPER CONFIDENCE: 32.16 _____

We measure at 0,2

12 -. 59

measured 0,45

63

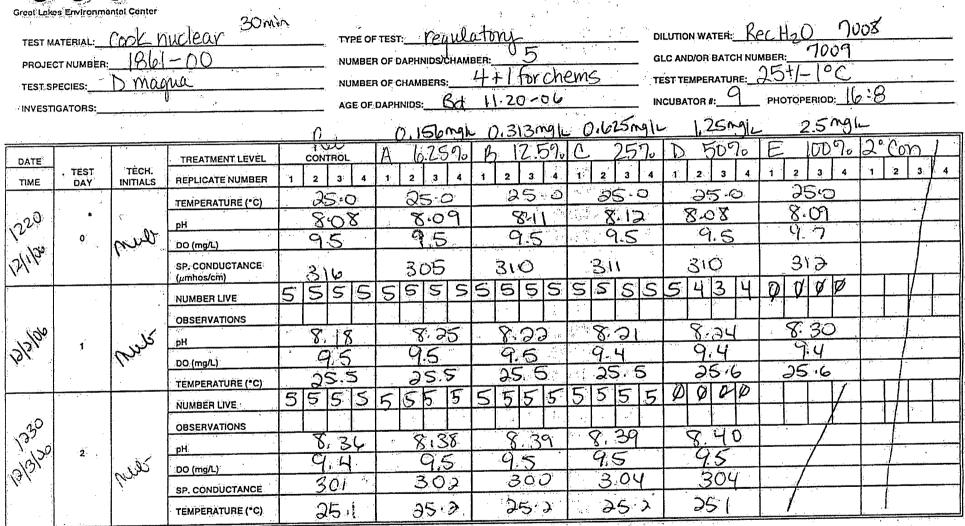
TRIMMED SPEARMAN-KARBER METHOD. MONTANA STATE UNIV

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 TE CHEMICAL: COOK NUCLEAR GLC#70	ST NUMBI 009 2.5	ER: 1861 MG/1	- 0,0		DURATION SPECIES :	i de la companya de l	
RAW DATA: CONCENTRATION (MG/L) NUMBER EXPOSED: MORTALITIES: SPEARMAN-KARBER TRIM;	.16 20 0	.31 20 0 .00%	. 63 20 7	1.25 20 20	2.50 20 20	· · ·	
SPEARMAN-KARBER ESTIMATES: 95% LOWER CON 95% UPPER CON		•		.69 .60 .80			



DAPHNID 48-HOUR STATIC ACUTE TOXICITY TEST



Observation Key:

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

REVIEWED BY: MCV

TRIMMED SPEARMAN-KARBER METHOD. MONTANA STATE UNIV

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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:12/1/06TEST NUMBER:D MAGNADURATION:48 48CHEMICAL:COOK NUCLEAR 30 MINUTESPECIES:D MAGNA

AW DATA: CONCENTRATION (PERCENT)	6.25	12.50	25.00	50.00	100.00	
NUMBER EXPOSED:	20	20	20	20 20	20	
MORTALITIES	0	0	Ō	20	20	
SPEARMAN-KARBER TRIM:	- ~	.00%	· ·			
SPEARMAN-KARBER ESTIMATES:	LC5		35	.36 DENCE I	0.884	myl
				ELIABLE		V

حاحا

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 TE CHEMICAL: COOK NUCLEAR 2.5 M	DURATION	and the second second				
				~		
RAW DATA:					· .	
CONCENTRATION (MG/L)	.16	.31	. 63	1.25	2.50	
NUMBER EXPOSED:	20	20			2.0	
MORTALITIES:	0		20 0	20 20	20	
SPEARMAN-KARBER TRIM:	2-	0 •00%		÷ ·	-,, ,	
SPEARMAN-KARBER ESTIMATES:	LC50					
· · · ·		95% ARE	IMITS			
		سانية : مرجزي مرجز الانج			• • • • •	

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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 *Daphina* 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 H(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 48hour 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 Rower-Donald C. Cook Nuclear Plant.

Sincerely,

Mailee W. Garton Laboratory Coordinator

TM Car

Dennis J. McCauley Principal Research Scientist/ Senior Operations Manager

MWG mg Enclosures

Great Lakes Environmental Conter

Ápplied Envirónmental 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

TABLE 1

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

·
Pimephales promelas, (Fathead minnow), 4 days-August 25, 2007
96-hour Static, with renewal at 48 hours
August 29-September 02, 2007
25 ± 1
Amblent Laboratory, 10-20 µE/m³/s
16 h light, 8 h darkness
48 hours.
250 mL glass beaker
200 mL, 65 mm
10:
2
20
100, 50, 25, 12,5, and 6.25
48-hour renewal
Lake Michigan GLC# 7161
Synthetic Laboratory (Moderately Hard MH# 1543)
None
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: <u>N/A</u>
Test Dates: 08/29/07 - 09/02/07	Test Species. Fathead minnows	Age Range: 4 days old
Test Laboratory: Great Lakes Environmental C	enter (GLEC)	Report Date: September 18, 2007
		_

BULK SAMPLE INFORMATION SAMPLE DATE ARRIVAL ARRIVAL DECHLORIN ARRIVAL ARRIVAL ARRIVAL DATE OF COLLECTION RECEIVED TEMPERATURE FIRST USE TRC ATION? pH DO AMMONIA DATES 08/28/07 0.6°C 1. 08/28/07 08/29/07 ŇM No NM 8.35 10,1

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

Effluent Sample Type: Sample 1: Composite

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

TEST DESCRIPTION

Fed/Un-fed: Fed

No. Replicates per

Concentration: 2

No. Organisms per Replicate: 10

Effluent Filtered? No.

Sample 2:____

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

Secondary Control (02): <u>Synthetic Laboratory Water</u> (Moderately Hard) MH#1543

SUMMARY OF RESULTS

48-hour LC₅₀: <u>68:3%</u> 96-hour LC₅₀: <u>65:9%</u>

Percent Mortality per Concentration (Percent Effected per Concentration)

0	1 0 (0) 0 (0) 0 (0) 2 '0 (0) 0 (0) 0 (0)							
			6.25_Percent	12.5 Percent	25_Percent	50 Percent	100 Percent	Percent
1'	1· /	1	0 (0)	0 (0)	0.(0)	5 (5)	100 (100)	
2	⁷ 0 [°] (0)	0 (0)	0 (0)	<u>(0)</u>	0.(0)	5 (5)	100 (100)	<u>.</u>
.3	0 (0)	0'(0)	0 (0)	5 (5)	0,(0)	5 (5)	100 (100)	
4	0 (0)	o (o)	0 (0)	5 (5)	0.(0)	5 (5)	100 (100)	

Raw data sheets are included in Appendix A. 02: Synthetic Laboratory Water (Moderately Hard)

Investigator: Mailee W. Garton

Contact: Dennis McCauley.

Title

Principal Research Scientist/Manager of Operations

Phone No .: (231) 941-2230

Date

Signature

TABLE 2

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

Summary of Toxicity Test Conditions	
1. Test Species and Age:	Ďaphnia 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 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 (percent);	100, 50, 25, 12,5, and 6.25
4. 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: <u>AE</u>	P Cook Nuclea		NPDES Pe	rmit No.:				
Receiving Water:	Lake Michigan		fall:			RWC: N/A		,
Test Dates: <u>08/29</u>	/07 - 08/31/07	Tes	st Species <u>: Dàr</u>	ohnia màgha		Age Range	<24 hours	
Test:Laboratory:_	<u> Great Lakes Er</u>	nvironmental Cente	er (GLEC)			Report Dat	e: <u>Séptembe</u>	r <u>18, 2007</u>
						-		
	<u> </u>	·E	ULK SAMPLE	INFORMAT				
SAMPLE Collection Dates	DATE RECEIVED	ARRIVAL TEMPERATURE	DATE OF FIRST USE	ARRIVAL TRC	DECHLORIN ÁTÍON?	ARRIVAL	ARRIVAL DO	
108/28/07	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

No. Replicates per

Concentration: 4

No. Organisms per

Replicate: 5

Food/Feeding Frequency:None

Effluent Filtered? No

Effluent Sample Type: Sample 1: Composite

Diluent (01): Lake Michigan Water (GLC# 7161)

Sample 2:____

Secondary Control (02) <u>Synthetic Laboratory Water</u> (Moderately Hard) MH# 1543

SUMMARY OF RESULTS

48-hour LC₅₀: <u>65.9%</u> 48-hour EC₅₀: <u>65.9%</u>

Percent Mortality per Concentration (Percent Effected per Concentration)

B	Con	trols	· · · · · · · · · · · · · · · ·		Effluent Con	centrations-		
Day	01	. Ö ₂	6.25 Percent	12.5 Percent	25 Percent	50 Percent	100 Percent	Percent
<u> </u>	(Ö.(O)	0 (0)	0-(0)	0.(0);	0 (0)	0.(0)	95 (95)	
2	(0) (0)	0(0)	0 ¹ (0)	0.(0)	0.(0)	10 (10):	100 (100)	

Raw data sheets are included in Appendix A. 02: 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



Great Lakes Environmental Center

donar Groom Communication Conserva-

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

Facility: Coold Nuclear Plant Location: One Coole Place Bridgman 17 49106 Contact Person: Eric Mallen Phone Number: 269-465-5901 × 1540

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

Por 8/2-107 Toque Badear Collector: 8/72/0 Date: Fric Meller Witness? 8/28/127 Date:

GLC NUMBER (Lab ID)	SAMPLE ID			PRESERVATION	ANALYSES	Additional Parameters Measured at Collection			
(Lau ID)	17			~	characteristics)			Ammonia mg/L	Chlorine mg/L
6981	07-01	8/28/07/10:05	Igullon	Cubitaina	Mexil Fronti I Alliest & lideal 3.	1 none	WIT	NA	NA
6	07-02			cu Stains	Lake Water	None	dilutions	įV _X	149
7161	07-03	8/28/0712.12	1 gullon	Cultuina	Lake water	None	Stations.	MR	/V-A
				· · · · · · · · · · · · · · · · · · ·				· · · · ·	· · · · · · · · · · · · · · · · · · ·
	•4				· · · · ·				
						· · · ·			
			· · · · ·		· · ·	··			
		· · · · · · · · · · · · · · · · · · ·							

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

TRANSFER OF SAMPLES:

(Î

(First signature is sampler, last signature is authorized laboratory representative.)

SHIPPER DATE RECEIVER Plant 1. Actan 123/07 2. Condition of Sample Upon Receipt: S(zS)9000

e/07 TEMPERATURE TIME 7/61: O. O. Be H20 7100 0.1 O FEFFICET Received on Ice 16 80



EFFLUENT AND RECEIVING WATER CHECK-IN FORM

Great Lakes Environmental Center

CLIENT: COOK NUCLEAR PRO.

PROJECT NUMBER: 1861

INITIAL WATER CHEMISTRY (UPON RECEIPT)

DATE RECEIVED: 8/28/07	INITIALS SR	Final Effluent	Rec HzÖ
GLC NUMBER:		7160	7161
COLLECTION DATE: (Time Interval)		8 2807	8128107
TEMPERATURE		0,6	0.0
EFFLUENT DESCRIPTION:		Clear	clear
· · · · · · · · · · · · · · · · · · ·		NO ODOR	NO ODOR

WATER CHEMISTRY AT TEST TEMPERATURES

DATE RECEIVED: 8/28/07 CHECK IN DATE: 8/29/07	INITIALS	Final Effluent	Rec MzO	· · · · ·
CHECK IN PRICE OF CITOT				
GLC NUMBER:	•	7160)101	
TEMPERATURE	Ň	25.0	25.0	
рН	SZ	0,35	833	
DISSOLVED OXYGEN (mg/L)		(0.)	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.

71 (oC End ml Start mL: 35.5

Hardness: 7161 End mL: <u>36.5</u> Start mL: <u>31.7</u>

<u>Alkalinity:</u> 7161 End mL: 41.2 End mL Start mL: 360 Start mL: 50 5

Sample Volume: 25mL

Sample Volume: 25nL

Sample Volume: 50mL Sample Volume: 50mL



DAPHNID 48-HOUR STATIC ACUTE TOXICITY TEST



Great Lokes Environmental Center DOK Nuclear Hard Rec HoO TYPE OF TEST: RIPAIN UTDIFU DILUTION WATER: MICH TEST MATERIAL: NUMBER OF DAPHNIDS/CHAMBER: PROJECT NUMBER: GLC AND/OR BATCH NUMBER: TEST TEMPERATURE: 25±(°C for chems maana NUMBER OF CHAMBERS:_++ +/ TEST SPECIES: Ho:X Roit7 MH 8/17/07 AGE OF DAPHNIDS: 24 NIN INVESTIGATORS: INCUBATOR #: PHOTOPERIOD: 2 Con MH R CONTROL 6.25% C 25% E Work A B 12.5% SS'lo D TREATMENT LEVEL DATE TEST TECH. 3 TIME REPLICATE NUMBER 2 -É 3 .4 ·2 3 4 21 2 3: 2 3 2 .3 :4 2. INITIALS 3. 1 4 1 4 **:1**1 ÷Ť. :3 DAY .4 25.0 25.0 25.0 250 250 250 2 50 TEMPERATURE (*C) 8 29/07 83 8.33 833 S 8.33 81 8 35 SR_ pH' 95 1235 0 9-88 0.0 9.4 a 00 5 DO (mg/L) 320 314 SP. CONDUCTANCE 309 300 314 307 30 (µmhos/cm) 400 5 555 5 χ 5 5 5 5 5 5 5 5 5 5 S 5 5 ς' 5 \$ 5 Ś NUMBER LIVE 3F 35 35 35 iF ¥ 2F IF 12. JE OBSERVATIONS 530/07 Sr 8104 8.24 794 8.11 814 816 7.74 pH 1 8.4 83 83 8.4 8.4 8.4 8.4 3 DO (mg/L) 24.9 24.0 24.8 74.9 247 25.1 24.9 TEMPERATURE (*C) 55 S 5 5 55 55 S 5 5 S 5 5 5 5 5 0 S 5 5 5 4 NUMBER LIVE • Here is a second OBSERVATIONS 8.8 8.29 831 794 8.23 8.26 8 31 pН 2 () P 8.5 8.5 85 8.5 85 8.5 XIS DO (mg/L) 318 2 392 322 321 323 29% SP. CONDUCTANCE 24.7 24 8 248 TEMPERATURE (*C) 24.7 248 247 24.7

Observation Key:

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

REVIEWED BY: // Y(DATE

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 CHEMICAL: COOK NUCLEAR-AEP

TEST NUMBER: 1861-00 SPECIES: D. MÁGNÁ

1 X

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

	4.8	65.98	60.12	72,.41
.00		4		

	De la compañía de la comp	FISH 96-HOUR STATIC ACUTE TOX WITH 48-HOUR RENEWA															
TEST MATERIA	i ind	<u> 1 Vuct</u> -00		· · ·	CHAMBER:		Ino	8/251	57 10	:07		OPERIOD (L		16:8	<u></u>		
TEST					N WATER:			ec the				TINTENSITY		Ambient 25° ± 1			
DATE	TEST DAY:	TECH.	TREATMENT LEVEL.	Control	ec the	A (24	25%	B //	2,5%	c 24	5%	Ď Ċ	52	Ë /0	670	S'Con	MH
THE		·····		1	2:	<u>, i</u>	. 2;	· <mark> · · ·</mark>	2		2		2	,	2	<u> </u>	.2
3/29/07		SR	Temperature (*C)	\$33		8.31		25.0 8.3		250		833		25.0 8:35	-	25.0	<u> </u>
	0	100	pH	00	<u> </u>	97		95		9.5		94		100		88	<u> </u>
11.15			DO (mg/L)	309	1	30	1 7	30	<u>ا</u>	51-31	1		14	307	<u> </u>	320	1
			Sp. Cond: (umhos/cm)	10	10	10	1.0	10	10	19,10		9	10	$\overline{0}$	0	10	10
1			Observations			<u> </u>			<u></u>		<u> </u>						17
6/39/01	1,	TK		24.8	74.8	25.2		251	<u> </u>	246		24.7		24.7	†	24.9.	
			Temperature (*C)	781579		8.16		8:16		5.17	<u>.</u>	815		7.96		3.5	
			DO (mg/L)	7.8	2.6	7.6	7.6	7.6	<u> </u>	7.6	<u> </u>	7.6		7.0		7.9	8.0
<u> </u>	Temperatur		Temperature (*C)	25.0		25 0		25.0		25.0		25.0	1	25.0		25.0	
48-H Rene		T کئی ا	pH	8.32		8,33		8.33	<u> </u>	8.33		834	1	8.34	/	8.28	
Ne	w	1.0	DO (mg/L)	9.4		9.5		95	•	95	_	9.8		98	1	8.5	
			Special Con. (umhos/cm)	31	Ö	(ÿ)	610	3	813	Į.	313	31	Ś	/ 30	29	376	• .
			taumber Live	i0	10	10	10	10	10	0	10	0	10			10	10
6310		ity ??	Observations			<u> </u>		·						<u> </u>	<u> </u>		
03	2)Temperature (*C)	24.7		247		249		25.1		25.1			Y	24-7	
-			рН	7.99		8,10		8.13		815		8.15				7.81	
·····			DO (mg/L	8.0		8.0		8.0		8.0		80				1,8	
	. : .		Number Live	IO	10	10	10	10	9	10	10	4	<u>IÙ</u>	<u> </u>	1	10	10
1157		al-	Observations -					<u> </u>				<u> </u>		1			
A.V.	3	G)Temperature (*C)	248		248		24.7		248		249		ļ/	ľ	248	
			рн	823		3.24	· 	82.6		827		8.29	[/-	 	792	
			:DQ (mg/L	78		79	-10	78		8.0		8.0	1 :15		<u> </u>	7.8	
			Number Live	10	10	10	<u> </u>	1D	9	1D	_10	1-7-	10	ļ		10	10
1/11		SR.	Observations		· ·	17.17.1			<u> </u>		<u> </u>		<u> </u>	<u> </u>	<u> </u>	Course -	
11401	4)Temperature (*C)	24.1	1 1.1	24.1	<u> </u>	124,7,		245		244			<u> </u>	245	
125			pH	0,35		8,31		\$55		830	······	824				745	<u> </u>
14.3.	· · ·		DO (một.	<u>17,91</u>		<u> </u>		140		801	<u></u>	<u> 9.0</u>	<u>I</u>	<u>k</u>	<u> </u>	6.0	
	•										1 1 1 1 1 1 1 1	55 B					
<u>servation Roy.</u> Normal (1 - Eriatic Swimm			PM - Particulate Manor	i - Immobilized	t			Flaviowed E		Dato:	9 4 (i)	1400	10th	<u>–</u>			

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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: 8/29/07 CHEMICAL: COOK NUCLEAR GLC7160

TEST NUMBER: 1861-00 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 SPECIES: FHM

72.64

RAW DATA:

	TRATION (P EXPOSED:		(5.25 20	12.50 20	25.00 20	50.00 20	100.00 20		
DÜRĂTIÔN, TRÌM,	(HOURS)	LC50	L	OWER 953	É LÎMIT	Ŭ₽₽	ER 95%	LIMIT	PERCENT

59.93

96 65.98 .00

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

Sample Veliger	Mexel - U	ntreated	Mexel - 1	Freated
Number	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)
1	2	78	2	78
2	16	627	Construction of the local division of the lo	98
			2.5	and the second
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				
21			-	
22				
22				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33			-	
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
43				
45				
46				
47				
48				
49				
50				
Aug		245		102
Avg.		245	_	103
Min.		78		78
Max.		627		353
Dens.		427		1067

and a second statement of the		Date:	9/13/200
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.		Avg.	la ensiste anticipitation of the second
#/slide	0.8	#/slide	2

Miller 9/22/06 Date 221 Reviewed by

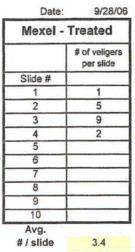
E. Scott Rose Analyzed by Corrected/84 / 9-16-06 Date 9.19.00

83

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

Sample Veliger	Mexel - U	ntreated	Mexel - 1	Treated	Mexel
Number	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)	
1	12	470	10	392	Slide #
2	6	235	8	314	1
3	11	431	8	314	2
4	10	392	13	510	3
5	14	549	2.5	98	4
6	9	353	2.5	98	5
7	2.5	98	6	235	6
8	8	314	8	314	7
9	2	78	11	431	8
10	2	78	3	118	9
11	8	314	7	274	10
12			8	314	Avg.
13			2	78	#/slide
14			7	274	
15			9	353	
16			3	118	
17	-		9	353	
18					Commit
19					Sampl
20					
21					
22				and the second s	
23					
24					
25		and a second second second		أبريح البرابي تحتركا الرز	
26					
27					
28					
29 30					
Contraction of the local division of the loc					
31 32					
33					
33					
35					
36					ан 1
37					
38					
39					
40					
41					
42					
42					
43					
45					
46					
47					
48					
49					
50					
Avg.		301		270	
Min.	F	78		78	
Max.	-	549	-	510	
TATONY?		1173		1813	

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



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

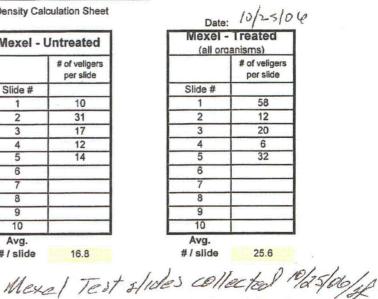
Maller 7/23/06 Analyzed by Date e Reviewed by

		Treated	Mexel-		ntreated	Mexel-U	Treated	Mexel -	ntreated	Mexel - U	Sample Veliger
		# veligers per slide	•		# veligers per slide		Size (u)	Micrometer Reading	Size (u)	Micrometer Reading	Number
		per silde	Slide #		per side	Slide #	314	8	353	9	1
		7	1		4	1	274	7	510	13	2
	A	94	2		1	2	392	10	255	6.5	3
		7	3		2	3	78	2	392	10	4
	в	15	4		2	4	78	2	823	21	5
		17	5		15	5	98	2.5	314	8	6
	*:		6			6	353	9	78	2	7
			7			7	431	11	118	3	8
			8			8	353	9	1098	28	9
			9			9	98	2.5	784	20	10 11
			10			10	706	18	1176	30	
		28	Avg. #/slide		4.8	Avg. #/slide	470	12 9	2234 549	57	12 13
		20	#7 silde		4.0	#/silde		and the second			
	A					4	314 823	8 21	314 98	8	14 15
with 65-75 Individ and the other with (-	314	8	118	3	16
nge. This total of 9						-	470	12	98	2.5	17
s" as well as 16 of			includes 7			1	78	2	98	2.5	18
lide	ind on the sl	fou				1	98	2.5	118	3	19
	В					1	392	10			20
"clumps" of 5 veli	es 2 smaller	of 15 include	This total			1	745	19			21
n the slide	ers found or	plus 5 oth				1	470	12			22
Contraction of the second s		-				1	549	14			23
										and a second second second	
					:		314	8			24
		mples	Steel Sa	Carbon	Mexel		314 588	15			25
	oved from		Steel Sa			One Test		and the second se			
	wide X ~6"	ns were rem ons are 1/2"	steel coupor d. The coupo	ntrol carbon and analyzed	and one cor int system a	the treatme	588 98 78	15 2.5 2			25 26 27
	wide X ~6" under the	ns were rem ons are 1/2" ere viewed	steel coupor d. The coupo total area) w	ntrol carbon and analyzed ons (.75 in ² t	and one cor ent system a 2 1/2' section	the treatme long. 3 (588 98 78 137	15 2.5 2 3.5			25 26 27 28
	wide X ~6" under the	ns were rem ons are 1/2" ere viewed	steel coupor d. The coupo total area) w e 3 sec tions	ntrol carbon and analyzed ons (.75 in ² t gers on thes	and one cor ent system a 2 1/2' section	the treatme long. 3 (588 98 78 137 235	15 2.5 2 3.5 6			25 26 27 28 29
anted Courses	wide X ~6" under the ted and	ns were rem ons are 1/2" ere viewed s were coun	steel coupor d. The coupor total area) w e 3 sec tions sured	ntrol carbon and analyzed ons (.75 in ² t gers on thes mea	and one cor ent system a 2 1/2' section	the treatme long. 3 (588 98 78 137 235 353	15 2.5 2 3.5 6 9			25 26 27 28 29 30
eated Coupon	wide X ~6" under the ted and	ns were rem ons are 1/2" ere viewed s were coun	steel coupor d. The coupo total area) w e 3 sec tions	ntrol carbon and analyzed ons (.75 in ² t gers on thes mea	and one cor ent system a 2 1/2' section	the treatme long. 3 (588 98 78 137 235 353 78	15 2.5 2 3.5 6 9 2			25 26 27 28 29 30 31
	wide X ~6" under the ted and Tr	ns were rem ons are 1/2" ere viewed s were coun	steel coupor d. The coupor total area) w e 3 sec tions sured treated Coup	ntrol carbon and analyzed ons (.75 in ² t gers on thes mea: Un	and one cor ent system a 2 1/2' section	the treatme long. 3 (588 98 98 78 137 235 353 78 78 78	15 2.5 2 3.5 6 9 2 2 2			25 26 27 28 29 30 31 32
Section 2 Sect	wide X ~6" under the ted and Tro Section 1	ns were rem ons are 1/2" ere viewed s were coun con Section 3	steel coupor d. The coupor total area) w e 3 sec tions sured treated Coup Section 2	ntrol carbon and analyzed ons (.75 in ² t gers on thes mea: Un Section 1	and one cor ent system a 2 1/2' sectic Settled velic	the treatme long. 3 (scope.	588 98 98 78 137 235 353 78 78 98	15 2.5 2 3.5 6 9 2 2 2 2 2.5			25 26 27 28 29 30 31 32 33
Section 2 Sect	wide X ~6" under the ted and Tro Section 1 18	ns were rem ons are 1/2" ere viewed s were count pon Section 3 30	steel coupor d. The coupor total area) w e 3 sec tions sured treated Coup Section 2 14	ntrol carbon and analyzed ons (.75 in ² t gers on thes mea: Un Section 1 71	and one cor ent system a 2 1/2' sectic Settled velic	the treatme long. 3 (588 98 98 78 137 235 353 78 78 78 78 78 98 78	15 2.5 2 3.5 6 9 2 2 2 2 2.5 2			25 26 27 28 29 30 31 32 33 33 34
Section 2 Sect	wide X ~6" under the ted and Tro Section 1	ns were rem ons are 1/2" ere viewed s were coun con Section 3	steel coupor d. The coupor total area) w e 3 sec tions sured treated Coup Section 2	ntrol carbon and analyzed ons (.75 in ² t gers on thes mea: Un Section 1	and one cor ent system a 2 1/2' sectic Settled velic	the treatme long. 3 (scope.	588 98 98 78 137 235 353 78 78 98	15 2.5 2 3.5 6 9 2 2 2 2 2.5			25 26 27 28 29 30 31 32 33
Section 2 Section 3 3 5 676 25	wide X ~6" under the ted and Tro Section 1 18 725	ns were rem ons are 1/2" ere viewed s were count oon Section 3 30 725	steel coupoi d. The coupoi total area) will a 3 sec tions sured treated Coup Section 2 14 1,449	ntrol carbon and analyzed ons (.75 in ² t gers on thes mea: Un Section 1 71 1,497	and one cor ent system a 2 1/2' sectic Settled velic	the treatme long. 3 (scope.	588 98 98 78 137 235 353 78 78 98 78 314	15 2.5 2 3.5 6 9 2 2 2 2.5 2 8			25 26 27 28 29 30 31 32 33 34 35
Section 2 Section 3 3 5 676 25 290 25	wide X ~6" under the ted and Section 1 18 725 242	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531	steel coupoi d. The coupoi total area) will e 3 sec tions sured treated Coup Section 2 14 1,449 676	htrol carbon and analyzed ons (.75 in ² t gers on thes mear Un Section 1 71 1,497 483 386 386	and one con ent system a 2 1/2' sectic Settled velic veligers	the treatme long. 3 (scope. # post-	588 98 98 78 137 235 353 78 78 98 78 314 353 353	15 2.5 2 3.5 6 9 2 2 2.5 2 2.5 2 8 9			25 26 27 28 29 30 31 32 33 34 35 36
Section 2 Section 3 3 5 676 29 290 29 290 19	wide X ~6" under the ted and Section 1 18 725 242 483	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531 966	steel coupoi d. The coupoi total area) will e 3 sec tions sured treated Coup Section 2 14 1,449 676 821	ntrol carbon and analyzed ons (.75 in ² t yers on thes mea: Un Section 1 71 1,497 483 386 386 1,449	and one con ent system a 2 1/2' sectic Settled velig veligers	the treatme long. 3 (scope. # post-	588 98 98 78 137 235 353 78 78 98 78 314 353 78 314 353 78 392 431 351	15 2.5 2 3.5 6 9 2 2 2.5 2 2.5 2 8 9 2 10 11			25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Section 2 Section 3 3 5 676 29 290 29 290 19 38 38	wide X ~6" under the ted and Section 1 18 725 242 483 386	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531 966 869	steel coupoi d. The coupoi total area) will e 3 sec tions sured treated Coup Section 2 14 1,449 676 821 580	ntrol carbon and analyzed ons (.75 in ² t yers on thes mea: Un Section 1 71 1,497 483 386 386	and one con ent system a 2 1/2' sectic Settled velic veligers chosen post r size	the treatme long. 3 (scope. # post- # post-	588 98 98 78 137 235 353 78 78 98 78 314 353 78 314 353 78 392	15 2.5 2 3.5 6 9 2 2 2.5 2 2.5 2 8 9 2 10 11 2			25 26 27 28 29 30 31 32 33 34 35 36 37 38
Section 2 Section 3 3 5 676 29 290 29 290 19 38 38	wide X ~6" under the ted and Section 1 18 725 242 483 386	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531 966 869 386	steel coupoi d. The coupoi total area) will e 3 sec tions sured treated Coup Section 2 14 1,449 676 821 580	ntrol carbon and analyzed ons (.75 in ² t yers on thes mea: Un Section 1 71 1,497 483 386 386 1,449	and one con ent system a 2 1/2' sectic Settled velic veligers chosen post r size	the treatme long. 3 (scope. # post-	588 98 98 78 137 235 353 78 78 98 78 314 353 78 314 353 78 392 431 351	15 2.5 2 3.5 6 9 2 2 2.5 2 2.5 2 8 9 2 10 11			25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Section 2 Section 3 3 5 676 29 290 29 290 19 38 38	wide X ~6" under the ted and Section 1 18 725 242 483 386	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531 966 869 386 918	steel coupoi d. The coupoi total area) will e 3 sec tions sured treated Coup Section 2 14 1,449 676 821 580	ntrol carbon and analyzed ons (.75 in ² t yers on thes mea: Un Section 1 71 1,497 483 386 386 1,449 725	and one con ent system a 2 1/2' sectic Settled velic veligers chosen post r size	the treatme long. 3 (scope. # post- # post- Randomly o velige	588 98 98 78 137 235 353 78 78 98 78 314 353 78 398 78 314 353 78 392 431 78	15 2.5 2 3.5 6 9 2 2 2.5 2 8 9 2 10 11 2 2.5 3			25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Section 2 Section 3 3 5 676 29 290 29 290 19 38 38	wide X ~6" under the ted and Section 1 18 725 242 483 386	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531 966 869 386 918 435	steel coupoi d. The coupoi total area) will e 3 sec tions sured treated Coup Section 2 14 1,449 676 821 580	ntrol carbon and analyzed ons (.75 in ² t yers on thes mea: Un Section 1 71 1,497 483 386 386 1,449 725 628 580 676	and one con ent system a 2 1/2' sectic Settled velic veligers chosen post r size	the treatme long. 3 (scope. # post- # post- Randomly o velige	588 98 78 137 235 353 78 98 78 314 353 78 398 78 314 353 78 392 431 78 98 98	15 2.5 2 3.5 6 9 2 2 2.5 2 8 9 2 2 10 11 2 2.5 3 3.5			25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43
Section 2 Sect 3 5 676 29 290 29 290 19 38 24 - - - -	wide X ~6" under the ted and Section 1 18 725 242 483 386 290	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531 966 869 386 918 435 531 773 580	steel coupoi d. The coupoi otal area) we e 3 sec tions sured treated Coup Section 2 14 1,449 676 821 580 628	ntrol carbon and analyzed ons (.75 in ² t yers on thes mea: Un Section 1 71 1,497 483 386 386 1,449 725 628 580 676 918	and one con ent system a 2 1/2' sectic Settled velic veligers veligers	the treatme long. 3 (scope. # post- Randomly o velige measuren	588 98 78 137 235 353 78 98 78 314 353 78 398 78 314 353 78 392 431 78 98 118	15 2.5 2 3.5 6 9 2 2 2.5 2 8 9 2 10 11 2 2.5 3			25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
Section 2 Section 3 3 5 676 25 290 25 290 15 36 36	wide X ~6" under the ted and Section 1 18 725 242 483 386	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531 966 869 386 918 435 531 773	steel coupoi d. The coupoi total area) will e 3 sec tions sured treated Coup Section 2 14 1,449 676 821 580	ntrol carbon and analyzed ons (.75 in ² t yers on thes mea: Un Section 1 71 1,497 483 386 386 1,449 725 628 580 676	and one con ent system a 2 1/2' sectic Settled velic veligers veligers	the treatme long. 3 (scope. # post- # post- Randomly o velige	588 98 98 78 137 235 353 78 78 98 78 314 353 78 398 78 314 353 78 392 431 78 98 118 137 137	15 2.5 2 3.5 6 9 2 2 2.5 2 8 9 2 2 10 11 2 2.5 3 3.5			25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45
Section 2 Sect 3 5 676 29 290 29 290 19 38 24 - - -	wide X ~6" under the ted and Section 1 18 725 242 483 386 290 	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531 966 869 386 918 435 531 773 580 671	steel coupoi d. The coupoi otal area) we e 3 sec tions sured treated Coup Section 2 14 1,449 676 821 580 628 628 831	ntrol carbon and analyzed ons (.75 in ² t jers on thes mea: Un Section 1 71 1,497 483 386 386 386 1,449 725 628 580 676 918 773	and one con ent system a 2 1/2' sectic Settled velic veligers veligers	the treatme long. 3 (scope. # post- # post- Randomly o velige measuren	588 98 98 78 137 235 353 78 78 98 78 314 353 78 398 78 314 353 78 392 431 78 98 118 137 137	15 2.5 2 3.5 6 9 2 2 2.5 2 8 9 2 2 10 11 2 2.5 3 3.5			25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46
Section 2 Sect 3 5 676 29 290 29 290 19 38 24 - - - - 419 28 18,600 31,0	wide X ~6" under the ted and Section 1 18 725 242 483 386 290	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531 966 869 386 918 435 531 773 580	steel coupor d. The couport total area) we e 3 sec tions sured treated Coup Section 2 14 1,449 676 821 580 628 831 831 86,800	ntrol carbon and analyzed ons (.75 in ² t yers on thes mea: Un Section 1 71 1,497 483 386 386 1,449 725 628 580 676 918	And one coment system a 2 1/2' sectic Settled velic veligers thosen post r size thents(um) ze (um) (#/M ²)	the treatme long. 3 (scope. # post- Randomly o velige measuren Avg. Si.	588 98 98 78 137 235 353 78 78 98 78 314 353 78 398 78 314 353 78 392 431 78 98 118 137 137	15 2.5 2 3.5 6 9 2 2 2.5 2 8 9 2 2 10 11 2 2.5 3 3.5			25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
Section 2 Sect 3 5 676 29 290 29 290 19 38 24 - - -	wide X ~6" under the ted and Section 1 18 725 242 483 386 290 	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531 966 869 386 918 435 531 773 580 671	steel coupoi d. The coupoi otal area) we e 3 sec tions sured treated Coup Section 2 14 1,449 676 821 580 628 628 831	ntrol carbon and analyzed ons (.75 in ² t jers on thes mea: Un Section 1 71 1,497 483 386 386 386 1,449 725 628 580 676 918 773	And one coment system a 2 1/2' sectic Settled velic veligers thosen post r size thents(um) ze (um) (#/M ²)	the treatme long. 3 (scope. # post- # post- Randomly o velige measuren	588 98 98 78 137 235 353 78 78 98 78 314 353 78 398 78 314 353 78 392 431 78 98 118 137 137	15 2.5 2 3.5 6 9 2 2 2.5 2 8 9 2 2 10 11 2 2.5 3 3.5			25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
Section 2 Sect 3 5 676 29 290 29 290 19 38 24 - - - - 419 28 18,600 31,0	wide X ~6" under the ted and Section 1 18 725 242 483 386 290 	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531 966 869 386 918 435 531 773 580 671 188,000	steel coupoi d. The coupoi otal area) we e 3 sec tions sured treated Coup Section 2 14 1,449 676 821 580 628 831 831 86,800 237,667	ntrol carbon and analyzed analyzed ans (.75 in ² t yers on thes mea: Un Section 1 71 1,497 483 386 386 1,449 725 628 580 676 918 773 440,200	And one coment system a 2 1/2' sectic Settled velic Settled velic	the treatme long. 3 (scope. # post- Randomly o velige measuren Avg. Si.	588 98 98 78 137 235 353 78 78 98 78 314 353 78 398 78 314 353 78 392 431 78 98 118 137 137	15 2.5 2 3.5 6 9 2 2 2.5 2 8 9 2 2 10 11 2 2.5 3 3.5			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
Section 2 Sect 3 5 676 29 290 29 290 19 38 24 - - - - 419 28 18,600 31,0	wide X ~6" under the ted and Section 1 18 725 242 483 386 290 	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531 966 869 386 918 435 531 773 580 671 188,000	steel coupor d. The couport total area) we e 3 sec tions sured treated Coup Section 2 14 1,449 676 821 580 628 831 831 86,800	ntrol carbon and analyzed analyzed ans (.75 in ² t yers on thes mea: Un Section 1 71 1,497 483 386 386 1,449 725 628 580 676 918 773 440,200	And one coment system a 2 1/2' sectic Settled velic Settled velic	the treatme long. 3 (scope. # post- Randomly o velige measuren Avg. Si.	588 98 98 78 137 235 353 78 78 98 78 314 353 78 398 78 314 353 78 392 431 78 98 118 137 137	15 2.5 2 3.5 6 9 2 2 2.5 2 8 9 2 2 10 11 2 2.5 3 3.5			25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
Section 2 Sect 3 5 676 29 290 29 290 19 38 24 - - - - 419 28 18,600 31,0	wide X ~6" under the ted and Section 1 18 725 242 483 386 290 	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531 966 869 386 918 435 531 773 580 671 188,000	steel coupoi d. The coupoi otal area) we e 3 sec tions sured treated Coup Section 2 14 1,449 676 821 580 628 831 831 86,800 237,667	ntrol carbon and analyzed analyzed ans (.75 in ² t yers on thes mea: Un Section 1 71 1,497 483 386 386 1,449 725 628 580 676 918 773 440,200	And one coment system a 2 1/2' sectic Settled velic Settled velic	the treatme long. 3 (scope. # post- Randomly o velige measuren Avg. Si.	588 98 78 78 137 235 353 78 78 98 78 314 353 78 392 431 78 98 118 137 98 118 235 284	15 2.5 2 3.5 6 9 2 2 2.5 2 8 9 2 2 10 11 2 2.5 3 3.5	501		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
Section 2 Sect 3 5 676 29 290 29 290 19 38 24 - - - - 419 28 18,600 31,0	wide X ~6" under the ted and Section 1 18 725 242 483 386 290 	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531 966 869 386 918 435 531 773 580 671 188,000	steel coupoi d. The coupoi otal area) we e 3 sec tions sured treated Coup Section 2 14 1,449 676 821 580 628 831 831 86,800 237,667	ntrol carbon and analyzed analyzed ans (.75 in ² t yers on thes mea: Un Section 1 71 1,497 483 386 386 1,449 725 628 580 676 918 773 440,200	And one coment system a 2 1/2' sectic Settled velic Settled velic	the treatme long. 3 (scope. # post- Randomly o velige measuren Avg. Si.	588 98 78 137 235 353 78 98 78 314 353 78 398 314 353 78 398 314 353 78 392 431 78 98 118 137 98 118 284 78	15 2.5 2 3.5 6 9 2 2 2.5 2 8 9 2 2 10 11 2 2.5 3 3.5	<u> </u>		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
Section 2 Sect 3 5 676 29 290 29 290 19 38 24 - - - - 419 28 18,600 31,0	wide X ~6" under the ted and Section 1 18 725 242 483 386 290 	ns were rem ons are 1/2" ere viewed is were count oon Section 3 30 725 531 966 869 386 918 435 531 773 580 671 188,000	steel coupoi d. The coupoi otal area) we e 3 sec tions sured treated Coup Section 2 14 1,449 676 821 580 628 831 831 86,800 237,667	ntrol carbon and analyzed analyzed ans (.75 in ² t yers on thes mea: Un Section 1 71 1,497 483 386 386 1,449 725 628 580 676 918 773 440,200	And one coment system a 2 1/2' sectic Settled velic Settled velic	the treatme long. 3 (scope. # post- Randomly o velige measuren Avg. Si.	588 98 78 78 137 235 353 78 78 98 78 314 353 78 392 431 78 98 118 137 98 118 235 284	15 2.5 2 3.5 6 9 2 2 2.5 2 8 9 2 2 10 11 2 2.5 3 3.5			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.

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

Sample Veliger	Mexel - L	Intreated	Mexel - Treated		
Number	Micrometer Reading	Size (u)	Micrometer Reading	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	1040	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	and the second	242		Contraction of the local division of the loc	
and the second se	5	and the second	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.	ŀ	97	F	72	
Max.	ŀ	4492	H	2705	
and the second second second second	org/m ²	8960	Ļ	13653	
Dens.	ora/m ⁻	0900		13003	

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



	Treated
	# of veligers per slide
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 translocatorsized veligers were found on one slideone "clump" of 14 (72-145um length) and another of 31 (72-170um length).

Malla, 10/25/06 1/0/x Dáte

E.J. Analyzed by

Reviewed by

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

Sample Veliger	Mexel - U	Intreated	Mexel - Treated			
lumber	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 15	5	242 290	25 10	1208 483		
16	10	483 725	10	483		
17	15		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		
	-	and the second se		and the second states in the second states in the second		
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.	Γ	193	Γ	48		
Max.	F	2318	ſ	2125		
Dens.	-	40,107	F	28,907		

	# of veligers
	per slide
Slide #	
1	72
2	87
3	55
4	69
5	93
6	
7	1
8	
9	
10	

Date:	11/9/06	
Mexel -	Treated	
	# of veligers per slide	
Slide #		
1	36	
2	39	
3 .	116	ŀ
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).

	# of veligers per slide
Slide #	1
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 Analyzed by / 11-9-06 Date

Date 2 Reviewed by

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

Sample Veliger	Mexel - L	Intreated	Mexel -	Treated	Mexel-U	ntreated		Mexel-	Treated			
Number	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)		# veligers per slide			# veligers per slide			
1	25	980	14	549	Slide #			Slide #				
2	22	862	10	392	1 1	75		1	134			
3	9	353	20	784	2	214		2	94			
4	20	784	9	353	3	202		3	114			
5	8	314	31	1215	4	228		4	141			
6	25	980	15	588	5	82		5	87			
7	22	862	29	1137	6			6				
8	63	2470	30	1176	7			7				
9	13	510	27	1058	8			8				
10	14	549	15	588	9			9				
11	13	510	13	510	10			10				
12	10	392	18	706	Avg.			Avg.				
13	28	1098	16	627	#/slide	160.2		#/slide	114			
14	83	3254	16	627	1							
14	81	3175	8	314	1							
16	56	2195	9	353	1			There	was, for th	ne first time	e, no evider	ice of
17	13	510	43	1686	1						-treated slid	
18	7	274	37	1450	1							
19	8	314	16	627								
20	7	274	7	274	-			L				
21	7	274	27	1058	4							
22	26				4							
22	31	1019 1215	29 9	1137 353	4							
23	31	1215	10	392	4			1				
25	and the second se										1	
	21	823	12	470	41			Steel Sa				
26	8	314	10	392				steel coupoi				
27	14	549	10	392	the treatme	ent system a	ind analyzed	d. The coupo	ons are 1/2"	wide X ~6"		
28	8	314	13	510				total area) with a sections				
29 30	19 9	745 353	13 12	510 470	scope.	Settled veni		se a sections	were court	eu anu		
and the second se			and the second							T.	reated Coup	
31	8	314	6	235			Un	treated Cou	noc	11	eated Coup	on
32	7	274	22	862					0 11 0	0	Destine 0	Section :
33	7	274	15	588		0	Section 1	Section 2	Section 3	Section 1	Section 2	
34	57	2234	12	470	# post-v	/eligers	90	87	134	40	14	15
35	9	353	17	666			3,719	918	242	2174	1063	1014
36	8	314	17	666	41		2,463	1352	338	1014	1159	435
37	35	1372	15	588			676	1159	290	725	821	580
38	12	470	14	549	Randomly	hosen nort	1,256	869	531	1256	1546	1401
39	14	549	14	549	velige		1,063	1546	628	531	1063	531
40	27	1058	10	392	measuren		918	580	242	580	918	580
41	60	2352	80	3136			1,014	1014	1,787	483	676	1449
42	8	314	37	1450			1,304	725	531	580	869	966
43	6	235	30	1176			2,029	1063	1,401	1111	531	1739
44	12	470	24	941			483	918	386	966	725	725
45	19	745	8	314	Avg. Si	ze (um)	1,492	1,169	638	942	937	942
46	6	235	27	1058								
47	9	353	57	2234	Density		279,000	269,700	415,400	124,000	43,400	46,500
48	15	588	9	353	Avg dens	ity (#/M ²)		321,367			71,300	
49	6	235	15	588								
50	8	314	16	627			Densities	s based o	n 1550in	²/M²	1645	
Avg.	-	1073 274		749 235								
Min		614		200								
Min.	F	2051		0400	1							
Min. Max. Dens.		3254 85440		3136 60800								

E. Scott Rose // 1 12-7-06 Analyzed by Date

Reviewed by Date

	el Control			ATED	TDE	1		TROL	CON		
	y (#/m²) # of	T	lovel	2006 1		2007	Mexel	la contra con		2007	Sample
	veligers/ml	Subsample	Size	Micrometer	Size	Micrometer	Size	Micrometer	Size	Micrometer	Veliger
20.0	11 22	1 2	(u) 1835	Reading 38	(u) 97	Reading 2	(u) 966	Reading 20	(u) 121	Reading 2.5	Number 1
20.0	7	3	3526	73	145	3	1449	30	338	2.5	2
	15	4	1352	28	97	2	1884	39	97	2	3
	45	5	1449	30	193	4	1691	35	121	2.5	4
-		6	2125	44	97	2	5410	112	97	2	5
2007 Mexel Cont		7	4057	84	145	3	2608	54	72	1.5	6
Density		8	1352 2560	28 53	193	4 31	1449 2850	30 59	193 97	4	7
(#/m3) 10,667		9 10	1787	37	1497 97	2	1980	- 59 - 41	72	1.5	9
10,007	el Control		2801	58	97	2	1449	30	97	2	10
	y (#/m ²)		1497	31	483	10	16519	342	97	2	11
	Holigoro (m)	T	1208	25	121	2.5	2125	44	97	2	12
	Holigaro (m)	Subsample	1352	28	97	2	1208	25	145	3	13
	166	1	3043	63	72	1.5	1449	30	145	3	14
204.3	227	2	1449	30	121	2.5	3478	72	145	3	15
	220	3	628	13	121	2.5	1497	31	97	2	16
		4	3381	70	169	3.5	2512	52	121	2.5	17
		5	2512	52	97	2	1932	40	145 145	3	18 19
2006 Mexel Cont		6	2946 821	61 17	97 97	2	1497 4685	31 97	145	2.5	19 20
Density		8	2657	55	145	3	4005	87	145	3	20
12100 31		9	1932	40	97	2	1449	30	145	3	22
108,978		10	1063	22	97	2	2415	50	169	3.5	23
an e			1691	35	145	3	3574	74	97	2	24
	el Treated	a second s	1014	21	97	2	1884	39	97	2	25
	y (#/m²)	Density	821	17	97	2	2657	55	97	2	26
	# of	0.1	3719	77	145	3	1352	28	121	2.5	27
	veligers/ml 23	Subsample	1497 531	31 11	97 97	2	1932 1014	40 21	97 97	2	28 29
	14	1 2	2077	43	97	2	1014	21	97	3	30
13.0	14	3			97	2			193	4	31
	6	4			97	2			121	2.5	32
	8	5			121	2.5			145	3	33
		6			145	3			145	3	34
2007 Mexel Treat		7			97	2			145	3	35
(#1		8			193	4			242	5	36
6,933		9			97 97	2			97 97	2	37 38
0,933	and the second se	and the second se					-				
	el Treated	and the second se			97	2			145	3	39
	y (#/m²)	Density			97	2			121	2.5	40
	# of veligers/ml	Cubaccula			97	2			97	2	41
	78	Subsample 1			97 97	2			193 193	4	42 43
	64	2			97	2			97	2	43
73.7	79	3			VI.	~			97	2	45
		4							97 .	2	46
		5							97	2	47
		6									48
2006 Mexel Treat		7									49
(#1-2)		8									50
		9	1655				0.000		100		
39,289		10	1956		154		2677	Ļ	129	L	Avg.
			531		72	ļ	966	ļ	72	Ļ	Min.
A		-	4057 #REF!		1497 #REF!		16519	186-7.0	338		Max. Dens.

See here

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	ME	XEL-C	ONT	ROL	ME	XEL-	TREAT	ED		tel Control	
ample /eliger	2007		2006		-	Mexel	2006	intelline to the patterner	Subsample	# of veligers/slide	#@ <~100um
umber	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)	Micrometer Reading	Size (u)	1		
1			5	267			4	214	2		
2			8	427			163	8704	3		
3			5	267			8	427	4		
4			4	214 320			17 10	908 534	5	#DIV/0!	Avg.
6			17	908			12	641	7	#01010	2007 Mexel Control
7			21	1121			7	374	8		Density
8			280	14952			7	374	9		(#/m3)
9			157	8384			15	801	10	el Control	#DIV/01
10 11			75 5	4005			15 140	801 7476		ter Control	
12			7	374			140	641	Densit	# of	
13			4	214			10	534	Subsample	veligers/slide	
14			8	427			10	534	1	1204	
15			6	320			8	427	2	872	1038.0 Avg./slide
16			6	320 320			10	534 .	3		Due to heavy and mature
17 18			6 9	481			41 10	2189 534	4		settlement, only 2 slides were analyzed. Visually the most-
19			127	6782			13	694	6		and the least-populated.
20			203	10840			12	641	7	×.	2006 Mexel Control
21							166	8864	8		Density
22				_			11	587	9		(#/m3)
23 24							10 12	534 641	10		553,600
25							8	427	2007 Mex	el Treated	
26							13	694		y (#/m ²)	
27							9	481		# of	#@
28							10	534	Subsample	veligers/slide	<~100um
29 30							6 8	320	1 2		
31							18	961	3		
32							12	641	4		
33							10	534	5		
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45							6	320	4	174	271.4 AV9./3000
47						-	14	748	5	203	
48							13	694	6		
49							12	641	7	-	2006 Mexel Treated
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APPENDIX 4

FINAL REPORT

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

Prepared for:

AEP Cook Nuclear Plant One Cook Place Bridgman, MI 49106

Prepared by:

Great Lakes Environmental Center

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April 20, 2006

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EXECUTIVE SUMMARY

The Indiana Michigan Power Company's Donald C. Gook 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 μ g/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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APPENDIX

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.

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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 halfmile 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 space 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.

Discharge Configuration

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.

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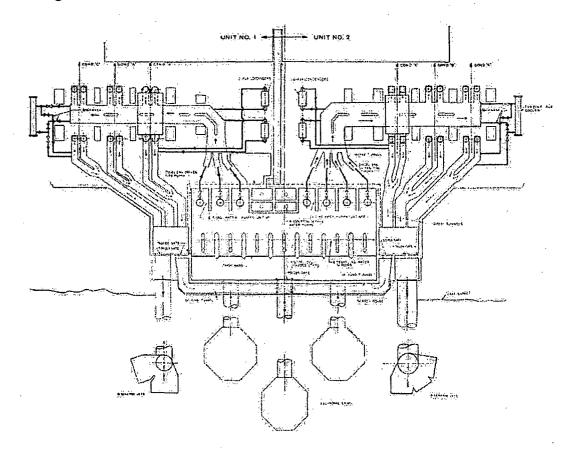


Figure 1. Plan View of D.C. Cook Condenser Cooling Water System

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

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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.

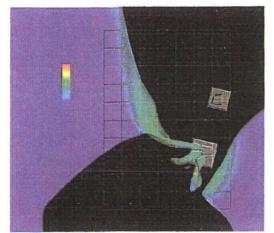


Figure 2. Two fps Isopleth.

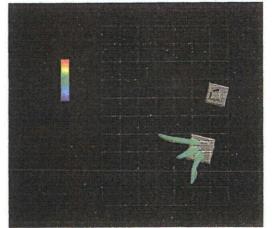


Figure 3. Three fps Isopleth.

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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 (redyellow) 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.

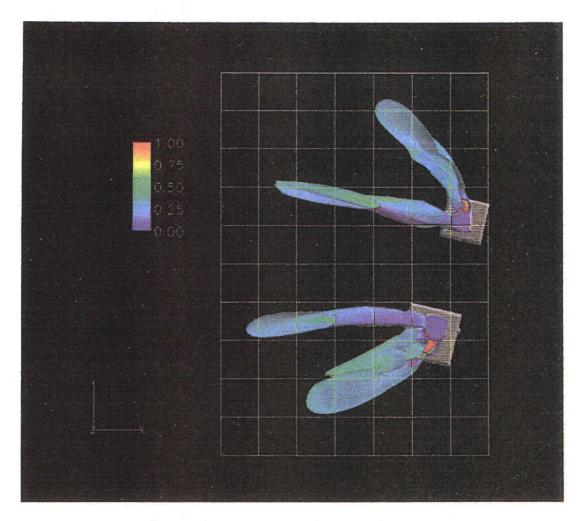


Figure 4. Visualization of effluent dilution within the discharge-induced mixing zone (plan view). FLUENT model prediction of ambient lake water fraction (i.e., 1/DR) on 2 fps plume surface velocity isopleth for zero ambient velocity, 2 discharge units operating and treating simultaneously.

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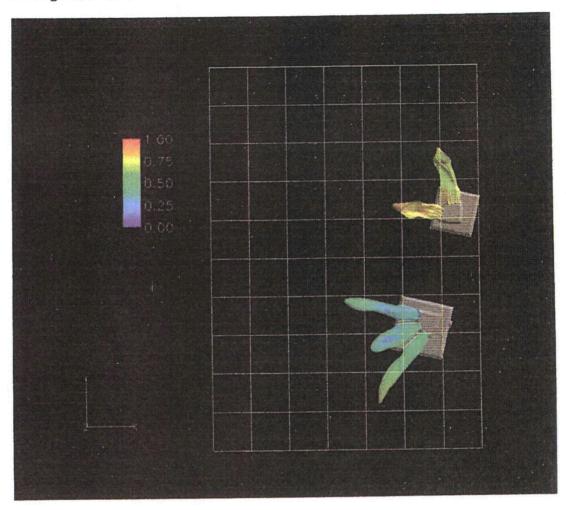


Figure 5. Visualization of effluent dilution within the discharge-induced mixing zone (plan view). FLUENT model prediction of ambient lake water fraction (i.e., 1/DR) on 3 fps plume surface velocity isopleth for 1 fps ambient velocity, 2 discharge units operating and treating simultaneously.

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

discharge units operating	1&2	<u>1</u>	2	1&2	1 & 2
discharge units being treated	1&2	1	2	1	2
ambient cur	rent vel	ocity (f	ps): 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	,		· ·	: <u></u>
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 curr	ent velo	ocity (fp	os): 0.5		
average DR at 1 fps jet velocity		7.14		4.00	
average DR at 1.5 fps jet velocity		1 1 1 1	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 curr	ent velo	ocity (fp	os): 1.0	ľ	
average DR at 1.5 fps jet velocity	a a second and an a s	4.76			e 1
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 curr	ent velo	ocity (fr	os): 2.0	Ĵ	1. Mat . A
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

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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.

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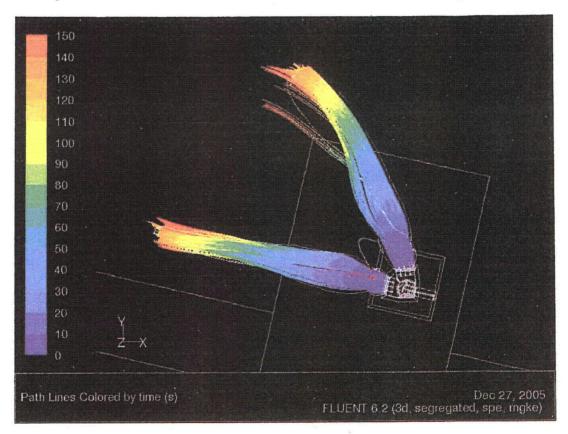


Figure 6. Visualization of stream paths for particles injected into the plume at the discharge point(s)

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.

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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 founded 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 \times (1-0.38) \times (1-0.09) \times (1-0.38) \times (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 \times (1-0.38) \times (1-0.61) \times (1-0.38) \times (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 \times (1-0.38) \times (1-0.15) \times (1-0.38) \times (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:

- The maximum expected concentration of Mexel A-432 at the edge of the nearfield 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 sitespecific 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.

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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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AEP Cook Nuclear Plant Mixing Zone Evaluation

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

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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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	GLEC, 2004	8.82		
tentans				
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

Table 3. Summary of Acceptable [@]Mexel Toxicity Test Data (December 2004)

* 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.

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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

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

- 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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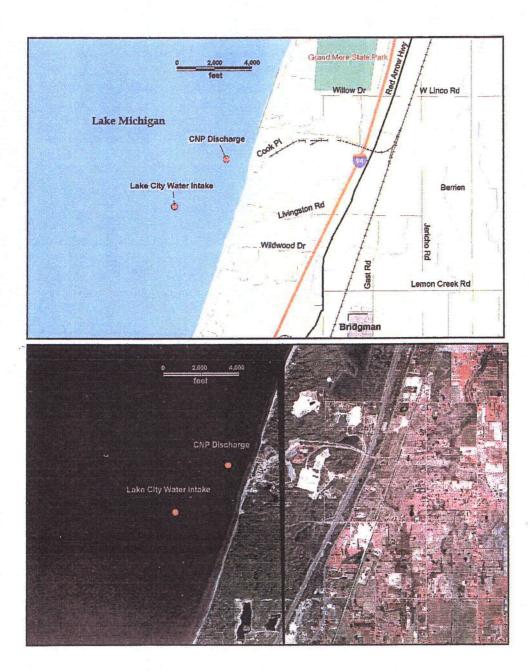


Figure 7. Map Indicating Location of Lake Township Public Water Supply Intake and CNP Discharge Structures in Lake Michigan. The distance between these points was measured as 3,220 feet using survey methods and GPS controls.

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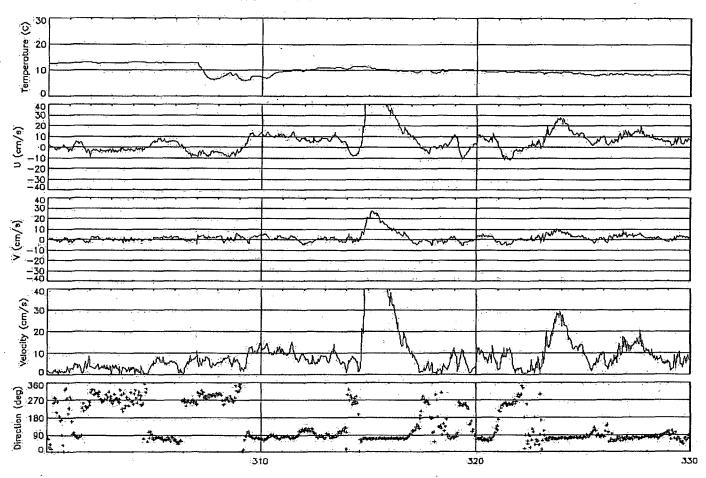
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Appendix A. Current Meter Data from NOAA/GLERL EEGLE Project. Data Measured at Station C4, Moored in 11 Meters of Water Offshore of the D.C. Cook Nuclear Power Plant.

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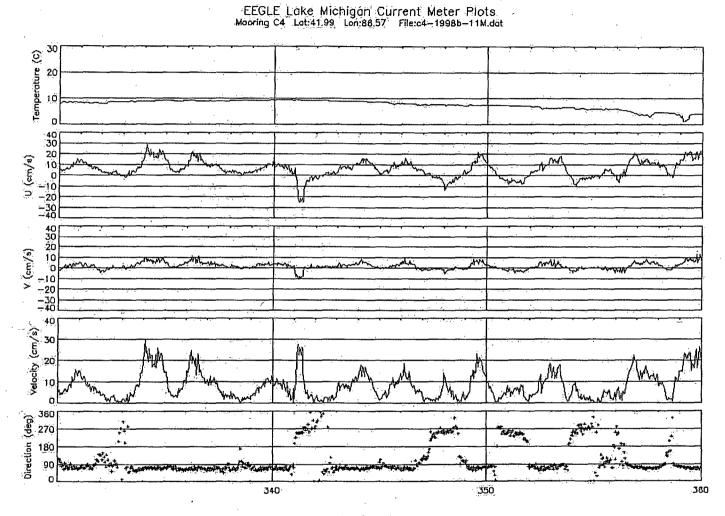
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EEGLE Lake Michigan Current Meter Plots Mooring C4 Lat 41.99 Lon:88.57 File:64-1998b-11M.dat

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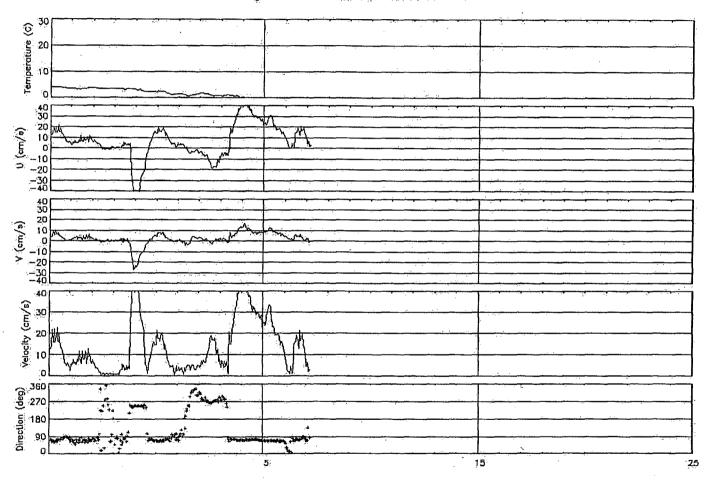


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EEGLE Lake Michigan Current Meter Plots Mooring C4 Lat 41.99 Lon:88.57 File:c4-1998b-11M.dat

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APPENDIX 5

Designation: D 2688 - 94 (Reapproved 1999)*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 samber immediately following the designation (adicates the year of This standard is issued under the first designation D 2658; the semistr immediately following the designation original schiption or, in the case of revision, the year of last sevision. A samiser in parameters indicates the year superscript equilon (4) indicates an editorial change since the last revision or receptored.

a" Nora-Pootnoics 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:

Recto Corrosivity Test of Tesi Method 10 10 18 internal Metablic Pipes (Coupon) City and Buttering Distribution Water (1, 2, 2, 4, 5)² 12 10 50

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.

¹These sets methods are under the jurisdiction of ASTM Occordines D-19 on Where easi are the direct empirically of Subcommines D19,03 on Sanoting of Water and Water-Formed Depails, and Surveillaire of Water. What and Whitz-Formad Liepatile, and Surveillance of Whete. Cerrois edition approved Argli 15, 1994. Politikad has 1994. Originally published to 2018a - 69. Last servicias edition 2018a - 92. Phil boldEnce numbers in parentheses rafer to the list of references as the end of "The boldEnce numbers in parentheses rafer to the list of references as the end of

this standard.

Cepyings 6 A\$114 International, 100 Barr Hartin Odre, PO Box (270), Wasi Constantiation, PA 19428-2529, United Barboo

2. Referenced Documents

- 2.1 ASTM Standards: A 120 Specification for Pipe, Steel, Black and Hot-Dipped Zinc-Conted (Galvanized) Welded and Seamless, for Qr
- dinary Use D 1129 Terminology Relating to Water*
- D 1193 Specification for Reagent Water
- D 2331 Practices for Preparation and Preliminary Testing of Water-Formed Deposits

3. Terminology

3.1 Defaultions: -- For definitions of terms used in these ter methods; refer to Terminology D 1129.

4. Significance and Use

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

5. Composition of Specimens

5.1 The specimens shall be similar in composition 3.1 for specifiens shall be similar in composition piping in the system in which the corrosion test is being Welded or seamless pipe shall be used in Test Metrohowever, butt-welded piping specimens may be used Method B provided care is inken to pick smooth species

Discontinued 1923 (Replaced by A 53)-Sec 1925 Annual Boot of Stendards, Vol 01.01. Anumal Bank of AST&I Standards, Vol 11.01.

Annual Book of ASTM Standards, Vol 11.02.

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(excluding but joints). Effect of Cald 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.

T. Types of Corresion

(11) 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 moting 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.

(72.1 A system may be devised for grading pitting (7). 12 A system may be deviated in a pertinent factor to consider in consion testing, since active corrosion sites may develop in such locations. Crevices may exist at threads and joints and inder 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 activentuces this influence on the overall corrosion results. Light sanding is necessary to remove edges of coupon mark-In Test Method B, areas subject to crevice corrasion are ted with paint.

Edge Corrosion- The increased corrosion that occurs ges of corrosion specimens, where the metal may be of ent composition or structure, must be given attention. In Method A, specimens of a high ratio of surface area to luca reduce this effect. In Test Method B, the edges are dib prevent fluid contact. If an abnormally high degree corrosion is observed in the case of Test Method A, the imay be evaluated by measurement of the specimen ations previous to and following exposure. Use of a min of less thickness may also reduce the edge effect in hidose,

Simplingement Attack (Erosion-Corrosion), associated incodent, and high-velocity flow, particularly when soft and copper are involved, is characterized by continuous ype pits and bright metal from which protective films centecoured away. Some under-cutting also may be

Rer-Formed Deposits

viet-formed deposits observed on the specimens may receive the methods listed in Practices D 2331. The common constituents will be calcium, magnesium, alo-Zint copper, iron, carbonate, phosphate, sulfate, chlo-

ATP D 2688

9. Purity of Reagents

9.1 Rengent 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." 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-Coupor

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 plus, 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 contion

12. Apparatus

12.1 Coupon Specimens- Prepare coupons in accordance with Section 14

12.2 Insulating Washer, Screw, and Nur-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,

* Rengent Chaulcule, American Chamileul Society Specifications, American ¹ Margani, Chenkarki, American, Chenkari Saekey, Sherffentsus, American, Occinical Society, Weihington, OC. For suggestations on the testing of response not listed by the American Chenkel Society, ten Analer Standards for Laboratory Cheminelli, BOH Lich, Poets, Dornet, U.K., and the United States Pharmacepiels and National Forundary, U.S. Pharmacepiela Convention, Inc. (1997), Robelling.

Allied industrial Electronics, 100 N. Western Ave., Chicago, IL 60680, extruded fiber washer for No. 8 scnss, Past No. 26D-3226, manufactured by G. C. Electronics, Rockford, IL (as Part No. 6526C), has been found extinfactory for this purpose. The dimensions are as follows: outside discourse 9.5 mm (Ha ha.), inside dismeter of hele 4.0 mm (%) in.), total thickness including the oried are approximisely 1.5 mm (Vs In.), musica chameter of relaced are 6.4 mm (Vs In.), and thickness of relacid are approximately 0.4 mm (Vs In.).



(D) 2688

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."

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 Entery Paper, Number 0.

To

Water

臣

0190

Globe Valve

or Gate Volve

Basin

13. Rengents and Materials

13.2 Chromic Acid-Phosphoric Acid Solution-Dissolve 30 g of chromic acid (chromium trioxide, CrO) in approximately

"It may be preferred to obtain the complete correlation tester and enupous from the may be preteriou to monthly the company continues where no company them. Metal Samples, P.O. Box 8, Murdlard, AL 35263, who construct the rad form shon or aylon, include a screw made from this some material and avoid the necessity of including a washer and not by providing serve threads in the

mounting. • Pariolie. rod meeting the National Eléverical Manufactures Association (NEMA) Guido CE or LE is salifariary. The play play is mainted enternally in (NEMA) mill orientation of the coupon is destred.

500 mL of water and add 36 mL of phosphoric acid (H,PO, 35 %). Dilute the resulting solution to 1L.

13.3 Chromium Trioxide (CrOs), 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, alcohola, and less than 10.55 by volume of synergists, for hydrochloric acid.

13.5 Corroston Inhibitor II, a nonflammable liquid contain ing heterocyclic nitrogen bases (usually in the form of salis). surface active agents, and synergists, for sulfuric acid.

13.6 Hydrochloric Acid (1+4)-Mix 1 volume of concenunited HCl (sp gr 1.19) with 4 volumes of water.

13.7 Hydrochlaric 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.

I" Pipe Plug

33.4 mm OD) -

2" Min. (51 mm)

(1315"or

13.9 Methyl Orange Indicator Solution (0.5 g/L)-Dissolv 0.05 g of methyl orange in water and dilute to 100 mL with

whiter 13.10 Nuric Acid-Dichromate Solution-Mix 224 mL of HNO, (ap gr 1.42) with twice the volume of water. Add 22.75 g of sodium dichromate (Na₂Cr 207 H2O) and dissolve. Dilut the resulting solution to 1 L

13:11 Sulfuric Acid, Inhibited-Slowly add 29 mL of H-SO4 (sp gr 1.84) to approximately 500 mL of water. Add

Holder

6"(150 mm)

1

Plastic Coupon

Test

Alternative

Installation

4"x 1/2"

(102 x 13 mm)

Coupon

and dissolve 0.5 g of Inhibitor II (see 13.5). Dilute the resulting solution to I L with water. 13.12 Trichloroetinviene. 13.13 Tripoll-Finely granulated, porous, siliceous rock;

amorphous silica (SiO2), soft, porous, and free of sharp edges or other suitable crosive-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 enst bronze, it may be necessary to prepare coupons from enstinps_

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 mm²(4 in.²), the principal emirement being to keep the flat area large compared to the algo area.

143 Sheet Metal Coupon Preparation-Obmin 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

143.7 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 (14 in.) from one end of the coupon.

14.3.3 Deburr all sharp edges on the coupon specimen using sile or emery belt, and debur the hole with an oversize drill. 41434 Stamp Identifying numbers or letters on the coupon rearbelow the mounting hole.

144 Cast Metal Coupon Preparation-Obtain rough casthigt of the desired metal, measuring about 19 by 114 by 6 mm Why 412 by 14 in.) from a commercial foundry or elsewhere. 14:4.1 Surface grind to the dimensions of 13 by 102 by 3 (0.5 by 4.0 by 0.125 in.) and a surface roughness of about 124 um :

1442 Drill a 7-mm (1/12-in.) hole with its center about 8 ma (Yis'in) from one end of the coupon.

114.4.3 Deburr all sharp edges on the coupon specimen using file or emery helt, and debur the hole with an oversize drill. 1444 Stamp Identifying numbers or letters on the small Separate between the edge and the mounting hole.

10.35
11.85
:13.83
8.7
16.50

Additional Remove oil by ion in benzene, Dry. Immerse in a solution containing 14) for 30 min at room temperature.

Remove acid from the coupon by three rapid succes-Falla separate water baths; the last rinse water bath lan/methyl orange solution and must be kept neutral

ook, Vol 1, American Society for Metals, Metals Park, OH Mirp. 430

AND 2688

(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 CuproNickel Coupans-Clean, dry, and store coupons exactly as for ferrous coupons (sec 14.5).

14.7 Cleaning Stainless Steel Coupons-Degreese with benzene, dry with a clean cloth, and passivate by immersing in which a circle dictromate solution (see 13. β) at 43 to 49°C (110 to 120°F) for 15 to 30 min; rings with water, then benzene, drywith a clean cloth, and store in a desiccator.

14.8 Cleaning Aluminum Counons-Degreese with henzene and dry. Immerse in HNO₃ (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 acede acid for 30 s. Rinse off the acid with flowing deionized water for 30 at 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 halance to the nearest 0.1 mg.

15.2 After weighing, store the specimens in a designator until ready for use. If storing in a desiccator is inconvenient or impractical, use an alternative method for providing a corresion-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 ftys. 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 fail 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

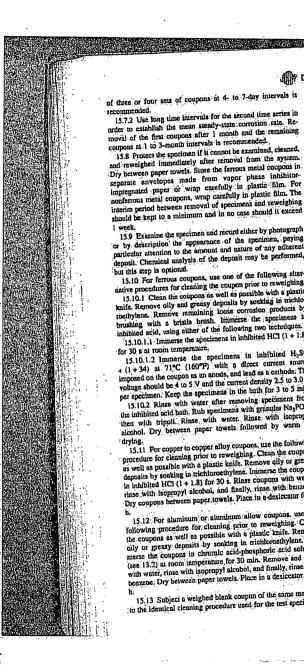
FIG. 1 Installation of Corrosion Coupons

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12" Min:

(300mm)





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15.7.2 Use long time intervals for the second time series in

15.8 Protect the specimen if it cannot be examined, cleaned,

interim period between removal of specimens and reweighing

should be kept to a minimum and in no case should it exceed

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,

15.10 For ferrous coupons, use one of the following alter-

15.10.1 Clean the coupons as well as possible with a plastic

knife. Remove oily and greasy deposits by sonking in trichlo-

resthylene. Remove remaining loose corrosion products by

brushing with a bristla brush. Immerse the specimens in

inhibited acid, using either of the following two techniques,

15.10.1.1 · Immerse the specimens in inhibited HCI (1 + 1.8)

15.10.1.2 Immerse the specimens in inhibited HaSO

+ (1+34) at 71°C (160°P) 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 specimiens from

the inhibited acid bath. Rub specimens with granular Na3PO 4.

then with tripoli. Rinse, with water. Rinse, with isopropyl

alcohol. Dry between paper towels followed by warm air

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 sonking in trichloroethylene. Immerse the coupons in inhibited HCl (1 + 1.8) for 30 s. Rinse coupons with water,

rinse with isopropyl sicobal, and finally, rinse with benzene. Dry coupons between paper towels. Place in a desiceator for 1 15.12 For aluminum or aluminum allow coupons, use the following procedure for cleaning prior to reweighing. Clean

to the identical cleaning procedure used for the test specimens

native procedures for cleaning the coupon prior to reweighing.

1 week:

but this step is optional.

for 30 s at room temperature.

drving.

and reweigh to determine the blank correction factor to be of three or four sets of coupons at 4- to 7-day intervals is applied to the coupon weight losses.

15.14 Reweigh each coupon to the nearest 0.1 mg.

15:15 If pluing (see 7.2) is apparent on the coupon, measure the depth of the pits in a representative area with the dial depth

rage. Record the resultant values as pit deputs. The numbersize, shape, and distribution of the pits shall also be determined and recorded

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

16. Colculation

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 Corrosian Rate:

16.2.1 To calculate the corrosion rate (8, 9, 10) in mils of

year for each coupon, use Eq 1: "

Convision Rate (mils per year, mpy) = 22.3 Wilder)

where:

W = weight loss, mg, d = density of the metal, g/cm³

exposed area of coupon, in.3, and

- nma (mvs.

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

Costission Rate (micrometers per year, minty) - 3650 Wilder

where

weight loss, mg, e density of the metal, g/cm³,

= exposed area of coupon, cm², and

s time, days.

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16.3 The specific gravities of various metals (g/cm.)

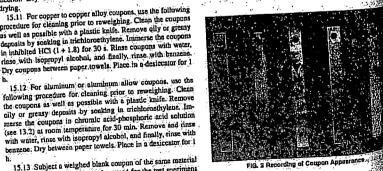


FIG. 2 Recording of Coupon Appearance.

Alderstandles has 8.17 8.8 6.02 2.70 7.85 Copper Yellow brass Low carbon staa 16.4 Calculate the offling rate using Eq 3:

Pitting rate, mills (mm) per year = maximum pit depth × 365/r

where:

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 conconclion 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 2917:1.3 Deviations in crevices, deposits, or biological emoths.

Precision and Bing

181 Precision is a function of each individual system. Threfore, a general statement regarding this property is not pactical at this time.

18.2 This is a comparative type test, for which precision cannot be evaluated. There are many variables, such as reacity, temperature, water quality, and the presence of other icials that may influence the rate of corrosion of the conpons. Arrivel, the composition of the test mend and the different series of corrosion which can occur, such as general corresion, arrively and microbiological type, may affect the results appre-

TEST METHOD B-Pipe Inserts in Pinstic Pipe (1, 2, 3, 4. 5)

INTRODUCTION

is method of corrosion testing in municipal distribution Fisistems has been used effectively for many years; ver the assembly has been cumbersome and costly to

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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 sleave 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 34-in. outside diameter (26.7-mm) assembly, rather than 1-in. (33:4-mm). Table 1 provides the dimensions for preparing 15-in: outside diameter (21.3-mm), 1/4-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 nine 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, of present, testing of the corrosion resistance of lead is confined to Der 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 cravice 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 corrusion 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 insents, constructed from a representative lot of W-in, outside

¹⁾ PVC piping is specified to be PVC Type I, Grada I, Cell classification (2454-B), and CPVC finings, Type IV, Grade I, Cell classification (2447-B).

TABLE 1 Specifications for ISWS Type Corrosion Specimens

	Materials of Construction	erisis of Construction			Olmanationa	
a shre, ki	Class	Matel	Longth, In.	insida di- , ameter, in,	Outside di- emeter, In.	Aten, In. ³
14	Bchadula 60, pipe	steel	4,00	0.548	0.626	6.85
	Schedule 80, pipe	galvanized.	4.00	0.638 2	0.825	6.78
	Type L, tuba	COOD4/	4.00	0,548	0.625	6.85
	Schoolds 40, pipe	stepi	4.00	0.824	1.050	10.35
	Schedule 40, pipe	gstventzed	4.00	0.818.4	1.050	10.25
	Type L, tube	copper	4.00	. 0.824	1.050	10.35
1	Schedule 40, pipe	atool	4,00	1.049	1.125	13.18
	Schedule 40, pipe	Galvanizad	4.00	1.037 4	1.125	13.03
area.	Type L, tube alling thicknose of 0.004 th.	copper	4.00	1.025	1.125	12.68

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(C) 2688 21.4. Hydrochloric Acid (3+8), Inhibited-Add 465 mL of concentrated hydrochloric acid (HCL, sp gr 1.19) to 1200 mL of

dilute to 1 L.

water, then add 4 ml. of substituted keto-amine corrosing

21.6 Sulfamic Acid (100 g/L), Inhibited-Dissolve 10 g of

sulfamic acid (HSO_NH2) in 90 mL of water and diute to 100

mL. Add 5 mL of alicyclic abietylamines (see 21:2) and mit,

21.8. Passivating Stock Solution-Dissolve 40 g of sodium

Line rausvanny succe Soundan-Unserve wo 5 of soundan-minic (NaNO.), 23 g of sodium acid phosphate (Nail-PO.), and 20 g of disodium phosphate (Na-HPO.) in water, ad

21.9 Passivating Solution, Dilute-Add 50 mL of passive

22.1 After stamping an insert number on the exterior surface

22.2 If the inserts show the presence of rust or oth

coolings that were not removed, clean copper and steel inset

with (1+3) hydrochloric acid, inhibited, until free of the

conting. Place rubber stoppers in each end of galvanized intert

to prevent attack of internal galvanized surface by the acid is

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, en

pussivate (see Nois 1) steel (not copper or galvanized mirrat

surface) surfaces by soaking inserts in dilute passivilly

solution for at least 1/2 min. Now air-dry and keep in desig

with o die, degrease the inserts by immersion in trichloroes

inhibitor (see 21.3), mix well, and dilute to 2 L.

ing stock solution to 350 mL of water.

22. Preparation of Inserts

ylene and air-dry.

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 cter uy maching scincule to havanico pilo in dist are desirably in the assembly) or copper piping. The inserts are held in place by 34-in, cutside diameter (26.7-mm) spacers, as shown in Fig. 3 and Fig. 4, in a 1-in. (33.4-mm) PVC mion, socket type, installed in a typical 4-in. (26.7-mm) service line. Recently, 1/-in. (21.3-mm), 1/-in. (26.7-mm), and 1-in. (33.4mm) 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.

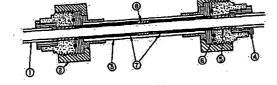
20.2 Dial Depth Gage-See 12.5. 20.3 Ultrasonic Cleaning Equipment, 150-W, 6-qi (6-L) tank capacity to hold 2-L beaker.

21. Reagents and Materials

21.2 Alleyelic Abterylamines, formulated (including ethylene oxide address of these amines and nonphenyl and 5% diethylthiourea in isopropanol solution), liquid corrosion in-

21.3. Substituted Keto-amine Corrosion Inhibitor¹², for hyhibitor for sulfamic acid. drochloric acid.

¹³ Complex substituted krio-smins (50 to 50 %) correston lobiblier is Redian-313 manufactural by American Products Inc., Ambler, PA 19002 has been found subfactory for this parpose.



1 3/4" (L9i cm) PVC Service Line

(2) 1" (2.54 cm) Union, PVC, Sockel Type, Sch BO

- (3) 1" (2.54 cm) x 10" (25.4 cm) Pipe Nipple, PVC, Sch40
- (1) (2.54 cm) x 3/4" (19) cm) Reducing Bushing, PVC, Socket

(6) 3/4" (1.91cm) PVC Spacer, Sch 40, QL Reduced OOI5"(QO38cm) 11 Needed, Reducing Union I.D. to Pipe I.D. to Hold Specimen in Place

6 0-Rbg

Correction Spectmens, 3/4" (1.9) cm) OD. Reduced 0.030" (0.076 cm) Machined from Sch 40 Galvanized Steel or Steel Pipe.

(a) Specimen Separator, 3/4"(1.9) cm) PVC, Sch 40, O.D. Reduced QOIS" (DO38 cm). Length is Adjusted to Provide Flush Fill with Inner Faces at Union. FIG. 3 Pipe Spacimens (CERL)-V-In. (1.91-cm)

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TABLE 2 Factors for Converting Weight Loss Measurements Into Specimen Hotor the Same at Bath Ends - Both Specimen Mold the Same an Bath Airles of Long

44" (1.51 cm) + 244" (5.35 cm) La Spacimen Separation - PVC Sch 40, 0.0. Reduced 0.015" (0.038 cm) is Allow Fining Anno 1" 12.34 cm) Fipe

Corregion Somianne (LD Reduced (1000 (10076 cm) from Sch 40 Gels Statt er Brast Pipe (Jtal Shown)

1"(2.54 cm) = 10"(25.4 cm) PVC Sch 40

Type of S	ipecimen	Conv	ention Fector	∎ (P) ^	
Pipe size (in.), Class	Misterial		(weight loss (g/d) to: corrosis/t rate)		
fort craat	-	mdd	mpy	mmpy	
% Schedula 80	atient pipe	8259	413	10.49	
Vi, Schedula 60	gaivanized pipe	2293	462	11.74	
va, Type L	copper tube	2263	364	B.24	
V. Schedule 40	etesi pipa	1497	274	-8.95	
YA Schedulo 40	palvanized pipe	1512	305	7.74	
¥i, Schechda 40	copper pipe	1497	.841	. 8.11	
1, Schedute 40	staal ptoo	1178	215	5,46	
1, Schedulg 40	astvenized plas	1169	240	6.09	
1, Type L	copper tube	1203	193	4.91	

andd - millorams per square decimatre par day.

^C mpy = mile per year. ^C mmpy = mili matres 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 rateand 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.



1" (2.84 ant Union - Mats Part

I" [2.64 cm] = %" (LSi cm) PVC Scb 80 Reducar Suzking, Sector Type

1" (2.54 cm) Sother Type Union

1. (2.54 cm) Union Plangs

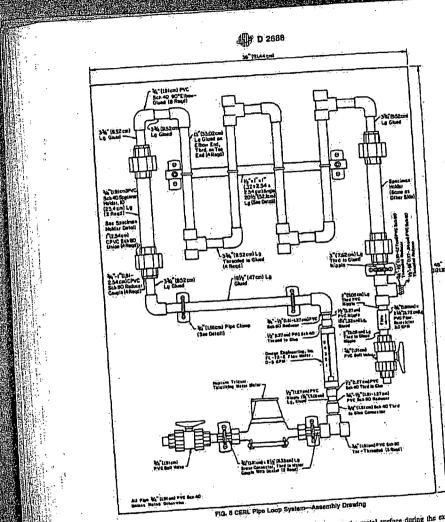
tales O-Rho Bests

WillBlant + Sta (BAR an) La PVG Seh 40

19 4 CERL Plos Loop System-Specimen Holder Details

reighed. Record weight and insert number; then inserts to be painted

It's not necessary to passivale step laserts if they are not tons and then allowed to air dry. For long periods of storage conditions of storage passivation may be justified.



questioned.

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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 puinted surface (excellent, blistered, preling, etc.). If the puint has failed to

effectively coat the metal surface during the exposiand appreciable corrosion has occurred on the external the accuracy of the corrosion test results may be

ADY D 2688 Institution or Plant Locations Type of Waters Insert Type: Date Installed; Date Removed: Insert Ho. 1 Lab No.1 Total Daves Distribution: _____ Size and Shapes Danth Discribucion: Indef Weight: (1) Pravious to installation: (2) After installation (+) scale and cottonion prods: (3) After installation (-) locus scale and cottonion (-) locus scale and correction produt (4) After installation (-) all removable scale and corresion prodes Scale and Corresion Products; (A) Gain or loss during installation (1-2) (B) Loose scale and correction prode (2-3) (C) Tight scale and correction prode (3-4) (D) Total scale and correction prode (3-4) (B) Letual weight loss of lasert (1-4) = W g/a_{2} d (for statel, galvanized) = 117 W/T = g/a_{2} d (for statel, galvanized) = 117 W/T = g/a_{2} d (for statel, galvanized) = 117 W/T = g/a_{2} d (for statel, galvanized) = 117 W/T = c/day

FIG. 8 Report Sheet on Corroaton Spechnens (Test Method 8)

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16 Cleaning of Inserts

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261 After removal from the corroding environment, dry mentine 105°C oven for 24 h (except for copper inserts which will be dried in a desiccator for 24 h), close ends of insert with ober stoppers, immerse insert in an epoxy paint stripper to bosen the paint on the exterior, and remove all the paint film familie insert. After removing the stoppers, dry again in a MiC oven for 1 h, cool in a desicentor for 1 b (except for topper inserts which shall be dried in a desiccator for 24 h), ind weigh to the nearest 0.001 g; Record the weight on line (2) whe report sheet (Fig. 6).

2611:1: Cantian: While removing paint, avoid contact with Sipper solution by wearing rubber gloves and working in an ist hood.

252 Sempe the insert with a spatula to remove loose polls and wash with a brush and scouring powder. Dry the and weigh as previously noted after stripping. Record the

Station line (3) of Fig. 6. 1763 Immerse steel inserts in a freshly prepared solution of bled hydrochloric acid (see 21.4) for several minutes or Will corrosion products are removed. Copper inserts are rejoid in concentrated hydrochloric acid for 1 to 2 min to steposits, but do not use the copper acid bath to clean

10311 immerse galvanized inserts in an inhibited sulfamic tion (10 %) (see 21.6) for 5 min to loosen the deposits. deposits by brushing and placing in an ultrasonic incressary. In this case, place inserts in a 2-L the braker containing the inhibited acid and place altrisonic equipment containing water.

Rinse all inserts with water and acctone, dry in a en for 1 b (except for copper inserts, which shall be desiccator for 24 h), cool in a desiccator for 1 h, and the nearest 0.001 g. Record the weight on line (4) of

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 pluing evaluation column shown in Fig. 6. Also inspect copper inserts using a microscope to determine if strintions 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 pensiration. The accepted units are grams per square metre per day (g/m²/day) and millimetres penetration per year (mmpy) mils per year (mpy). Calculations in gmd or g/m²/day may be made using Eq

g/m2/ day = 117 W/T, for steel and galvanized specimens. and g/m ³/day = 120 W/T, for conner specime

(4)

where W = actual weight loss of insert, g, and

T = installation time, days.

27.3 The relationship between corrosion rate in grid, 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/cm3) 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.

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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 n_{01} practical at this time.

M

30.2 See 18.2.

31. Keywords

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

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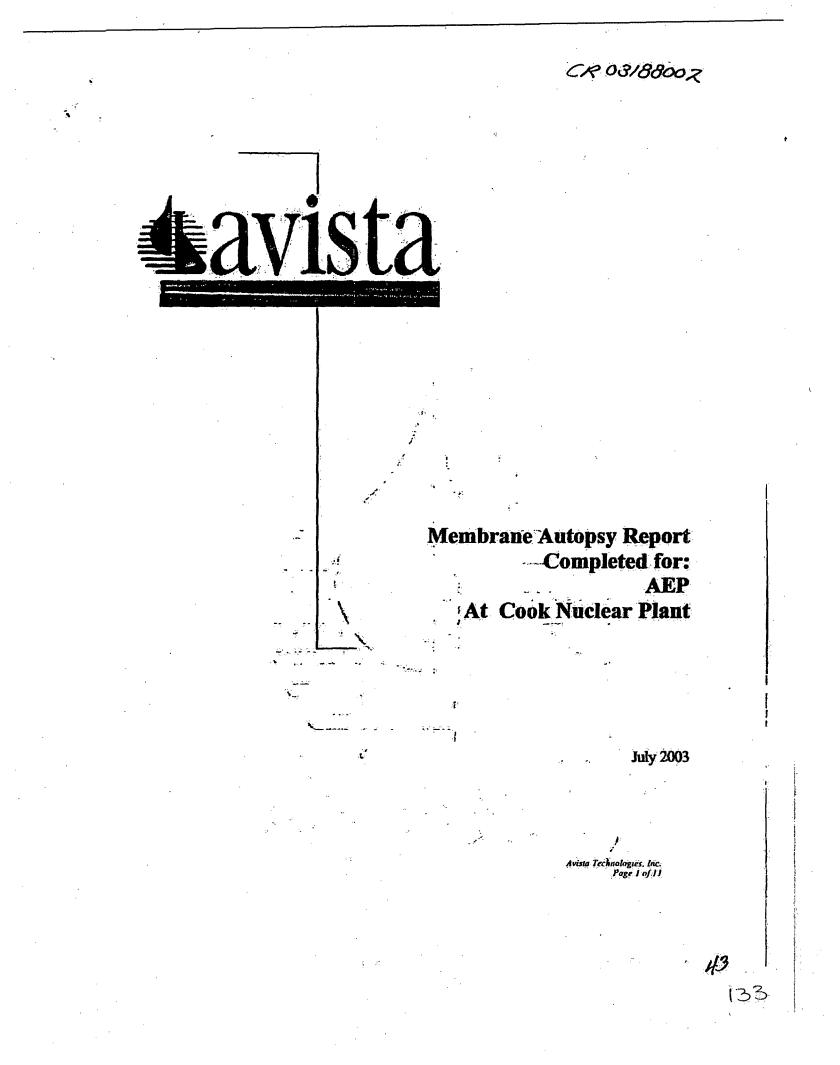
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APPENDIX 6

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CON	T	Èľ	V7	S	

PROCEDURES AND RESULTS Wet Test Element Weight External Inspection Fiberglass Wrap Telescoping of Element Leaves Brine Seal Anti-telescoping Device (ATD) Penneate Tube Internal Examination Membrane Pujiwara Test) Reed Spacer (Vexar) Permeate Spacer (Tricot) Glue Lines Cell Test Foulant Analysis Loss on Ignition (LOI) Membrane Foulant Deusity Bubble Test EDX/SEM Analysis	••••
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	1.2.9
Microbiological examination	14.14
Compatibility test	
SUMMARY AND CONCLUSIONS	
APPENDIX A -	••••
Diagram of an RO Element	
APPENDIX B	

Photomicrographs SEM Photograph

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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 Filmter 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.

Avista Technologies, Inc. Page 3 of 11

Permente 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 (Verar) designed to separate membrane leaves to form a flow path and to promote unbulence within feedwater passages. The feed spacer was free of foulant.

Permeate spacer:

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

Glac 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 physical grouperties of the membrane physical grouperties of the membrane physical solution of the membrane physical properties of the membrane physical solution of the membrane phys

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
Scrial # 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/cm² and average 0.203 mg/cm². Membrane foulant density for this element was 0.235 mg/cm².

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 (1.94B-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.

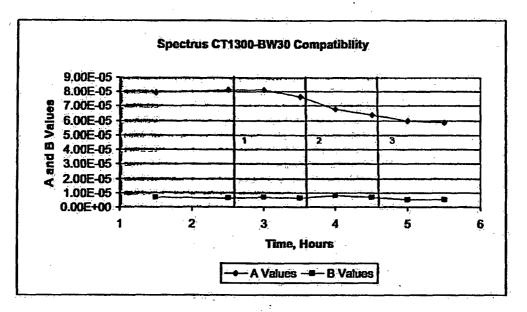
COMPATIBILITY TEST

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

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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.

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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.

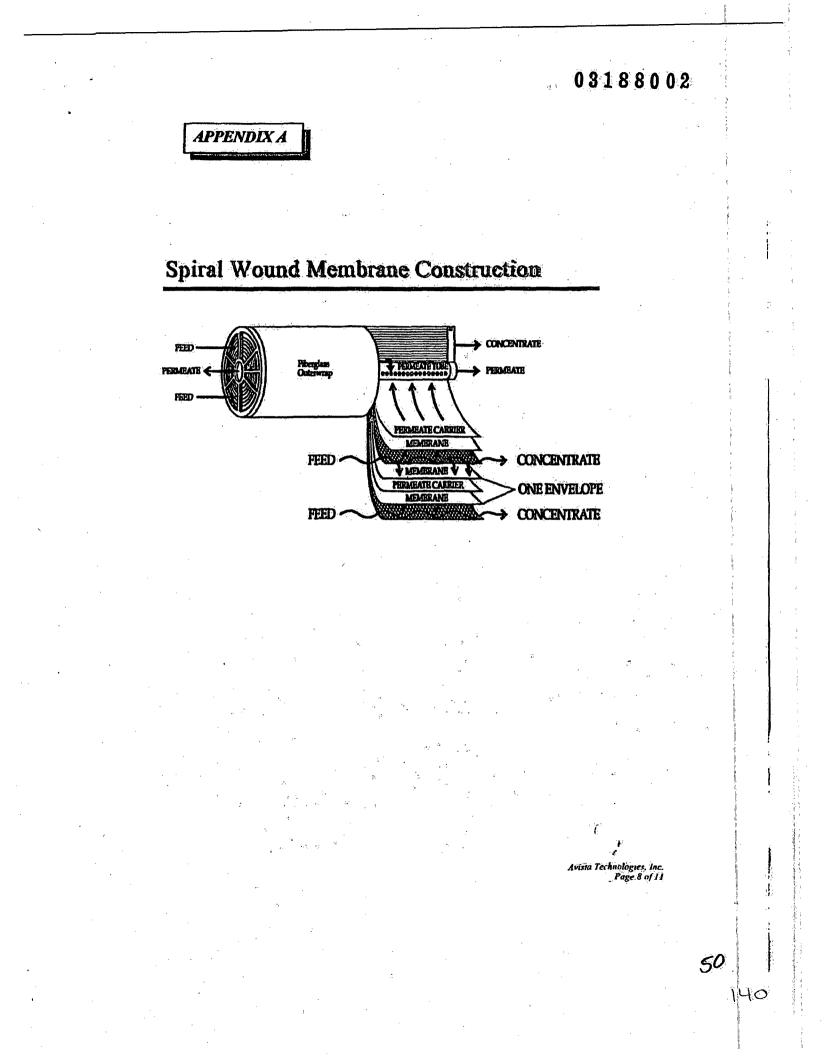
A cleaning test was performed on a fouled membrane sample. Excellent cleaning results were obtained with Avista's RoClean P111 cleaner. However, salt passage did increase significantly following the clean. This is probably due to damaged areas of the membrane being uncovered by the cleaning.

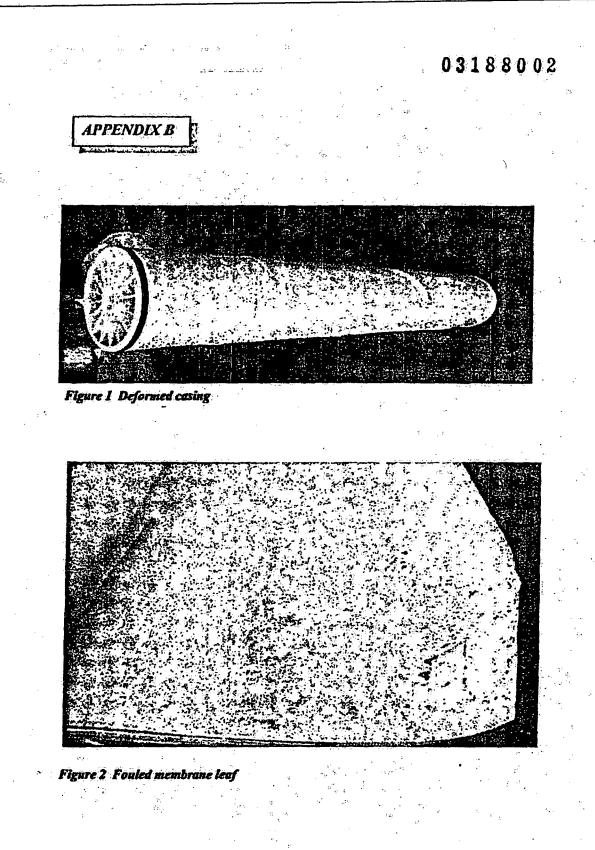
RECOMMENDATIONS

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 ineversible fouling of the RO membranes.

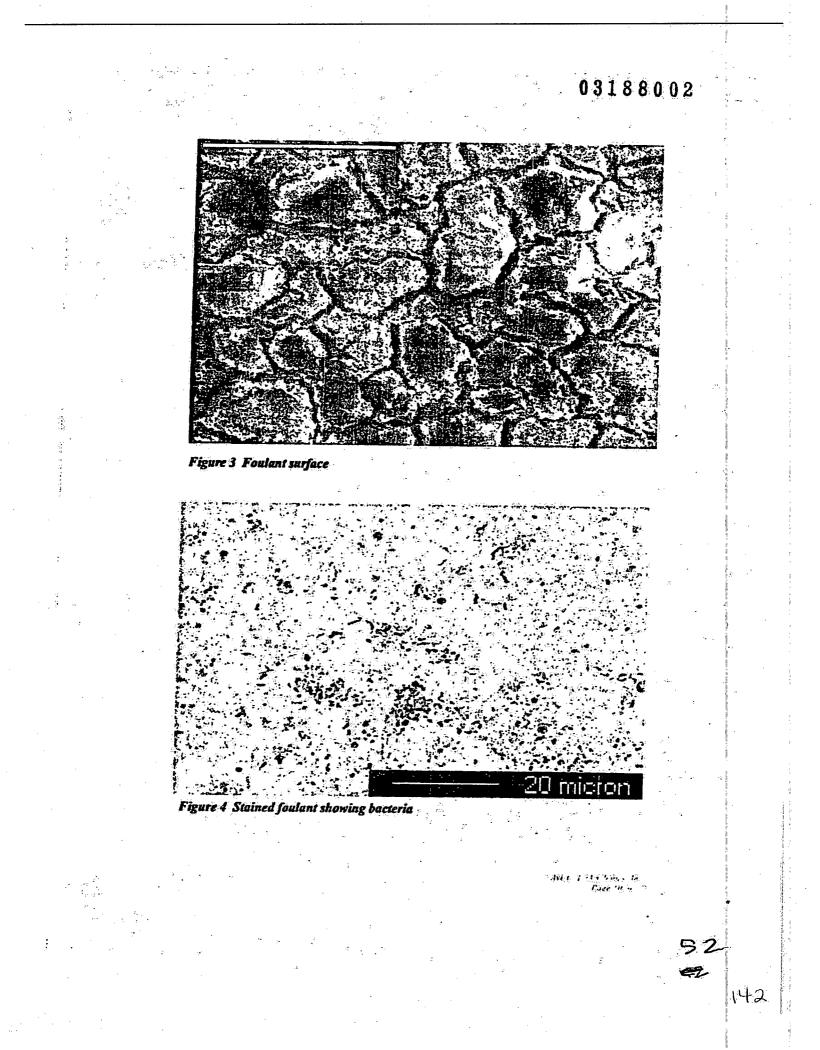
Avista RoClean P111 cleaner should be evaluated. It may be a more cost-effective product for cleaning the RO system than the acid and caustic currently used.

Plant dechlorination procedures should be reviewed.





Avisia Lechnologies Inc.



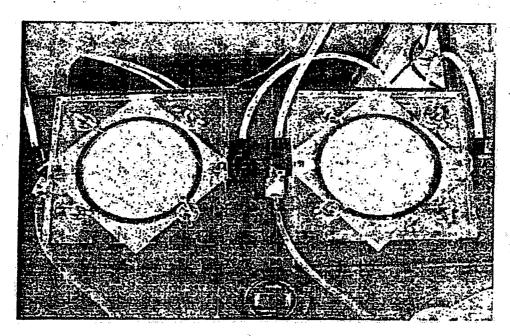


Figure 5 Cleaning results

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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



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	concernance of	Chromate as CrO ₄ Fluoride as F					~ ~ ~		0.08		0.05	
	eret served of a	Formate as CHO ₂	0.07	angagar itory gen takana 21	0.08		0.07	a e decomponience	0.08		0.05	
		Glycolate as C ₂ H ₃ O ₃	0.00	na an in the second	0.00	e en gelan på e lagnapå sameter	0.00		0.00		0.00	and the second s
	address from t	Molybdate as MoO ₄	0.02		0.00		0.01		0:00		0.00	Contraction of the contract
	Information Character	Nitrate as NO3	0.73		0.78		0.80		1.03	interaction of a set of the set of the	0.81	
		Nitrite as NO ₂	0.00		0.00		0.00		0.00		0.00	a and a second second
		Nitrogen (total) as N			.							
		Oxalate as C ₂ O ₄ Phosphate (ortho) as PO ₄	0.00		0.00	······································	0.00		0.01		0.00	
		Phosphate (poly) as PO ₄	0.00			·	0.10		0.00		0.07	an ganganga salawan j
A		Phosphate (organo) as PO ₄			·	· · · · · · · · · · · · · · · · · · ·		10. 1999 1996 1996 1999 1 999 1999 1999 1999 1999 1999 19	· · · · · · · · · · · · · · · · · · ·			
P	Sec. 19 (1977)	Phosphorus (total) as P	0.00	0.10	0.00	0.10	0.00	0.17	0.00	0.14	0.00	0.09
0		Sulfate as SO4	21.8		21.7		.21.6		22.1	in the standard and a second	21.7	
n s		Sulfur (total) as S	6.59	0.61	6:47	0.25	6.79	0.00	6.69	a in coherently? Ages supporter mataboli		0.82
1	*****	Total Anion Millequivalents	3.218		3.378		4,119	,	3,975		3.182	
	in marine .	Ammonia as NH ₃	· · · · · · · · · · · · · · · · · · ·	بيمادر والمستنب								
	a record of the	Benzotriazole as C ₆ H ₅ N ₃ Boron as B	0.00		0.00		0.00		0.00		0.00	
	Water and a state of the	Silica as SiQ ₂	0.83	1.07	0.95	1:80	21.1	0.00	18:2		Constantion - Lange Constant of Secondary	
ļ		Sodium Nitrite as NaNO ₂										
•		Sodium Sulfite as Na ₂ SO ₃	· · ·									1
	58,	Tolyltriazole as C7H6N3								1		
-		All data except pH in parts per million or as indicated	<i>·</i> .	· · ·	Cor	ntinued on	reverse sid	A:				

46

		H-O-H Chemicals, Inc.			ORY RE					Customer Report No		1001392 indicated
		500 S. Vermont St.		Donald C	Cook N	uclear Pl	ant			Report Da		
		Palatine, IL 60067		1 Cook F	Place	doloa 11				Analysis [- <u>.</u>
				Bridgma		·				Sample D		indicated
		847/358-7400		Diagric				<u> </u>		Oampie D	<u>aic. do</u>	maloutou
		Fax: 847/358-7082		1 9/7/06 723)		1 9/7/06 723 <u>)</u>		9/14/06 5743)		9/14/06 743)		9/21/06 781)
			Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
<u> </u>	59:	Bromate as BrO3		1				. į				
c	60;				a para ana ang ang ang ang ang ang ang ang an			*** (\$1,4,4,1%) to be proceeding #***	1	, in the second se		
0	61.		- 1						*****		. ، سیسی شقارین	ب بینیسیسیشاری
m	62.											
P	63.	Contraction and a second data and the second d	-						à			· · ·
u	64.	Ethylamine* as C ₂ H ₇ N		* • • • • • • • • • • • • • • • • • • •	6 - Almanna - ang 11		sented at one of constants					
ŋ,	65.	Morpholine* as C ₄ H ₉ NO					·/··	17	in		•	
d	66.	a contraction of a descent state of a second sta					در محمد المعنوبين		······			and memberships of a large man
	67.	Ethylene Glycol* % by weight Propylene Glycol* % by weight				n versitari	· ·····		ana an			سوميلات برورا بعضم
	69.	Propylene Glycol* % by weight Aerobic Plate Count org's/ml		····						ne transformation and a second		
м	70.	Anaerobic Plate Count org's/ml					1			·····		
	71.	Fecal Coliform org's/100ml		````` ````````````````````````````````	in the second				yaaan oo qofuuladaan		• • • • • • • • • • • • • • • • • • •	
c		Iron Bacteria	haddaaraa kan aanaana ,				, .	······	·····	and the first of the second		
1	73.	Moid org's/ml	a da ang ang ang ang ang ang ang ang ang an			alarian) - ana na manana ana ana ana ana ana ana a	el e anarañ 196 - Levelenn L	ada an ta		 	haaraa kababaara	les e les e propries de la companya
b.	74.	Nitrate Reducers org's/ml									·	
Ū	75.	Slime Formers org's/ml										
0	76.	Sulfate Reducers org's/ml	·		·			and the second s		amenter teksteringen	Samanan wasan	-
0	77.	Total Coliform org's/100ml			*****							
g	78:	Yeast org's/ml				ورجعه والمعمولية المعادية	يميدمينين متشمسة	ngerse etserversennerset	1. 9 - 19 - 22 - 19 - 19 - 19 - 19 - 19 - 1			an in a sure of the second second
11	79.	Residue by Evaporation		annan an a		"				energiane nada,		
С' а	80.	" announcement announcement announcement and a second and a		····	••••••••••••••••••••••••••••••••••••••	د ف د چششتیندید در د						
1		System Capacity gal. Propionate as C ₃ H ₅ O ₂	0.00		0.00	-annonadarrais.	0.00		0.00	e armana an an angela.	0.00	
	- 83.	Total Organic Carbon	2.10	muninterror al a far	2.50	and a state of the second s	1.90	ngen angen sondersenen er er	2.50	stranie - mine	1.37	i je odraž ovijana ne
1.	84.	Total Organic Nitrogen		San da ana sa makanka da k		· · · · ·	0.29		<0.124			
	85.	Mexel (A-432)			3.0	Server - Links in Property			3.0	er annerer i den		
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	en handelen		n en		•	بالابتين والطيناني						
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					at de contañant		<u>سار، مسارهٔ در بار ماره</u>		,			
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1		s and a second state of the second state of the second states and the se	1999 - San		andala anayaa ilaa	سيد المتأدستين			·····	19 - 19 - 19 - 20 - 20 - 20 - 20 - 20 - 20 - 20 - 2	hite-parameter	
	لسينيسنا	All data except of in cents per million or as indicated		<u> </u>		·	L	l	l	Annhuis hu C	as Chromatoura	·

0, All data except all in parts per million or as indic

		x		ËA	BORAT	ORY REF	PORT -	NATER	ANALYS	sis: I	Customer	No	1001392
Geo		H-O-H Cher	nicals, Inc.								Report No		indicated
	ſ		ermont St.	Location:	Donald C	Cook Nu	Iclear Pla	ant	.		Report Da		и 1
	U		e, IL 60067		1 Cook F		·				Analysis D		
					Bridgman			•		· · · · · · · · · · · ·	Sample Da		indicated
		84	7/358-7400			<u>, , , , , , , , , , , , , , , , , , , </u>			1		· [
C			7/358-7082	Treated (#26	9/21/06 781)	Control 9 (#268		Treated (#268			10/5/06 859)	Treated (#26	
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
Ē	1.	Alkalinity ("P")	as CaCO3	0		6		6		Q	•	0	ļ
		Alkalinity ("M")	as CaCO ₃	118	The state of the s	112		114		114		114	
		and a second	as CaCO ₃		s								·····
W		Free Mineral Acidity	as CaCO ₃					inio cineta a constrant a					
a	5.	Chemical Oxygen Demand	(C.O.D.)	4.4		6,4		9,6		8:6		12.7	manun - minimur -
1	6.	Chloroform Extractables Dissolved Solids	10 (10) - 1 (10) - 10)	193		405	·	198		199			
•	7.	Hardness (Calcium)	as CaCO ₃	80	,	195 81		198		78	متوسيتها مرمع	78	6
	9	Hardness (Magnesium)	as CaCO ₃	44		44		44	nggi 16 - oʻng son mananan a	43	1999 - Conference and consider	43	
é	10.	Hardness (Total)	as CaCO ₃	124		125	· ·	125	94994444444444444444444444444444444444	122		122	
1	11.	pH		8.1	1.44-24444.00,2044.004	8.2		8.2		8.2		8.1	
o	12.	Specific Conductance	μmhos	285		290		295	and the second sec	294		303	
P	13.	Specific Gravity	g/mi			÷							
ê,	14.	Suspended Solids				المتينية محرب مستربي	47.0	, , , , , , , , , , , , , , , , , , , ,	8.0	Lugaran tanggangan	15.5		12:0
5	15.	Aluminum	as Al	0.01	0.05	0.01	0.55	0.01	0.08	0.01	0.25	0.01	0.16
1.	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.	Călcium Chromium	as Ca as Cr	<u>31.8</u> 0.01	0.00	32.2 0.01	6.04	32.1 0.01	0.02	31.3 0.01	0.00	31.3 0.01	0.00
0	19	Copper	as Cu	0.00	0.00	0.00	0.00	0.01	0.00	.0.00	0.00	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
ŀ	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	Ò.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	. Secondaria	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
Ca	28. 29.	Sodium Strontium	as Na as Sr	6.43 0.11	0:00	6.49 0.11	0.01	7:00 0.11	0.00	6.17 0.11	0.00	6.57 0.11	0.00
ty	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	conservation of the second second	2.796		2.810		2.840		2.734		2.754	
o n	32.	Acetate	as C ₂ H ₃ O ₂	0.00		0.00	14 7 - 16 7 - 19 7 - 1 - 10 7 - 10 7 - 10 7 - 10 7 - 10 7 - 10 7 - 10 7 - 10 7 - 10 7 - 10 7 - 10 7 - 10 7 - 10	0:00		0.00		0.00	
8	33.	Bromide	as Br	0.00	Same and a second	0.00	-ch-ar champirorange dependener i	0.00		0.00		0.00	
	34.	Chloride	as Cl	11.5		11.3	1	12.2		11.5		12.1	
	35.	Chlorate	as CIO ₃	0.00	atus namu a na	0.00		0.00	landerseriering terreture	0.00		0.00	······
ŀ.	36	Chromate	as CrO ₄				une de contraction de la contraction de		· · · ·	and the second	-		
ŀ.	37.	Fluoride	as F	0.06	ang ng n	0.06		0.06		0.08	COMPANY AND A 1991	0.08	
ŀ.		Formate	as CHO ₂ as C ₂ H ₃ O ₃	0.00	1919, X.S	0.00 0.00		0.00		0.00	announce a subset data	0.00	ere ere de le composition de la composition de l
	*******	Glýcolate Molybdate	as MoO ₄	0.00		0.00	· ····	0.00		0.00		0.00	
		Nitrate	as NO ₃	0.81		0.75		0.00		0.92	Processing and the second second second	0.68	
		Nitrite	as NO ₂	0.00		0.04		0.00		0.00		0.00	
		Nitrogen (total)	as N					الشفاقد وحوادي					n an an tanan ang manananan an a
	44.	Oxalate	as C ₂ O4	0.00		0.00	· · · · · · · · · · · · · · · · · · ·	0.00	and the second	0.00	a fundamenta of a statement.	0.00	
	And and a second of	Phosphate (ortho)	as PO ₄	0.00		0.00	·····	0.00		0.06		0.00	
A		And a second	as PO4	1979								 	
n		Phosphate (organo)	as PO ₄									0.04	
. I 0		Phosphorus (total) Sulfate	as P as SO4	0.00 21.8	0.03	0.00 21.8	0.04	0.00	0.00	0.02	and a state and a second state and a	0.01 23.3	0.00
n		Sulfur (total)	as SU4	21.8 6.90	0.00	6.80	0.11	23.3	0.00	6:80	reading of the scheme surface and a second state of	6.81	0.00
S		Total Anion Millequivalents		3.185	0,00	3.094	<u> </u>	3.175		3.122		3.148	·····
	service of a		as NH ₃								· · · · · · · · · · · · · · · · · · ·		nanite national i
	ina opening and	Benzotriazole	as C ₆ H ₅ N ₃	Yer 4	and the second			iyin sananan i				· · · · · · · · · · · · · · · · · · ·	
	54.	Boron	as B	0.00		1 36		0.95		0:00		0.00	1
	55.	Silica	as SiO ₂	0.88	0.67	0.94	3.65	0.80	1.24	0.89		0.78	1.20
	www.enterbeiter	Sodium Nitrite	as NaNO2	ağada sərəsi və arasını									an manga ng pangan ng
	BARRIER COLD I	Sodium Sulfite	as Na ₂ SO ₃		andra surre chardine								·····
	58.	Tolyltriazole: All data except pH in parts per million or as in	as C ₇ H ₆ N ₃				ntinuedice				<u> </u>		
		w wate except but at baits ber witten of as if	THE CALCULA				ennued on	reverse side	7 .				

,	,	H-O-H Chemicals, Inc.						ANALY:	SIS	Customer Report No		1001392 indicated
		500 S. Vermont St.	Location:	Donald (C. Cook N	luclear Pl	ant			Report Da		
		Palatine, IL 60067		1 Cook	Place				******	Analysis D		
			· ·	Bridgma			• •			Sample D		indicated
		847/358-7400		a.tugina	1		r		,	ourtiple D	uto, uo	maioatoc
		Fax: 847/358-7082		d 9/21/06 6781)		9/28/06 6813)		l 9/28/06 813)		10/5/06 859)		10/5/06 859)
			Soluble	Insoluble	Soluble	Inscluble	Soluble	Insolubie	Soluble	Insoluble	Soluble	Insoluble
Ē	50	Bromate as BrO3		1						- Middland	Coldbio	110010010
		Chlorite as CIO ₂						internet contractor i con a	•		~~ • dy where you are	
C.		A State of the second s		• • · · · · · · · · · · · · · · · · · ·	÷					·	e se ha a san thir an	~~~~~
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P		Diethylamine* as C ₄ H ₁₁ N Diethylaminoethanol* as C ₆ H ₁₅ NO	494. · 1. ·				, mangang manananan a		·····			1,000 to 10, 10 codestro
ò		and the second				anatomaticitante d'anglada e na 12 a a a	< 1 Mg 100 (10 10 10 10 10 10 10 10 10 10 10 10 10 1					
u.		Morpholine* as C ₄ H ₉ NO	·	· [·		·		······	· · · · · ·	·······		
n d		service which compare and compare of a compare or a compare or a compare of the service of the s		· [· · · · · · · · · · · · · · · · · · ·	and attend constants				4 1	aananaan nahefilan (nama in sasa ka
s	00.						anno basa da ana a		•••••••		***	
			et i constant		· ····································	an a	·····	·				
		Propylene Glycol* % by weight				n National and a state of the s				. ~************************************		
		Aerobic Plate Count org's/ml Anaerobic Plate Count org's/ml			····	han har and have been a start and have been a start a s	Mighten		aksia aksia ana ata t	ومستحدث محتشب	· · · · · · · · · · · · · · · · · · ·	ستابية بهادية مشماليه
M	Acres and	a and a second	www.wite.h				ستوريده والامع				÷	an an air an
c	an other sides.	Fecal Coliform org's/100ml Iron:Bacteria			· · · · · · · · · · · · · · · · · · ·							
r			·	lanartheres ana is .	. daamaatataa	see of some time a			an an include) generalistiskalijanst soci - cito	~~~~~
0		Möld org's/ml Nitrate Reducers org's/ml				here a survey of	·				hand and the second second	
D			ny dia Santa ang ang ang ang ang ang ang ang ang an		- <u> </u>	mananatanti ya k			····· /#. ; ;	e 10 a tau chhanna Sachara		, er se i er Amaritan
	75.	A REAL PROPERTY OF THE OTHER PROPERTY.				·····	· · · · · · · · · · · · · · · · · · ·					presiden of a spiritering a sub-second
٩ ١		and an and a second				••••••••••••••••••••••••••••••••••••••				*		
0		a complete de la complete		v 41 Dr. Anar gudy, yakyayang	•	Saissan		i Selectronisation and second	et considere no consectori		beamed constate	
g	78.			Antonia constant				1 			1938-18-16-16-16-16-16-16-16-16-16-16-16-16-16-	
	79.	Residue by Evaporation	·						ran ann ann ann ann a'		New analysis and a fee grows (194	(
ic.	spectrum services	Volatile Solids	• •••• •• • • • • • •••••••••					Sama and a star				
a. 1	81.	System Capacity gal.				••••••••••••••••••••••••••••••••••••••			ananana an inanya	· · · · · ·	······	
			0.00	Proget Scheropetary and a constraint of	0.00		0.00		0.00	ser-o-senses-senser	0:00	
	83.	Total Organic Carbon	2:42	a bur wie in are more ar	2.10		7:62		3.00		3.50	
		Total Organic Nitrogen			1.47		1.48		0.38		1.48	
	85.	Mexel (A-432)	3.0				5:0		man a sugaranan		1.0	
			 /	1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.					diges commences	-		
	e deservation				Survey of pursuinger		·····	·····	•			waanangan paripa isan as
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n i o n s

		LÂ	BORAT	ORY RE	PORT -	WATER	ANALYS	SIS	Customer	Noa	1001392
	H-O-H Chemicals, inc.	Regarding:	Indiana a	nd Michig	gan Powe	er Compai	ny		Report No	.: as	indicated
	500 S. Vermont St.								Report Da	te:	
U Ye	Palatine, IL 60067		1 Cook F						Analysis D		
	2		Bridgman			·····			Sample D		indicated
	847/358-7400					I.					7
	Fax: 847/358-7082	1 1 Decem	10/12/06 908)		10/12/06 908)		10/19/06 957)	1 X * * * P	10/19/06 957)	Control (#27	10/26/06 021)
		Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insolubie	Soluble	Insoluble
· · · 1.	Alkalinity ("P") as CaCO3	6		6	110010010	10		4		8	
2.	Alkalinity ("M") as CaCO ₃	120		120	16.0 / ADDE Y A. ABR A (* 1)	120	·····	120		114	
3.	Alkalinity ("OH") (calculated) as CaCO3					ganging of the second sec			a fan swarp in it as ei awr a	a ar an	en one compression
4.	Free Mineral Acidity as CaCO ₃	******	Winnerson (1993), 1 (1993), 1				saria alian sinakina akiri		,	and a lar over sents a tree *	1
5.	Chemical Oxygen Demand (C.O.D.)	10.1		. 9.7		6.6		11.1		7.3	l
6	Chloroform Extractables			;			an provins about our			aron er orenationer	
-7.	Dissolved Solids	198		202		198	and shates and shates a	205		201	
8.	Hardness (Calcium) as CaCO3	7.6		75		78		78		73	
9.	Hardness (Magnesium) as CaCO ₃	43		42		44		44	ra antiara dana ana	41	ana na mana da mana ana ana ana ana ana ana ana ana a
10.	Hardness (Total) as CaCO ₃	119		117		122		122		115	
11	pH Specific Conductores	8.2		8.2		8.2		8.1	<u>.</u>	8.5	national construction on figuration in
12.	Specific Conductance µmhos	294	······	295		289	ىيىدىد د ىكەلكەلىد	299		296	<u>i.</u>
13.	Specific Gravity g/ml Suspended Solids		80.0		27.0	·	7.0	· · · · · · · · · · · · · · · · · · ·	16.0		15.0
14.	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	0.00	0.01	0.00	0.00	0.00	0.00	0.00	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.	Lithlum 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	an an an an an	1.54		1.45		1.68	تيديد بستنصب	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
28.	Sodium as Na	6.11		6:31		6.97		7.29	······	6.09	
29. 30.	Strontium as Sr Zinc as Zn	0.11	0.01 0.04	0.11	0.01	0.12	0.00	0:12	0.00	0.10	0.00
30. 31.	Total Cation Millegulvalents	2.680	0:04	2.656	0:36	0.00	<u></u>	2.803		2.589	.0.00
32.	Acetate as C ₂ H ₃ O ₂	0.00		0.00	ang ar or antipologikang	0.00		0.00	สมมาร์การระ เรารายสมัง ก	0.00	
33.	Bromide as Br	0.00		0.00	بعص محرب ميا درم محد	0.00		0.00		0.00	
34.	Chloride as Cl	11.6		12.5	19. a.	12.3		12.9		11.5	
35.	Chlorate as CIO3	0.00		0.00	parameter and the scient so	0.00		0.00		0.00	
36.	Chromate as CrO4					and a state of the second					-
37.	Fluoride as F	0.06		0.06		0.06	lana ana ang	0.06		0.06	·····
38.	Formate as CHO ₂	0:00		0.00		0.00	gammanagan gi giliku kara ang	0.04		0.00	angang and a second
	Glycolate as C ₂ H ₃ O ₃	0.00		0.00	*****	0.00	Lanciana aquina	0.00		0.00	· · · · · ·
	Molybdate as MoO ₄	0.02		0.00		0.09		0.00	search and the state of the second second	0.00	
*****	Nitrate as NO ₃ Nitrite as NO ₂	0.00		0.95		0.77	din se di stateni ana a	0.90 0.00		0.81	h
	Nitrite as NO ₂ Nitrogen (total) as N	0.00		0.00		0,00	hann hallandran (,	0.00		0.00	ana tanan talam ata a
	Oxalate as C_2O_4	0.00		0.00		0,00	1	0:00		0.00	
	Phosphate (ortho) as PO ₄	0.00		0.00		0.00	·····	0.00		0.00	
	Phosphate (poly) as PO4										
	Phosphate (organo) as PO4				·						
****	Phosphorus (total) as P	0.00	0.04	0.00	0.03	0.00	0.01	0.01	0.03	0.00	0.00
	Sulfate as SO4	22.1	in a strange	23.7		23.1		23.8		20.7	
*****	Sulfur (total) as S	6.61	0.71	6.92	0.64	7.30	0.00	7.64	0.00	7.13	0.00
	Total Anion Millequivalents	3.218		3.291		3.274		3.308		3.088	
11 10 10 10 10 10 10 10 10 10 10 10 10 1	Ammonia as NH ₃										
in the following	Benzotriazole as C ₆ H ₅ N ₃				anananan ananan an						, in the second
ter opened	Boron as B	0.00		0.00	ا مىيىتىسىمىمىدىن 14 مۇرىلى	0.00		0.00	<u> </u>	0.00	
*********	Silica as SiO ₂	0.81	4.47	0.78	1.54	0.91	0.88	0.87	0.85	1.11	1.04
	Sodium Nitrite as NaNO2 Sodium Sulfite as Na2SO3	· · · · ·	محرث وروب محق				د مېرون ورو سر سر د.				under services ;
	Sodium Sulfiteas Na2SO3Tolyitriazoleas C7HeN3						kanalan nashayana s	1.12			
	All data except pH in parts per million or as indicated.	<u> </u>	Ļ	l	antinuad on	reverse sid			L	الب ني ني ا	<u> </u>

All data except pH in parts per or a Continued on reverse side.

		H-O-H Chemicals, Inc.				PORT -			SIS	Customer Report No		1001392 indicated
		500 S. Vermont St.	Location:	Donald C	Cook M	uclear DI-	ant			Report Da		
		Palatine, IL 60067	Location	1 Cook F	Diaca:	UCIEAL FIG				Analysis (
			·	Bridgmai						Sample D		indicated
				Driuginai	1, IVN		· · ·			Sample D		mulcaleu
		847/358-7400 Fax: 847/358-7082		10/12/06 908)		10/12/06 908)	200 g	10/19/06 957)		10/19/06 957)		10/26/06 /021)
			Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
<u> </u>	59.	Bromate as BrO3							=			·
C.	60.	Chlorite as ClO ₂									·····	
0	61.	Cyclonexylamine* as C ₈ H ₁₃ N	a									
m		Diethylamine* as C4H11N							·····			********
P	63.		••• ••••	· · · · · · · · · · · · · · · · · · ·	**************************************				desentation of Restantion Contraction Contraction			**
0 u	64.	Ethylamine* as C ₂ H ₇ N				~~~~	A REAL PROPERTY AND A DEC					
0	65.	Morpholine* as C4H9NO	·		· · · · ·		1					
d	66.	Diethylene Glycol* % by weight				,		- operior of the temperature descenter.				
S.	67.	Ethylene Glycol* % by weight	,					÷				
	68.	Propylene Glycol* %,by weight										
	69.	Aerobic Plate Count org's/ml	Augusta and and and and and and and and and an									
M		Anaerobic Plate Count org's/ml					· · · · · · · · · · · · · · · · · · ·					
11	71.	Fecal Coliform org's/100ml										-
10	~~~~~~	Iron Bacteria	ويعضمنه بنوينا والمحاول	-	* • • • • • • • • • • • • • • • • • • •				and the second			
0	73.	Mold org's/ml		· · · · · · · · · · · · · · · · · · ·	·····							, and the boundary of the second
b	74.	Nitrate Reducers org's/ml		A.v. a.g			and in the same because and					
T.	75.	Slime Formers org's/ml		مىيىسىيىن بىر ويەر						·		
0		Sulfate Reducers org's/ml		··· •······			• •				And the second	
0	77:	Total Coliform org's/100ml	na constant of the second	••••••••••••••••••••••	1 เราะ และสุขานั้งและเลง	r Generational	and the second second	د. در دورور ورسره داشت ریشیم) De garage ar conservations			
9	78.	Yeast org's/ml	ana manana mining karana ana a		۰	-		- 			in a char charaileacharaileachara	dentri inter oli i inda radamatar i
Ĩ	79.	Residue by Evaporation							rginal à tradithadalar deservées		lan i mana asaw	,
C,		Volatile Solids									بىسىمىدىت بەت رە يېچە د 14 ۋ	
а	81:										1	
		Propionate as C ₃ H ₅ O ₂	0.00	• • • • «چېردرونو ورونو و	0:00		0.00		. 0.00		0.00	
		Total Organic Carbon	<1.00	········	2.70	lanar to community	1.79	man and a second	4.85	standing of the second labor	4.07	*****,** + + + + + + + + + + + + + + + +
	84.	Total Organic Nitrogen Mexel (A-432)	<.124		1.06 6.0		0:55		0.48		<0.500	
	85.	Mexel (4432)	******		0.0							· · · · · · · · · · · · · · · · · · ·
					*****			·······				· ·····
	لنغاب منبر		***			. مىرىيە بىرىم بەر مۇرىم بار	and an approved to the second	·• •• •• •• •• •• •• •• •• ••				199 (1), (4)90
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		and a second sec										
		in the second					· · · · · · · · · · · · · · · · · · ·				l	
Armine		All data except of in parts per million or as indicated									as Chromatoon	

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			LA	BORAT	ORY REP	PORT -	WATER	ANALYS	SIS	Customer	No.:	1001392
(H-O-H Chemi	icals, Inc.	Regarding:	Indiana a	and Michig	an Powe	r Compai	iy		Report No	.: as	indicated
		rmont St.			Cook Nu					Report Da	te:	
U (, IL 60067		1 Cook F						Analysis D	ate:	
				Bridgma	n, MI				···· ,	Sample Da		indicated
ente	(ascentrer) 847/	/358-7400					· ·			1		
		/358-7082		10/26/06 021)	Control (#270		Treated (#27			11/9/06 107)	Treated (#27	11/9/06 107)
			Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	Alkalinity ("P") a	s CaCO ₃	6		0		0		6		6	
2	Alkalinity ("M") a	s CaCO ₃	118		134		128		118		116	
3		s CaCO ₃										
W 4		s CaCO ₃					·····					
a 5		:O.D.)	7.5		11.4		9:1		5.2		7.7	
t 6												
e 7			205		222		212	است موسعفته ادا مایا	200		206	
r8	• Contraction of the second strength of the contraction of the methods of the second strength of the second str	s CaCO ₃	7,4 41		81 44		80 44	······································	81 44		83 45	
P 10		s CaCO ₃	115		125		125		125		45 128	i
r 11	A State of the second s	P A rest of the second state of a rest of	8:5		7.8		7.8	······	8.4	· · · · · · · · · · · · · · · · · · ·	8.4	·····
0 12		mhos	300		332	······	315	ر سليل و مورد مر	301		310	
p 13	the second state and the second state second state sta	/ml				n a c' die der angeweite						
e 14	a - a fanta yn a'r anwynafar y nawna ar			5.5		3,023		167		6.0		4.0
r 15	To block and an experimental result and former than the second second second second second second second	s Al	0.01	0.05	0.01	3.98	0.01	0.94	0.02	0.03	0.02	0.01
t 16	· · · · · · · · · · · · · · · · · · ·	s Ba	0.02	0.00	0.02	0.03	0.02	0.01	0.02	0.00	0.02	0.00
1 17	· · · · · · · · · · · · · · · · · · ·	s Ca	29,5	1.13	32.4	48,9	32.1	10.1	32.3	0.00	33.2	0.00
e 18 s 19		s Cr	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
20	a a second a second	s Cu s Fe	0.00	0:00	0.00	0.02 8.01	0.00	1.67	0;00	0.10	0.00 0.00	0.00
21		s Pb	0.000	0.001	0.001	0.001	0.002	0.000	0.000	0.000	0:000	0.000
22		s Li	0.00	0.00	0.00	0.00	0.00	0.00	0:00	0.00	0.00	0.00
23.		s Mg	10:00	0:23	10.6	17.9	10.7	3.30	10.7	0.00	10.9	0.00
24.	Manganese a	s Mn	0.00	0.00	0.00	0.30	0.00	0.06	0.00	0.00	0.00	0.00
25		s Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0:00	0.00	0.00
26.		s K	1.33		1.77		1.66		1.39		1.56	n 115m marka ity mange
27		s Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 28	· · · · · · · · · · · · · · · · · · ·	s Na	6.15		8.30	0.00	8.23	0.00	6:95		7.30	
a 29. 1 30.	· · ··································	s Sr s Zn	0.10	0.00	0.11	0.03	0.11	0.00	0.11	0:00 0.08	0.01	0.00
1	Total Cation Millequivalents	<u>5 ZII</u>	2.600		2.903		2.892	0.01	2.842	0.00	2.921	
n 32		s C ₂ H ₃ O ₂	0.00		0.00		0.00	·····	0.00		0.00	
8 33.		s Br	0.00	الطد وليادوا ويرويونونا	0.00	····	0.00		0.00		0.00	
34.		s Cl	11.9		13.7		14.0		12.4	-	12.4	
35.	· · · · · · · · · · · · · · · · · · ·	s CIO3	0.00		0.00		0.00		0.00		0.00	
36.		s CrO ₄							•···•·			
37	I take the second	s F	0.05	en ingener en anglesen permet	0.06		0.05		0.06	Ar 1,1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1	0.05	
		s CHO ₂	0.00	74 Garan Auronau	0.00		0.00		0.00		0.00	
		s C ₂ H ₃ O ₃ s MoO ₄	0.00		0.00	r	0.00		0.00		0.00	······
40.		s NO ₃	0.00		0.00		0.00		0.00		0.00	
42.		s NO ₂	0.00	******	0.00		0.00		0.00		0.00	
43.		s N								···· +		
44		s C ₂ O ₄	0.00		0:00		0.00	n a ann an tra chuirean an	0.00		0.00	
45.		s PO4	0.00		0.00		0.00		0.00		0.00	
A 46.		s PO4			;		,		ىنىمىغى ئۇ سىم بەرمەرىغى يەسىم.	***		· · · · ·
n 47.		s PO4		nya shaqaqadi				himmonogenza.	o de managemente construé de la	• • • • • • • • • • • • • • • • • • •		
48.	and a second of a second	s P	0.00	0.00	0.00	0.27	0.00	0.04	0.00	0.01	0.00	0.01
0 49 1 50	determined and a second s	s SO4	21.4	~ ~ ~	24.5	A.74	.24.6	A 'AA	22.9		22.4	
n 50. s 51.	Sulfur (total) as Total Anion Milleguivalents	s S	7.08	0.00	8.31	0:73	8.13 3.578	0.00	7.47 3.242	0.00	7.63 3.190	0.00
52.		s NH ₃	3.192	** ******	5.750		3.3/8		3:242		0.08	
53.	a the first second s	s C ₆ H ₅ N ₃		1999 - Maria Maria Managaran I.			аласынын онын осулаг		0:00		0.00	
54		s B	0.00		3.80		2.29		0.00).	0.00	and a standard later a st
55.		s 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	s NaNO ₂										. [
110.001210.001		s Na ₂ SO ₃							kragenine odle av sjølet of a kjelling af			ŀ
58.		s C ₇ H ₆ N ₃				Alla				ļ		
knanyst	All data except pH in parts per million or as indic	2160			Co	nunued on	reverse sid	θ.				1

		H-O-H Chemicals, Inc.						ANALYS		Customer Report No		1001392 indicated
		500 S. Vermont St.	Location:	Donald C	Cook N	uclear Pla	ant	<u></u>		Report Da		
		Palatine, IL 60067	Looution	1 Cook F	lace	uoicui it	AT 11.			Analysis I		
				Bridgmar					· · · · ·	Sample D	ate as	indicated
		847/358-7400		Dridgittal	t <u>,</u> 1911	<u> </u>		1		oumpic o	;	in dioutou
		Fax: 847/358-7082	Treated	10/26/06	Control	11/2/06	Treated	11/2/06	Control	11/9/06	Treated	11/9/06
				021)	(#27			'043)		107)		(107)
							*					
<u> </u>			Soluble	Insoluble	Soluble	Insoluble	Soluble.	Insoluble	Soluble	Insoluble	Soluble	Insoluble
· [, 59.	Bromate as: BrO3	****	n in the second s		annan an iordinada.					<u></u>	
C		Chlorite as ClO ₂		·				لأحاصد محاط مأصلك معطوا والأ		······		
o m	61.	Cyclohexylamine* as C ₆ H ₁₃ N Diethylamine* as C ₄ H ₁₁ N	****		*****	nan annan e e an agus da' a b gong		er ales fix jours and dur				
P		Diethylamine*as C4H11NDiethylaminoethanol*as C6H15NO			·*···	••• ••••			alalan manang panga		and the foreign statements	
0 U	64:	Ethylamine* as C ₂ H ₇ N		anne an				jan panananan ka	and photogram in the second		1. 1. jun 19. utvoj stranje a m radavanj	anaanaa maadaa ahkaana'
n n	85.	Morpholine* as C ₄ H ₉ NO		12 - Sangar Managaran Managaran				······································		······	- ite was also de transferie	
d	66.	Diethylene Glycol* % by weight		nonta (desca, a Canana da parte en como en c		maturias				·. · · · · · · · · · · · · · · · · · ·	a na	
S	67.	Ethylene Glycol* % by weight				and a support of the second				The second second second		
		Propylene Glycol* % by weight	 		**************************************		مر وملاحر تشت			÷		-
		Aerobic Plate Count org's/ml	tatanatarinan	1-1-1-10-10-10-10-10-10-10-10-10-10-10-1								
M		Anaerobic Plate Count. org's/ml					annon ann ann an	-		· · · · · · · · · · · · · · · · · · · ·		
c	71.	Fecal Coliform org's/100ml Iron Bacteria			÷			· · · · · · · · · · · · · · · · · · ·			· · · · · · · · · · · · · · · · · · ·	
, îr	73.	Mold org's/ml					unionen enimerrane.		aya e nationalit	nanara dinaha na		Lar ba, anagana, a mana ana ana ana
0	74.	Nitrate Reducers org's/mi	•••••••••••••••••••••••••••••••••••••••		· · · · · · ·	St			•	manage finders rate 1, 24, 176 for 5 and		r Ab
		Slime Formers org's/ml					·	·		÷		-
0	78.	Sulfate Reducers org's/ml					ana na na pina pina pina k					
0	77.	Total Coliform org's/100ml		Summer of the second	مشعر بر بر در مارد در بر بر م				·			
9	78.	Yeast org's/mi	أنهدا براغط فحرابين	وسو درب دب دست	÷				, . 	e elemente del e político constante de la	alanatian cardine e	
-1	79.	Residue by Evaporation	ny mananan yy tay a iyo a				ginnen and and		Lanson in province		···· ·····	-
ca	80.	Volatile Solids System Capacity gal.			·····				رونون			
15	81. 82.	System Capacity gal. Propionate as C ₃ H ₅ O ₂	0:00	annan shirin ar	0.00		0.00		0.00		0.00	
		Total Organic Carbon	4.77		1.67		2:95	concerning and a second s	<1.00		2.74	,
		Total Organic Nitrogen	<0,500	Recorderation and the second second	<0.500	an ann a conaightean a' c	0.54	and a second	<0.500	مىيىن بەربەيىرى بارامىيە ب	<0.500	
		Mexel (A-432)	2.0				1.0	an a	and the second sec	· · ·	3.0	
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			••••	a vyza zorałałanatuł r		n manana a sa					مدرية ويستشته	11 S 10 S
Ϊ.	iq	an an a' an a' an	pre , , and ² , , , , , , , , , , , , , , , , , , ,	i International and a state of the state of					ş		jana - ana	
	ŀ	anter and a second s										en
							and the second	in the second	<u>.</u>	mining support		,
F			arrows an an an fill and and a	nteenned 1 - 19, 1999 - 1999 V	······································	· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·		·/·····	the hardware of agreedy comparison of	nden meneral second as a second	
				ar a data sa sa sa sa sa sa sa sa ta ta ta ta ta ta	11 fr bay 1,00 a part of an analysis of		a	1	1000	An		
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		Surgers and the second surgers of the second surgers and the second second second second second second second s		èsen manipalante	بليسمندم الاعوه	, 			·			
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1		annan 1965 <mark>(gan</mark> o di secerati di di di secerati nan manana manana manana ana sa manana manana mana a		in the survey of the second	and the second second second	hannintan santa a astari		*****	*****	in the second second		
Ŀ		กรรุงการสาว _ท ี่สุดสั <mark>นหมัดและเหลือการสาว</mark> การที่มีผู้รู้สินสำคัญการสาวการสาวการสาวการสาวการสาว		mente insurante province	فعصادات تتعاطي			yuuu are yeeyyaayo			hanininan tara araw inana 1	
1		рто что на 1868 в лите и сладини и на страто с страто и при на страто на страто на страто на страто на страто н	, 196 (° 1999) - 196 (° 1967)	*****					ii			· · · ·
ŀ					* 194. s 1. s			· · · · · · · · · · · · · · · · · · ·		1.8 (0.7).1 (0.9)		
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	/*******	รากกระบบการกระบบการกระบบการกระบบการกระบบการกระบบการกระบบการกระบบการกระบบการกระบบการกระบบการกระบบการกระบบการกระบ				·····		······	÷	5		inginimananan s
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	i	an a							·			
	<u>i</u>	Ali data except pH in parts per million or as indicated					L	L	<u> </u>	*Application by C	as Chromatoora	in hu

					ORY RE				SIS	Customer		1001392
Ö	4	H-O-H Chemicals, Inc.						ny		Report No		indicated
		500 S. Vermont St.	Location:			uclear Pla	ant			Report Da		
		Palatine, IL 60067		1 Cook F						Analysis L		
				Bridgma	n, MI					Sample D	ate: as	indicated
	est	847/358-7400 Fax: 847/358-7082		11/16/06 142)	Treated (#27			11/22/06 142)		11/22/06 7142)		11/29/07 7177)
			Soluble	Insoluble	Soluble	Insoluble	Soluble	insoluble (Soluble	Insoluble	Soluble	Insoluble
Γ	<u> </u>	Alkalinity ("P") as CaCO3	.0	mer han dina an an a'	0		0		. 0		. 0	-
		Alkalinity ("M") as CaCO3	134	······································	136		122		120		122	
w	3. 4.	Alkalinity ("OH") (calculated) as CaCO ₃ Free Mineral Acidity as CaCO ₃			1	1 	providence and an	Mari and strategi		aurana ana ang sala baga sala ito	a se inne manai	
a	5.	Chemical Oxygen Demand (C.O.D.)	10.0	1	9.5		3.8		9.2		4.0	1
1	6.	Chloroform Extractables			· · · · · · · · · · · · · · · · · · ·	·;	<u>,,,</u>		,			·
e	7.	Dissolved Solids	232		236		207	a na manana a sa a na manana ma	218		213	ļ
Ŷ	8.	Hardness (Calcium) as CaCO3	91		93	ana ana ang ang ang ang ang ang ang ang	.82				85	
P	9. 10.	Hardness (Magnesium) as CaCO ₃ Hardness (Total) as CaCO ₃	49		49		44	a angestian tanananan .	44		45	·
	11.	Hardness (Total) as CaCO ₃ pH	139 7.8		142 8.1		126 8.2		127 7.9		130 8,1	·····
0	12.	Specific Conductance umhos	7.0 . 347	····	350		o.2 315		7.9 325		o.i 320	······
P	13.	Specific Gravity g/ml				nen danara karaktesendar				anantara dia mananga		
ė	14.	Suspended Solids	-	106	····	30:0		51:0		15.8		133
r,		Aluminum as Al	0.01	1.42	0.01	0.21	0.00	0.45	0.00	0.19	0.01	0.63
ľ	16. 17.	Barium as Ba Calcium as Ca	0.02	0.01	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.01
e	18.	Calcium as Ca Chromium as Cr	36.2 0.00	5.81 0.00	37.3 0.00	0.00 0.00	32.7 0.00	3.66 0.00	33.0 0.00	0.05	34.1 0.00	5.75 0.00
S	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	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
		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. 26.	Nickel as Ni Potassium as K	0.00 1.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00 1.36	0.00
	27.	Silver as Ag	0.00	.0:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C	28.	Sodium as Na	7.61		7.89		6.40		6.62		6.95	0.00
8	29.	Strontium as Sr	0.11	0.00	0.11	0.00	0.10	0.00	0.10	0.00	0.11	0.01
1	14.1014.04.4	Zinc as Zn	0.00	0.03	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.03
0	31.	Total Cation Millequivalents	3.153		3.230		2.831		2.865		2.945	
n s	32. 33.	Acetate as C ₂ H ₃ O ₂ Bromide as Br	0.00	, -16-20.000.000.0000.0000.0000.0000.0000.00	0.00	a da sa	0.00	ana in traces	0.00		0.00	
	34.	Bromide as Br Chloride as Cl	0.00		0.00		0.00 11.1	i serve a company	0.00	······	0.00 11.5	·····
·	35.	Chlorate as CIO ₃	0.00	ind the second se	0.00	·*) · · · · · · · · · · · · · · · · · ·	0:00		0.00	and a set of a second sec	0.00	
	36.	Chromate as CrO4		yaanaa ah oo dhaanaa		· · · · hanna · una dendaren		ahanimumeta direta j		1		
·	 10.0000 	Fluoride as F	0.05		0.03		0.00		0.Ò0		0.04	
	**********	Formate as CHO ₂	0.00		0.00	- 1011 100050000.000 - 1000500.05	0.00		0.00	and the second sec	0.00	
	frances and serves	Glycolate as C ₂ H ₃ O ₃ .	0.00	an ching	0.00		0.00		0.00	~	0.00	9 Mar
:		Molybdate as MoO ₄ Nitrate as NO ₃	0:00 1:66		0.00	· · ·	0.00		0.00	·	1.08	and a station and
	What's measures.	Nitrite as NO ₂	0.00		0.00		0.90		0.93		1.08	
•		Nitrogen (total) as N		· · · · · · · · · · · · · · · · · · ·				ny santa a taitain a santan a	0.00			······
. [44.	Oxalate as C ₂ O ₄	0.00		0.00		0.00		0.00		0.00	j.
:		Phosphate (ortho) as PO ₄	0.00		0.00		0.00		0.00		0.00	
A		Phosphate (poly) as PO4										
្តាៈ		Phosphate (organo) as PO4 Phosphorus (total) as P	0.00	0.07	0.00	0.00	0.00	0.01	0.00			0.21
0		Sulfate as SO4	22.6	.0.07	22.8	0.00	21.0	0.01	24.4	0.00	0.00	
n		Sulfur (total) as S	7.93	0:00	8.09	0.00	7.16	0.00	8.39	0.00	8.23	0.00
5	51.	Total Anion Millequivalents	3.602		3.652		3.244	No. 191 and a day to a day	3.281		3.291	<u> </u>
	description of the second	Ammonia as NH3						and the second sec			and the second second second second	
	Astron to to the	Benzotriazole as C ₆ H ₅ N ₃) 		, ,	
		Boron as B	0.40		0.26		0.18	0100	0.12		0.99	
	********	Silica as SiO ₂ Sodium Nitrite as NaNO ₂	1.66	5.63	1.56	1.08	1.04	2.03	1.08	1:32	1.16	1.81
		Sodium Sulfite as Na ₂ SO ₃		unates victoreau e				· · · · · · · · · · · · · · · · · · ·		· · · · · · · · · · · · · · · · · · ·		
	58.	Tolyltriazole as C7H6N3			·····		·	in an	÷		••••••••••••••••••••••••••••••••••••••	
anya.		All data except pH in parts per million or as indicated			Co	ntinued on	reverse side	9.				

				BORAT					SIS	Customer		1001392
		H-O-H Chemicals, Inc.	Regarding:	Ingiana a	ADD MICH	gan, Powe	r Compa	ny		Report No		indicated
		500 S. Vermont St.	Location:	Donald C	COOK N	uclear Pla	ant			Report Da	ate:	
		Palatine, IL 60067		1 Cook F						Analysis I		
			<u> </u>	Bridgmai	n; MI					Sample D	bate: as	indicated
		847/358-7400										
		Fax: 847/358-7082		11/16/06		11/16/06		11/22/06		11/22/06		11/29/07
			(#27	142)	(#27	142)	(#27	'142)	(#27	142)) (#27	(177)
			Soluble	Insoluble	0-2-515		0/1/1		<u>`</u>	Line Bra	· · ·	<u> </u>
<u> </u>			Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
ľ		Bromate as BrO3			·····	-	, q	*****		*****		
C	60.		*** • ***					· · · · · · · · · · · · · · · · · · ·				
o m	-61.		·	÷	,							
		Diethylamine* as C4H11N										
P	63.		·				·		·····			
U.		Ethylamine* as C ₂ H ₇ N		**	······							
n	65.	Morpholine as C ₄ H ₉ NO			*****	·		·····				
d s	68.	Diethylene Glycol* % by weight Ethylene Glycol* % by weight	Manager and the state of the st		·····		· ••••••••		أماد سيبتغ بريان يردد الردام وراسان			
	07.	Ethylene Glycol* % by weight Propylene Glycol* % by weight	en constitut de l'hele la constitut e	العابقة مسترسيا	······································	• • • • • • • • • • • • • • • •	ninennan mark vitatur					ser ge, w P
	69.	Aerobic Plate Count: org's/ml	raararahirin to diktopoon			·····	manani arra i sama,		÷			·
		Anaerobic Plate Count org's/ml.		<u>ي ، محمد المحمد الم</u>	,,. ,.	· ·	······································	*				
,M		Fecal Coliform org's/100ml			······	÷	· · · · · · · · · · · · · · · · · · ·	·				
0		Iron Bacteria:				······		·				
Г	73.	Mold org's/ml									····	~ •
0	74.	And a state of the second state of the second state of the state of the second state o										··· · · · · · · · · · · · · · · · · ·
	75.							n,	• • • • • • • • • • • • • • • • • • • •			••••••••••••••••••••••••••••••••••••••
		Sulfate Reducers org's/ml										
ľ	77.	Total Coliform org's/100ml	· · · · · · · · · · · · · · · · · · ·	····· Barrow	an tanta article Conger Constant	harnonoron o popolernak verave					Namp 141.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.	
ю,	78.	Yeast org's/ml					,				······	
:9. -	79.	Residue by Evaporation			······			**************************************		1	**************************************	
ic.	80.								• ·			
а	81.		•••••						·	· · · · · · · · · · · · · · · · · · ·		
1	82.	Propionate as C ₃ H ₅ O ₂	0.00		0.00		0.00		0:00		0.00	
		Total Organic Carbon	1:80	and a distribution of the second	3.14	· •. · · · · · · · · · · · · · · · · · ·	2.26		2.16		4.98	·····
	84.	Total Organic Nitrogen	<0.500	eren 19. den non annandisser	1:23		1.42		1.09		0.97	
ſ	85.	Mexel (A-432)			3.0		and a second second second	anner 1	3.0			,
ŀ.		· · · · · · · · · · · · · · · · · · ·										
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					** '8-10			·····				
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	••• <i>•</i> ••						····				····· ;·····	
	<u>.</u>		A									
			<u>.</u>	· · · ·	.	~~~~~	1.9-9-10-00-00-00-00-00-00-00-00-00-00-00-00-	•				
:				, /	v'i-,		Second Second				······································	
		1999		~~~~		······	,					
	61.13 www.						999 (1999) - State (1999) - State (1997) -		. »		· · · · · · · · · · · · · · · · · · ·	
	•						- <u>1</u>	andana ana ang barang sa	6.990 m	-		
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	. بەتەرىغان			، فسیسی ند داده س	*******	····	*******					
		All drite events abi in marte des million or pe indicated.			L			the second se			1 Sas Chromalouru	

All data except of in parts per million or as indicated

				LA	BORAT	ORY REP	PORT - Y	WATER	ANALY	SIS	Customer	No.:	1001392
6		H-O-H Chem							ny		Report No	as as	indicated
		500 S. Ve	rmont St.			Cook Ni	uclear Pla	ant	· · · ·		Report Da		1 14
Ş.,	ч ((ふ) 「 Palatine	, IL 60067		1 Cook F				·		Analysis E		
2					Bridgma	<u>n, MI;</u>					Sample D	ate: as	indicated
L	රාක		/358-7400 /358-7082	Treated (#27	A	Control (#272		Treated (#27			12/14/06. 246)	Treated (#27)	
				Soluble	insoluble	Sotuble	Insoluble	Soluble	Insoluble	Soluble	insoluble	Soluble	Insoluble
Ĩ.	1.	Alkalinity ("P")	as CaCO ₃	4		0				0		ol	4
	2.	"A brief a beams and the first " start " showing a grant of the start start and the part of the st	is CaCO3	130	~~~~~·····	134		0 134		124	*****	130	
	.3.		as CaCO3										
Ŵ			as CaCO ₃						<u></u>				
a	5.	Chemical Oxygen Demand (C	C.O.D.)	8.0		11.8		22.6		7.9		14.7	****
1	6,	Chloroform Extractables		010			·····	007					
e	7.	Dissolved Solids Hardness (Calcium) a	as CaCO ₃	210 83		230 89		237	umanena alexa este e	203	······	203 79	
1	9	Construction of the constr	as CaCO ₃	45		47		89 47		43	And the second s	43	······
P	10.	and an analysis of the state of	as CaCO ₃	128		136		136		122		122	****
$\left \right $	11.	pH		8.2		7.9		7:8		8.0		7.9	·
0	12.	sense and seasons and s	imhos'	:314		337		350		308		296	
Ρ	13		ı/ml	a							,		
e		Suspended Solids			6.0		315		78.0		340		21.0
I.	15.		is Al	0.01	0.03	0.01	3,35	0.01	1.02	0.02	2.34	0.01	0.46
	16: 17:	and a second	ns Ba ns Ca	0.02	0.00	0.02	0.03	0.02	0.01	0.02	0.02	0.02	0.00
	18.	state and a subject of the second	is Ca	0.00	0.00	35:5	0.01	35.6 0.00	0,00	31.5	where processing and the second secon	0.00	0.00
	19		is Cu	0.00	D.02	0.00	0.01	0.00	0.00	0.00	that an encoder or reserves of a	0.00	0.00
	20		ns Fe	0.00	0.05	0.00	6.03	0.00	1.56	0.00	4.34	0.00	0.54
	21.	and the state of the second	as Pb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000
	22.	Lithium a	is Li	0.00	.0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	23.	Magnesium a	as Mg	10.8	0.00	11.5	11.0	11.5	1,98	10.5	9.43	10.5	0.71
ſ	.24.	and a second and the second se	is Mn	0.00	0.00	0.00	0.22	0.00	0.05	0.00	0.13	0.00	0.01
	25.	a la gran er	is Ni	0.00	0.00	0.00	0.00	0:00	.0.00	0.00	0.00	0.00	0.00
	26.	Property of the second state of the second sta	is K	1.53		1.56		1.65		1.23		1.25	
	27 28	and the second	as Ag	0.00 7.02	0.00	0.00	0.00	0.00	0.00	0.00 6.60	.0.00	0.00	0:00
a	28.		is Na is Sr	0.11	0.00	7.61	0.03	<u>7.73</u> 0.11	0.00	0.10	0.03	0.05	0.00
T.	30.	2 Pro - 1 a Tana and a tana and a tana and a tana ang ang ang ang ang ang ang ang ang	is Zn	0.01	0.02	0.00	0.06	0:00	0.00	0.00	0.04	0.00	0.00
	31.	Total Cation Millequivalents		2.896		3.095	التهقيقية, ريسيات	3.100		2.756		2.758	
n.	32.		IS C2H3O2	0.00		0.00		0.00	· • • • • • • • • • • • • • • • • • • •	0.00		0.00	
s	33.		is Br	0.00		0.00		0.00		0.00		0.00	
	www.en.		is Cl	11.7		13.4		14.1	·	11.9		11.7	
	35.		IS CIO3	0.00		0.00	مستمده ببذيره الم	0.00	محمليت فيستحدث	0.00		0.00	
	36.	An end of the second	is CrO ₄									·	······································
ſ	37.	service and the service of the servi	is F is CHO ₂	0.05		0.00		0.04		0.04		0.04	
	an any comparison in the		is C ₂ H ₃ O ₃	0.00		0.00		0.00 0.00		0.00		0.00	
			IS MOO4	0.00		0.00		0.00	*******************************	0.00		0.00	
			IS NO ₃	1.07		2.03		2.13		1.02	Parameter a 198 per	1.10	
	Arministry .		IS NO ₂	0.00		0.00		0.00	• • • • • • • • •	0.00	and the second s	0.00	
	43.	Nitrogen (total) a	IS N										
			IS C ₂ O ₄	0.00		0.00		0.00		0.Ò0		0.00	
	a management		IS PO4	0.00		0.00		0.00		0.00		0.00	
A	46. 47.	second	is PO4				(4) a	**************************************				:	
l n	47.		is PO ₄	0.00	0.14	1.01	0.00	0.45	0.00	0.00	0,15	0.00	0.03
0	49.		IS SO4	21.5	0.14	23.3	0.00	28.4		22.3		21.9	
n	50.		IS S	7.69	0.00	7:97	1 19	9.31	0.56	7.02	1.14	7.02	0.00
8		Total Anion Milleguivalents		3.446		3.685		3.795		3.342		3.451	
1		Ammonia a	s NH3			-					·········		······
	Sector Se		IS C6H5N3	+ + + + + + + + + + + + + + + + + + + +					have any are as a set of the				
		and press resides the property of the press of the property of	s B	0.59		0.05		0.01	المتعقبين والمتعقب	0.00		0.00	
	55,		s SiO ₂	1.06	0.26	2:25	11.02	2.26	3,69	1.37	8.42	1.35	2.05
	56:		IS NaNO2										
	and the second second second		IS Na ₂ SO ₃ IS C ₇ H ₆ N ₃		·····	··································	÷	·····					
		All data except pH in parts per million or as indix		I		Co	ntinued on	reverse sid	e.	L	L		

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		H-O-H Chemicals, Inc.								Customer Report No		1001392 indicated
		500 S. Vermont St.	Location:	Donald C	Cook N	uclear Di	a Compai			Report Da		nulualeu
		Palatine, IL 60067	Location.	1 Cook F	Place	ucical rik	<u>ant</u>			Analysis I		
		Falatilie, IE 00007		Bridgmar					·	Sample D		indicated
		847/358-7400 Fax៖ 847/358-7082		11/29/06. (177)	Control	12/7/06 204)		12/7/06 204)		12/14/06 246)	Treated	12/14/06 246)
		· ·	Soluble	Insoluble	Soluble	insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
Π	59:	Bromate as BrO3				,						
c	60:											
0		Cyclohexylamine* as C ₆ H ₁₃ N			-	Anno 1990 Anno 1990 - 1997	·····	* :	a him to a summinum			
n p		Diethylamine* as C ₄ H ₁₁ N				-				· · · · · · · · · · · · · · · · · · ·		ware of economics for the set
0		Diethylaminoethanol* as C ₆ H ₁₅ NO		··· ····			· · · · · · · · · · · · · · · · · · ·		• 			4
L u		Ethylamine* as C ₂ H ₇ N Morpholine* as C ₄ H ₉ NO					······		19. r.a			
n d		Diethylene Glycol* % by weight			,		**************************************	*****	······			
5		Ethylene Glycol* % by weight	:			.	· · · ·	·····				
		Propylene Glycol* % by weight	بينفينسيون والأدما ممرز	14 al secondena n al Princ			·		n an		······	
		Aerobic Plate Count org's/ml			**************************************	المستعملة متدوعهم						,
м	70.	Anaerobic Plate Count org's/ml							· · ·			
],i]	71.	Fecal Coliform org's/100ml										
C C		Iron Bacteria		, 								
ò	73:	Mold org's/ml		2	in -	*****						
:Б.	74.	Nitrate Réducers org's/mi						. مود سینی بارین	*·····			
	75.	Slime Formers org's/ml										.
0		Sulfate Reducers org's/ml Total Coliform org's/100ml				****						**************************************
0	78.	Yeast org's/ml		· ······			······				·····	
9		supervised is here a manufacture of the supervised states of the supervised states of the supervised states and the superv		·		······································		**************************************	 ;			
	80.	Volatile Solids					atoma .	******				، مسلح بي عد معد محمد ، روسيد.
a	81.	and a second s			**************************************	····· • ······························	· · · · · · · · · · · · · · · · · · ·				·· ***********************************	
[4]	82.	Propionate as C ₃ H ₅ O 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	And the second s
	84.	Total Organic Nitrogen	1.23		<0.500		1.01		<0.812		<0.800	
	85.	Mexel (A-432)	2.5				5.0			·.	4.5	• ####################################
				• · · · · · · · · · · · · · · · · · · ·	·		· · · · · · · · · · · · · · · · · · ·	·····			i	
			·	·····		• .•	······	->	54	,	an an an air an a' a' an	
	** ** ******	and the second secon	سر بردینینینین		• And .	mana di seconda da seconda di s		****				
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		· · ·		Carlos and C		9-1 Consumeror 416-0			+			
11		an a	-francessing a minute									
	·		~			-Liminut						
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	·	1.9.9		·····	•		•	•				
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ŀI	······				·····	• •		ر سرد بر میکرد معر ب مر				· · · · ·
			·····			·						
							the production					he countries and a second
		المراجع من المراجع الم المراجع المراجع	المستعينية المستنبس	• bayes			1					
					1.1%							
		ราก พระการการการการการการการการการการการการการก	· · · · · · · · · · · · · · · · · · ·							1		
	·					سيبيوه متعققته		, ».†••••••••••••••••••••••••••••••••••••				
			محمد بسب محمد م		······	••••				·····	·	
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					· · · · · · · · · · · · · · · · · · ·			***	****			
		a mananana ana ana ana ana ana ana ana a		······			<u></u>					in.j. (4.000)
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	··· ~~.	an 1949 (199		•				·		fammin astration		,
			•									
ſĺ												
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	_	All data except off in parts per million or as indicated									as Chromatoora	

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				ĹÂ	BORAT	ORY REF	PORT -	WATER	ANALYS	SIS	Customer	No.:	1001392
r	~		Chemicals, Inc.						ıy.		Report No	o.: as	indicated
7		500	0 S. Vermont St.	Location:	Donald C	Cook Nu	clear Pla	ant			Report Da	ite:"	•
ŀ	U ((alatine, IL 60067		1 Cook F		· · ·				Analysis [Date:	
1.		7 41			Bridgmai	n, MI					Sample D		indicated
Ľ.	ವರರು	CORDINATION OF	847/358-7400			·			· 1				
C			x: 847/358-7082	Control 1	2/21/06	Treated 1	2/21/06	Control 1	2/28/06	Treated	12/28/06	Control	1/4/07
				(#27)	294)	(#272	294)	(#27:	323)	(#27	323)	(#27	352)
		,											
·		A.0		Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	<u>1.</u> 2.	Alkalinity ("P") Alkalinity ("M")	as CaCO ₃ as CaCO ₃	0		0	antonominija jinda ću 4.400 (in 1.2	0		8 104		0	
	3.	Alkalinity ("OH") (calcul		110		116		116		104	anter anter anter a second a s	118	• ••••••
w	4:	Free Mineral Acidity	as CaCO ₃	1997-999 - 19 - 19 - 19 - 19 - 19 - 19 -			te anno an tai ann an tai t		eren en e		·		·····
a	5.	Chemical Oxygen Der	and a second sec	7:5		16.0	* 17 % - 16. 18 m a 16. Frankrike warmen	6.4		29.4		14.3	
t	6.	Chloroform Extractabl	A REAL PROPERTY OF A REAL PROPER				-41-64 8 (1911) - 1911 - 1919			nan nottetiis	*****	n ann an ann an Anna Anna an Anna Anna	··· •··
e	7.	Dissolved Solids		208		198	a aya alin (in angan ana ana ang	196		191		199	· · · · · · · · · · · · · · · · · · ·
	8.	Hardness (Calcium)	as CaCO3	81		79		79		79		80	
[_	9.	Hardness (Magnesiun		43		43		44		44		43	
Р	10.	Hardness (Total)	as CaCO3	124		123		123		123		123	
0	11. 12.	pH Specific Conductance	umbon	7.7 308		8.0 293	~ ~~+~~	8.2		8.4		8.0	
	13.	Specific Gravity	μmhos g/ml	<u>-308</u>				295	·	293		295	·····
e	14.	Suspended Solids	a		108		3.0		13.0		13.0		305
E.	15.	Aluminum	as Al	0.02	1.07	0.02	0:03	0.02	0.80	0.02	0.12	0.01	3.11
1.1	16.	Barium	as Ba	0.02	0.00	0.02	0.00	0,02	0.00	0.02	0.00	0.01	0.02
11	17.	Calcium	as Ca	32.3	7.13	.31.8	0.00	31.6	3:27	31.8	0.00	31:8	31.9
:e	18.	Chromium	as Cr	0.00	0:00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
S	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 Lithium	as Pb as Li	0,000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	23.	Magnesium	as Mg	10.5	0.00 2.91	0.00	0:00 0:00	0.00	0.00	0.00	0.00	0.00	0.00 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
ľ	.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
C	28.	Sodium	as Na	5.89	-	6.12		6.70		6.65	arig 100-10-10-10-10-10-10-10-10-10-10-10-10-	6:34	
a	29.	Strontium	as Sr	0.11	0.00	j0.11	0.00	0.10	0.00	0.11	0.00	0.10	0.02
1	30.	Zinc:	as Zn	0:01	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.06
Ó	31. 32.	Total Cation Millequiva Acetate		2.776		2.762		2.779	. <u></u>	2.792		2.769	·····
n,	33.	Bromide	as C ₂ H ₃ O ₂ as Br	0.00	** ***********	0.00		0.00		0.00	· • • • • • • • • • • • • • • • • • • •	0.00	
"	34.	Chloride	as Ci	8.74		0.00		0.00		0.00 10.5		0.00	· ··· ····
	******	Chlorate	as ClO ₃	0.00	·····	0.00		0.00		0.00	·	<u>11.0</u> 0,00	
	36.	Chromate,	as CrO4						·····	0.00			
	37.	Fluoride	as F	0.01		0.00		0.02		0.00		0.03	
	e ne nagigeren e	Formate	as CHO ₂	0.00		0.00		0.00		0.00		0.00	
		Glycolate	as C ₂ H ₃ O ₃	0.00		0.00		0:00		0.00		0.00	
		Molybdate	as MoO ₄	0.00		0.00		0.00		0.00		0.00	
		Nitrate Nitrite	as NO ₃ as NO ₂	1.28		0.60		0.85		1.03		0.98	
		Nitrogen (total)	as NO ₂	0.00		0.00		0:00	miner as	0.00		0.00	
		Oxalate	as C ₂ O 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	en en de la constante de la con	0.00	
A		Phosphate (poly)	as PO ₄				·				1		
'n	- PRATE ROOM	Phosphate (organo)	as PO4							المنابعة ومنابعة والمحاودين	N.V.14		ļ
		Phosphorus (total)	as P	0.09	0.06	0.00	0.02	0.04	0.04	0.00	0.02	0.00	0.19
o n	*******	Sulfate	as SO4	20.4		19.8		21.4		21.6		21.4	í
5		Sulfur (total). Total Anion Millequival	as S	6.54	0.94	6:59	0.88	6.80	0.75	6.78	0.62	7.32	1.99
	********	Total Anion Millequival Ammonia	as NH ₃	3.064	iii	3.029		3.142		2.900		3.132	
		Benzotriazole	as NH ₃ as C ₆ H ₅ N ₃	l.						n alaskerna	~~~~		
		Boron	as B	0.00		0.00		1.45		0.82		0.00	
		Silica	as SiO ₂	1.44	1.88	1.08	0.00	1.15	2.15	1.12	0:00	0.00	9:75
		Sodium Nitrite	as NaNO ₂							• • • • • • • • • • • • • • • • • • •			
	an common a	Sodium Sulfite	as Na ₂ SO ₃			······································							
		Tolyltriazole [,]	as C ₇ H ₆ N ₃										
100		All data except pH in parts per million	n or as indicated	· · · · · · · · · · · · · · · · · · ·		Cor	ntinued on	reverse side					

								ANALYS	SIS	Customer		1001392
1		H-O-H Chemicals, Inc.	Regarding:	Indiana a	and Michi	gan Powe	er Compa	ny		Report No	o.: as	indicated
	•	500 S. Vermont St.	Location:	Donald C	Cook N	luclear Pl	ant		_	Report Da	ate:	
		Palatine, IL 60067		1 Cook F	lace	· • • .				Analysis I		
		· · · · · · · · · · · · · · · · · · ·		Bridgma						Sample:D		indicated
		847/358-7400 Fáx: 847/358-7082		12/21/06 294)	Treated	12/21/06 7294)	Control (#27	12/28/06 (323)		12/28/06. '323):	Contro	i 1/4/07 352)
			Soluble	Insoluble	Soluble	insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
Г	59.	Bromate as BrO3				[1		
l.c	60	Chlorite as ClO ₂					ar an an an an an Art an Anna an	marina i hannad		•		
jò.	61.	Cyclohexylamine* as C ₆ H ₁₃ N							••••••••••••••••••••••••••••••••••••••	····		
m		Diethylamine* as/C ₄ H ₁₁ N	······	·•••••••••••••••		,,						
P	63.	Diethylaminoethanol* as C ₆ H ₁₅ NO	5 a.a				**************************************	·····	و بر در به مشاور شده المسلم الم		en dimensionen	
0 U	64:	Ethylamine* as C ₂ H ₇ N			All and a second se		1999 A.P. 1999 (1999) 111				-	**************************************
- n	65.	Morpholine* as C4H9NO		,		In the second				18. martine a series	and and the providence of the state of the s	
d	68.	Diethylene Glycol* % by weight				ALL DESCRIPTION OF THE PARTY OF		······	ie. New			
8	67.	Ethylene Glycol* % by weight		postation of the second			And the second sec					
·		Propylene Glycol* % by weight										
ľ		Aerobic Plate Count org's/ml										
M		Anaerobic Plate Count org's/ml									in the second second	· · · · · · · · · · · · · · · · · · ·
12	and the second second	Fecal Coliform org's/100ml	···									
C	72.	Iron Bacteria	- 									
0	73.	Mold crg's/ml						······				
b	74.	Nitrate Reducers org's/ml		······	÷						· · · · ·	
	75.	Slime Formers org's/ml			·····		•••••	····			·····	
1°		Sulfate Reducers org's/ml Total Coliform org's/100ml	i					·····				·····
	77: 78.			• • · · · · · · • • ·								
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11	80:	Volatile Solids					rð. í næra ar sen a		lanina a rrainn		· · · · · · · · · · · · · · · · · · ·	
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Ĩ		Propionate as C ₃ H ₅ O ₂	0.00		0.00		0.00		0.00		0.00	
		Total Organic Carbon	1.94		4.29		3:09		7.78		5.63	
	84.	Total Organic Nitrogen	<0:500	for the second s	0.51	North Marcola Contraction of the	<0.500	and the second s	0.93		<0.500	
ľ	85.	Mexel (A-432)			8:0				8.0			
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Bit Strate Bool S. Vermont St. Leselistic Denald C. Cook Nuclear Plant Repent Date: Sample Date: Analysis Date: 1 Akalinity (TP) as CaCO, 3 Treated 1/407 Control 1/11/07 Treated 1/407 (#27369) Control 1/11/07 (#27436) 2 Akalinity (TP) as CaCO, 3 10 0 0 0 12 6 124 6 124 124 6 124		H-O-H Chemicals, Inc										indicated
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r 15. Auminum. as Ai 0.01 0.30 0.02 2.55 0.01 0.38 0.01 0.05 0.01 0.00 <t< td=""><td></td><td></td><td></td><td></td><td>· · · · · · · · · · · · · · · · · · ·</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>					· · · · · · · · · · · · · · · · · · ·							
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a 19. Copper as Cu 0.00 0.00 0.00 0.00 0.00 0.00 20. Iron as Fe 0.00 0.81 0.00 4.43 0.00 0.72 0.00 0.90 0.90 21. Lead as Fe 0.00 </td <td></td> <td>A BARANG A AND A</td> <td>a meteration analysis and the second state</td> <td>VL4 when an an</td> <td></td> <td>and a subsection of the</td> <td>management of the second</td> <td>The state of the s</td> <td></td> <td>On a many set of set of a Section,</td> <td>hat the person in the sector of the sector of the</td> <td>0.00</td>		A BARANG A AND A	a meteration analysis and the second state	VL4 when an		and a subsection of the	management of the second	The state of the s		On a many set of set of a Section,	hat the person in the sector of the sector of the	0.00
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23. Magnesium es Mg 10.6 0.75 10.6 5.60 10.8 0.05 10.7 0.90 10.7 24. Manganese as Mn 0.00	21.	warners with a second state and a second state and second state and second states and se	" Introduce and and a second second		*************			0.000		-0.000	0.000	0.000
24. Manganese as Mn 0.00 0.02 0.00 0.16 0.00 0.03 0.00 0.00 26. Nickel as Ni 0.00	22.	Lithium as Li	0.00	0.00	0.00	0:00	0.00	0.00	0.00	0.00		0.00
25. Nickel as Ni 0.00 <		and the second s	-			· · · · · · · · · · · · · · · · · · ·	anisia as spinister	***************************************				0.03
28. Potassium as K 1.27 1.40 1.65 1.29 1.32 27. Silver is Ag 0.00		and shall be the second s									***************************************	0.01
27. Silver as Ag 0.00 0.01 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 <			·	0.00		0.00		0.00		0.00	***************************************	0.00
C 28. Sodium as Na 6.43 6.70 7.34 6.83 6.83 3 Strontium as Sr 0.10 0.00 0.10 0.00 0.10 0.01 0.11 30. Zinc as Zr 0.00 0.02 0.01 0.18 0.00 0.04 0.00 31. Total Cation Millequivalents 2.775 2.810 2.891 2.845 2.852 32. Acetate as C_H_SQ_2 0.00 0.00 0.00 0.00 0.00 0.00 34. Chloride as Cl 11.10 12.7 12.5 11.3 11.1 35. Chiorate as ClO ₃ 0.00 0.00 0.00 0.00 0.00 36. Chromate as CHO ₂ 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00			When one consideration and the second s	0.00	Ward Block Sciences and an and an	0.00		0.00		0.03		0.00
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n 32. Acetate as C ₂ /H ₃ Q ₂ 0.00 0.00	^t 30.	Zinc as Zn	0.00	0.02	0.01	0.27	0.01	0.18	0:00	/ 0.04	0.00	0.02
8 33. Bromide as Br 0.00 <th< td=""><td>V</td><td></td><td></td><td></td><td></td><td>• ••••</td><td></td><td></td><td></td><td></td><td></td><td></td></th<>	V					• ••••						
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35. Chiorate as ClO ₃ 0.00 0.00 0.00 0.00 0.00 38. Chromate as F 0.03 0.00 0.00 0.00 0.00 0.00 38. Formate as CHO ₂ 0.00 0.00	1.000 March 10	a hand the state of the state o	- Careboard and the state of the Second Science of the		propriate a construction for factors and	•	Art crossessessesses		and the second		and a second	
38 Chromate as CrO ₄		a a far i fa far ann an an ann an an a' Chairmean an a	A AND A A A A A A A A A A A A A A A A A		he is not an					·		· · · · · ·
37. Fluoride as F 0.03 0.00 0.00 0.00 0.00 38. Formate as CHO2 0.00		The public determines the resulting of the second	0.00	···· ·································		or and a	0.00	*****	0.00		0.00	
38. Formate as CHO2 0.00		A spectrum de la construction de la const esta construction de la c	0.03		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		A second and introductions of a general second seco	advertising the set of a state of a set		0.00		0.00	······································				
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42 Nitrite as NO2 0.00 0.00 1.00 0.34 43 Nitrogen (total) as N 0.00	Contraction of the local division of the loc						encourse of whether projection ?					
43: Nitrogen (total) as N	********				**************************************				in the law second second second			·
44: Oxalate as C ₂ O ₄ 0.00 0.00 0.00 0.00 0.00 45: Phosphate (ortho) as PO ₄ 0.00 0.00 <td< td=""><td>1.12-16</td><td></td><td></td><td>······</td><td>0.00</td><td></td><td>0.00</td><td></td><td>1.00</td><td>·</td><td>0.34</td><td>*****</td></td<>	1.12-16			······	0.00		0.00		1.00	·	0.34	*****
45 Phosphate (ortho) as PO4 0.00 <td></td> <td></td> <td>0,00</td> <td></td> <td>0.00</td> <td></td> <td>0.00</td> <td></td> <td>0.00</td> <td>· ·</td> <td>0:00</td> <td></td>			0,00		0.00		0.00		0.00	· ·	0:00	
n 47. Phosphate (organo) as PO4		Phosphate (ortho) as PO4		ana		·····						
48 Phosphorus (total) as P 0.00 0.02 0.00 0.06 0.00	A	A CONTRACT OF A		······					· · ·			
o 49: Sutfate as SO4 21:1 23:3 22:7 21:3 20:8 1 50: Sutfur (total) as S 7.33 0.54 7.52 0.76 7.77 0.31 7.33 0.87 7.38 51: Total Anion Millequivalents 3.167 3.388 3.365 3.325 3.254 52: Ammonia as NH ₃	and the second second second	· · · · · · · · · · · · · · · · · · ·	-									
n 50. Sulfur (total) as S 7.33 0.54 7.52 0.76 7.77 0.31 7.33 0.87 7.38 9 51. Total Anion Millequivalents 3.167 3.388 3.365 3.325 3.254 52. Ammonia as NH ₃	********	A second se		.0.02	and a second sec	0.06		0.00				0.00
s Solution (strate) as S 7.55 0.04 7.52 0.16 7.65 0.01 7.55 51 Total Anion Milleguivalents: 3.167 3.388 3.365 3.325 3.254 52 Ammonia as NH ₃				0.54		0.76		0.21			The second second second second	0.63
52 Ammonia as NH3 53. Benzotriazole as CeHaN3	a	· · · · · · · · · · · · · · · · · · ·		0.54		0.10				And a state of the state and a state of the		0.03
53. Benzotriazole as:CeHeN3.			<u> </u>		0.000		3.303		0.020			
	mound	a state was a state of the stat					· · · · · · · · · · · · · · · · · · ·	·······				
	54.	Boron as B	0.00		0.00		0.00		0.00	and the second s	0.00	
55. Silica as SiO ₂ 0.00 0.93 0.00 7.75 0.00 0.00 0.00 0.00 0.00		· · · · · · · · · · · · · · · · · · ·	0.00	0.83	0.00	7.75	0.00	0.00	0.00	0.00	0.00	0.00
56. Sodium Nitrite: as NaNO2	An publication			i.				······································				
57. Sodium Sulfite as Na2SO3 58. Tolyltriazole as C7H6N3	her a she was a she was	· · · · · · · · · · · · · · · · · · ·							:			
Aure. All data except pH in parts per million or as indicated Continued on reverse is ide :			Ll	·	Co	ntinued on	reverse sid	e:	<u></u>	<u></u>	·,	L

							WATER		SIS	Customer Report No		1001392 indicated
		H-O-H Chemicals, Inc. 500 S. Vermont St.	Regarding:	Donald C		Jan POWE	a Compai	iy		Report Da		muicated
			Location:	1 Cook F	DOOK IN	uclear Pla				Analysis [{
		Palatine, IL 60067		Bridgman		······			<u>·</u>	Sample D		indicated
		847/358-7400 Fax: 847/358-7082		3 1/4/07 352)	Control	1/11/07 7369		1/11/07 369)		1/18/07 '436)	Treated	1/18/07 7436):
-			Soluble:	Insoluble	Soluble	Insolúble	Soluble	Insoluble	Soluble	Insoluble	Soluble	insoluble
i –	59.	Bromate as BrO3			Controle,	madidulo	- Gonzbio	Anodia dia				
c	60.	Chlorité as ClO ₂										
6		Cyclohexylamine* as C ₆ H ₁₃ N	9. Je mjer och samer er er po		······································							
m		Diethylamine* as C ₄ H ₁₁ N										
P	63.	Diethylaminoethanol* as C6H15NO			····	1	4.,					· · · · · · · · · · · · · · · · · · ·
.0. .u	64.	Ethylamine* as C ₂ H ₇ N				-	······································	· · · · · · · · · · · · · · · · · · ·			ογο - ο για δαφτέκα αποστρούτη - -	
n	65.	Morpholine* as C ₄ H ₉ NO				and the second						
d	66.	Diethylene Glycol* % by weight										
S		Ethylene Glycol* '% by weight	· · · · · ·	-	S							
	68.	Propylene Glycol* % by weight		الجبيبينية بمرمهدهن وداده				· · · · · · · · · · · · · · · · · · ·		·····		
1		Aerobic Plate Count org's/ml	• 2.00.000000000000000000000000000000000	· · · · · · · · · · · · · · · · · · ·	·····	نى يىتىت ىپىرىيە ، ، ،						
M	70.	Anaerobic Plate Count: org's/ml				·····						
		Fecal Coliform org's/100ml		· · · · · · · · · · · · · · · · · · ·	······	د د مناطقه می می او د او د						
Ç. r		tron Bacteria Mold org's/ml		haran baharan si saba	······	· · · · · · · · · · · · · · · · · · ·				uniste 14,0	199 mar of 199 mar 199	
ö	73. 74.	Mold org's/ml Nitrate Reducers org's/ml		ada, daggi produce katanan kata ka		yapanananya katala A. A.			in an			
b	74.	Slime Formers org's/mi				a Palmannanaa da tan 1974		an Karimatan	ince récommen		1	11.8 ···
1,		Sulfate Reducers org's/ml	مىمەرىدى كەرىر ئەرىسىسىسىرى		·	an ristantin and a second	1		15 www.www.www.www.	······································	***************************************	-1-,-
1 r		Total Coliform org's/100ml						. en consignation a			~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	
o	78,	Yeast org's/ml		· *	**************************************		المناكفة بسيسيس			a (a conservation of \$100)		
19 1	79.	Residue by Evaporation		1		, in other contractions and					anter a sub-	·····
Ç,	80.	Volatile.Solids			* ***********************					· · · · · · · · · · · · · · · · · · ·		**********
8		System Capacity gal.	مدهد موجد بکاری به از ریامه میشوییی	• • • • • • • • • • • • • • • • • • •	1	Securituri da secola		······	****			
1		Propionate as C ₃ H ₅ O ₂	0.00	····	0.00	· ····	0.00		0.00		0.00	
1	83.	Total Organic Carbon	10.20		8.22	adamanan organ Jawa	. 9.07				and the second second	epopulation constants of a large
	.84.	Total Organic Nitrogen	0.86		<0:500		<0.500	•				
	85.	Mexel (A-432)	10.0	·			4.0				4.0	
				······					·	* 1		
						محملة بيقود وماستمي						kadagan mang mga kati kapitan paté dan sama
												·····
				• •••••••••••••••••••••••••••••••••••••								
		annen er		الداء فنجاهصنا ومنكوم والمراجع			<u> </u>					
		and a second a second	·	مىيىشە بەر ئايىيىم	maine - Seennen							
	<	error and product and the statements of a second second statement of										and real and the second
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		anna a gu an tantat mutan a <u>ataa an uun taga ta ta ta ta ta ta aa</u> daba	·····									
						مىمىشەر بىرىغا مەمىشە مەربىيە بىرىكى مەمىشە		·		•		
		barana kun manalan da Manga patamatananan p. 4 taun ana ana ana ata <b>ma</b> tananan kata barana kun taun kata da kata							14 ¹¹			·
		1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 -	······		• • • • • • • • • • • • • • • • • • •	en el compositor de compos		in here to a sure	,	· · · · · · · · · · · · · · · · · · ·		
		1			erene sek Parahanan			,				
			16 ann an 18 an	······		ستعضب شسيس		in the second	Militari mitana ang kalarang k	i huranan na daama		
<u> </u>	0	All data except pH is parts net million of as indicated	·	ļ	L	L	l:	L	L	يسبب وسروها	as Chromatoor	J

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				LA	BORAT	ORY REF	PORT -	WATER	ANALYS	sis 👘	Customer	No ::	1001392
Ģ		H-O-H Chemi	cals inc						1		Report No		ndicated
1	السنام					Cook Nu			<u> </u>		Report Da		
1	57	Palatine,			1 Cook F				, 4		Analysis D		
F.	s i N				Bridgma						Sample Da		ndicated
ŝ	•.•	847/	358-7400		Diridgina		·						
Ľ	2120	Eax: 847/		Control	1/25/07	Treated	1/25/07	Control	2/1/07	Treater	2/1/07	Control	2/8/07
					429).	(#274		(#27			466)	(#27	
				.X		y. –.		No care		<b>y</b> . ±.		3	
_		· · · · · · · · · · · · · · · · · · ·		Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble_
	1.		s CaCO ₃	0		0		8		6	·	10	
ŀ	2.	the second secon	s CaCO ₃	120		120		122		120		126	anna last o titligensium.
	3.	ware and a second	s CaCO ₃										
W	.4.		3 CaCO ₃										
a	5. 6.	Chemical Oxygen Demand (C. Chloroform Extractables	.U.D.)	3.9		7:1		11.8		7.0		7.4	
e	7	Dissolved Solids		212		214		211		208		209	
1,1			s CaCO ₃	82		82		81		200		80	
	9.		CaCO ₃	45	1999 - Angel I, ang	45		43		44		45	
Р	10.	manual manual at the set and some of the standard and the set and the set and the set of	CaCO ₃	127		127		124		125		125	
[ ]	11.	рН		8.2		8.2		8.2		8.2		8.1	
0	12.	and a second s	nhos	,317		318		310		309		.310	· · · · · · · · · · · · · · · · · · ·
р	13.	terre and a second s	ml										· · · · · · · · · · · · · · · · · · ·
е.	14.	Suspended Solids			427		37.0		10.0		11.0		234
11	15.	senses of the N-N-Friday's manufactures and an N-N-S straining repairments by N-N-S strain have been sense	s Al	0.01	2.09	0.01	0.50	0.01	0.19	0.01	0.13	0.01	1.98
	16.	and the second state of the second state of the second second state of the second second	s Ba s Ca	0.02 32.8	0.01	0.01 32.8	0.00	0.02	0.00	0.02	0.00	0.02	0.01
e	18.		s Ca s Cr	0.00	0.00	0.00	0.00	0,00	0.00	0.00	0.00	0.00	0.01
	19.		s Cu	0.00	0.00	0.00	0.00 D.01	0.00	0.00	0.00	0.00	0.00	0.00
	20.	the root of a monormal second s	s Fe	0.00	3:57	0.00	0.75	0.00	0,24	0.00	0.20	0.00	3.38
	21.		Pb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	22.		i Li	0.00	0.00	0.00	0.00	0.00	0.00	0:00	0:00	0.00	0.00
11	23,	a a second design of the second s	s Mg	10.9	5,84	10.8	0.57	10.5	0.54	10.7	0.35	11.0	4.56
	.24.		s Mn	0.00	0.11	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.09
	25.	sector statement and the sector secto	Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	26.		s K	1.46	*** Face-1 == = = = = = = = = = = = = = = = = =	1.63		1.29		1.34		1.06	
	27.	Search and show and the second statements to an a second statement of the seco	Ag	0.00	0.00	0.00	0.00	0.00	.0.00	0.00	0.00	0.00	0.00
a	28. 29.		s Na s Sr	7.37	0.02	7.70 0:10	0:00	6.74	0.00	6.74 0:11	0.00	6.44	0.01
Ĩ	30.	An immediate second and the second	zn.	0.00	0.02	0.00	0.00	<u>-0.11</u> 0.01	0.00	0.00	0.05	0.00	0.05
Ŀ	31.	Total Cation Milleguivalents		2.896	0.02	2.908	0.01	2.811		2.817	0.00	2.807	0.00
n	32.		6 C ₂ H ₃ O ₂	0.00		0.00		0.00		0.00		0:00	
s	33.		Br	0.00	**************************************	0.00	nanapat	0.00		0.00	······	0.00	
11	34.		CI	12,2		12.0		10.2		10.3		9.34	
	<u>35.</u>	serve for a serve of the serve		0.00		0.00		0.00		· 0.00		0.00	
	36.		CrO₄										
{ {	37.		S F	0.00	······	0.00		0.00		0.00		0.00	
			CHO₂	0.00	·····	0.00		0.00		0.00		0.00	
			C ₂ H ₃ O ₃ MoO ₄	0.10	× • • • • • • • •	0.00		0.00		0.00		0.00	<b>`</b>
11		And a second	NO ₃	1.13	-,	1.0B		0.00		0.00		1.05	
			NO ₂			·····		0.00	. <b></b> .	0.00		0.00	
	43:	Nitrogen (total) as	N							***** : '******************************			
		Oxalate as	C ₂ O ₄					0.00		0.00		0.00	
			PO4					0.00		0,00		0.00	
Ă			PO4	·									
n			PO ₄						~ ~ ~ ~	0.00			A 10
0	48. 49.	1 Mon and 1 M and and a second s	SO4			•		0.00	0.00	0.00 22.1	0.00	0.00	0.10
n			S S	•••••		·•		7.66	0.75	7.60	0.52	7:55	0.50
S	51.	Total Anion Millequivalents		#VALUE!		#VALUE!	manin	3.206		3,165		3.267	
	*****	and the second state of th	NH ₃		······		······						
1		energy of the Children present to the order to set an an an and the set of the set of the set of the set of the	C ₆ H ₅ N ₃										
			В			· · · · · · · · · · · · · · · · · · ·		0.92		0.63		0.00	
			SIO ₂					0.00	.0.00	0.00	0.00	0.00	0.00
	here to be read		NaNO ₂	#VALUE!		#VALUEI		ه استواط به ده ده مشهور مش					
	www.com.ters	construction of the second	Na ₂ SO ₃	·····									
11		Tolyitriazole as Ali data except pH in parts per million or as indica	C ₇ H ₅ N ₃				ntinued on	reverse side	I	i	إ	,	

	H-O-H Chemicals, Inc. 500 S. Vermont St. L Palatine, IL 60067	egarding:	Indiana a	and Michi C. Cook N Place	PORT - 1 gan Powe luclear Pla	r Compa			Customer Report No Report Da Analysis I Sample D	o:: as ate: Date:	indicated
	847/358-7400 Fax: 847/358-7082		1/25/07 (429)		1/25/07 7429)		1 2/1/07 466)		42/1/07 (466)		n 2/8/07 7502)
		Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
60.	Bromate as BrO ₃ Chlorite as ClO ₂		<b></b>		· •••••••						ar fyr yngalaniaet a'r y gydangae
	Cyclohexylamine* as C ₆ H ₁₃ N		······································		·*··						
-	Diethylamine* as C ₄ H ₁₁ N Diethylaminoethanol* as C ₆ H ₁₅ NO			* ~							
	Ethylamine* as C ₂ H ₇ N		÷		-					-	
	Morpholine*         as C ₄ H ₉ NO           Diethylene Glycol*         % by weight					- 		··		1. 1. p. ca	
	Ethylene Glycol* % by weight			1		······································				· · · · · · · · · · · · · · · · · · ·	
	Propylene Glycol* % by weight Aerobic Plate Count org's/ml								<u></u>		
	Anaerobic Plate Count org's/ml	····								المحمد المسلم الم	
	Fecal Coliform org's/100ml										
	Mold org's/ml	······································									
	Nitrate Reducers org's/ml		·				······		·		
	Slime Formers, org's/ml Sulfate Reducers org's/ml								····· .	·····	
	Total Coliform org's/100ml					·····					
	Yeast org's/ml Residue by Evaporation	ar sa matanan sa	·····	·····			• • •	·····			1
i	Volatile Solids					• • • • • • • • • • • • • • • • • • •					
	System Capacity gal. Propionate as C ₃ H ₅ O ₂			,. ,						·	i
	Total Organic Carbon		an an tai		ر بندن سند	**************************************					
	Total Organic Nitrogen							· · · · · · · · · · · · · · · · · · ·			
	Mexel (A-432)		<u></u>					1.50			
										· · ·	·····
					14.00° an 10° a		anna a searanna ann ann ann ann ann ann ann ann a		· · · · · · · · · · · · · · · · · · ·	•	
						an han mark a same	مسيمير بمندر مستندين	· · · · · · · · · · · · · · · · · · ·	-		hand a second se
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	ander de la constante de la con Interés de la constante de la co		· ····································								
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			array References, of a		•			·		· · · · · · · · · · · · · · · · · · ·	
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	รางประกันการสรางสาวาร และสาวสาวสาวสาวสาว และสาวสาว 25 และสาวสาวสาวสาวสาวสาวสาวสาวสาวสาวสาว เกมส์เป็นการสราชสาวสาวสาวสาวสาวสาวสาวสาวสาวสาวสาวสาวสาวส		······································							······	
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			- 		i		****			·	
A	Il data except oH in parts per million or as indicated		· · · ·	•	• <u> </u>	L	ļ	L	Analysis by C	as Chromatoor	aphy.
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			LA	BORAT	ORY RE	PORT -	WATER	ANALYS	SIS:	Customer	No.:	1001392
00002	H-O-H Chem							iy 👘		Report No	.: as i	ndicated
	500 S. Ve	rmont St.	Location:	Donald C	Cook N	uclear Pla	ant			Report Da	ite:	
"~U.(	(a) n Palatine	, IL 60067		1 Cook P	lace					Analysis D	)ate:	·
				Bridgmar	n, MI					Sample D	ate: as i	ndicated
	ACCERTICATION 847.	/358-7400								1		
<u>(</u>		/358-7082	Treated (#27		Control (#27			2/15/07 541)		l 3/1/07 (631)	Treated (#27	
			Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	insoluble
	Alkalinity ("P") a	s CaCO	12	Induidale_	6	11(39/20/0	8		0	Indolargio	0	110010010
2		as CaCO ₃	128		144	· · · · · · · · · · · · · · · · · · ·	144		122	***	120	
3		as CaCO ₃								v	* • • • • • • • • • • • • • • • •	naninan na darah . J
W 4	and and a share a second department of the second	s CaCO ₃										
a 5.	Chemical Oxygen Demand (C	C.O.D.)	16.6		8.6		7.7		5.4		6.1	
t B	and the second se											
e 7.			210		232		235		208		208	
r <u>8</u> .	and the second	as CaCO ₃			95		95		87	A 4 minute and the second s	86	
9	and announcers where we said the said and and the said of the said and and and and and and and and and an	as CaCO ₃	45	·	.49		50		46		46	
P 10	a a service a service of the service	as CaCO3	125		145		145		133		132	· · · · · · · · · · · · · · · · · · ·
r. 11.		art managements	8.3 312		8.1		8.1		8.0 311	A	8.2 304	<u> </u>
o 12. p 13.	and the second	mhos /ml	312		346		350		-311			
e 14	and have a have been and a second sec	<u>µ110</u>		4.5		7.0		7.0	*****	83.0	******	3.0
r 15		is Al	0.01	0.08	0.00	0.09	0.01	0.08	0.01	0.63	0.01	.0.03
t 16.		is Ba	0.02	0.00	0.02	0.01	0.02	0.01	0.02	0.00	0.02	0.00
1 17.		is Ca	31.8	0.00	38.1	0.00	38.1	0.00	34.6	4.75	34.4	0.00
e 18.	The second secon	as Cr	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00
s 19.	. Copper a	is Cu	0.00	0:00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.03
20.	lron a	ns Fe	0.00	0)10	0.00	0:15	0.00	0.14	0.00	1.46	0.00	0.06
21.	and a second	ns Pb	0.000	0.000	0:000	0.000	0.000	0.000	0.000	0.003	0.000	0.000
.22	11 Real survey and the state of	is Li	0.00	0.00	0.00	0.00	.0.00	0.00	0.00	0.00	0.00	0.00
23	and the set of the set	is Mg	11.0	0.00	12.0	0:17	12.1	0.24	11.3	1.58	11.3	0.00
24.	***	is Mn	0:00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0:00	0.00
25.		is Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
26		is K	1.09	0.00	1.53	0.00	1.49	0.00	1.42	0.00	1.31	0.00
C 28		as Ag as Na	0.00 6.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.49	0.00
a 29		is Na	0.45	0.00	7.51 0.10	0.00	7.31	0.00	0.11	0.00	0.49	0.00
1 30	The second and the second seco	is Zn	0:00	0.03	0.00	0.02	0.00	0.00	0.01	0.02	0.01	0.00
1 31.			2.800		3.255		3.261		2.982		2.963	
n 32.		IS C2H3O2	0.00	·····	0.00		0.00	,	0.00		0.00	<u>i</u>
s 33.	the second s	ns Br	0.00		0.00		0:00	reversion when the s	0.00	Transatana I Transatana	0.00	
34.	Chloride a	is Cl	9:78		13.5		13.8		11.4		11.3	
35.		as CIO ₃	0:00		0.00		0.00		0.00		0.00	
36.		s CrO4			~~~~~							
: 37		IS F	0.00		0:10		0.11		0,10		0.10	
38;		IS CHO ₂	0.00		0.00		0.00		.0.00		0.00	
1		IS C ₂ H ₃ O ₃	0.00		0.00		0.00		0.00		0.00	
40.		is MoO₄ Is NO₃	0.00		0:00	na. (	0.00		0.01		0.00	
41.		IS NO ₂	0.96		1.84		1.90		1.45		1.29	···· • • • • • • • • • • • • • • • • •
42.	and a second	IS NU ₂	0.00		0.01	,	0.00	innngaire a bar carana	0.00		0.00	
44		IS C ₂ O ₄	0.00		0.00		0.00		0.12		0.00	
45.		s PO4	0.00		0.49	······	0.00		0.00		0.00	
46.		IS PO4		I		·····						
A 47		s PO4										
1 48.		is P	0.00	0.00	0.00	0.00	0.00	0.01	0:00	0.05	0.00	0.00
0 49.		is SO4	22.3		24.4		24.7	لىرىمىيەر مەردى مىد	21.2		21.6	
n 50. s	were and the second s	is S	7.52	0.00	8.08	0.00	8:25	0.00	7.44	0:25	7.51	0.00
51.			3.316		3.808		3.821	، ، مىمە ھەملەغىمەمەمەت	3.290		3.262	
52:		IS NH3				÷						
53.		S C ₅ H ₅ N ₃							0.00			
54.		IS B	0.00		0.16		0.10		0.00		0.00	
55.		IS SIO2	0.00	0.00	0.00	0.00	0.00	0.00	1.65	2.38	1.99	0.06
50.		s Na ₂ SO ₃			······	·	<u>.</u>		• •••••••••••••••••••••••••••••••••••••			
PERMIT		IS C ₂ H ₆ N ₃			·:	·····	مەربەيچىنىيە چەربايىتىدى مەربايا تەربايا تەربايا تەربايا تەربايا تەربايا تەربايا تەربايا تەربايا تەربايا تەرباي		*****			<u>n a</u> tan
	All data except pH in parts per malion or as india					attend on	reverse sid	l				

			LA	BORAT	ORY RE	PORT -	WATER	ANALY	SIS	Customer	No.:	1001392
		H-O-H Chemicals, Inc.	Regarding:	Indiana a	and Michig	gan Powe	r Compa	ny		Report No	as as	indicated
		500 S. Vermont St.	Location:	Donald C	Cook N	uclear Pla	ant			Report Da		
		Palatine, IL 60067		1 Cook F						Analysis I	Date:	
				Bridgma	n, ML					Sample D	ate: as	indicated
		847/358-7400 Fax: 847/358-7082		1 2/8/07 '502)	Control (#27	2/15/07 541)		2/15/07 541)		) 3/1/07 (631)		d 3/1/07 /631)
_			Soluble	Insoluble.	Soluble?	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	linsoluble.
		Bromate as BrO3			4							5
C.	60.	a statute of the stat			······							
l.º		Cyclohexylamine* as C ₆ H ₁₃ N						ورود والمحمد المحمد ال				
m P	62.	Diethylamine* as C4H11N				·····						
်း		Diethylaminoethanol* as C ₆ H ₁₅ NO		140000 1000 1000, 1000						regeneration d'erregen		
ų,		Ethylamine* as C ₂ H ₇ N Morpholine* as C ₄ H ₉ NO	······				-					
â		Diethylene Giycol* %by weight										
. 5	67	Ethylene Glycol* % by weight			<del>مىسى</del> دە ، يېزىر ۋەر يې			, and the second se			**************************************	
		Propylene Glycol* % by weight		• ************************************	a	······································						*****
		Aerobic Plate Count org's/ml	nniger - _{Stand} a Jaconsopourgeson.				alalagaan 1941 oo dalaalaan mada	1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.	47.4 <b>444.4.</b> -	alamannaho n,	line i i constructioner	·
м		Anaerobic Plate Count org's/ml	ájnan a 16.200.000.000		······				iling there are a provident	••••••••••••••••••••••••••••••••••••••		
l'i		Fecal Coliform org's/100ml					*	بمعملة حجاه ورودك ملغان				
ć	72.							· · · · · · · · · · · · · · · · · · ·	•			
3   0			Parts a superior control to be		-							
Ь		Nitrate Reducers org's/ml		- 			······					
ΓF.		have been a second of the seco				•• •••••						
0		Sulfate Reducers org's/ml		•·····		••• •••••••		·		12+ ¹⁰	- 	
.0.		Total Colliform org's/100ml	~								····	·
9	78.	Yeast org's/ml Residue by Evaporation	÷		<del></del> iaua			··· *······	·····	÷		
					- 4,200,000,000,000,000,000					• •,		···
C B		System Capacity gal.	<u></u>	·······							·	
1.		Propionate as C ₃ H ₅ O ₂	0.00	*	0.00	• • • • • • • • • • • • • • • • • • •	0.00		0.00		0.00	
		Total Organic Carbon				anna ann an a						
1		Total Organić Nitrogen	Pr									
	85.	Mexel (A-432)	2.5				1.0				2.5	
ľ	by er an maine		·	**************************************	*				*****			
	لتحصو			in an					<b>i</b>		·	
				·	·····	مود ولمنتسبين						
	ومقصفهم		÷						به <del>د</del> ورسینی سیسی که			a shannan in orde
	<u>.</u>	анандаран талара – учулу талан талар кулан калара калар калар калар калар калар кулар кулар калар калар калар к Салар калар	19794 (J. <u></u> 999999 (J		····					internet and a second	· · · · · · · · · · · · · · · · · · ·	····
	بنينينين.	анун түүнээ нэлэлтээн түүн түүнээ нэлэлтээн түүлэр нэлэлтэг (алан түүнээ) байлаг түүнээ нэлэг нэлэг нэлэг нэлэ Т	·····				1		laanaan ka ahaana	,	Andre and March 1977 1	
	*	and which contained and by the contained and because and an an an and		anners ann an	Contraction of the second	homeninesis securitarian		warness nation to the	parameterin an a Samer	**************************************	) ay a contraction of the second s	
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匚	ليد	All data except of in parts per million or as indicated				<u>&gt;:</u>		L	l	1	as Chromatogra	

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			LA	BORAT	ORY REP	ORT -	WATER	ANALYS	SIS	Customer	No.:	1001392
<b>—</b>		-H Chemicals, Inc.		Indiana a	and Michig	an Powe	r Compai	ny j	•	Report No	as as	indicated
		500 S. Vermont St.	Location:		Cook Nu	iclear Pla	ant			Report Da	te:	
1 1 (	ப	Palatine, IL 60067		1 Cook F						Ánalysis D		
<b>I</b>				Bridgma	n, Ml					Sample D	ate: as	indicated
CITC:	CONTRACTOR	847/358-7400			÷ .			1				
		Fax: 847/358-7082		1 3/8/07	Treated		Control			3/15/07		3/22/07
			(#27	631)	(#276	31)	(#27	677)	(#27	677)	(#27	694)
			Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
	Alkalinity ("P")	as CaCO ₃	0		0	11000000	10	110018910	10		10	
2		as CaCO ₃	132		134		126		126	······	138	
3	The second se		,	And a state of the	· · · · · · · · · · · · · · · · · · ·				•••••••••••••••••••••••••••••••••••••••	an Personal Anna Persona P	And a second	anier a arténuer
W 4	Free Mineral Acidi	ty as CaCO ₃										
a .5			2.7		4.4	10 - 21 - 21 - 21 - 21 - 21 - 21 - 21 -	20.7		5.2		14.6	
1 6		tables										
e 7	and a standard the standard and the characteristic differences	n), as CaCO ₃	237	· · · · · · · · · · · · · · · · · · ·	241	• • • • • • • • • • • • •	209		200		226	
г <u>8</u>		and some soft the first second and the second se	99 52		99 52	· · · · · · · · · · · · · · · · · · ·	.80 44	****	79 43		86 46	
P 10	an un beiden bermeinen an einen besternen auf einen auf bereinen aufer	as CaCO ₃	151		151		124		123		133	······
r 11		· · · · · · · · · · · · · · · · · · ·	8.2		8.2	·····	8.2		8.3	++-+++++++++++++++++++++++++++++++++++	8.2	
0 12		nce µmhos	358		359		316		308	······	338	
p 13	an pro i annoneratione and and an anno an anno an an anno an	g/ml		. بارېسىمىمەر يىسم	3			-				
e <u>14</u>		A starter was a start of the second starter to be a starter of the second starter of the		20.0		.54.0		543	÷ - :	19.0		280
1 <u>15</u>		as Al	0.01	0.19	0.01	0.32	0.01	5.30	0.01	0.29	0.01	2.44
1 16	ntis //	as Ba as Ca	0.02 39.4	0.00	0.02	0.00	0.02	0.03 42.7	0.02	0.00	0.02	0.02
e 18		as Cr	0,00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
s 19		as Cu	0.00	0.02	0.00	0.03	0.00	0.01	0.00	0.00	0.00	0.00
20		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	· · · · · · · · · · · · · · · · · · ·	as Li	0.00	0.00	0.00	0.00	0.00	0.00	0:00	0.00	0.00	0.00
23	· · · · · · · · · · · · · · · · · · ·	as Mg	12.6	0.00	12:6	0.97	10.6	17.0	10.6	.0.08	11:2	9.27
24	······································	as Mn	0.00	0.01	0.00	0.03	0.00	0.33	0.00	0.02	0.00	0.24
25		as Ni as K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00 1.44	0.01
27		as Ag	0.00	0.00	0:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 28		as Na	8.44		8.52		6.61		6.57		6.81	
8 29	And and and a substantial an	as Sr	0.12	0.00	0.11	0.00	.0.11	0.04	0.11	0.00	0.10	0.03
30		as Zn	0.01	0.01	0.01	0.01	0.01	0.04	0.00	0.01	0.01	0.05
0 31			3.415		3.424		2.792		2.776	يستحصرنه مشعشت	2.984	
n 32		as C ₂ H ₃ O ₂	0.00		0.00		0.00		.0,00		0.00	
s 33	and and a state of the state of	as Br as Cl	0.00		0.00		0.00		0.00		0.00 12.9	
34	· · · · · · · · · · · · · · · · · · ·	as Cl as ClO ₃	0.00		0.00		<u>11.7</u> 0.00		0.00	···· 7	0.00	•
38		as CrO ₄		• •••• •••••••••••••••••••••••••••••••	0,00		0.00					
37	a a a destruction of the second se	as F	0.11		0.11		0.11		0.11		0.11	
38	are strangered a Barran construction of the stranger of the	as CHO ₂	0.00		0.00	· · · · · · · · · · · · · · · · · · ·	0.00		0.00		0.03	
	Glycolate	as C ₂ H ₃ O ₃	0.00	·	0.00		0.00	······································	0.00		0.00	
	. Molybdate	as MoO ₄ ,	0.00	: •#•	0.00		0.00		0.00	reverent and and a second	0.00	
41	1	as NO ₃	2.24	••••••••••••	2.32		1.27		1.16		1.94	
42		as NO ₂ as N	0.00		0.00		0.00		0.00		0.00	
44		as C ₂ O ₄	.0.00		0.00		0.00		0.00	······	0.00	
45		as PO4	0.00		0.00		0.00	·····	0.00	······································	0.00	
A 46	and an and the second s	as PO4										
n 47		and the second										
i <u>48</u>	and a second of the second sec		0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.01	0.12
0 49 n 50		as SO4 as S	24.2 8.39		24.6		21.3		21.2 6.79	0.00	22.6	0.04
s 50	and another a second a second s	and a support of the support of the support	3.683	0.00	8.42	0.00	7.01	1.02	3.358	0:00	7.51 3.689	0.91
52		as NH ₃	0.003				5.504		0.000			
53		as C ₆ H ₅ N ₃		·····								
54	and the second s	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
58		as NaNO ₂				····	·					
57	and a summarial and the second s	as Na ₂ SO ₃			,							·
58.	All data except pH in parts per	BS C7H6N3.	I		Co	ntinued on	reverse sid	e	<u> </u>	ļ		

		H-O-H Chemicals, Inc.	Regarding	BORAT	and Michi	gan Powe	er Compa	ANALY:	SIS	Customer Report No		1001392 indicated
		500 S. Vermont St.	Location:	Donald C	Cook N	uclear Pl	ant			Report Da		
		Palatine, IL 60067		1 Cook F	Place					Analysis (		
				Bridgma						Sample D		indicated
		847/358-7400 Fax: 847/358-7082		1 3/8/07 7631)	Treater	i 3/8/07 631)		3/15/07 (677)		1 3/1 5/07 7677)	Control	3/22/07 (694)
	•		Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
Γ	: 59.	Bromate as BrO3								<u> </u>		•
C.	60.	Chlorite as CIO2	+ (-, d) when recommendation the fi									
0	61.	Cyclohexylamine* as C ₆ H ₁₃ N		Second and the second and	**********	Ø44				······	*************	1999 - Anna Anna ann an 1976 - Maria Sanai,
m		Diethylamine* as C ₄ H ₁₁ N	**************************************		****	- fu - summer a - 118 h -					nine a service and the service of th	
P	63.	Diethylaminoethanol* as C ₆ H ₁₅ NO	and a state of the		*						Parameter and a start of the st	
0 .u	64.	Ethylamine* as C ₂ H ₇ N					and the second second					
n l	-85.	Morpholine* as C ₄ H ₉ NO					Martin Martin Contract					
d	66.	Diethylene Glycol* % by weight										
S	67.	Ethylene Glycol* % by weight				- ,						
	68.	Propylene Glycol* % by weight										
	.69.	Aerobic Plate Count org's/ml										
М.	.70.	Anaerobic Plate Count org's/ml										
1	.71.	Fecal Coliform org's/100ml			· · ·							
C		Iron Bacteria					-					
0	73.	Mold org's/ml										
ь	74.	Nitrate Reducers org's/ml										
Ĩ.	75.	Slime Formers org's/ml							- it and 1000			
0	76.	a standard a				¥	-					artiture bil paraset and a
	77.	Total Coliform org's/100ml				-						
0.	78.	Yeast org's/ml										
1 T	· 79:	Residue by Evaporation										
c	80.	Volatile Solids										-
ia	81.	System Capacity gat.										
r t	82.	Propionate as C ₃ H ₅ O ₂	0.00		0.00		0.00		0.00		00:00	
ч.,	. 83.	Total Organic Carbon					:	,		,		
	84.	Total Organic Nitrogen									-	
:	:85.	Mexel (A-432)			<1.0				1.5			
-							4014					
:												
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Annual D All data except of in parts per million of as indicated

			LÁ	BORAT	ORY RE	PORT -	WATER	ANALYS	SIS	Customer	No.:	1001392
(CEESS	H-0-	H Chemicals, Inc.								Report No		indicated
		00 S. Vermont St.								Report Da	ate:	
JU 1		Palatine, IL 60067		1 Cook F						Analysis [	Date:	3
N.C.	SAK	·		Bridgma	n, Ml					Sample D		indicated
100	(desizere)	847/358-7400										
1999 Ball		Fax: 847/358-7082		3/22/07 694)	1 ·	3/28/07 725)		3/28/07 725)		4/10/07 790)		4/10/07 790)
			Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	insoluble	Soluble	Insoluble
	. Alkalinity ("P")	as CaCO ₃	10		8	•	8		0		. 0	
2	- water water and the set of the	as CaCO ₃	138		126		126		132		132	
3	a a managementer and the formation and the second		****	و به منطقه من طورة معطومهما و	-							
W 4			B-# -94.445.000.00.00							·····		
8 5			8.2		16.2		7.6	·····	6:6		7.5	
t 6		adies	222		209		209		211		222	
r a		) as CaCO ₃	-86		82		82		88		89	·
9		and a second	46	*******	45		45		48		48	·····
P 10	un anticipation and the state of the state o	as CaCO ₃	132		128		127		136		137	
r 11	. рН	CONTRACTOR AND DESCRIPTION OF AN ADDRESS PARTY AND A MARKED AND A MARK	8.2		8.2		8.2		8.1		8:0	
o 12	<ol> <li>First district an exploration of a construction of the construction of th</li></ol>		335		312		312	·····	332		323	
p 13	a and management and a second second	g/ml		** * * * ** ***								
e 14	and a similar on a secondar, or the physical disconteness			21,5		154		1.0		2.5		1.5
r 15		as Al	0.01	0.26	0.01	1.27	0.01	0.04	0.01	0.06	0.01	0.06
t 16		as Ba as Ca	0.02	0.00	0.02	0.01	0.02	0.00	0.02	0.00	0.02	0.00
e 18		as Ca	0.00	0.00	0.00	0:00	0,00	0.00	0.00	0.00	0.00	0.00
s 19	-	as Cu	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00
20	and an and the second sec	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		as Mg	11.1	0.59	1,1.0	4.05	11.0	0:00	11.5	0.00	11:6	0.00
24	· ····································	as Mn	0.00	0.02	0.00	0.15	0,00	0.00	0.00	0.00	0.00	0.00
25		as Ni	0.00	0.00	0.00	0.00	0.00	0:00	-0.00	0.00	0.00	0.00
26		as K	1.35		1.31		1.29		1.56		1.45	
C 28		as Ag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C 28 a 29		as Na as Sr	6.57 0.10	0:00	7.09	0.01	0.95	0.00	9.04	0.00	0.29	0.00
1 30		as Zn	0.01	0.03	0.00	0.01	0.01	0.01	0.01	0.08	0.01	0.01
0 31	Total Cation Millequ		2.952		2.893		2.884		3.153		3.140	
n 32		as C2H3O2	0.00		0.00	(* <del>* * * * * * * * * * * * * * * * * * </del>	0.00		0.00		0.00	
s 33		as Br	0.00		0.00		0.00		0.00		0.00	
34		as Cl	12.6		11:6		12.1		13.4		13.7	
35		as ClO ₃	0.00		0.00		0.00		0.00	4.4	0.00	<u></u>
36		as CrO4	0.10		0.10							
3/	Fluoride:	as F as CHO₂	0,10		0,10		0.10 0.00		0.11		0.11	**********************
	Glycolate	as C ₂ H ₃ O ₃	0.00	,	0.00	······	0.00	• • • • • • • • • • • • • • • • • • •	0.00		0.00	******
40		as MoO ₄	0.00		0.00		0.00		0.00		0.00	
41	and successive procession and the second sec	as NO ₃	1.79		1.22		1,13		1.44		1.32	
42		as NO ₂	0.00		0.08		0.00		.0.00		0.00	
43		as N										
44	· · · · · · · · · · · · · · · · · · ·	as C ₂ O ₄	0.00		0.00		0.00	-	0.00		0.00	
.45	and the second	as PO4	0.00		0.00		0.00		0.00		0.00	;
A 46		as PO ₄	·····	·····				***				
n 47	······································	as PO ₄	0.00	0.00	0.00	<u></u>	0.00	0.01	0.01	0.00	0.02	0,00
0 49		as SO4	22.4	0,00	21.0	0,09	21.8	0.01	22.2	0.00	22:7	0,00
n 50	· ····································	as S	7.57	0.00	6.93	0.80	8.97	0.00	7.70	0.00	7.76	0.00
s 51	a second and a second		3.632		3.357		3.384		3.546	0.00	3,561	
52		as NH ₃										¢
53	Benzotriazole	as C ₆ H ₅ N ₃										
54		as B	0.00		0.00		0.00		:0.00		0.00	· · · · · ·
55.	n , shows one have seen that the reading sector sector and	as SiO ₂	1.64	2.01	1.37	.5.67	1.35	0.49	1:05	0.00	1.05	0.10
56		as NaNO2	·····	······		<u>``</u>						
57	4 Second descent rendered with the solid state of the second s		·····					y	+	······		ay an a signa a signa ana a
58.	Tolyltriazole All data except off in parts per n	as C ₇ H ₆ N ₃			l	ontinued on	reverse sid	A				

Store         Location:         Donald C. Cook Nuclear Plant         Report Date:           Palatine, IL 60067         1 Cook Place         Analysis Date:           Bridgman, MI         Sample Date:         as indica           847/358-7400         Treated 3/22/07         Control 3/28/07         Treated 3/28/07         Control 4/10/07         Treated 4/10/07           Fax: 847/358-7082         Treated 3/22/07         (#27725)         (#27725)         (#27790)         (#27790)						ORY RE				SIS	Custome		1001392	
Palaţine, IL 60067         1. Cook Place         Analysis Date:         Saindlez           B47/358-7400         Frax:847/338-7602         Treated 3/20/07         Control 3/28/07         Control 4/10/07         Treated 3/28/07         Control 4/10/07         Control 4/10/07 <td< th=""><th></th><th></th><th>H-O-H Chemicals, Inc. 500 S. Vermont St</th><th>Regarding: Location:</th><th>Indiana a Donald (</th><th>and Michi C. Cook N</th><th>gan Powe</th><th>er Compa ant</th><th>ny</th><th></th><th colspan="4"></th></td<>			H-O-H Chemicals, Inc. 500 S. Vermont St	Regarding: Location:	Indiana a Donald (	and Michi C. Cook N	gan Powe	er Compa ant	ny					
Bridgman, MI         Sample Date: as indice           Paix:847/359-7062         Treated 3/28/07 (#27790)         Control 3/28/07 (#27790)         Control 4/10/07 (#27790)         Treated 3/28/07 (#2790)         Control 4/10/07 (#2790)         Treated 3/28/07 (#2790)         Control 4/10/07 (#2790)         Treated 3/28/07 (#2790)         Control 4/10/07 (#2790)         Treated 3/28/07 (#2790)         Control 4/10/07 (#2790)         Control 4/10/07 (#2790)         Control 4/10/07 (#2790)         Control 4/10/07 (#2790)         Control 4/10/07 (#2790) <th></th> <th></th> <th></th> <th></th> <th>1 Cook F</th> <th colspan="4"></th>					1 Cook F									
Fax: 647/358-7062         Treated 3/22/07         Control 3/28/07         (#27725)         Treated 3/28/07         Control 4/10/(#27790)         Treated 4/10/(#27790)           50/UP         Insoluble         Soluble         Insoluble				· ·						indicated				
(#27694)         (#27725)         (#27725)         (#27790)         (#27790)           58/ Bronata         as BPO, 60. Chione         as CP, 60. Chione			- 847/358-7400									<u></u>		
Soluble         Insoluble         I			Fax: 847/358-7082	Treated 3/22/07								Treated 4/10/07 (#27790)		
99.         Bromate         as BrO3           C         90.         Chlorite         as C41 ₂ N           61.         Cyclolexylaminet         as C41 ₂ N           63.         Detrylaminet         as C41 ₂ N           64.         Dyclolexylaminet         as C41 ₂ N           65.         Morpholinet         as C41 ₂ NO           66.         Dietrylane Glycot*         % by weight           67.         Aerobe Plate Could         org/smil           70.         Aareobe Plate Could         org/smil           71.         Fead Callform         org/smil           72.         Inon Bacteria         org/smil           73.         Suffer Formers         org/smil           74.         Nota Bacteria         org/smil           77.         Total Callform         org/smil           78.         Regregers         org/smil           77.         Total Callform         org/smil           78.         Residue by Evaporation         org/smil           79.         Residue by							•			-			Insoluble	
c         6. Chlorine         as C4L,N           9         50. Cyclorine         as C4L,N           9         50. Diethylamine*         as C4L,N           10         56. Diethylamine*         as C4L,N           11         Feadore Bits Count         org/smin.           11         Feadore Piate Count         org/smin.           11         Feadore Piate Count         org/smin.           12         Iron Backeria         org/smin.           13         Markat Reducers         org/smin.           14         77. Static Collform         org/smin.           17. Silitie Reducers         org/smin.         org/smin.           17. Total Collform         org/smin.         org/smin.           17. Total Collform         org/smin.         org/smin.           18. Velatie Selds         org/smin.         org/smin. <t< th=""><th></th><th>59.</th><th>Bromate as BrO</th><th></th><th></th><th></th><th></th><th>·</th><th> </th><th></th><th></th><th></th><th></th></t<>		59.	Bromate as BrO					·						
o         6.         5.         Overlag         See Diethydam/net as C, H, N           r2.         Diethydam/net/aminet as C, H, N	.C:	60,	Chlorite as CIO ₂				f af af meng na san ang tilanan na na s		• • • ·	•		2	******	
33. Dickytamine         as Celtyka           33. Dickytamine         as Celtyka           34. Dickytamine         as Celtyka           35. Morpholine*         as Celtyka           36. Morpholine*         as Celtyka           37. Dickytamine         as Celtyka           38. Morpholine*         as Celtyka           39. Dickytamine*         as Celtyka           37. Ethyka         as Celtyka           38. Morpholine*         as Celtyka           39. Acrobic Plate Count orgis/mi         as Celtyka           37. Moratobic Plate Count orgis/mi         as Celtyka           37. Mold         orgis/mi           37. Moratobic Plate Count orgis/mi         as Celtyka           38. The Single Februers         orgis/mi           39. Taking Reducers         orgis/mi           39. Taking Reducers         orgis/mi           30. Taking Reducers         orgis/mi           39. Taking Caliform         as Celtyka           39. Taking Caliform         as Celtyka           39. Taking Caliform         as Celtyka           39. Taking Reducers         orgis/mi           39. Taking Caliform         as Celtyka           39. Taking Caliform         as Celtyka           39. Taking Caliform	o			1000 0 . 1			\					/2		
0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0					*****			nýmením na cír era ana m		n an	<b>50.5</b> .100.69.0000			
n         68. Morpholine*         as 2,H_NO					darren at space program	1712 1010 1010 1010 1010 1010 1010		na ana a' a ana co a Mitata				·		
q         6         Distribution Glycott*         % by weight           67         Ethylang Glycott*         % by weight				anananan in ananan					······	ز در بارستر سرز .	ade betra in el casa aprimpa	<del>/////////////////////////////////////</del>		
88. Procylene Gilycol*         % by weight           88. Procylene Gilycol*         orgis/mi           70. Anaerobic Plate Count         orgis/mi           71. Facal Colliform         orgis/mi           72. Jino Bacteria	đ													
60:         Aerobic Plate Count         orgis/mi           17:         Fead Colligrm         orgis/mi           17:         Slinife Formers         orgis/mi           17:         Total Colligrm         orgis/mi           17:         Total Colligrm         orgis/mi           17:         Total Colligrm         orgis/mi           10:         78:         Yeasi         orgis/mi           10:         78:         Sistem Capacity         gal           10:         79:         Sistem Capacity         gal         orgis/mi           10:         79:         Sistem Capacity         gal         orgis/mi           10:         79:         Sistem Capacity         gal         orgis/mi           10:         70:         0.00         0.00         0.00	8				1979 - 197 Parks (1989-1979-1997-1997)			******			•••••••			
M         70.         Anaarobic Plaie Count         org's/100ml           1         71.         Fecal Coliform         org's/100ml	{				hte the arc is a care to be		·······	proved as an					· · · · · · · · · · · · · · · · · · ·	
71.       Fecal Coliform       org's/100ml         7.3.       Mold       org's/ml         7.3.       Mold       org's/ml         7.3.       Mold       org's/ml         7.4.       Nitrate Reducers       org's/ml         7.5.       Stifie Formers:       org's/ml         7.6.       Suffice Reducers       org's/ml         7.7.       Total Coliform       org's/ml         7.8.       System Capacity       gal.         8.2.       Propicate       as CaHsO2         8.3.       Total Organic Nitrogen       org's/ml         8.4.       Organic Nitrogen       org's/ml         9.3.       Orgonale Nitrogen       org's/ml         9.4.       org's/ml       org's/ml         9.4.       Total Organic Nitrogen       org's/ml         9.4.       org's/ml       org's/ml         9.4.       org's/ml       org's/ml	м			····	<u></u>	••••••••		·		senten er i sin i ge				
c       72. Ifon:Bacieria		71.	Fecal Coliform org's/100ml	·;··;·		**		·		-4-2-5 ml - 1999 to 1999 and		·		
1       74. Nitrate Reducers       org's/mi         1       75. Sliffer Formers:       org's/mi         76. Sulfate Reducers       org's/mi         1       77. Total Coliform       org's/mi         78. Yeast       org's/mi         78. Yeast       org's/mi         79. Residue by Evaporation	°C		Iron Bacteria					· · · · ·						
1         75:         Slime Formers:         org/s/ml           7         Total Coliform         org/s/ml	0	73:	Mold org's/ml			·	······						****	
o       76.       Suifate Reducers       org's/ml         1       77.       Total Colliorm       org's/ml         78.       Yeast       org's/ml         80.       Volatile, Solids       org's/ml         82.       Propionate       as C ₂ H ₂ O ₂ 0.00       0.00       0.00       0.00         93.       Total Organic Nitrogen       15         84.       Total Organic Nitrogen       15         85.       Mexel (A-432)       2.5         86.       Mexel (A-432)       0.00         87.       Organic Nitrogen       0.00         88.       Mexel (A-432)       0.00         99.       0.00       0.00         90.       0.00       0.00	۰b			·						************			·····	
1       77.       Total Coliform       org's/100ml         78.       Yeasi       org's/100ml         1       78.       Residue by Evaporation         6       80.       Volatile Solids         78.       Total Cognitics		******	and a second			<del></del>		-					·····	
9         78         Yeasi         org's/ml           1         7.8         Residue by Evaporation	Ŧ,									eter an an an air an an an a				
a       B0. Volatie Solids	:0 :0	78.	Yeast org's/ml											
Image: second	1						Launa 2000 -		1.4					
1       62       Propionate       as C_Hi ₂ O ₂ 0.00       0.00       0.00       0.00       0.00         383       Total Organic Carbon					. • • • • •							hadan marina hadan kara kara kara kara kara kara kara ka		
183.         Total Organic Carbon         1           86.         Mexel (A-432)         2.5         1:5         1.5	( <b>1</b> .)		Propiopate as C-H-Os	0.00		0.00	·····	0.00		0.00		0.00		
B4:         Total Organic Nitrogen         /           B5:         Mexel (A-432)         2.5         1:5         1.5           Image: Solution of the second sec	F	83.	Total Organic Carbon		;	0.00	-1Th schedurence of the		••••••••••••••••••••••••••••••••••••••		tatta kana kanana bajar dar.			
		84.	Total Organic Nitrogen	1									1911 1919 194 194 194 194 194 194 194 19	
Image: sector		85.	Mexel (A-432)	2.5	1 			1:5		•		1.5	n 1911 - Sefferent Lata, in Charlos and	
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				LA	BORAT	ORY RE	PORT -	WATER	ANALYS	SIS	Customer	No	1001392	
C		H-O-H Ch	emicals, Inc.	Regarding:	Indiana a	and Michig	an Powe	r Compar	y.		Report No	o:: as	indicated	
			Vermont St.		Donald (	Report Da								
	Ur		ine, IL 60067		1 Cook F					· · ·	Analysis E			
	. `				Bridgma						Sample Date: as indicated			
			347/358-7400		Dridgina							· ·	maicated	
L	<b>G</b>		347/358-7400 347/358-7082	Control (#27		Treated 4/19/07 (#27817)		Control 5/3/07 (#27972)		Treated 5/3/07 (#27972)		Control 5/10/0 (#27972)		
				Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	
Г	1	Alkalinity ("P")	as CaCO ₃	0		. 10		10		10		-10	······	
	2	Alkalinity ("M")	as CaCO ₃	162	ita adalah katalan katalan ini ka	162	*****	134		144		138	ى. تەڭ بەملىكەموقىمىرە، يىنىت	
	3	Alkalinity ("OH") (calculated)	as CaCO ₃			The second second second	Party and a second s					ing and a second for chain a		
W	4	Free Mineral Acidity	as CaCO ₃		·			· ·					ľ	
a	5	Chemical Oxygen Deman	d (C.O.D.)	15.4	-	9.0		6.1	Tophar Mar	6.5		6.5		
t.	6	Chloroform Extractables			•		i				~			
8	7	Dissolved Solids		263		263		218		227		229		
1	8	Hardness (Calcium)	as CaCO ₃	118		109		88		93	يد بعداد مسبسين	.92		
	9	Hardness (Magnesium)	as CaCO ₃	62		57		47		51		51		
P	10	Hardness (Total)	as CaCO ₃	180		166		134		144		143		
1	11	pH Specific Coordustopee	1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.	8.0		8,3		8.2		8.2	·	8.3	*****	
2	12	Specific Conductance Specific Gravity	umhos	399		392		327		. 341		343		
P	13 14	Suspended Solids	g/ml		175			····			1.0		4 7	
je r	14	Aluminum	as Ai	0:02	1/5	0.02	<u> </u>	0.01	1.0 0.02	0.01	1.0	0.01		
	16	Barlum	as Ba	0:02	0.01	0.02	0.15	0.01	0.02	0.01	0.01	0.01	0.01	
	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	
9	19.	Copper	as Cu	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
10	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.	Lithlum .	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	andalah ing kanala para k	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	
C	28.	Sodium	as Na	9.19		8.68		6.87		7.19		7.13		
a	29.	Strontium	as Sr	0.13	0:00	0.11	0.00	0.11	0.00	0.11	0.00	0:11	0.00	
14	30.	Zinc	.as Zn	0.01	0.09	0.01	0.00	0.00	.0.23	0.00	0.08	0.00	0.05	
0	31.	Total Cation Millequivalen	ts	4.045		3:735		3.019		3.232	r merina an a	3 197		
n	32.	Acetate	as C ₂ H ₃ O ₂	0.00		0.00		0.00		0,00		0.00		
8	33.	Bromide	as Br	0.00		0.00		0.00		0.00		0.00		
1	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	e	0.00	,	
	38.	Chromate	as CrO4											
	37.	Fluoride	as F	0.10		0.10		0.09		0.08		0.09	در وهم و الم و الم و الم و الم و الم و الم	
	38.	Formate	as CHO ₂ as C ₂ H ₃ O ₃	0.05		0.00		0.04	سسبونين ، د	0.00		0.00	······ ; ······;	
	<u> </u>	Glycolate Molybdate	as MoO ₄	0.00		0.00		0.00		0.00		0.00	,	
	40.	Nitrate	as NO ₃	2.58	·	2.52	Å	0.02		0.01	·•••	0.00		
	41.	Nitrite	as NO ₂	0.06	*****	0.00	·····	1.40		0.24	····	0.32	······	
	43.	Nitrogen (total)	as N					1.00		0.24	****			
	44.	Oxalate	as C ₂ O ₄	0.00		0.00	·····	0.00	، بالمستخدمة معرومة ا	0.00		0.00		
	45.	Phosphate (ortho)	as PO4	0.00		0.00		0.00	·	0.00		0:00	······	
	46.	Phosphate (poly)	as PO4	*****					manana pananga di sa				8.808. 2. 12 <del>Lakerdon</del>	
n n	47.	Phosphate (organo)	as PO ₄								-			
[ ii]	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	
0	49.	Sulfate;	as SO ₄	24.8		25.1		21.8		23.4	andro adre adre	22.8	ŀ	
ň	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	
S	51.	Total Anion Millequivalents		4.460		4.397		3.624		3.888		3.731		
	52.	Ammonia	as NH ₃										***	
	53;	Benzötriazole	as C ₆ H ₅ N 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 Suifite	as Na ₂ SO ₃							·				
ŀ	58.	Tolyltriazole All data except pH in parts per million or as	as C ₇ H ₆ N ₃					reverse side				•	·····	

h

			LA	BORAT	ORY RE	51S 1	Customer No.: 1001					
		H-O-H Chemicals, Inc.								Report No	indicated	
		500 S. Vermont St.	Location:	Donald C	Cook N	uclear Pl	ant			Report Da		1/0/00
		Palatine, IL 60067		1 Cook P	lace					Analysis [		1/0/00
		r aladirojan obobr		Bridgma						Sample D		indicated
		847/358-7400		anagina			<u> </u>				<u>u.o.</u>	
		Fax: 847/358-7082			Treated 4/19/07 (#27817)		Control 5/3/07 (#27972)		Treated	5/3/07	Control	5/10/07
		1.ax. 0411000-1002								972)		972)
			( <i>i</i> , <b>z</b> )	0.117	X	011.)	( <u>1</u>	,	Vi i	() ( <u>-</u> )		<i>u, _,</i>
			Soluble	Insoluble	Soluble	Insoluble	Soluble:	Insoluble	Soluble	Insoluble	Soluble	Insoluble
F	-59,	Bromate as BrO3		[								<del></del>
c	60.	Chlorite as CIO2	**************************************	••••••••			•	·				
C		Cyclohexylamine* as C ₆ H ₁₃ N	· · · · · · · · · · · · · · · · · · ·				******				2.5.	
m		Diethylamine* as C4H11N									· · · · · · · · · · · · · · · · · · ·	a a sector a
P	63.	Diethylaminoethanol* as C ₆ H ₁₅ NO					****		· •••••••••••••••••••••		•	
0.	64.	Ethylamine* as C ₂ H ₇ N									•	
n		Morpholine* as C ₄ H ₉ NO							-			
d		Diethylene Glycol* % by weight								atra internationalistica		
.8	67.	an and an		interaction sufficiencies				and an international states (second second				
1	68.	Propylene Glycol* % by weight		Martin Propagation				************			، ر ، بي بين الم	
		Aerobic Plate Count org's/ml					·····					·····
M		Anaerobic Plate Count org's/ml					have a summer	••••••••••••••••••••••••••••••••••••••			· · · ·	·,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
11		Fecal Coliform org's/100ml										
1.9		Iron Bacteria	· · · · · · · · · · · · · · · · · · ·		1999-93 - 51 - 6296/1-1999999			processor i ca primadore.			سيبين فدورة مست	
6		Mold org's/ml			·····	······			*	· · ·		
Þ		Nitrate Reducers org's/ml							****		, 	
1		Slime Formers org's/ml Sulfate Reducers org's/ml									·····	
1°	76.	Sulfate Reducers org's/ml. Total Coliform org's/100ml		· ·			* <b>-</b>	. حاف ما ما ما ما ما ما ما ما ما				
6	77. 78.	Yeast org's/ml	/····		····	*******		1'* h				
:9		Residue by Evaporation		· ·	<b>**</b> •					N-2 1		
11	80.	Volatile Solids	• # · •	<u>`</u> -					,			
C ie	81.	System Capacity gal.	***					تىبايىر بىرىد مەممىيىرىر :			in an	
I:		Propionate as C ₃ H ₅ O ₂	0.00	····	Ò:00		0:00		0.00		0:00	······
Ľ.		Total Organic Carbon		e		••••••••••••••••••••••••••••••••••••••		** *** *************			9	
	84.	Total Organic Nitrogen	······································		• •••••••••••••••••	***** · ·					****	
		Mexel (A-432)	• •		1.5	·····	·····		2.5			
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	ليب	All data except off in parts per million or as indicated		·		L	L	L	ļ	*Anabusia bu 2	as Chromaloon	

			LA	BORAT		PORT -	WATER	ANALYS	IS	Customer	Nö.:	1001392	
C		H-O-H Chemicals, Inc								Report No		indicated	
1.	نيم	500 S. Vermont St		Donald C	Report Date:								
Ĩ.	UTE	Palatine, IL 60067		1 Cook F						Analysis Date:			
÷.	C.	옥길()		Bridgmar						Sample Date: as indicated			
Ē.		847/358-7400						1	_				
C		Fax: 847/358-7082			Control ! (#279		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	
F	1.	Alkalinity ("P") as CaCO3	10		. 0		0		- O		0		
	2.	Alkalinity ("M") as CaCO3	134		152		154	2	122		124		
	3.	Alkalinity ("OH") (calculated) as CaCO3,					*			•····			
W	4.	Free Mineral Acidity as CaCO ₃										*****	
a	5.	Chemical Oxygen Demand (C.O.D.)	7.1		16.0		16.3		5.9		6.3	maniation	
	6.	Chloroform Extractables	016						214		210	9 <i></i>	
e	7.	Dissolved Solids Hardness (Calcium) as CaCO ₃	216		231 86		236 86		2.14		68	·	
11	· · 9.	Hardness (Magnesium) as CaCO ₃	.00		46		47		40		40		
P	10.	Hardness (Total) as CaCO ₃	136		132		134	l	108		108	,	
1	11.	pH	8.2		7.8		8.0		7.8	1	8.1	i	
0	12.	Specific Conductance , µmhos	327		346		346		319		320		
P	13.	Specific Gravity g/ml											
e	14.	Suspended Solids		1.0		160		8.0		7.0	-	2.0	
[ r	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	<u>15:2</u> 0.01	34.6	3.80	27.3	1.44 0.02		0.00	
e	18. 19.	Chromium as Cr Copper as Cu	0.00	0.00	0.00	0.01	0.00	0.01	0.03	0.02	0.03	0.01	
1	20.	lron as Fe	0.00	0.10	0.00	2.76	0.00	0.32	0.00	0.22	0.00	0.00	
	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	. 10:00	0.00	0.00	Ó.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	
Ca	28.	Sodium as Na	6.63		7.39		7.72		8.47		8.35	·····	
t.	29.	Strontium as Sr	0.11	0.00	0.11	0.02	0.11	0.01	0,12	0.00	0.13	0.00	
Ľ	<u>30.</u> 31.	Zinc as Zn Total Cation Millequivalents	0.00	0.05	0.00	.0.17	0.00	0.13	0.01 2.583	0.45	0.00 2.570	0.30	
0 .n	32.	Acetate as C ₂ H ₃ O _{2*}	0.00	, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	0.00		0.00		0.00		0.00		
:14 ≥8	33.	Bromide as Br	0.00		0.00		0.00		0.00	ana saingangan	0.00		
	34	Chloride as Cl.	11.9		12.7		13.1		12.7	ana an	12.0		
	35.	Chlorate as CIO ₃	0.00		0.00		0.00		0.00	۵۰۰۰۰۰ ۲۵۰۰ ۲۵ _۹ ۰۰ ۲۹۹۹ ۲۹۹۹ ۲۹۹۹ ۲۹۹۹ ۲۹۹۹ ۲۹۹۹ ۲۹۹۹	0:00	······································	
	36.,	Chromate as CrO ₄		97.72 k = 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6 k + 6									
ŀ	.37.	Fluoride as F	0.09		0.00		0.11		0.09	a national de la construction de la	0.10		
	.38.	Formate as CHO2	0.00		0.00		0.00		0.00		0.00		
t I	MARKAN COMMANDER	Glycolate as C ₂ H ₃ O ₃	0.00	*.*.* / *	0.49		0:00	*****	0.00	·····	0.00		
	and an an an an an	Molybdate as MoO ₄	0.00	·····	0.00	·	0.00		0.01		0.01	÷	
	41.	Nitrate as NO ₃	0.00		1.74		0.00	******	0.91		0.00		
ŀ	43.	Nitrogen (total) as N	V.00				0.00		0.00	المحاد بخسيتين وأعراضهم	0.00		
	44	Oxalate as C ₂ O ₄	0.00		0.00		0.00		0.00	· · · · · · · · · · · · · · · · · · ·	0.00	······································	
t I		Phosphate (ortho); as PO4	0.00		0.00		0.00		0.00		0.00		
	46	Phosphate (poly) as PO4											
n	47.	Phosphate (organo) as PO4										· · · · · · · · · · · · · · · · · · ·	
μŸ.	48.	Phosphorus (total) as P	0.00	0.00	0.00	0.06	0.00	.0.01	0.00	start and a second second second second	0.00	0.00	
0	49	Sulfate as SO4	21.6		23.6		24.7		21.5		20.9		
S	50.	Sülfür (tótal) 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 Ammonia as NH ₃	3.566		3.991		4.061		3.317		3.365		
	52. 53.	Ammonia as NH ₃ Benzotriazole as C ₆ H ₅ N ₃	·		·								
		Boron as B	0.00	······	0.00		0.00		0.00	······································	0.00	•••••	
		Silica as SiO ₂	2:23	0;00	2.00	5:15	1.91	1.27	1.47		2.69	0,00	
	56.	Sodium Nitrite as NaNO2									7-	· · · · · · · · · · · · · · · · · · ·	
	57.	Sodium Sulfite as Na ₂ SO ₃			-								
$\Box$		Tolyltriazole as C7H8N3	L		;			- · · ·		1			
Anatysi		All data except pH in parts per million or as indicated			Co	ntinued on	reverse side	<b>a</b> :			· · · · · · · · · · · · · · · · · · ·		

		H-O-H Chemicals, Inc.	LA Regarding:	BORAT	Customer No.: 100139 Report No.: as indicated								
		500 S. Vermont St.	Location:	Donald C	Report Date:								
		Palatine, IL 60067		1 Cook F	· ·	Analysis Date:							
				Bridgman						Sample Date: as indica			
		847/358-7400 Fax::847/358-7082			Control	Control 5/17/07 (#27958)		5/17/07 /958)	Control 5/24/07 (#27999)		Treated	5/24/07 '999)	
			Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	
	59.	Bromate as BrO3							,		· · · ·		
с	60.	Chlorite as ClO ₂		Mar 212 20 0000000000000000000000000000000						• •,=		40. <b>1</b> 40.000 00000000000000000000000000000000	
0		Cyclohexylamine* as C ₅ H ₁₃ N	****	·	****						••••••••		
m		Diethylamine* as C4H11N		·									
P		Diethylaminoethanol* as C ₆ H ₁₅ NO	and the second second second			francosciloration ( Martin ) Martine	·	*****					
.о. П	64.	Ethylamine* as C ₂ H ₇ N		The second s		1	A				Canada Calcondo a		
n	65.	Morpholine* as C ₄ H ₉ NO					10 quite and a second			:		· ·	
ď	66.	Diethylene Glycol* % by weight											
S	:67.	Ethylene Glycol* % by weight											
	68.	Propylene Glycol* % by weight	·····									-	
	69.	Aerobic Plate Count org's/ml			·							*	
M	70.	Anaerobic Plate Count org's/ml				and the second secon		- 1	-				
	71.	Fecal Coliform org's/100ml									·		
<u>د</u> ر بر		Iron Bacteria										·	
0	73.	Mold 'org's/ml	randrandras _{nar} assassassa										
6	74.	Nitrate Reducers org's/ml				·····		•					
1	75.	Slime Formers org's/ml							) 25			لمجخبع ستستس	
0	76.		- 	المعادية ورد ومعادمات						-	-		
6	77.	Total Coliform org's/100ml	Lane :: (	· · · · · · · · · · · · · · · · · · ·				anananan ara ara		nor have been a second		Included in the specific property contacts	
9	78.	Yeast org's/mi		******		ىمىسىسىيە بارىپ ، مە	·			• <b></b>	· · · · · · · · · · · · · · · · · · ·		
1	79.	Residue by Evaporation											
Ċ	80.	Volatile Solids						······			·		
8	81	System Capacity gal.				مشماندین مشمس							
'	- second and	Propionate as C ₃ H ₅ O ₂	0.00	····	0.00	:= •	0.00		0.00		0.00		
	: 83.	Total Organic Carbon		· ////////////////////////////////////	an andrastrationstration		·····				···· •	<b></b>	
	84:												
	85.	Mexel (A-432)	2:5			······	2.5				2.5	iii	
ŀ		······································						د د مسجعیت	·				
										، بەرمەر <mark>بىرىكى بىرىكى بىرىك</mark> ى ب	· ····································	••••••••••••••••••••••••••••••••••••••	
	<u>.</u>	ייי איז איז איז איז איז איז איז איז איז	• • • • • • • • • • •	, in the second		<u>:</u>		ware the straight threatenes.		se with manage or communities of	Sectorane Course and		
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1		and a second							·····			•	
		······································	**	·** •******							·····.	·~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	
<u> </u>		All data except pH in parts per million or as indicated		i		<u>ا</u>		1	1	La contraction of the	as Chromatoon		

			LA	BORAT	ORY RE	PORT -	WATER	ANALYS	SIS	Customer	No.:	1001392	
Ć	<u>`</u>	H-O-H Chemicals, Inc.			Report No.: as indicated								
Ŀ.		500 S. Vermont St.				Report Date:							
1	ν.(C	Palatine, IL 60067		1 Cook P						Analysis Date: Sample Date: as indicated			
	3 S 😤		Bridgman, MI								ate: as	indicated	
L		847/358-7400 Fax: 847/358-7082	Control (#27		Treated 5/31/07 (#27999)		Control 6/21/07 (#28100)		Treated 6/21/07 (#28100)		Control 6/28/07 (#28129)		
			Soluble	Insoluble	Soluble	Insoluble	Solubie	Insoluble	Soluble	Insoluble	Soluble	Insoluble	
	1	Alkalinity ("P") as CaCO3	.0		6		:0		10		Ő		
	2.	Alkalinity ("M") as CaCO ₃	118		120		154		150		130		
1.5	3	Alkalinity ("OH") (calculated) as CaCO3									·		
Ŵ	4. 5.	Free Mineral Acidity as CaCO ₃ Chemical Oxygen Demand (C.O.D.)	12.6		13.0		8.9	* * *******	7.3		23:4		
Ĩ	6.	Chloroform Extractables	12:0		10.0			1.1144.65 <i>0.066</i> .0688.85					
e	7.	Dissolved Solids	210		211		213	er verstaanseel op staan en v	210		224	lı	
T I	8	Hardness (Calcium) as CaCO3	70		68		82		81		86		
Р	9	Hardness (Magnesium) as CaCO3	41		40		46		45		.46		
17	<u>10.</u> 11.	Hardness (Total) as CaCO ₃	<u>111</u> 8.1		108 8.4		128 7:9		127 8.2		7.7		
0	12	Specific Conductance µmhos	317		315		318		314		338		
p.	13	Specific Gravity g/ml			n an general general de la companya	1.549 149 49 49 49 49 49 49 19 19 19 19 19 19 19 19 19 19 19 19 19			angengengtageng en en gener en fan en staats gebiene teksteren en staatse tekste in 1968			1	
e.	14.	Suspended Solids		73.0		7.0		144		6.5		213	
19	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. 17.	Barium as Ba Calcium as Ca	0.02	0.01 3.37	0.02	0.00 0.99	0.02 32.6	0.01 8.78	0.02	0.00	-0.02 34:5	0.01	
e	18.	Chromium as Cr	0.04	0.01	0.03	0.01	0.01	0.01	0.01	0.00	0.00	0.02	
s	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	Second contraction of the second	0.00	2.51	
	21.	Lead as Pb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-spistenages raine te tot rate :	0.001	0.002	
	22. 23.	Lithium as Li' Magnesium as Mg	0.00	0.00	0.00 9,62	0.00	0.00	0:00	0.00		0.00	0.00	
	23.	Manganese as Mn	9.93	0.05	0.00	0.02	0.00	0.11	,0.00		0.03	0.14	
1	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	0.13	
a	28. 29.	Sodium as Na Strontium as Sr	8.38 0.12	0.00	8:08 0:12	0.00	7.69	0,00	7.49	0.00	7.51	0.01	
t	30.	Zinc as Zn	0:00	0.29	0:00	0.00	0.01	0:02	0.01	0.00	0.00	0.04	
ŏ	31.	Total Cation Millequivalents	2.631		2:546	•	2.924		2.896	· · · · · · · · · · · · · · · · · · ·	3.009	on an	
n	32:	Acetate as C ₂ H ₃ O ₂	0.00		0.00		0.00		0.00		0.00		
Ş	33.	Bromide as Br	0.00		0.00		0:00		0.00		0.00	-	
	34. 35.	Chloride as Cl Chlorate as ClO ₃	12.5 0.00	·····	12.4		12.0 0.00		12.8	a a a ser a real a real real and a de de de de d	12.2 0.00	haninaan A Thormough	
	36.	Chromate as CrO ₄	0.00		0.00		0.00	CT ( 0 \$ 475, -16, 200 (\$747, 10) \$ \$ \$800.11	0.00		0.00		
	37.	Fluoride as F	0.10		0.09		0.08		0.08		0.07	······································	
	38.		0.00		0.00		0.00		0.00		0.00		
		Givcolate as C ₂ H ₃ O ₃	0.00		0:00		0.00		0.00	ta farenta be bade de Rete da fartes.	0.00		
	40:	Molybdate as MoO ₄ Nitrate as NO ₃	0.01	·	0.01 0.87		0.00		0.00		0.00		
	41.	Nitrite as NO ₂	0.92		0.87		0.00		0.00		0.00		
	43.	Nitrogen (total) as N							angenerate y a selectedade				
	44.	Oxalate as C ₂ O ₄	0.00		0.00		0.00		0.00		0.00	!	
	45.	Phosphate (ortho)         as PO4           Phosphate (poly)         as PO4	0.00		0.00		.0.50		0.52		0.00	i,·	
A	48.	Phosphate (poly) as PO4 Phosphate (organo) as PO4					<u></u>		1-1-1-1				
	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	
ò	49.	Sulfate as SO4	20.9		21.2		20.2	·····	21.4	and a sub-plant of the s	21.9	ŀ	
n s	50.	Sulfur (total) as S	6.43	0.36	6.23	0.50	7.03	1.56	7.01	· Free Parentes researchents	7.02	0.96	
	51.	Total Anion Millequivalents Ammonia as NH ₃	3.223		3.252		3.948		3.889		3.502		
	52. 53.	Ammonia as NH3 Benzotriazole as C6H5N3									*		
	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	ales of challengester to to the bottom of	2.60	4.39	
	58.	Sodium Nitrite as NaNO2				3,			ىرىيە مەلەرلىڭ ئەرچەمغە				
	57;	Sodium Sulfite as Na ₂ SO ₃		·					inan makatina noon				
intra intra	58.	Tolyltriazole: as C ₇ H ₅ N ₃ All data except pH in parts per milition or as indicated			C	ontinued on	reverse side		·	1	L	с <u> </u>	

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		500 S. Vermont St.			Customer No.: 10013 Report No.: as indicate Report Date:							
		Palatine, IL 60067	200001011.	1 Cook P		Analysis Date:						
				Bridgmar				,		Sample D		indicated
		847/358-7400 Fax: 847/358-7082		5/31/07 '999)		5/31/07 Control 6/21/07 999) (#28100)			Treated 6/21/07 (#28100)		Control	6/28/07 129)
			Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Inscluble	Soluble	insoluble
Ţ	59.	Bromate as BrO3										
c		Chlorite as ClO ₂										
		Cyclohexylamine* as C ₅ H ₁₃ N			••••••				• •···		••••••••••••	
		Diethylamine* as C ₄ H ₁₁ N Diethylaminoethanol* as C ₆ H ₁₅ NO		<del></del>				• • •,•,•,•	······································			
0		Ethylamine* as C ₂ H ₇ N		<del>.</del>	<u>.</u>				·····			
u		Morpholine: as C ₄ H ₉ NO		·i	fra				,			
d		Diethylene Glycol* % by weight										
		Ethylene Glycol* % by weight										
		Propylene Glycol* % by weight	· · · ·						م		, 	••
		Aerobic Plate Count: org's/ml Anaerobic Plate Count org's/ml							<u>.</u>			· · · · · · · · · · · · · · · · · · ·
		Anaerobic Plate Count org's/ml Fecal Collform org's/100ml							÷			*****
		Iron Bacteria						and a top of the second second				
T		Mold org's/ml						······································		· · · · · · · · · · · · · · · · · · ·		
	74.	Nitrate Reducers org's/ml				د مربع برم می مربع از م مربع از مربع از						08 - 1 uppela,
í 🔡		Slime Formers org's/ml						1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-				
		Sulfale Reducers org's/ml				•*****		·····				·····
		Total Coliform org's/100ml	alta yan amarar akada saariya t				ستحسبه فاحتوجا عو		معتبار لمته المداء مالغ			·····
g   -		Yeast org's/ml Residue by Evaporation		••••		,			anan waaraa	·•••••	·····	
1.1~~~		Volatile Solids	i		······	• • • • • • • • • • • • • • • • • • • •				· · · · · · · · · · · · · · · · · · ·		
- 1		System Capacity gal.	**************************************	·····				····~·································		• • • • • • • • • • • • • • • • • • •		
		Propionate as C ₃ H ₅ O ₂	0.00		0.00		0.00		0.00		0.00	
	83.	Total Organic Carbon					1				·	
		Total Organic Nitrogen								ile jummer and		
1	85.	Mexel (A-432)			2.5			·····	2:5			
		·				·	diadaten menyaman .	. <u></u>				
			a National and a second standard state of				- 140.0.				,	
-		dente construction and the second			"We in the continues		5 m				••••••••••••••••••••••••••••••••••••••	
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				LA	BORAT	ORY REP	PORT -	WATER	ANALYS	sis I	Customer	No.:	1001392		
(Car		H-O-H Chemica	ls. Inc.			and the second sec		in the second second		·····	Report No		indicated		
1	ليندأ	500 S. Verm				Cook Ni			·	·	Report Date:				
	U (	(a) Palatine, IL			1 Cook P						Analysis Date:				
	C.N				Bridgman			<u>,                                     </u>			Sample D		indicated		
12		847/35	8-7400								<u>compre s</u>				
C	4.354	Fax: 847/35		Treated 6/28/07 (#28129)		Control 7/5/07 (#27190)		Tréated 7/5/07 (#27190)		Control 7/12/07 (#27190)		Treated 7/12/07 (#27190)			
				Soluble	Insoluble:	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble		
$\Box$	1:	Alkalinity ("P") as C	CaCO ₃	0		0		0		0		10			
	2.		CaCO ₃	126		134		134		134		130			
	.3.		CaCO ₃												
Ŵ	4.	with manufacture of the second s	CaCO ₃												
8	5.	Chemical Oxygen Demand (C.O	. <u>D.)</u>	15.6		7.8		7.5		6.9	·····	6.6			
	6:	Chloroform Extractables								014	<b>.</b>	200			
e r	<u>7.</u> 8:	Dissolved Solids Hardness (Calcium) as C	CaCO ₃	214 84		<u>,219</u> 84		206 81		214 83		206 .81			
'	9.	and the second sec	CaCO ₃	46				44		44					
ŀр	10,		CaCO ₁	131		128		125		127		126			
1	11.	pH	and the second s	B.1	······	7.8		8.1		7:8		8.2	· · · · · · · · · · · · · · · · · · ·		
0	12.	Specific Conductance µmh		:318		327		310		318		307			
P.	13.	Specific Gravity g/m										;			
e	14.	Suspended Solids			0.0	····	174		2.0	· ······	245		8.0		
[1]	15.	Aluminum as A		0.01	0.02	0.01	1.78	0.02	0.03	0.01	2.00	0.01	.0.09		
E	16.	Barium as E		0.02	0.00	0.02	0.01	0.02	0.00	0.02	0.02	0.02	0.00		
	17.	Calcium as C Chromium as C	njular navranska (* 1	33.7	0.96	33.4	12.4	32.3	0.97	33.1	20.8	0.00	1.52		
	19.	Chromium as C Copper as C		0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.02	0.00	0.03		
2	20,	Iron as F		0.00	0.01	0.00	2.73	0.00	0.09	0.00	3.55	0.00	0.30		
	21.	Lead as F		0.000	0.000	0.000	0.002	0.000	0.000	0.000	0:004	0.000	0.001		
	22.	Lithium as L		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	23.	Magnesium as M		11.2	0.00	10.8	3.87	10.8	0.00	10.7	5.75	10:8	0.12		
	24.	Manganese as N		0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.19	0.00	0.01		
	25.	Nickel as N	8	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
	26	Potassium as K	"Arthmenterson."	1.42		1.43		1.31		1.34		1.31			
	27.	Silver as A		0.00	0,05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
^C	28.	Sodium as N		7.23		7:12		6.80		6.82		6.79			
Î	29. 30.	Strontium as S		0.11	0.00	0.11	0.01	0.11	0.00	0.11	0.02	0.11	0.00		
, ŧ.	31.	Zinc as Z Total Cation Millequivalents	<u>n</u>	0.01 2.960	0.34	0.01	0.05	0.01	0.01	0.01 2.871	0.05	0.01 2:839	0.09		
°	32.		2H3O2	0.00		0.00		0:00		0.00		0.00			
s	33.	Bromide as B		0.00	wawi	0.00	and a second	0.00		0.00	-se é éntre management e	0.00			
	34.	Chloride as C	commentation and and a	12:1		11.9		12.0		.12.0		12.2			
	35.	Chlorate as C		0.00	· · · · · · · · · · · · · · · · · · ·	Ò.00	· · · · · · · · · · · · · · · · · · ·	0.00		0.00		0.00			
	36.	Chromate as C	rO4		1						leng approximation and the of		1 1		
F 1	37.	Fluoride as F	and a second	0.06		0.07		0.08		0.07		0.07	المراجعة المحمودية المراجع		
		and any second set pay was the transformer and the transformer better to an an an and the second s	HO ₂	0.00		0.00		0.00	974) 8	0.00	In sector of the sector of the sector of	0.00			
			2H3O3	0.00		0.00		0.00	in the second second second	0.00	Same interesting	0.00			
	40.	an a	100	0.00	fe ne sa an	0.00		0.00		0.00	The second second second second second	0.00			
	41. 42.	Nitrate as N Nitrite as N		1.09		2.66 0.00		1.10 0.00		1.35		<u>1.12</u> 0.00			
		Nitrogen (total) as N		0.00	استنب جنسية			0.00	the management in the second second	0.00		0.00	* 1		
	44:	Oxalate as C		0.00		0.00		0.00		0:00		0.00	······································		
	www.wiger	Phosphate (ortho) as P		0.00		.0.00		0.00		. 0.00		0.00			
ام ا	46.	Phosphate (poly) as P	Target and the second second		,					· · · · · · · · · · · · · · · · · · ·					
6	47.	Phosphate (organo) as P	and the second						· · · · · · · · · · · · · · · · · · ·						
14	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		
0	49.	Sulfate as S		22.7		21.8		22.3		22.3	4.65	22.7			
s	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		
	51. 52.	Total Anion Millequivalents Ammonia as N		3.426	·····	3.737		3.586		3.653		3.509			
r I	53.	and a second state of the second s	₆ H ₅ N ₃	···			·····					·····			
	54.	Boron as B	a service of the serv	0.00		0.00		0.00	·	0.00		0.00			
	55.	Silica as S		2.14	0.99	6.62	7 54	2.55	1.99	4:33	8.27	2.14	0.98		
			IaNO ₂				······································								
l I	57.	Sódium Sulfite as N	la ₂ SO ₃												
ப	58.		7H6N3								L				
Anaryst.		All data except pH in parts per million or as indicated	ь			Co	intinued on	reverse side	9.			. –			

		H-O-H Chemicals, Inc.	LABORATORY REPORT - WATER ANALYSIS Regarding: Indiana and Michigan Power Company Location: Donald C. Cook Nuclear Plant							Customer No.: 1 Report No.: as indi		
			Location:	Donald C	Cook N	uclear Pl	ant	<u> </u>		Report Da		· ·
		Palatine, IL 60067		1 Cook F					······	Analysis I		
				Bridgman	<u>n, MI</u>		` 			Sample D	ate: as	indicated
		847/358-7400 Fax: 847/358-7082		6/28/07 129)		17/5/07		d 7/5/07 (190)		7/12/07 7190)		17/12/07 7190)
		ŀ	Soluble	insoluble	Soluble	insoluble	Soluble	Insoluble	Soluble;	Insoluble	Soluble	Insoluble
i T	59.	Bromate as BrO3										
		Chlorite as CIO ₂	······					. Canadia and and				
		Cyclohexylamine* as C ₆ H ₁₃ N		ور معدست المنظو حدد ا				,		·		
1.1.0		and provide the second state of the second sta	· · · · · · · · · · · · · · · · · · ·				·····				Lawrence or in the second	
P.		Diethylaminoethanol* as C ₈ H ₁₅ NO					• • • • • • • • • • • • • • • • • • •		lanalasian sinna		mangin namiyar	
0	64.	Ethylamine* as C ₂ H ₇ N	inne of the state			benne e consistentes y	5				annos is commentana	
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. 5		Ethylene Glycol* % by weight	<b></b>				Sanna annananana a T	2.000000000000000000000000000000000000		-		a ya kunanya manga manan ku 🦕
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9	rranka N	Iron Bacteria			· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·					3	
15		Mold org's/ml				and and a second se			Jush manage			
b		Nitrate Reducers org's/mi	-		*****	Conservation Manual				1		
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0		Sulfate Reducers org's/ml		· ·				in the second second			the second s	
1.01		Total Coliform org's/100ml							340° or 1744	14.5p		
a		Yeast org's/ml	na marine and the formations		•			Server an announcement			i. Alaraning astronom	
i.,		Residue by Evaporation			····	Activities and a survey						
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	H-O-H Chemicals, I						ny 🗌		Report No	o.: as	indicated
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		-	Bridgma	n, Ml					Sample D	ate: as	indicated
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	5. Chemical Oxygen Demand (C.O.D.)	6.0		8.1	Latutininterne ro	·5.5		6.4		10:2	· · · · · · · · · · · · · · · · · · ·
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[]_]	and a second	0.01	0.66	0.01	0.05	0.01	1.10	0.02	0.04	0.01	0.84
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i 1 e 1	and a second	31.9	6.22	31.5	0.00	32.5	8.06	31.8	0.00	32.0	5.39
e 1 s 1	and a second	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00 0.00
2	and a second	0.00	1.05	0.00	0.01	0.00	1.70	0.00	0.00	0.00	1.33
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	,	H-O-H Chemicals, Inc.	LABORATORY REPORT - WATER ANALYSIS Regarding: Indiana and Michigan Power Company Location: Donald C. Cook Nuclear Plant								Customer No.: 1001392 Report No.: as indicated		
		500 S. Vermont St.	Location:			luclear Pla	ant'		<u> </u>	Report Da			
		Palatine, IL 60067		1 Cook F						Analysis I			
				Bridgma	n, Ml					Sample D	ate: as	indicated	
	•	847/358-7400 Fax::847/358-7082		7/19/07 3250)		7/19/07 250)		7/25/07 3250)		7/25/07 3250)		1 8/2/07 3301)	
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	59.	Bromate as BrO3						<u></u>		Į.			
c	, 60.	Chlorite as ClO ₂	*	·,		·····	· · · · · · · · · · · · · · · · · · ·	A	******				
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m		Diethylamine* as C ₄ H ₁₁ N	نا شا شاه معنا ما ما ما	·		1			····· 45979-96194.0414				
P		Diethylaminoethanol* /as C ₆ H ₁₅ NO	raaka ka ugu ugu ugu ugu ayaa ayaa ka		**************************************	ەمەھەردە بەر. 1945 ( הەەھەر	na managana and Whether (signat) -	······		-	a constant of the spectrum of	-	
o' u	64.	Ethylamine* as C ₂ H ₇ N		and the second sec			and a second	······································	· · ······		aratis.c		
n		Morpholine* as C ₄ H ₉ NO				······································			annead in the second second				
d	66.	Diethylene Glycol* % by weight	· · · · · · · · · · · · · · · · · · ·						,				
8	67.	Ethylene Glycol* % by weight					art 1997 (1997)		ar a miljan oʻla Kodin aranasad miri	and the second second second			
11	-68.	Propylene Glycol* % by weight				And a feature of the second	······································		•				
	69.	Aerobic Plate Count org's/ml											
м		Anaerobic Plate Count org's/ml											
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ļ e	72.								ļ	-			
0	73.	Mold org's/ml		<del>,</del> ,									
b	74.	Nitrate Reducers org's/ml	•								******		
	75.	Slime Formers org's/ml				-							
0		Sulfate Reducers org's/ml					*****						
0	77:	Total Coliform org's/100ml	A			4					<b></b>		
ġ	78.	Yeast org's/ml							÷	A	*		
i	79	Residue by Evaporation	······	······					÷		da. sanjanang		
C ⊧a'	80.	Volatile Solids			·····		÷						
	81.	System Capacity gal Propionate as C ₃ H ₅ O ₂	0.00	•••••			0.00		0.00		0.00		
	82. 83.	Propionate as C ₃ H ₅ O ₂ Total Organic Carbon	0.00		0,00	Amatherina (1999)	0.00		0.00	na in ininana	0.00		
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(#28301) (#28301) (#28301)	Report No Report D Analysis Sample D ontrol 8/15/07 (#28332) luble Insoluble 0 134 6.7 212 85	ate: Date: Date: as ind Treated 8/1 (#28332	
500 S. Vermont St. Palatine, IL 60067         Location:         Donald C. Cook Nuclear Plant           1 Cook Place         Bridgman, MI           847/358-7092         Treated 8/2/07. (#28301)         Control 8/8/07 (#28301)         Treated 8/8/07 (#28301)         Control 8/8/07 (#28301)         Con	Analysis Sample D Sample D (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332) (#28332)	Date: Date: as ind Treated 8/1 (#28332 Soluble In 8 130	15/07 2)
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Bridgman, MI           Bridgman, MI           Fax: 847/358-7082         Treated 8/2/07. (#28301)         Control 8/8/07 (#28301)         Treated 8/2/07. (#28301)           1         Alkalinity ("P")         as CaCO ₃ 16         0         14           2.         Alkalinity ("M")         as CaCO ₃ 134         128         128           3         Alkalinity ("OH") celculated)         as CaCO ₃ 134         128         128           4         Free Mineral Acidity         as CaCO ₃ 134         128         7.0           4         Free Mineral Acidity         as CaCO ₃ 7.0         20.8         7.0           a         5.         Chemical Oxygen Demand (C.O.D.)         7.0         20.8         7.0         20.2           a         5.         Chemical Oxygen Demand (C.O.D.)         7.0         20.8         7.0         20.2           a         Hardness (Calcium)         as CaCO ₃ 204         205         202           7         8.         4.2         120         7.8         2.0           9         10.         Hardness (Total)         38 CaCO ₃ 122         123         3.00           9         13.	Sample C ontrol 8/15/07 (#28332) iuble Insoluble 0 134 6.7 212	Date: as ind Treated 8/1 (#28332 Soluble In 8 130	15/07 2)
Fax: 847/358-7082         Treated 8/2/07 (#28301)         Control 8/8/07 (#28301)         Treated 8/8/07 (#28301)         Control 8/8/07 (#28301)           1         Alkalinity ("P")         as CaCO3         16         0         14         50           2         Alkalinity ("P")         as CaCO3         16         0         14         50           2         Alkalinity ("OH")         as CaCO3         134         128         128         128           3         Alkalinity ("OH")         as CaCO3         134         128         128         128           4         Free Mineral Acidity         as CaCO3	(#28332) <u>luble Insoluble</u> 0 134 6.7 212	(#28332 Soluble in 8 130	2)
Fax: 847/358-7082         Treated 8/2/07 (#28301)         Control 8/8/07 (#28301)         Treated 8/8/07 (#28301)         Control 8/8/07 (#28301)           1         Alkalinity ("P")         as CaCO ₃ 16         0         14         50           2         Alkalinity ("P")         as CaCO ₃ 16         0         14         50           3         Alkalinity ("OH")         as CaCO ₃ 134         128         128         128           4         Free Mineral Acidity.         as CaCO ₃ 134         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128         128 <td< td=""><td>(#28332) <u>luble Insoluble</u> 0 134 6.7 212</td><td>(#28332 Soluble in 8 130</td><td>2)</td></td<>	(#28332) <u>luble Insoluble</u> 0 134 6.7 212	(#28332 Soluble in 8 130	2)
Soluble         Insoluble	iuble         Insoluble           0         134           6.7         212	Soluble In 8 130	
1.         Alkalinity ("P")         as CaCO ₃ 16         0         14           2.         Alkalinity ("M")         as CaCO ₃ 134         128         128           3.         Alkalinity ("OH")         caculated)         as CaCO ₃ 134         128         128           3.         Alkalinity ("OH")         caculated)         as CaCO ₃	0 134 8.7 212	8	soluble
1.         Alkalinity ("P")         as CaCO ₃ 16         0         14           2.         Alkalinity ("M")         as CaCO ₃ 134         128         128           3.         Alkalinity ("OH")         caculated)         as CaCO ₃ 134         128         128           3.         Alkalinity ("OH")         caculated)         as CaCO ₃	0 134 8.7 212	8	
2.       Alkalinity ("M")       as CaCO3       134       128       128         3.       Alkalinity ("OH")       as CaCO3       134       128       128         4.       Free Mineral Acidity.       as CaCO3       14       128       128         a.       5.       Chemical Oxygen Démand (C.O.D.)       7.0       29.8       7.0         t       6.       Chloroform Extractables       204       205       202         e       7.       Dissolved Solids       204       205       202         f       8. Hardness (Calcium)       as CaCO3       79       80       78         9.       Hardness (Magnesium)       as CaCO3       122       123       120         r       11.       pH       8.4       8.0       8.4       7.9         o       12.       Specific Conductance       µmhos       303       308       300       120         r       11.       pH       8.4       8.0       8.4       6.0       6.4       7.9         o       12.       Specific Conductance       µmhos       303       308       300       14.         suspended Solids       3.5       213       8.0       1	134 6.7 212	130	
3. Alkalinity ("OH") (calculated) as CaCO3         W       4. Free Mineral Acidity as CaCO3         a       5. Chemical Oxygen Démand (C.O.D.)       7.0         t       6. Chloroform Extractables         e       7. Dissolved Solids       204         s       205       202         r       8. Hardness (Calcium) as CaCO3       79         9. Hardness (Calcium) as CaCO3       122         10. Hardness (Total) as CaCO3       122         11. pH       8.4         8.4       8.0         6. 11. Specific Conductance       µmhos         303       308         9. 13. Specific Conductance       3.5         14. Suspended Solids       3.5         15. Aluminum       as Ai         16. Barium       as Ba         17. Calcium       as Ca         18. Chromium       as Ca	6.7 212		1
W         4.         Free Mineral Acidity         as CaCO3           a         5.         Chemical Oxygen Démand (C.O.D.)         7.0         29.8         7.0           i         6.         Chloroform Extractables         204         205         202           e         7.         Dissolved Solids         204         205         202           r         8.         Hardness (Calcium)         as CaCO3         79         80         78           9.         Hardness (Magnesium)         as CaCO3         122         123         120         120           r         11.         PH         8.4         8.0         8.4         7.9           o         12.         Specific Conductance         µmhos         303         308         300         120           r         11.         PH         8.4         8.0         8.4         7.9           o         12.         Specific Conductance         µmhos         303         308         300         120           r         13.         Specific Gravity         g/ml         14         Suspended Solids         3.5         213         8.0           r         14.         Suspended Solids         3.5 <td>212</td> <td>7.2</td> <td></td>	212	7.2	
a         5.         Chemical Oxygen Demand (C.O.D.)         7.0         29.8         7.0           1         6.         Chloroform Extractables         204         205         202           r         8.         Hardness (Calcium)         as CaCO ₃ 79         80         78           9.         Hardness (Calcium)         as CaCO ₃ 79         80         78           9.         Hardness (Magnesium)         as CaCO ₃ 122         123         120           r         11.         pH         8.4         8.0         8.4         7.9           0         12.         Specific Conductance         µmhos         303         308         300         9           13.         Specific Gravity         g/ml         9         13.         Specific Gravity         9         14.         Suspended Solids         3.5         213         8.0         16           r         14.         Barium         as Ba         0.02         0.04         0.01         2.55         0.01         0.08         17.           14.         Barium         as Ba         0.02         0.00         0.02         0.02         0.00         0.00           15. <td>212</td> <td>7.2</td> <td></td>	212	7.2	
e         7.         Dissolved Solids         204         205         202           r         8.         Hardness (Calcium)         as CaCO ₃ 78         80         78           9.         Hardness (Magnesium)         as CaCO ₃ 78         80         78           9.         Hardness (Magnesium)         as CaCO ₃ 43         43         42           P         10.         Hardness (Total)         as CaCO ₃ 122         123         120           r         11.         pH         8.4         8.0         8.4         7.9           o         12.         Specific Conductance:         µmhos         303         308         300         7           13.         Specific Gravity         g/ml         5         213         8.0         7           14.         Suspended Solids         3.5         213         8.0         7           15.         Aluminum         as Ai         0.02         0.04         0.01         2.55         0.01         0.08           1         16.         Barinum         as Ba         0.02         0.02         0.02         0.00         0.00           1         17.			·····
r       8.       Hardness (Calcium)       as CaCO3       79       80       78         9.       Hardness (Magnesium)       as CaCO3       43       43       42       120         r       10.       Hardness (Total)       as CaCO3       122       123       120         r       11.       pH       8.4       6.0       8.4       7.9         o       12.       Specific Conductance       µmhos       303       308       300         p       13.       Specific Gravity       g/ml			
9.         Hardness (Magnesium)         as CaCO3         43         43         42           P         10.         Hardness (Total)         as CaCO3         122         123         120           r         11.         pH         8.4         8.0         8.4         7.9           o         12.         Specific Conductance:         µmhos         303         308         300         7.9           13.         Specific Gravity         g/ml	85	206	nye innane
P         10.         Hardness (Total)         as CaCO3         122         123         120           r         11.         pH         8.4         8.0         8.4         7.9           o         12.         Specific Conductance         µmhos         303         308         300           p         13.         Specific Gravity         g/ml		83	
r         11.         pH         8.4         8.0         8.4         7.9           o         12.         Specific Conductance         µmhos         303         308         300         7.9           p         13.         Specific Gravity         g/ml         7.9         7.9         7.9           e         14.         Suspended Solids         3.5         213         8.0         7.9           r         15.         Aluminum         as Al         0.02         0.04         0.01         2.55         0.01         0.08           t         16.         Barium         as Ba         0.02         0.00         0.02         0.02         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00 </td <td>45</td> <td>· 45 128</td> <td>·</td>	45	· 45 128	·
o         12.         Specific Conductance         μmhos         303         308         300           p         13.         Specific Gravity         g/ml	130	8.3	
p         13.         Specific Gravity         g/ml           e         14.         Suspended Solids         3.5         213         8.0           r         15.         Aluminum         as Al         0.02         0.04         0.01         2.55         0.01         0.08           t         16.         Barium         as Ba         0.02         0.00         0.02         0.02         0.00           i         17.         Calcium         as Ca         31.5         0.46         31.9         17.5         31.1         0.00           e         18.         Chromium         as Cr         0.00         0.00         0.01         0.00         0.00	315	308	
e         14.         Suspended Solids         3.5         213         8.0           r         15.         Aluminum         as Al         0.02         0.04         0.01         2.55         0.01         0.08           t         16.         Barium         as Ba         0.02         0.00         0.02         0.02         0.00         0.02         0.00         0.02         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00		[	
t         16.         Barlum         as Ba         0.02         0.00         0.02         0.02         0.00         0.00           i         17.         Calcium         as Ca         31.5         0.46         31.9         17.5         31.1         0.00           e         18.         Chromium         as Cr         0.00         0.00         0.00         0.00         0.00	166		7.0
i         17.         Calcium         as Ca         31.5         0.46         31.9         17.5         31.1         0.00           e         18.         Chromium         as Cr         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0.00         0	0.01 2.05		0.08
e 18 Chromium as Cr 0.00 0.00 0.00 0.01 0.00 0.00	0.02 0.02	0.02	0.00
	33.9 12.2	33:1	0.00
	0.00 0.00	0.00	0.00
20. Iron as Fe 0.00 0.06 0.00 4.04 0.00 0.13	0.00 0.01	0.00	0.00
	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	Another and the substration of the second second	0.00
28.         Potassium         as K         1.25         1.25         1.27           27.         Silver         as Aq         0.00         0.08         0.00         0.04         0.00         0.00	1.32	1.26	
27.         Silver         as Ag         0.00         0.08         0.00         0.04         0.00         0.00           C         28.         Sodium         as Na         6.36         6.27         6.27         6.27	0.00 0.00	0.00	0.00
a 29 Strontium as Sr 0.11 0.00 0.10 0.02 0.10 0.00	0.11 0.01	0.11	0.00
1 30. Zinc as Zn 0.00 0.00 0.00 0.07 0.00 0.00	0.00 0.06	0.00	0.18
	2.920	2.860	
n 32: Acetate as C ₂ H ₃ O 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         10.3         9.99         10.3           35         Chloride         as Cl         2.00         3.00         3.00	10.4	10.6	
35.         Chlorate         as ClO ₃ ,         0.00         0.00           36.         Chromate         as CrO ₄ 0.00         0.00         0.00	:0:00	0.00	••••••
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: Glyčolate as C2H3O3 0.00 0.00 0.00	0.00	0.00	
40. Molybate as MoO4 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 NO2         0.00         0.00           43.         Nitrogen (total)         as N         0.00         0.00         0.00	0.00	0.00	
43.         Nitrogen (total)         as N           44.         Oxalate         as C ₂ O ₄ 0.00         0.00	-0.00	0.00	· · · · ·
45:         Phosphate (ortho)         as PO4         0.00         0.00         0.00	0.00	0.00	
46: Phosphate (poly) as PO			i
n 47. Phosphate (organo) as PO			ï
1. 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
0         49.         Sulfate         as SO4         21:3         20:2         20:8           0         50.         Sulfate         as SO4         21:3         20:2         20:8	20.5	21.5	
	7.21 0.51	7.11	0.00
51.         Total Anion Millequivalents         3.505         3.373         3.333           52.         Ammonia         as NH ₃	3.533	3.407	
53. Benzotriazole as C ₆ H ₅ N 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 NaNO2			
57. Sodium Sulfite as Na ₂ SO ₃			•
S8.         Tolyltriazole         as C ₇ H ₆ N ₃ verset         All data except pH in parts per malion or as indicated         Continued on reverse side.			

		H-O-H Chemicals, Inc.[	Regarding:	BORAT	and Michi	gan Powe	er Compa		SIS	Cüstomer Report No	o.: as	1001392 indicated
		500 S. Vermont St.	Location:	Donald C	Cook N	luclear Pl	ant			Report Da	ate:	
		Palatine, IL 60067		1 Cook F	lace					Analysis I		
		i maniet interest		Bridgmai						Sample D		indicated
		847/358-7400 Fax: 847/ <u>35</u> 8-7082		d 8/2/07 3301)	Contro	I 8/8/07 3301):		1 8/8/07 301)		8/15/07 3332)	Treated	1.8/15/07 [*] 3332)
			Soluble	Insoluble	Soluble	insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble
1	59.	Bromate as BrO ₃		<u> </u>						,		
c	60.	Chlorite as CIO ₂			••••••••••••••••••••••••••••••••••••••							
. a!	61.				*************************		ar ( 1999 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1	·		**************************************	· · · · ·	
m	62.											······
P		Diethylaminoethanol* as C ₈ H ₁₅ NO							1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 -		c.,+	**************************************
	64,	Ethylamine* as C ₂ H ₇ N	· · · · · · · · · · · · · · · · · · ·				<b></b>					****
U n	65.	Morpholine* as C ₄ H ₉ NO					·					
n∙ d	66.	Diethylene Glycol* % by weight							*****			
S	67.	Ethylene Glycol* % by weight	<u>.</u>	·		·						
		Propylene Glycol* % by weight							·····		;.,	
	69.	Aerobic Plate Count org's/ml	······				g		******			
								i	······		:	
.M	70:	Anaerobic Plate Count org's/ml									·····	
1	71.	Fecal Coliform org's/100ml		· · · · · · · · · · · · · · · · · · ·								
C (ř		Iron Bacteria			····		40 - 10 m	~~ ~~			5. 2.	
ò	73:	Mold org's/ml								<u> </u>	. يەخبىسىيە بىپ	
b	. 74:	Nitrate Reducers org's/ml-					-				: sor manualitie	
, i	75.	Slime Formers org's/ml			-			-				
0	76.	Sulfate Reducers org's/ml	· ·				a da a constante da			-		-tomore
1	77.	Total Coliform org's/100ml		annaradi soso, secare s		1					al and the second	
0	78.	Yeast org's/ml	an ann an t-shows									
9: 1	79.	Residue by Evaporation										
ċ	80.	Volatile Solids							and a state of the		·	
a	81.	System Capacity gal.								· · · · · · · · · · · · · · · · · · ·		
J.	82.	Propionate as C ₃ H ₅ O ₂	0.00		0.00	*****	0.00	an a	0.00		0.00	
	83.	Total Organic Carbon		and a constant				,	******			
	84.	Total Organic Nitrogen						·	·			
		Mexel (A-432)	2.5	·····	••••••	*****************	2.5				2:5	
					•••••• <i>••••</i> •••••••••	·			**********			
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		ร้าง กรรมสารสรรรษฐาน - พระการสารสรรรษฐานสารสารสารการการการการการการการการสารสารสารสารสารสารสารสารสารสารสารสารส	·····		······	••••• <u>•</u> •••••••••			· · ·		·····	
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		All data accept old in easts per million or as indicated			1.2		·		l.	1	·	

			ĽÁ	BORAT	ORY RE	PORT -	WATER	ANALY	SIS	Customer	No.:	1001392
ſ		H-O-H Chemicals, Inc.	Regarding:	Indiana a	and Michig	gan Powe	er Compa			Report No		indicated
ľ	H	500 S. Vermont St.	Location:			uclear Pla	ant			Report Da		
Ę.	ų ((	Palatine, IL 60067	······.	1 Cook F					;	Analysis I		
÷	1.1.			Bridgma	n <u>i Ml</u>					Sample D	ate: as	indicated
Ľ	YIBD	847/358-7400 Fax: 847/358-7082	Treated (#28		1 1-6 x 1	8/23/07 436)						
			Soluble	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	insoluble	Soluble	Insoluble
	1.	Alkalinity ("P") as CaCO3	0		0							
	2	Alkalinity ("M") as CaCO ₃	122	·	118							
<b>.</b>	3.	Alkalinity ("OH") (calculated) as CaCO ₃ Free Mineral Acidity as CaCO ₃			······					-		
W	<u>4.</u> 5.	Free Mineral Acidity as CaCO ₃ Chemical Oxygen Demand (C.O.D.)	*		. 11.3		·····	••••••••••••••				·····
t	6.	Chloroform Extractables						•interiori				·····
e	7.	Dissolved Solids	222	,	200					· · · · · ·		
ſ	8.	Hardness (Calcium) as CaCO ₃	92	·	82							
	9.	Hardness (Magnesium) as CaCO3	47		46					-		
P	10. 11.	Hardness (Total) as CaCO ₃	<u>139</u> 7.9		128 8.1					-		
0	12.	Specific Conductance umhos	332		307		<u>.</u>			· [ ······		
p	13.	Specific Gravity g/ml			,			· · · · · · · · · · · · · · · · · · ·				
e	14	Suspended Solids		177		0.0						
ſ	15.	Aluminum as Al Barium as Ba	0.01	1.88	0.02	0.03				·	······	
т Т	16. 17.	Barlum as Ba Calcium as Ca	0.02	0.01	0.02 32,8	0.00 0.00	nesia, exemenana	·1.5,				
Ð	18.	Chromium as Cr	0.00	0.00	0.00	0.00				· · · · · · · · · · · · · · · · · · ·	······	
S	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			Andreas - 10 al 40 and an and a statements			-
	22. 23.	Lithiúm as Li Magnesium as Mg	0.00 11.4	0.00	0.00	0.00			m		in the second	·
	24.	Manganese as Mn	0.00	0.16	0.00	0.00						
	25.	Nickel as Ni	0.00	0.00	0.00	0.00			· · · · · · · · · · · · · · · · · · ·			a service a service of the service o
	26.	Potassium as K	1.27		1.29							
	27.	Silver as Ag	0.00	0.00	0.00	0.00						
a	28. 29.	Sodium as Na Strontium as Sr	6.82 0.11	0.00	<u>6.74</u> 0.11	0.00		,				
t	30.	Zinc as Zn	0.02	0.04	0.01	0.00		,			·	· · · · · · · · · · · ·
0	31.	Total Cation Millequivalents	3.108		2.888							
n.	32.	Acetate as C ₂ H ₃ O ₂	0.00		0.00							
S	33.	Bromide as Br Chloride as Cl	0.00		0.00							
	34.	Chloride as Cl Chlorate as ClO ₃	10.8 0.00	na an a	10.3 0.00						€ 2061,250 500 100 100 100 100 1	200 million and 4.5 million and 4.5
	.36:	Chromate as CrO ₄	0.00	ala - <b>Apalan ang P</b> artang Partang	0.00		*		ayuu kasaaya aya yiy			
ŀ	37.	Fluoride as F	0.10	per a constantinação de la constante	0.09					,		
Ľ.		Formate as CHO ₂	0.03		0.00				· · · ·	-	·	
		Glycolate as C ₂ H ₃ O ₃ Molybdate as MoO ₄	0.08	· .	0.00						2	
	40.	Nitrate as NO ₃	0.00	• ~~	0.01	- <u></u> ,				194 1969-1979 1974 1976 1976 1977 1977 1977 1977 1977 1977	1	
	Approximation of Street.	Nitrite as NO ₂	0:00		0.00							
	43:	Nitrogen (total) as N									<u>.</u>	
		Oxalate as C ₂ O ₄ Phosphate (ortho) as PO ₄	0.00		0.00							
		Phosphate (poly) as PO ₄	0.09	· • • • • • • • • • • • • • • • • • • •	. 0.00		,					
A	47.	Phosphate (organo) as PO4	· · ·						•			
1 i	48.	Phosphorus (total) as P	0.05	0.07	0.00	0.00						
Ó	49.	Sulfate as SO4	.21.0		19.4	n product and the second second		.,				
.n s	50.	Sulfur (total) as S	7.52	7.41	7.03	6.88	·		[			
	51. 52.	Total Anion Millequivalents Ammonia as NH3	3.568		3.183	•					:	
	52.	Benzotriazole as C ₆ H ₅ N ₃				· · · · · · · · · · · · · · · · · · ·		······	l			
	54.	Boron as B	0.04		0.09		ni Langur Lander ann 1	ala ara a prese e une	· · · · · · · · · · · · · · · · · · ·	,		
	55.	Silica as SIO ₂	10.2	8.35	3.34	0.40			<u>.</u>	-		h
	56.	Sodium Nitrite as NaNO ₂	900 mg - 1 400 mg m - 200 mg m - 200 mg m		·				<b></b>			·····
		Sodium Sulfite         as Na2SO3           Tolyltriazole         as C7HeN3			·····	<u></u>	·	· ·····	<u></u>			
ا		All data except pH in parts per million or as indicated			C	ontinued on	reverse sic	e.	L	<u>.</u>	<b>J</b>	<del>لے . ب</del> ا

		Ú o útokanistis m. T	LABORATORY REPORT - WATER ANALYSIS Regarding: Indiana and Michigan Power Company								Customer No.: 1001392 Report No.: as indicated		
		H-O-H Chemicals, Inc. 500 S. Vermont St.	Regarding:	Donald C		uclear Pla	a compa	<u>IV</u>	<u> </u>	Report Da		muicated	
			Location:	1 Cook F	COOK IN	uclear Pla	<u>ant</u>			Analysis [	ne.		
		Palatine, IL 60067		Bridgmai				<u> </u>		Sample D		indicated	
				Drivymal	1, 1711						a.c. dS	mulcaleu	
		847/358-7400 Fax: 847/358-7082		8/23/07 436)		8/23/07 436)							
			Soluble	Insoluble	Soluble/	Insoluble	Soluble	Insoluble	Soluble	Insoluble	Soluble	lnsóluble	
· · · · ·	59.	Bromate as BrO3								· ·			
c	60.	Chlorite as ClO ₂	anna aige 1799 1777 - 1936 agus 199			**************************************	· · · · · · · · · · · · · · · · · · ·		······	· · · · · · · · · · · · · · · · · · ·			
0	61.	Cyclohexylamine* as C ₆ H ₁₃ N											
1 mg		Diethylamine* as C4H11N			5				1 mart 1 mar				
P O	63.	Diethylaminoethanoi* as C ₆ H ₁₅ NO	· · · · · · · · · · · · · · · ·									•	
, u	64.	Ethylamine* as C ₂ H ₇ N	•		·	******							
n d	65.	Morpholine* as C ₄ H ₉ NO Diethylene Glycol* % by weight											
s		Ethylene Glycol* % by weight			<del></del>				, , ,				
		Propylene Glycol* % by weight	; 10.74 # ##################################								• بو <del>نسان</del> انونونونون بالارتيار ر	***************************************	
		Aerobic Plate Count org's/ml		*	an, rannan, ranna, r	an ann an t-t-t-tharann ann an	******* ,		* 10, - * * * * * * *				
M	70	Anaerobic Plate Count org's/ml	·										
Ľ	71.	Fecal Coliform org's/100ml											
r.		Iron Bacteria							•				
0	73.	Mold org's/ml Nitrate Reducers org's/ml							a - 2000 - 2000 - 2000				
Þ	74.	Slime Formers org's/ml		alin a mandariana	······		ana na taona taona ang			-			
1.0		Sulfate Reducers org's/ml					•			-		· •	
T.	77.	Total Coliform org's/100ml			t		······································					······································	
0	78.	Yeast org's/ml	******	ananinan straam	······	····							
.0, i¢	79.	Residue by Evaporation	** *. 		·		· · · · · · · · · · · · · · · · · · ·			1			
c	. 80.	Volatile Solids							Set of the second second				
a		System Capacity gal.		بينيار ( ( ( ( ( ( ( ( ( ( ( ( ( ( ( ( ( ( (	· · · ·			-	· · · · · · · · · · · · · · · · · · ·	·			
12		Propionate as C ₃ H ₅ O ₂	0.00		0.00			، - محمد معمد بودندر د			· ····		
1		Total Organic Carbon	······						····				
1	84.	Total Organic Nitrogen Mexel (A-432)	2.5					e			~~~~~ <del>~</del>		
		Mickel (C-192).	2.7					······································	1 A.A.	,			
	. مربعة أسعيد	· · · · · · · · · · · · · · · · · · ·	<b>4</b> •	······			····		•	•	1 - province and a second of the second		
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20 All data except nH in parts per million or as indicated

Analysis by Gas Chromatouraph

183



500 SOUTH VERMONT STREET 847/358-7400

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

184

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

<u>//</u>					RY REP		EPOSI	ANAL	/SIS	Custome		1001392
5	п н∙∪	-H Chemicals, Inc. 500 S. Vermont St.	Regarding:		Cook NL					Report No		26782
157	う !	Palatine, IL 60067		1 Cook F		Iclear Pla			••••••	Report Da Analysis [		9/25/06
	닉길			Bridgmar					· ·	Sample D		9/21/06
COPI	inserver a	847/358-7400	Fouled F		New Re				1			
		Fax: 847/358-7082	Ösm		New Re Osmo		A.4	132				
			Memb		Memb		<i></i>	,02.	N			
			· Percent	Equivalents	Percent	Equivalents	Percent	Equivalents	Percent	Equivalents	Percent	Equivalents
1.	Aluminum	as Al ₂ O ₃	0.20	0.012	0.31	0:019						
2.	Barium	as BaO	0:03	0.000	0.01	0.000	a a thatlan na bailid i ang haranananan.					
3.	Calcium	as CaO	51.70	1.844	2.22	0.079		1999 - C. 1		การ		e juennenn skirken og skor o
4.	Chromium	as Cr ₂ O ₃	0.01	0.000	0.02	0.001				an a dinang manang manang manang man		
5.	Copper	as CuO	0.14	0.003	0.06	0.002		e materie anna the an al destruct in	how'r conserving of	er en la fan te en	*********	
6.	Iron	as Fe ₂ O ₃	0:29	0.011	0.34	0.013	<u></u>			* - * ********************************		a paramat and advantations of the first
7.	Lead	as PbO	0.02	0.000	0.00	0.000	·			den vielen für gesigenen einen		• •• •••••••••••••••••••••••••••••••••
8.	Lithium	as Li ₂ O	0.00	•• • • • • • • • • • • • • • • • • • •	0.00	0.000						
9.	Magnesium	**************************************	4.44	0.220	0.15	0.007		***************		np	- 1992 - 1997	
10.	Manganese		0.01	0.000	0.04	0.001			- Ann 1.741, 1844.00	nda		
11.	Nickel	as Ni	0.07	0.002	0.02	0.001		÷			·····	
12.	Potassium	as K ₂ O	0:07	0.002	0.26	0.006					** ** • • • • • • • • • • • • • • • • •	
13.	Silica	as SiO ₂	0:22	0.007	1.81	0.060	·····					
	Silver	as Ag ₂ O	0.00	0.001	0.00	0,000		the Brandman coup is a conjunction	·····			
<u>14.</u> 15.	Sodium	as Na ₂ O	0.00	0.008	32.30	1.042		******				
	Strontium	·····	0.23	0.002	0.00	0.000	www.condition.com					
16.	Tin	as SrO	0.13	0.002		····	*******	109275, 1975, 1986, 1967, 1967, 1987			*****	
17.		as SnO	0.48	0.040	0.00	0.000		an contra contrame				
18.	Zinc	as ZnO	0.48	0.012	1.11	0.027	<del></del>	e vo táci - v ma			•••• ;••;• ··•	
19.	Distant in the second s						anna in a' annas					: 
20.	Boron	as B ₄ O ₆	0.00		0.00	0.000	******	مىلىمۇمىۋىمىزىمىغ				
21.	Carbonate	as CO ₂	39:24	1.784	0.00			· = in			1111 Acres	. <u> </u>
22.	Chloride	as Cl			0.00			******				
Apres along and	Molybdenur		0.00	0.000	0.05	0.000						
24.	Nitrate	as NO ₂	2. e.j.,				talitari di ananana				• ••••••	
, 25.	Nitrite	as NO	2 ¹	·			National Sciences and Strategy and					
26.	Phosphate	as P ₂ O ₅	0.14	<b>0.006</b>	1.72	0.073						
27.	Sulfate	as SO ₃	2.57	0.064	59.58	1.488		•				
28.	Tolyltriazole	as C ₇ H ₆ N	1									
29.		- Je		1	:							
,30.	Ignition Loss											
31.	Undetermine	ed										
32.	Total		100.00		100.00							
33.	Chloroform	Extractable	2.66		1.86		2.40			1		
3, ,									T			
	Physical	Properties and										
		Appearance:										
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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

		أحذا والأمانية						ANALY	SIS	Custome		1001392
n'		emicals, Inc. Vermont St.						ny		Report No Report Da		8/30/07
17		tine, IL 60067	Location.	1 Cook P		IUCIEAL FI	<u>an (</u>			Analysis		8/24/07
6				Bridgmar					,	Sample D		8/23/07
चाक (		847/358-7400 847/358-7082		Osmosis reated of Test						<u>roumpio b</u>		0.20101
			Percent	Equivalents	Percent	Equivalents	Percent	Equivalents	Percent	Equivalents	Percent	Equivalents
1.	Aluminum	as Al ₂ O ₃	0.09	0.005								
2.	Barium	as BaO	0.00	0.000	****							
3.	Calcium	as CaO	53.16	1.899				di tana di manana		China a sera mananana manana ma		a ann an an an an air an
4.	Chromium	as Cr ₂ O ₃	0.01	0.000	•	i		·····		• • • • • • • • • • • • • • • • • • •	<u>.</u>	
5.	Copper	as CuO	0.10	0.002					na mana a serena ay	and the second		
6,	Iron	as Fe ₂ O ₃	0.13	0.005					n ya makatata Katokatan Jawa		·	
	Lead	as PbO	0.02	0.000				4,1,1.00,1. <b>91.1.1.1.1</b> .1.1				·
7.	Lithium:	as Li ₂ O	0.02	0,000							·····	
. 8.			anne marine mantera ad								·	
9.	Magnesium	as MgO	2.42	0.120		nation of the states of the st						-
10.	Manganese Niekol	as MnO	0.01	0.000		-111.	·				ب بين مورون	
1.1.	Nickel	as Ni	0.02	0.001			n	****				
12.	Potassium	as K ₂ O	0.03	0.001								م
13.	Silica	as SiO ₂	0.19	0.006	in to construct		· · · · · · · · · · · · · · · · · · ·		·		• •••	
14.	Silver	as Ag ₂ O	0.00	0.000		*** *** * *** ********						
<u> </u>	Sodium	as Na ₂ O	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.							•			1		
20.	Boron	as B ₄ O ₆	0.00	0.000								
21.	Carbonate	as CO ₂	40.11	1.823								
22.	Chloride	as Cl						10001 24 194 194			;	
23.	Molybdenum	as MoO ₃	0.00	0.000	erinen er en en en	; ;	*****		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	e <mark>fangenisensi</mark> open open fan stele		
24.	Nitrate	as NO ₂			The second							
25.	Nitrite	as NO	uneren erentekenden in				ata alanta in 1997. I	2 (10 10 (10 ) 1 (1 ) 1 )	the second second second	ayon da maranandanaan		
Sec. 8.6	Phosphate	as P ₂ O ₅	0.14	0.006					g i s nite s			·
	Sulfate	as SO ₃	3.01	0.075					·	e e e estatoria de la compositiva de la Compositiva de la compositiva de la comp	4 AB4 4 - PAPARAMANIAN	
	Tolyltriazole	as C ₇ H ₆ N	······································		• • • • • • • • • • • • • • • • • • • •		•				1963) 1.52 married and an order	
20				1 .18 .79	•••••••		مەر مەرىپە يەرىپە يەرىپە يەرىپە	e none come e e e ence e el	- 	an a		
20.	Ignition Loss			· · · · · · · · · · · · · · · · · · ·		-	·····			ر بی الاستفادین میکند. د		
	Undetermined		0.27		A . ~		- <del></del>	pr	Saturation i Scheinen and			
there a sublease	Total	ana antonio di Anara ana a	100.00		······						÷	
	Chloroform Extra	octable		- 1000-900-00-00-00-00-00-00-00-00-00-00-00				1				-
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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		Days		System	Weight Loss	<b>Corrosion Rate</b>		
	No.	Material	Exposed	Treatment	Туре	(gm)	(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



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.

Address: Donald C.	Cook Nuclear Plant				
Your H-O-H Sales Representative:	Tom Armon	Manana an a		، بر میر میرونی کرد میراند. بر میر میرونی کرد میراند.	
Water Type:	Cooling Wa	ater	Open Recircul Closed Other	ating	
Treatment:	None		· · · · · · · · · · · · · · · · · · ·		
Location in System:	Coupon rack on Mexel	test rig			·
Representative:       Tom Armon         Water Type:      Condensate       Open Recirculating        Cooling Water      Closed        Once Through       Other         Treatment:       None					
	· · · · · · · · · · · · · · · · · · ·	H - O - H LABO	RATORY DATA	·	
Test Strip No::	T-75I		Metal:	Steel	
Days Exposed:	43		Laboratory No.:	26910	
WEIGHTS (in grams)	Final:	16.3235			
Mils Pene	ration per Year (MPX)	8 51			
· · · · ·					х. Х. с. с. с.
,					
		4.0 Maxi	mum Pit Depth (mils)	e e e e e e e e e e e e e e e e e e e	ан 1911 - Ал



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.

Company: American I				·	<u></u>
Address: Donald C.	Cook Nuclear Plant		······		
1 Cook Pla	ice: Bridgman, MI			·	
Your H-O-H Sales Representative:	Tom Armon				
Water Type:	Condensat	ater	Open Recircula Closed Other	ating	
Treatment:	A-432			•	
· · · ·	Coupon rack on Mexel	test rig	en en de la companya	nana	
Installation Date:	8/30/06		Removal Date:	10/12/06	
· · ·		H - O - H LABO	RATORY DATA	· .	· · · · · · · · · · · · · · · · · · ·
Test Strip No.:	T-75K		Metal:	Steel	- - -
Days Exposed:	43	• • •	Laboratory No.:	26910	· · · ·
WEIGHTS (in grams)	Original: Final: Loss:	16.6354 16.3365 0.2989		·	
Mils Penet	ration per Year (MPY):	3.89			
CORROSION DESCR	IPTION:				
		Moderate Uneven	Slight General num Pit Depth (mils)	Negligible Localized	- -



500 SOUTH VERMONT STREET 847/358-7400 PALATINE, ILLINOIS 60067 FAX NO. 847/358-7082

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:

TO:

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		Days		System	Weight Loss	<b>Corrosion Rate</b>	
 	No:	Material	Exposed	Treatment	Туре	(gm)	(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,

HAB/ld

H.A. Becker



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			· · · · · · · · · · · · · · · · · · ·	<u> </u>
Address: Donald C.	Cook Nuclear Plant			
	ice Bridghian, Mr	······································	<u></u>	; ;
Your H-O-H Sales Representative:	Tom Armon			
Water Type:	Condensate Cooling Water X Once Through	Open Recirc Closed Other	ulating	
Treatment:	A-432		· · ·	······································
Location in System:	<u></u>		·	
Installation Date:	8/30/06	Removal Date:	10/12/06	
			<u>د</u> ،	
	H - C	- H LABORATORY DATA		ľ
Test Strip No.:	H - C T-75J	- H LABORATORY DATA Metal:	Steel	
Tëst Strip No.: Days Exposed:	T-75J			
•	T-75J	Metal:		
Days Exposed: WEIGHTS (in grams)	T-75J 43 Original: Final:	Metal: Laboratory No.: 17.1817 16.8870 0.2947		
Days Exposed: WEIGHTS (in grams)	T-75J 43 Original: Final: Loss: ration per Year (MPY):	Metal: Laboratory No.: 17.1817 16.8870 0.2947		
Days Exposed: WEIGHTS (in grams) Mils Penel	T-75J 43 Original: Final: Loss: ration per Year (MPY):	Metal: Laboratory No.: 17.1817 16.8870 0.2947 3.84 3.84 Slight		



500 SOUTH VERMONT STREET 847/358-7400

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

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### **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.

Company: American I			<u> </u>	·	
Address: Donald C.	Cook Nuclear Plant				
T COUK FIE	ice biluginan; wit				
Your H-O-H Sales Representative:	Tom Armon				
Water Type:	Condensat	ater	Open Recircula Closed Other	ating	
Treatment:	None				
Location in System:				· · ·	
Installation Date;	.8/30/06		Removal Date:	10/12/06	
<u> </u>		H - O - H LABC	RATORY DATA		
Test Strip No.:	T-75L		Metal:	Steel	
Days Exposed:	43	•	Laboratory No.:	27022	
WEIGHTS (in grams)	Original: Final: Loss:	16.2880	 		
Mils Pene	tration per Year (MPY):	7.94	,		
<u> </u>	Severex Even	Moderate Uneven 8.0 Maxi	Slight General mum Pit Depth (mils)	Négligible Localized	
· · ·		, ·			



500 SOUTH VERMONT STREET 847/358-7400 PALATINE, ILLINOIS 60067 FAX NO: 847/358-7082

194

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		Days	•	System	Weight Loss	Corrosion Rate	
	Nö.	Material	Exposed	Treatment	Туре	(gm)	(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		6.19	Poor
4.	T-80S	Steel	56	None	Once Through		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/Id



500 SOUTH VERMONT STREET 847/358-7400

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

195

### **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.

Company: American					<u></u>	
Address: Donald C. 1 Cook Pla	Cook Nuclear Plant	<u> </u>	· · · · · · · · · · · · · · · · · · ·			
Your H-O-H Sales Representative:	Tom Armon			na na sana sa		
Water Type:	Condensat	ater	Open Recircula Closed Other	ating		
Treatment:	A-432	<u> </u>	·····		· .	·
Location in System:	Test ng over unit 2 dis	charge platform				
Installation Date:	10/12/06	÷	Other           ge platform           Removal Date:           12/7/06           O - H LABORATORY DATA           Metal:           Laboratory No.:           27212           17.1763           16.7654           0.4109           4.11           derate         Slight           Negligible           even         General			
an a		H - O - H LABO	RATORY DATA			
Test Strip No.:	T-80P	• ·	Metal:	Steel		
Days Exposed	56	•	Laboratory No.:	27212		
WEIGHTS (in grams)	Original: Final: Loss:	16.7654				
Mils Pene	tration per Year (MPY):	4.11		· .		
CORROSION DESCR	RIPTION:			• .		
	Severe x Even x	Moderate Uneven			· · ·	
•		0.5 Maxir	num Pit Depth (mils)			



500 SOUTH VERMONT STREET 847/358-7400 PALATINE, ILLINOIS 60067 FAX NO: 847/358-7082

191

### **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.

Company: American I	Electric Power				
Address: Donald C.	Cook Nuclear Plant				
1 Cook Pla	ce Bridgman, MI				
Your H-O-H Sales Representative:	Tom Armon				
Water Type:	Condensate Cooling Water x Once Through	• • • • • • • • • • • • • • • • • • •	Open Recircula Closed Other	tíng:	
Treatment:	None				, ,,
Location in System:	Test rig over unit 2 discharg	ge platform			······································
Installation Date:	10/12/06	•	Removal Date:	12/7/06	
elandi en	H÷(	O - H LABOR	ATORY DATA		<u></u>
Test Strip No.:	T-80Q		Metal:	Steel	
Days Exposed:	56		Laboratory No.:	27212	
WEIGHTS (in grams)	Original: Final: Loss:	17.2254 16.8808 0.3446			
Mils Penet	ration per Year (MPY):	3.45		•	
CORROSION DESCR	IPTION:			-	
	Severe <u>x</u> Mod Even <u>x</u> Unev	erate	Slight General	Negligible Localized	
	ب _{نهن} 2	2.0 Maxim	um Pit Depth (mils)	• •	



500 SOUTH VERMONT STREET 847/358-7400

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

197

### **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.

Company: American	Electric Power		 		
Address: Donald C.	Cook Nuclear Plant				
1 Cook Pla	ace Bridgman, MI				
Your H-O-H Sales Representative:	Tom Armon				
Water Type:	Condensat	ater	Open Recircu Closed Other	lating	
Treatment:	A-432				
Location in System:	Test rig over unit 2 dis	charge platform			
Installation Date	10/12/06		Removal Date:	12/7/06	<u></u>
	<u>dan yan kumu kumu kunu jakan kun</u> u kutu	H - O - H LÁBC	RATORY DATA		
Test Strip No.	T-80R	-3	Metal:	Steel	
Days Exposed	56	•	Laboratory No.:	27212	
WEIGHTS (in grams)	Original: Final: Loss:	16.7311			
Mils Pene	tration per Year (MPY):	6.19	<b></b> ,		
CORROSION DESC					,
<u> </u>	Severe	Moderate	Slight General	Negligible Localized	
3 	· ·	<u>1.5</u> Maxi	mum Pit Depth (mils	)	



500 SOUTH VERMONT STREET 847/358-7400 PALATINE, ILLINOIS 60067 FAX NO. 847/358-7082

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### **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.

Company: American		· · · · ·		- <u></u>	
Address: Donald C. Cook Nuclear Plant 1 Cook Place Bridgman, MI					
	ice Bridgman, Wi		<u></u>		
Your H-O-H Sales Representative:	Tom Armon		<u>.                                    </u>		
Water Type: Condensat Cooling Wa x Once Throw		ater	Open Recirci Closed Other	ulating	
Treatment:	None:	i,		•	; ·
Location in System:	Test rig over unit 2 dis	charge platform			
Installation Date:	10/12/06		Removal Date:	12/7/06	
		H - O - H LABO	RATORY DATA	-	
Test Strip No.:	T-80S	•	Metal:	Steel	· .
Days Exposed:	56	•	Laboratory No.:	27212	
WEIGHTS (in grams)	Original: Final: Loss:	16.6370		• ,	
Mils Pene	tration per Year (MPY):	3.59			
CORROSION DESCR	IPTION:			· .	
	Severe <u>x</u> Even <u>x</u>	Moderate Uneven 0.5 Maxir	Slight General num Pit Depth (mil	Neğliğible Localized s)	
				`	



500 SOUTH VERMONT STREET 847/358-7400 PÁLATINE, ILLINOIS 60067 FAX NO. 847/358-7082

TO: Tom Armon/Darius Barkauskas

DATE: September 12, 2007

1001392

99

.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:

	oupon		Days		System	Weight Loss	Corrosion Rate	
	No.	Material	Exposed	Treatment	Туре	(gm)	(MPY)	Evaluation
1. T	-83K	Steel	200	Mexel	Once Through	0.4594	1.29	Good
2. 1	ſ-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,

HAB/ld

H.A. Becker



500 SOUTH VERMONT STREET 847/358-7400 PALATINE, ILLINOIS 60067 FAX NO, 847/358-7082

200

#### **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.

	nd Michigan Power Compa	ny)	<u></u>		
Address: Donald C.					
1 Cook Pl	ace Bridgman, MI				<del></del> . ;
Your H-O-H Sales Representative:	Tom Armon/Darius Barka	luskas			
Water Type:	Condensate Cooling Water		Open Recirc Closed Other	culating	
Treatment:	Mexel				
Location in System:	Test rig over unit 2 discha	arge platform			````
Installation Date	2/4/07		Removal Date:	8/23/07	
·	Н	- 0 - Ĥ LABO	RATORY DATA		e • •
Test Strip No.	т-83К	· · ·	Metal:	Steel	
Days Exposed	200		Laboratory No.:	28856	• .
WEIGHTS (in grams)	Original: Final: Loss:	17.3728 16.9134 0.4594			 
Mils Pene	tration per Year (MPY):	1.29	<del>.</del> .		
CORROSION DESCR	RIPTION:				, ,
موجد مرکز میروند. موجد مرکز میروند.		oderate	Slight General	Negligible Localized	· · ·
	<del></del>	0.5 Maxi	mum Pit Depth (mi	ls)	



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**

	d Michigan Power Comp	bany <u>s</u>			<u></u>	
Carden Street	Cook Nuclear Plant	· · ·	- <u> </u>	· · ·	· · ·	
1 Cook Pla	ice Bridgman, MI		·····			
Your H-O-H Sales Representative:	Tom Armon/Darius Bar	kauskas		anta anta ana ana ana ana ana ana ana an	·	
Water Type:	Condensate Cooling Wa x Once Throu	ter	Open Recircu Closed Other	lating		
Treatment:	None					
Location in System:	Test rig over unit 2 disc	harge platform		·		
Installation Date:	2/4/07	· · ·	Removal Date:	8/23/07		
· · · · · · · · · · · · · · · · · · ·		H - 0 - H LABO	RATORY DATA			
Test Strip No.:	T-83L		Metal:	Steel	٢	
Days Exposed	200		Laboratory No.:	28856		
WEIGHTS (in grams)	Original: Final: Loss:	17.2034 16.7273 0.4761				
Mils Penel	tration per Year (MPY):_	0.50				
CORROSION DESCR	IPTION:					
		Moderate Uneven Maxi	Slight General mum Pit Depth (mils	Negligible Localized		

-----

# **APPENDIX 8**

90 Q

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: Enc Mallen

Peer Evaluator: Richard F. Green, Nine Mile Point Nuclear Station.

en 1/26/04 **Reviewed By** Lead Assessor

Annmyai Responsible Managemer

Page 1 of 13

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**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 blocide 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 blo-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 S2 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

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**

- 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 blocide application procedure could be enhanced including more contingencies into the procedure such as strainer pluggage, power reductions etc. The blocide application procedure 12-EA-6090-ENV-109, Intake Tunnel Molluscicide Treatment should be revised to include these contingencies.
- 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 sufficiate. 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

- No spill events or chemical discharge exceedences occurred during the application period. The vendor and plant proved that the preventive blocide application could be controlled within its MDEQ permitted conditions. This is the first known zebra mussel preventive blocide 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 blo-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 take water and intake forebay are better understood.

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#### **Objectives and Scope**

d)

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:</li>
  - 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.
  - Letters requesting approval of the blocide 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.
    - 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 blockde approval and responses from the MDEQ.
- 3) Review of procedure 12-EA-6090-ENV-109, Intake Tunnel Molluscicide Treatment.
- 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 blocide approval and responses from the MDEQ, the application procedure, settlement monitoring system and data, chemical residual blo-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 selfassessment report and comments were incorporated herein.

#### Assessment of Critical Attributes.

- 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 blocke 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 ment, 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 blocide injection. It is surmised that the blocide was stripping off blo-mass causing an increase in demand during the period of blocide addition. As such, the intermittent chlorination of the circulating water system was scheduled and completed before the 6-hr. blocide 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 blocide 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 blocke 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 blocide 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 blocide 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 blocide 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 blocide 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 blocide 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 blocide 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 blocide applications were having little effect, it was decided that continuing the blocide 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 blocide 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 wellpumps 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 blocide 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 fi/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 pump into the pump intet 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 bioboxes 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

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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 sumised 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 downstrearn 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 TM 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 blocide 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.

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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 bioboxes. 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 blo-box was 66 ppb, for the Center Intake Tunnel Manway blo-box it was 102 ppb and for the South Intake Tunnel Manway blo-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 blockde vendor believes that flow in the tunnel at a velocity of 6-7 ft./sec is turbulent. Therefore, the blockde 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 268 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) blocide 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 fl./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 1 Discharge and effluents from the South intake tunnel have a preference for being discharged out the Unit 2 forebay dout 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 mbding and system demand was determined for this data and is presented below:

Tunnel Treated	% Reduction in Effluent Concentration Discharged from Unit	% 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 blocide injection. This was remedied by scheduling the daily blocide 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 blocide 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 blocide 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 blo-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 blocide 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**

- No spill events or chemical discharge exceedences occurred during the application period. The vendor and plant proved that the preventive blocide application could be controlled within its MDEQ permitted conditions. This is the first known zebra mussel preventive blocide 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.

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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

- 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 block application procedure could be enhanced including more contingencies into the procedure such as strainer plugging, power reductions etc. The block application procedure 12-EA-6090-ENV-109, Intake Tunnel Molluscicide Treatment should be revised to include these contingencies.
- 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 sufficate. 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.

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# 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		14	8	4	8	19	24	28
% >500 μ	0	6	<b>4</b> :	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	438	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
<b>Control Forebay</b>					• /					
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	NĎ	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	364	376	547	623
# >500 μ	ND	0	0	Õ	· -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

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# 2003 Preventive Treatment Biocide Residual & Zebra Mussel Whole Water Monitoring Results

Date	North	Center	South	
	CT-1300 ug/i	CT-1300 ug/l	CT-1300 ug/l	Whole- Water
5/1/2003		0,07		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		· <b>.</b> .		107,600
7/11/2003	<b>.</b>	•		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		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	<b>.</b>		: <b>-</b> .	ND
7/22/2003	•	•	•	ND
7/23/2003	•. F		•	331,750
7/24/2003	72	128	72	ND
7/25/2003	•		•	ND
7/26/2003	-	•		ND
7/27/2003	-	<del>.</del>		ND
7/28/2003	-	•.	•	ND
7/29/2003	60	99	56	ND
7/30/2003	52	131	. 66	ND



7/31/2003	77	52	1 E7	331,000
	65	81		
8/1/2003			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	184,850
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		
	64		54	ND
8/24/2003		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		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
	<50	60	<50	ND
9/14/2003.1				
9/14/2003 9/15/2003	<50	60	<50	ND

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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

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	North	Center	South	
Max.	209	298	161	
Avg.	66	102	64	
Min.	<50	<50	<50	

- No Treatment ND No Data

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#### 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:

 The Plant intake tunnels were treated daily with a blocide to control zebra growth in the intake tunnels to <2 inches.</li>

- 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.

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Attribute evaluation will be performed by:

- 1) Review of Request for Proposal and responses from Chemical Vendors.
- Review of letters of request for blocide 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 blocide 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** 

Lead Assessor/ Date

ApprovedBy: 25-3 Responsible Management/Date

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# **APPENDIX 9**

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# TECHNICAL ANALYSIS REPORT

# **Indiana Michigan Power Company**

Donald C. Cook Nuclear Plant One Cook Place Bridgman, MI 49106

July 28, 2003

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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

# 03188002

# **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

Water & Power Technologies, Inc.

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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.
- Cook Nuclear Plant Procedure Number: 12-OHP-4021-062-011 Rev.3A, Title: Reverse Osmosis Operations.
- 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.
- 14. Betz letter of January 4, 1994 from W.K. Whitekettle to Robert Mosher, with attachment, pertaining to Clam-Trol CT-2 and CT-4 products.
- 15. Email from E.C. Mallen to William Jung and Wilburn Hester concerning sodium meta-bisulfite addition to retention tank.
- 16. Printed information titled, "Biocide Treatment, Intermittent Chlorination, Makeup Plant Operating Plant."
- 17. Hawley, Gessner G. The Condensed Chemical Dictionary, 9th Ed. Van Nostrand. Reinhold Company. 1977.
- 18. White, Geo. Clifford. The Handbook of Chlorination and Alternative Disinfectants, 3rd Ed. Van Nostrand Reinbold Company. 1992.
- Kim, Yong H. Coagulants and Flocculants Theory and Practice. Tall Oaks Publishing, Inc. 1995.
- 20. AWWA. Operational Control of Coagulation and Filtration Processes (AWWA Manual M37), 2nd Ed. American Water Works Association. 2000.

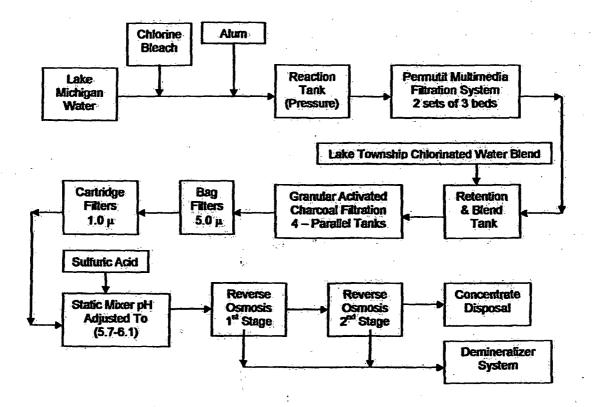
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21. Byrne, Wes. Reverse Osmosis – A Practical Guide For Industrial Users, 2 Ed. Tall Oaks Publishing, Inc. 2002.

22. Filmtec. Technical Manual. The Dow Chemical Company. 1995.

# 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 twostage 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.

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- 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.L 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.
- 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 highpressure 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

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(e 228 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

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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

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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 chumping 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

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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 abovementioned minerals could just be colloidal clay particles and nothing else.

#### **Onantification 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 eract 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  $0.45-\mu$  (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 antopsy 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

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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.

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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 (HOCI) is initially formed. Depending on pH and temperature, hypochlorous acid separates into another component in water, which is the hypochlorite ion (OCI⁻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

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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

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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 <u>www.simplesdi.com</u>. 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

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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.

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# 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.
- 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).
- 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.

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# **APPENDIX (Exit Meeting Report of Wednesday July 16, 2003)**

#### Date: July 16, 2003

Location: Cook Nuclear Plant, Bridgman, ML.

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.
- The RO system is also experiencing a decrease in salt rejection (an increase in conductivity).

#### **Client Expectations**

- 1. Find cause of high differential ( $\Delta$  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 APs were produced in the first stages.
- 4. After new biocide was added element failures occurred.
- 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.

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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.
- 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.

Norman R. Norvelle, M.S.

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