50-338/339

Dominion

Pamela F. Faggert
Vice President and Chief Environmental Officer
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September 12, 2000

Mr. Janardan R. Pandey, P. E.
DEQ - Valley Regional Office
4411 Early Road
P. O. Box 1129
Harrisonburg, VA 22801

RE: North Anna Power Station - Bearing Cooling Tower

Dear Mr. Pandey:

We request your concurrence that a one-time discharge of the bearing cooling tower at North Anna Power Station, while it is out of service for maintenance, is in compliance with the EPA's Steam Electric Guidelines and the current VPDES permit.

The Steam Electric Guidelines were used to develop the existing VPDES effluent limitations for the bearing cooling tower discharge which limit the concentration of the 126 Priority Pollutants "contained in chemicals added for cooling tower maintenance (except total chromium and total zinc)" to non-detectable amounts. The guidelines and permit also allow engineering calculations to be used to demonstrate that any pollutants added are not detectable in the final effluent.

Until July 2000, the cooling tower makeup water, taken from Lake Anna, was treated with the biocide Calgon H-510, which contains trace amounts of copper. Engineering calculations show that Calgon H-510 added 48 ug/l of copper to the system. Since the Calgon H-510 addition has been stopped, the copper concentration of the system has decreased from 92 ug/l to 34 ug/l (58 ug/l decrease). The decrease of copper exceeds the calculated contribution from Calgon H-510. Therefore, the concentration of copper in the system attributable to Calgon H-510 is considered non-detectable and the cooling tower can be discharged in compliance with the Steam Electric Guidelines.

The Steam Electric Guidelines only address blowdown of treated water from cooling towers. The bearing cooling tower will be removed from service to allow for structural repairs and removal of sediment in the basin of the cooling tower. While the system is out of service, it will be discharged to the main cooling water discharge canal. This is a one-time discharge resulting from maintenance activities and not a routine blowdown of the system as addressed by the Steam Electric Guidelines.

To assist you with your evaluation, enclosed is detailed information on the operation of the bearing cooling tower, the determination of the cooling tower concentration factor and engineering calculations to predict the contribution of copper due to Calgon H-510, and the impact the discharge will have on the quality of the receiving water. Based upon a telephone conversation my staff had with Dale Phillips on September 5, 2000, it is our understanding that approval from the EPA is not needed on this issue since a permit amendment is not required.

An expeditious determination is requested as the bearing cooling tower is scheduled to be taken out of service later this month. If you have any questions, please contact Ron Birckhead at (804) 273-2992.

Sincerely,

Pamela F. Faggert

Pamela F. Faggert
Dominion Generation

C001

cc:(w/attach.)
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Atlanta Federal Center
61 Forsyth St., SW, Suite 23T85
Atlanta, GA 30303
RE: North Anna Units 1 and 2
Docket Nos. 50-338/50-339
License Nos. NPF-4/NPF-7

U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555
RE: North Anna Units 1 and 2
Docket Nos. 50-338/50-339
License Nos. NPF-4/NPF-7

Mr. M.J. Morgan
NRC Senior Resident Inspector
North Anna Power Station

Mr. Dale Phillips
DEQ - Central office
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bc: (w/attach.)
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J. W. White
R. L. Birckhead
K. W. Roller
A. C. Cooke
Power Records Management – IN/GW

Concurrence:

Mr. D. A. Heacock _____

Mr. C. L. Funderburk _____

Mr. J. R. Hayes _____

Mr. A. C. Cooke _____

NORTH ANNA POWER STATION
BEARING COOLING WATER SYSTEM: RATIONALE FOR ONE-TIME SYSTEM MAINTENANCE DISCHARGE

PURPOSE

To obtain DEQ approval for a one-time system maintenance discharge of Bearing Cooling (BC) water. The discharge is required to allow the system to be placed in Lake-to-Lake mode for structural repairs to the cooling tower and to remove sediment in the basin of the cooling tower. EPA guidelines for blowdown of treated water from cooling tower applications limit the concentration of 126 Priority Pollutants "contained in chemicals added for cooling tower maintenance [except total chromium and total zinc]" to non-detectable amounts. These guidelines were used to develop the existing VPDES effluent limitations for the BC tower discharge. Based upon the following information, Virginia Power believes that discharge of the existing BC water would not result in a violation of the VPDES permit limits, or cause harm to the environment.

SYSTEM DESCRIPTION

The BC system supplies cooling and seal water flow for various steam and power-conversion equipment for full-load operation. The critical equipment supplied by the BC system includes the Main Turbine oil coolers, the Main Generator hydrogen coolers and various condensate/feedwater pump seal coolers. Since the BC system is a common system shared between 2 nuclear units, a loss of the BC system cooling is a significant event and would require a dual unit shutdown. Hence, the power-producing capability and efficiency of the plant is highly dependent upon the BC system. The critical system data is listed below:

System Data:

Design flow rate:	25,000 gpm (12,500 gpm per unit)
Main Pumps:	4 (2 per unit) with 12,500 gpm capacity
Design pressure:	80 psig
Max Design Temp:	95°F
Cooling Tower:	Marley – cross-flow, induced-draft type

SYSTEM OPERATION

The system is designed to be capable of operating in one of two modes:

i) Tower-to-Tower;
ii) Lake-to-Lake.

The closed-loop, Tower-to-Tower mode is employed under normal circumstances to eliminate the concerns associated with the use of untreated, Lake Anna water as the medium. In this mode, an induced-draft cooling tower serves as the primary heat sink. The BC pumps draw from the cooling tower basin to supply the system loads at the full-rated flow. Evaporation accounts for 75% of the total heat transfer from the tower; hence, system make-up water from the lake is needed to maintain the required system inventory. Normal system make-up flowrates are less than 10% of the design flow rate. If the cooling tower is unavailable, motor operated valves allow the system to be modified to a once-through system using Lake Anna water as the cooling medium. In this mode, the suction and discharge of the Bearing Cooling system ties into the Circulating Water Tunnel. The discharge is annotated as Outfall 107 in the current permit. The inability to perform Lake-to-Lake operation, because of copper

level restrictions, would significantly inhibit operation of both nuclear unit's since emergency procedures require Lake-to-Lake operation in the event of loss of the cooling tower.

SYSTEM BLOWDOWN REQUIREMENT

The inherent design of induced-draft cooling towers for closed-loop systems increases the cycles-of-concentration over time without adequate blowdown. The BC system at NAPS does not incorporate adequate blowdown in the system operational practices. The cooling tower manufacturer, Marley, recommends continuous blowdown or bleed-off to prevent the dissolved solids from concentrating to the point where they will form scale. Excess formation of scale reduces cooler efficiencies and obstructs pump seal water flow paths. In many instances, BC supplies plant equipment via small-bore piping and is routed through tight clearances under low flow conditions. These areas are more susceptible to scale accumulation. Without adequate scale control, the overall plant efficiency is decreased and the possibility of an unplanned shutdown could be experienced. Scale and total solids within the system are further exacerbated by sediment, which has accumulated in the basin of the cooling tower over the last 20 years.

SOURCES OF COPPER IN BEARING COOLING WATER

Until recently, the cooling tower make-up water was treated with the biocide Calgon H-510 (Isothiazolin), which contains trace amounts of the priority pollutant copper. The use of Calgon H-510 has been stopped resulting in a decrease in the bulk water copper concentration from 92 μg/L to its current steady state level of 34 μg/L. Engineering calculations indicate that this decrease is greater than the copper concentration that was contributed to the system by the addition of Calgon H-510. The current sources of copper in the bulk water include make-up (Lake) water added to the system and corrosion of copper components in the system. The copper levels within the sediment are approximately 5600 mg/L suggesting that the sediment is a major sink of copper present in the cooling tower water.

COPPER REMOVAL ALTERNATIVES

On-line sediment removal is considered dangerous since divers would be required to operate in a dynamic environment in adverse conditions. Additionally, on-line sediment removal is considered an operational risk since deposition of sediment and solids within the system would be expected. This deposition could result in loss of control valve function or heat transfer capability and ultimately cause one or both nuclear units to be taken off-line. Consequently, the following off-line methods were evaluated as a means to decrease current levels of copper. The technical issues involved with each method are also presented:

Method	Technical Issues
Polymer Addition/Ultrafiltration	Long clean-up due to sediment leaching, precipitate solids within system, can't discharge polymers, filtration designed for clean system
Diatomaceous Earth filtration and ion exchange	Large volume of earth may be required, filter cake material treated as a waste
pH Control	Can't increase pH high enough to cause precipitation, if precipitation was possible – this would deposit within the system
Filtration and Electromagnetic De-Ionization	Long clean-up due to sediment leaching, produce a concentrated waste stream that would require further treatment, filtration

NORTH ANNA POWER STATION
BEARING COOLING WATER SYSTEM: RATIONALE FOR ONE-TIME SYSTEM MAINTENANCE DISCHARGE

	designed for clean system

DISCHARGE OF THE BEARING COOLING WATER WOULD NOT VIOLATE CURRENT EFFLUENT LIMITS

The existing VPDES discharge limitations on the BC Outfalls are based on EPA guidelines, which limit the concentration of the 126 Priority Pollutants "contained in chemicals added for cooling tower maintenance [except total chromium and total zinc]" to non detectable amounts using EPA approved analytical procedures (40 CFR §423.13(d)(1)). As discussed above, the concentration of copper in the cooling tower water has decreased from 92 µg/L to 31 µg/L since the application of Calgon H-510 was stopped. Daily samples over the last month indicate a steady state average value of 34 µg/L has been achieved. Engineering calculations (see Attachment 1) performed by station personnel indicate that this decrease exceeds the amount of copper that was contributed by Calgon H-510. Therefore, Dominion Generation believes that the copper currently contained in the system originates primarily, if not exclusively, from sources other than the cooling water additive Calgon H-510.

One source of copper to the cooling tower is the make-up water obtained from Lake Anna. Total recoverable copper has been detected in Lake Anna near the power station intakes at concentrations ranging from 1 - 11 µg/L and even higher concentrations have been detected at other locations within Lake Anna (Attachment 2). Using data for silica measured in the BC system and in the make-up water, station personnel determined a cooling tower concentration factor of 4.2. Silica is recommended by the Electric Power Research Institute (EPRI) as outlined in the technical paper "Design and Operating Guidelines Manual for Cooling Water Treatment" (Attachment 1) to be used in calculations of concentration factors. The use of silica is validated by concentration factors based on calcium and magnesium. For the same time period, the calcium and magnesium concentration factors would be 3.8 and 4.0, respectively. Applying the silica-based concentration factor to the intake copper concentrations results in cooling tower concentrations of between 4.2 and 46.2 µg/L attributable to copper in the intake water. The existing cooling tower concentration of 31 µg/L (or steady-state value of 34 µg/L) is within the range of that predicted to occur based on Lake Anna copper levels alone. Another source of copper within the system is corrosion of yellow-based metals. In particular, the largest heat exchangers of the system, including the generator hydrogen coolers, turbine lube oil coolers, seal oil coolers, the mechanical chiller cooling condenser coils, and auxiliary seal coolers for the Condensate, Low Pressure, and High Pressure feed pumps all contain copper or copper alloys. Although not quantified, corrosion of these components contributes to copper within the system.

DISCHARGE OF THE BEARING COOLING WATER WOULD NOT VIOLATE WATER QUALITY STANDARDS

Virginia Water Quality Criteria for copper applicable to Lake Anna are acute and chronic aquatic life criteria of 4.8 µg/L and 3.62 µg/L, respectively. The acute criterion is a 1-hour average concentration and the chronic criterion is a 4-day average concentration. Both criteria allow for a single excursion once every three years on average.

The BC water will be discharged through Outfall 107 (when going Lake-to-Lake) and then Outfall 104 (when pumping the supernate in the basin). Both outfalls discharge to the main once-through Cooling Water discharge canal. The total volume of BC water to be discharged

is approximately 1,000,000 gallons, at a maximum rate of discharge of 25,000 gpm. The once-through cooling water flow is 2,000,000 gpm, resulting in a dilution factor of 60:1. Using the current (or steady-state average) BC water copper concentration of 31 μg/L (or 34 μg/L), the predicted copper concentration in the discharge canal would be 0.52 μg/L (or 0.57 μg/L). Both of these values are well below the acute and chronic water quality criteria, and represent insignificant increases over background, especially when one considers the duration of the discharge relative to the duration component of the criteria. Calculations of the predicted copper concentration are contained in Attachment 3.

CONCLUSION

Copper introduction into the BC system by chemical treatment has been stopped since it was determined that copper was being introduced via the use of H-510 biocide. Engineering calculations determined that the H-510 biocide added about 48 μg/L of copper to the system. Since the H-510 biocide addition has been stopped, the copper concentration of the system has decreased from 92 μg/L to 31 μg/L (steady state value of 34 ug/L). This decrease exceeds the Calgon H-510 contribution of copper to the system indicating that the current copper concentration is at a level that would exist had no H-510 had ever been added. In addition, engineering calculations indicate that the current copper concentration is also in the range of that predicted based on average copper concentrations determined for Lake Anna, the source of make-up water. Also, mass balance calculations demonstrate that discharge of the BC water would not cause a violation of Virginia water quality standards for copper. Consequently, Dominion Generation believes that discharge of the BC water is within compliance of the Federal guidelines, will not violate existing discharge limitations or cause adverse environmental impact.

Attachment 1

Bearing Cooling Water Copper Contribution From Calgon H-510

Engineering Calculations of Copper Contribution due to Calgon H-510

The following Engineering Calculations were performed to estimate the amount of copper contributed to the Bearing Cooling bulk water by the biocide Calgon H-510. The MSDS for Calgon H-510 lists the concentration of cupric nitrate at 0.16% by weight. About 40 gallons of H-510 were added to the Bearing Cooling tower each week based on two ten minute additions a week from a pump that was set to deliver 2 gallons per minute. The amount of copper added to the Bearing Cooling tower each week is calculated as follows:

Amount of H-510 added per week = 40 gallons
Specific gravity of H-510 = 1.02
1 gallon of water = 3774 grams at 25° C
Concentration of CuN_2O_6 = 0.0016 gram CuN_2O_6/ gram of H-510
Concentration of Cu in CuN_2O_6 = 0.3388 gram Cu/ gram of CuN_2O_6

Cu = (40 gal/wk)(1.02)(3774 gm/gal)(0.0016 gm CuN_2O_6/ gm of H-510)(0.3388 gm Cu/ gm of CuN_2O_6)

Cu = 83.5 gm/week

To determine the amount of copper that Calgon H-510 contributes to the Bearing Cooling bulk water the Bearing Cooling make up rate, copper content of the make up water, the system losses, amount of drift and the evaporation rate for the tower values are needed. The bearing cooling make up rate (194 gpm) is determined daily by the Chemistry Department based on integrator reading obtained from the bearing cooling make up pumps. The evaporation rate can be determined based on the concentration factor of ions in the bearing cooling water (See attached copy of EPRI CS-2276 Design and Operating Guidelines Manual for Cooling Water Treatment) as follows:

Evaporation rate = ((Make up rate)(concentration factor –1))/concentration factor

A concentration factor was calculated using silica as recommended by EPRI CS-2276. The average silica concentration of the bearing cooling system is 40 ppm with the lake (make up water) having an average silica concentration of 9.4 ppm. The concentration factor would be:

Concentration factor (CF) = 40/9.4 = 4.2

A concentration factor was calculated based on Ca or Mg to validate the CF obtained using silica. For the same time period, the Ca and Mg concentration factors would be 3.8 and 4.0 respectively which validates the silica value.

The evaporation rate would be:

Evaporation rate = ((194)(4.2-1))/4.2 = 148 gal/min.

Another system loss is drift. Drift can be estimated (reference EPRI CS-2276) as:

Drift = (.00005)(circulation rate)

Based on a circulation rate of 20,000 gal/min our drift would be:

Drift = (.00005)(20,000) = 1 gal/min

The equation for system equilibrium (reference EPRI CS-2276) is:

Make up = Evaporation + Drift + Blowdown

Where in the absence of blowdown, the blowdown term is system losses. System losses consist of water used for cooling purposes that is not recovered. Examples at North Anna include water used for cooling various secondary pumps and Vacuum Priming Pumps. These system losses, described as process wastes in our permit application, are directed to floor drains and are directed to the discharge canal. For our system with no blowdown, system losses are:

System losses = 194 – 1 – 148 = 45 GPM

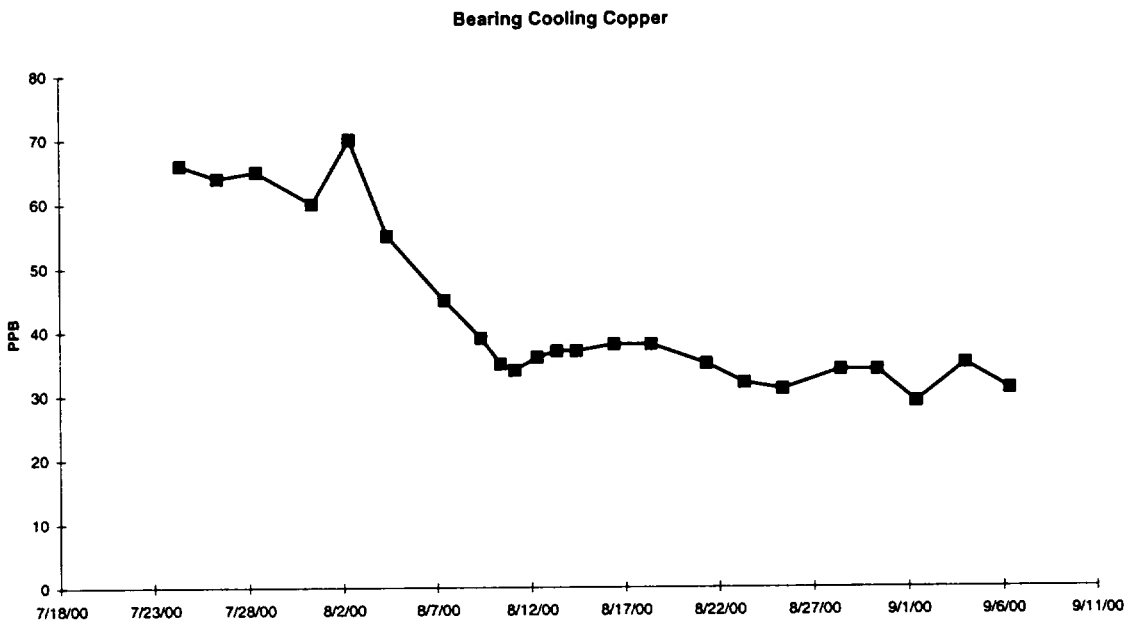
A copper sample of 92 ppb was obtained from the bearing cooling basin without blowdown in service. If we assume that the system was in equilibrium for copper (i.e., the copper concentration has reached a level where influent amount equals the effluent amount), then we can calculate the contribution of the copper in the H-510 to the copper in the system losses. The total copper removal from the system is:

Copper removal = (system loss + drift)(copper concentration)
Copper removal = (45 + 1 gal/min)(.092mg/l)(3.785 l/gal)(10080 min/week)(1 gm/ 1000 mg)
Copper removal = 161.5 gm/week

The 83.5 grams per week of copper from the H-510 additions represent 52% of copper being removed. Therefore, of the 92 ppb of copper in the system, 48 ppb would be due to the H-510 additions.

On July 12, 2000, H-510 additions to the Bearing Cooling system were discontinued. Daily copper analyses of the bearing cooling water were started July 24, 2000. The attached graph shows the decrease in copper concentration in the Bearing Cooling system. Since approximately August 10, 2000, the Bearing Cooling copper concentration has decreased to a steady-state average value of 34 ppb.

NORTH ANNA POWER STATION
BEARING COOLING WATER SYSTEM: RATIONALE FOR ONE-TIME SYSTEM MAINTENANCE DISCHARGE



The calculations described above show that H-510 was responsible for about 48 ppb of the total 92 ppb of copper in the Bearing Cooling system. Securing H-510 addition has resulted in a 58 ppb decrease in the Bearing Cooling water indicating that there is no copper contribution to the Bearing Cooling from H-510 additions. The additional 10 ppb decrease over the calculated value may be attributed to the dynamics of the system and uncertainty associated with these chemical analyses.

Design and Operating Guidelines Manual for Cooling-Water Treatment

Treatment of Recirculated Cooling Water

CS-2276
First Edition
Research Project **1261-1**

Final Report, March 1982

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NORTH ANNA POWER STATION
BEARING COOLING WATER SYSTEM: RATIONALE FOR ONE-TIME SYSTEM MAINTENANCE DISCHARGE

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GLOSSARY

Blowdown:
water that is removed from the recirculated cooling water system with the intent of controlling the concentration of various ions, suspended solids, organic matter, etc.

Concentration Factor:
also referred to as cycles of concentration; the ratio of the concentration of a specific dissolved constituent in the recirculated cooling water system to the concentration of the sane constituent in the makeup water.

Conserved Species:
any species which does not change appreciably in the recirculated cooling water loop when exposed to changes in temperature,, chemical addition and/or physical treatment. Frequently, chloride and nitrate fall into this category.

Drift:
water that is carried from the cooling tower because of the large volume of air flow. This water has the same composition as the circulating water and blowdown.

Evaporation:
water that is removed from the cooling tower by conversion from a liquid to a vapor. This water is essentially free from contamination.

Makeup:
water that is added to the cooling tower to replace recirculated cooling water system losses due to blowdown,, drift., evaporation and leaks.

Rule of Thumb:
a conservative operating limitation that is generally accepted by those in the utility industry.

Sidestrean, Treatment:
a physical treatment system, such as a lime-soda ash softener, which treats a portion of the recirculated cooling water and returns the treated water to the cooling tower.

C:
this symbol stands for the concentration of any specified constituent such as calcium, silica, nitrate, etc.

CF:
this symbol stands for concentration factor.

Q:
this symbol stands for the flow rate of a specified stream such as makeup., blowdown, etc.

Subsection 4

EVALUATION OF OPERATING MODES

There are two basic nodes of operation for control of the chemistry in a cooling tower circulating water system: operation at the minimum blowdown rate versus operation at a specified blowdown rate, The operating requirements, restrictions and application for both of these modes are discussed in this section.

OPERATION AT THE MINIMUM BLOWDOWN RATE

This node of operation has application primarily in stations that can neither discharge cooling tower blowdown nor reuse all of the blowdown water,
Consequently, the circulating water system is operated at the maximum concentration factor that is possible without scaling, fouling or corrosion occurring. The limiting constituents must be monitored continuously in the circulating water system to ensure trouble-free operation. The following sections describe the procedure for determining the minimum blowdown rate and operating limits assuming no use of chemical scale inhibitors,

Determine the Cooling Tower Drift Loss

This rate will be a matter of record for most existing stations, If records are not available, or a new station is being evaluated, a conservative drift rate of 0,005% of the circulating water flow rate can be assumed, Although the manufacturer's guaranteed drift rates are higher than 0.005%, measured drift rates of 0.002% for operating towers have been 'reported by Shofner and Thomas (15) and Bierman, et al (16). Measured drift rates of 0.004% for natural draft towers have been reported by Reisman and Ovard' (17). Since a potential for error in measurement of cooling tower drift exists, the value of 0.005% is recommended for estimation,

Determine Water Quality

The water quality of each of the following flows should be determined from plant records to aid in evaluation of the circulating water system and individual components.

- Makeup water.
- Recirculated cooling water.
- Treated water, either makeup or sidestrearm.

Calculate the Concentration Factor For Current Operation

Using Equation 5-1 and a conserved species (an ion, such as silica, nitrate, etc., whose concentration is not artificially changed in the circulating water system), calculate the existing concentration factor.

$$CF = \frac{C_{circulating\ water}}{C_{cooling\ tower\ makeup}} \qquad \text{Eq. 5-1}$$

CF is the concentration factor and C is the concentration of the conserved species in mg/l,

Calculate the Maximum Permissible Cycles of Concentration

Refer to the guidelines presented in Table 5-1 and calculate the maximum permissible cycles of concentration based on each of the following:

- Total alkalinity
- Calcium
- Magnesium silicate product,
- Silica.
- Suspended solids.
- Total dissolved solids,
- Phosphate,

The calculation which yields the lowest concentration factor reveals the limiting constituent. Compare this concentration factor to the current operating cycles of concentration to determine the relative potential for improved operation.

Determine The Cooling Tower Evaporation Rate

The cooling tower evaporation rate must be established in order to calculate the blowdown rate. Since this rate will vary with condenser design, cooling tower design, unit loading and atmospheric conditions, no "typical" evaporation ratio can

be established, Ideally, an average evaporation rate should be established for each month of the year, However, a design maximum evaporation rate assumption will suffice.

For existing stations where the makeup water flow rate and the corresponding concentration factor is known, calculate the evaporation rate using Equation 5-2. This equation was derived from a mass balance around the recirculated cooling water system depicted in Figure 5-4.

$$Q_{Evaporation} = \frac{Q_{Makeup}(CF-1)}{CF} \qquad \text{Eq. 5-2}$$

Q is the flow rate in gallons per minute.

Calculate the Cooling Tower Blowdown Rate

When the evaporation rate and maximum cycles of concentration are known., calculate the corresponding blowdown rate using equation 5-3. If the drift rate is not known, an estimate of 0.005% of the circulating water flow can be assumed.

$$Q_{Blowdown} = \frac{Q_{Evaporation} - Q_{drift}(CF-1)}{(CF-1)} \qquad \text{Eq. 5-3}$$

This blowdown is the amount that must be reused, treated and discharged, or routed to on site disposal.

Calculate the Makeup Rate

Use Equation 5-4 to calculate the makeup rate,

$$Q_{Makeup} = Q_{Evaporation} + Q_{Drift} + Q_{Blowdown} \qquad \text{Eq. 5-4}$$

Attachment 2

Lake Anna Total Copper Concentrations

Lake Anna Total Copper Concentrations

Total copper concentrations determined for samples collected by Virginia Power personnel from Lake Anna and the North Anna Power Station's once-through cooling water intakes.

SAMPLE LOCATION	DATE	VALUE mg/L	
RT 719	2/25/91	0.001	UPPER LAKE
RT 208	2/25/91	<0.001	
	1/13/93	0.003	
RT 652 Contrary Creek	2/25/91	0.096	
	1/13/93	0.07	
North Anna Intakes	11/14/89	0.009	
	1/23/90	0.003	
	5/29/90	<0.011	
	9/10/90	<0.011	
	12/3/90	0.004	
	2/25/91	<0.001	
	10/29/91	0.003	
	10/27/92	0.007	
	1/13/93	0.04	
	1/13/93	0.003*	
	11/1/93	0.001	
	9/6/94	<0.01	
	6/15/99	0.003	
Lower Lake Anna	1/13/93	0.003	LOWER LAKE

* Duplicate Sample

Attachment 3

Calculation of Predicted In-Stream Copper Concentration Following the Maintenance Discharge

Conservative Engineering Calculation based on steady-state average value of 34 µg/L:

Df = Dilution factor for bearing cooling water following discharge to the main once-through cooling water canal = $\frac{Qcw}{Qct}$

where,

Qcw = flow of once through cooling water discharge = 1,500,000 gallons per min (gpm)

Qct = design release rate of bearing cooling tower water to discharge canal = 25,000 (gpm)

Df = 60

Ccw = Predicted concentration of bearing cooling tower copper in final once-through cooling water discharge = $\frac{Cct}{Df}$

where,

Cct = Concentration of copper in bearing cooling tower = 34 µg/L

Ccw = 0.57 µg/L

Likewise, an Engineering Calculation based on the current value of 31 µg/L yields:

Df = Dilution factor for bearing cooling water following discharge to the main once-through cooling water canal = $\frac{Qcw}{Qct}$

where,

Qcw = flow of once through cooling water discharge = 1,500,000 gallons per min (gpm)

Qct = design release rate of bearing cooling tower water to discharge canal = 25,000 (gpm)

Df = 60

Ccw = Predicted concentration of bearing cooling tower copper in final once-through cooling water discharge = $\frac{Cct}{Df}$

where,

Cct = Concentration of copper in bearing cooling tower = 31 µg/L

Ccw = 0.52 µg/L