CH2M HILL
2485 Natomas Park Drive
Suite 600
Sacramento, CA 95833-2397
Tel 916.920.0300
Fax 916.920.8463

DOCKET
01-AFC-19C
DATE APR 25 2011
RECD. APR 25 2011

April 25, 2011

Ms. Christine Stora
Compliance Project Manager
01-AFC-19C
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Subject: Cosumnes Power Plant Project (01-AFC-19C) Petition for Post-certification License Amendment for Fuel Supply Modifications and Revisions to Conditions of Certification AQ-17, AQ-18, AQ-19, AQ-24 and WATER RES-1 Response to CEC Staff Data Requests # 1–11

Dear Ms. Stora:

Please find attached a copy of the Cosumnes Power Plant Project data responses. The data responses were prepared in response to California Energy Commission Staff Data Requests 1 through 11 for the Petition for Post-certification License Amendment for Fuel Supply Modifications and Revisions to Conditions of Certification AQ-17, AQ-18, AQ-19, AQ-24 and WATER RES-1 (01-AFC-19C), dated March 25, 2011.

If you have any questions, please contact me at (916) 286-0221.

Sincerely,
CH2M HILL

Keith McGregor
Project Manager

Attachment

Cc: Brad Jones, Sacramento Municipal Utility District

Cosumnes Power Plant Petition for Post-certification License Amendment

(01-AFC-19C)

Data Responses, Set 1

(Response to Data Requests Nos. 1 to 11)

Submitted to

California Energy Commission

Submitted by

Sacramento Municipal Utility District Financing Authority

With Assistance from

CH2MHILL
2485 Natomas Park Drive
Suite 600
Sacramento, CA 95833

April 2011

Contents

Section **Page**

Introduction

Attached are Sacramento Municipal Utility District Financing Authority's (SFA's) responses to the California Energy Commission (CEC) Staff data request numbers 1 through 11 for the Cosumnes Power Plant (CPP) Petition for Post-certification License Amendment (01-AFC-19C). The data requests were prepared by the CEC Staff on March 25, 2011.

The responses are grouped by individual discipline or topic area. Within each discipline area, the responses are presented in the same order as the CEC presented them and are keyed to the Data Request numbers (1 through 11). New graphics or tables are numbered in reference to the Data Request number. For example, the first table used in response to Data Request 6 would be numbered Table DR6-1. The first figure used in response to Data Request 10 would be Figure DR10-1, and so on.

Additional tables, figures, or documents submitted in response to a data request (e.g., supporting data, stand-alone documents such as plans, and folding graphics) are found at the end of each discipline-specific section and are not sequentially page-numbered consistently with the remainder of the document, although they may have their own internal page numbering system.

Air Quality (1-4)

Background: Fuel Use

The proposed petition to amend would allow the Cosumnes Power Plant Project (CPP) to incorporate digester gas into its fuel supply that would otherwise be burned at the Carson Ice-Gen. The incorporation of digester gas could enhance SMUD's renewable energy portfolio by using the fuel in a more efficient way. However, the proposed project would result in an increase of sulfur dioxide (SOx) emissions and an increase in the gas volume flow at CPP to maintain the rated turbine output.

Data Requests

1. What type of fuel would be used at the Carson Ice-Gen to displace the digester gas being redirected to the CPP?

Response:

The Carson Energy Ice-Gen facility, also known as the Central Valley Financing Authority (CFVA) Cogeneration plant, will burn natural gas to displace the digester gas being redirected to Cosumnes Power Plant (CPP) project.

2. Would there be a decrease in emissions of SO_x at the Carson Ice-Gen equal to, or greater than, the increase proposed at the CPP?

Response:

There will be a decrease in SO_x emissions at the Carson Ice-Gen facility that will be equal to or greater than the SO_x emission increase proposed at the CPP because of redirecting the digester gas from the Carson Ice-Gen facility to CPP. However, the CVFA requires the operational flexibility to burn the digester gas at the Carson Ice-Gen facility in the event that the gas cannot be sent to CPP because of equipment upset/malfunction or scheduled outage (e.g., a temporary shutdown of the gas turbines at CPP). Therefore, the SFA does not propose a condition of certification mandating this reduction in SO_x emissions at the Carson Ice-Gen facility.

Background: Cooling Tower

The proposed petition to amend would increase the allowable total dissolved solids (TDS) level in the cooling tower recirculation water from 800 ppmw to 1,500 ppmw, measured over 3-hour averaging period. The higher TDS levels would potentially result in higher emissions of particulate matter less than 10 micrometers in aerodynamic diameter (PM10) from the CPP cooling tower. CPP has requested the use of a correction factor of approximately 67%, when quantifying PM10 emissions from the cooling tower. The request is in light of a recent study that suggests a single particle will form when a single water droplet evaporates. From this, predicted mass distribution of drift droplet sizes for this project estimates that approximately 67% of the emissions would be PM10. Staff does not necessarily agree with this assumption, based on a lack of evidence.

The cooling tower was analyzed in 2003 during the licensing certification, and then again in 2007 during an amendment with the conservative assumption that 100% of the emissions are PM10. Staff has the obligation to ensure mitigation for the worst case scenario. The inability to accurately quantify emissions from these types of sources requires staff to conservatively assume that 100% of the emissions are PM10, unless proven otherwise.

Data Request

3. If the 67 percent correction factor is used, can CPP identify source testing methods that would confirm that PM_{10} emissions from the cooling tower are below 0.39 Ib/hr (or that 67 percent of the emissions are PM_{10}) and commit to a condition of certification that would require this as verification to ensure that all project emissions are appropriately mitigated?

Response:

SFA has reviewed U.S. Environmental Protection Agency (EPA)-approved particulate compliance test methods and is unable to identify a method that will account for the two-step process that forms the basis for the cooling tower PM_{10} emissions calculated in the CPP Petition to Amend. However, Step 1 in this cooling tower PM_{10} emission calculation is determining the size distribution of the water droplets in the drift exhausted from the CPP cooling tower. As discussed in the Petition to Amend, the water droplet size distribution of the CPP cooling tower drift was based on information provided by the manufacturer of the CPP cooling tower drift eliminator.[1] Step 2 involves calculating the resulting solid particulate diameter after the water droplets evaporate in the atmosphere. When a water droplet containing solids evaporates, the dissolved solids contained in the water droplet form a solid particle, which remains suspended in the air. The basis for step 2 was also discussed in the amendment petition and is based on the physical properties of aerosols. The amendment petition also included references to the studies/papers that supported the equations used in the amendment petition to convert the liquid droplet size to the corresponding solid particle size. Included in Attachment DR3-1 are copies of these studies/papers referenced in the amendment petition.

SFA also contacted three well-known stack testing firms—Airkinetics, Avogadro Group, and Broadbent and Associates—and learned that while these firms could take EPA-approved stack testing equipment/procedures and adapt them to sample the exhaust from wet cooling towers, this type of particulate testing has a number of significant issues that will affect the accuracy of the PM_{10} emission test results. These issues include sampling problems resulting from cyclonic flow of exhaust from the wet cooling tower fan vents and problems with using particulate size cut methods (e.g., cyclones) in the front part of the sampling probe so that only PM_{10} particles are captured by the sampling equipment.

In addition, as discussed in the petition to amend, the proposed approach to calculating PM_{10} emissions from a wet cooling tower was also used and approved by the CEC for the Elk Hills Power Plant. Based on a review of the CEC Conditions of Certification for the Elk Hills Power Plant, this facility is not required to perform a cooling tower PM_{10} compliance test to confirm the calculated PM_{10} emissions. In addition, based on a review of CEC

---

[1] Petition for Post Certification License to Amend, Appendix C, December 2010.

approvals of combined cycle power plants over the past several years, PM_{10} emission compliance testing of wet cooling towers is generally not required.

Because the SFA is concerned that the existing wet cooling tower test methods cannot replicate the two-step process in the PM_{10} calculation methodology and because of the above issues that affect the accuracy of PM_{10} emission testing methods adapted to sample wet cooling towers, the SFA does not believe a condition of cooling tower testing program for the proposed CPP amendment is appropriate.

Background: Mitigation

During the original licensing of the CPP, 158,984 lb/year of PM10 emission reduction credits (ERC) were provided to mitigate the facility impacts. During the 2007 amendment, another 1,411 lb/year of PM10 ERC's were provided to mitigate the change in operating parameters for the cooling tower. The ERC's provided were a combination of PM10/2.5 ERG's and inter-pollutant trading of SOx ERC's at a determined ratio. All ERC's provided were also adjusted with an appropriate distance ratio as required by the district. The current petition to amend would require mitigation for PM10 and SOx. The CPP has identified that PM10 ERC's would be required by the District and that SOx ERC's would be required by CEQA to mitigate secondary particulate formation. The CPP has requested using the surplus emissions provided in 2003, as required by the District's distance ratio, to offset the increase in Sox emissions. Although staff does agree that the surplus would adequately mitigate the increase in SOx emissions under CEQA, staff does not agree that the surplus of ERC's provided in 2003 would adequately mitigate for the current proposed emission changes from the facility as required by CEQA and analyzed in this petition to amend.

Data Request

4. Can evidence be provided to show that the effect of these old ERCs have not yet been included in the background PM_{10} concentrations that are being used in the current petition to amend to evaluate compliance with ambient air quality standards?

Response:

Included in the petition to amend were the estimated revised ambient sulfur dioxide (SO_2), PM_{10}, and $PM_{2.5}$ impacts associated with the proposed changes at the CPP. This analysis is based on 2007 to 2009 background ambient air quality data representative of the CPP project area. The ERCs retired as PM_{10} mitigation during the original licensing of the CPP project represented emission reductions that occurred contemporaneous with or prior to issuance of the CEC license in 2003. Because these emission reductions occurred prior to the 2007 to 2009 background ambient air quality data used in the petition to amend, these emission reductions are reflected in the current background ambient air quality data.

However, when considering whether the amended CPP project will result in significant ambient air quality impacts, it is important to note that the ambient impacts shown in the petition to amend (see Table 1 of petition) are below the EPA-developed Significant Impact Levels (SILs) for SO_2, PM_{10}, and $PM_{2.5}$. The primary purpose of the EPA SILs is to identify a level of ambient impact that is sufficiently low relative to ambient air quality standards such that the impact can be considered trivial or de minimis. Therefore, the EPA considers a source whose individual impact falls below a SIL to have a de minimis impact on background ambient air quality concentrations that already exist. Accordingly, if a project demonstrates that its ambient impact does not exceed a SIL for a pollutant, then the impact is not considered significant and is not considered to cause or contribute to a violation of the ambient air quality standard for that pollutant.

Furthermore, ERCs based on emission reductions that occurred years before emission increases from a new or modified stationary source are typically considered valid by the SMAQMD for purposes of complying with New Source Review (NSR) regulatory offset requirements and for CEQA mitigation purposes. Consequently, the SFA's proposal to use excess PM_{10} ERCs provided during the original 2003 CPP licensing to mitigate proposed emission increases is not unusual compared with typical NSR and CEQA mitigation practices for projects.

TABLE DR4-1
Ambient Air Quality Impacts
CPP Amendment

Pollutant	Ambient Impact (μg/m^3)[a]	SIL (μg/m^3)
SO_2 (1-hour)	0.74	7.8[b]
SO_2 (24-hour)	0.28	5
SO_2 (annual)	0.03	1
PM_{10} (24-hour)	0.223	5
PM_{10} (annual)	0.025	1
$PM_{2.5}$ (24-hour)	0.086	1.2
$PM_{2.5}$ (annual)	0.0096	0.3

[a] Petition to Amend, Table 3.1-6, December 2010.
[b] EPA has not yet defined a significance level for 1-hour SO_2 impacts. However, EPA has suggested that until the 1-hr SO_2 SIL is promulgated, an interim value of 3 ppb (7.8 μg/m^3) for SO_2 be used

Notes:
μg/m^3 = microgram(s) per cubic meter
ppb = part(s) per billion

Source: EPA guidance memo from OAQPS to Regional Air Division Directors, June 29, 2010.

Attachment DR3-1

Support of Equations for Converting Liquid Droplet Size to Corresponding Solid Particle Size

Data Request 5:

Please provide evidence and analysis to support the AFC assumption that no more than 50 percent of the cooling tower TSP emissions are PM10.

Response:

The background discussion to this data request states that "In all past siting cases, staff has assumed that 100 percent of the TSP emissions from the cooling tower are PM10." Actually, there have been several past siting cases where the analyses of cooling tower PM10 emissions have been based on less than 100 percent. Examples include the High Desert Power Project, which assumed 50 percent, and the Blythe Energy Project, which assumed 15 percent. Both of these projects are located in the Mojave Desert Air Quality Management District's jurisdiction. The Elk Hills Power Project, in the San Joaquin Valley Air Pollution Control District's jurisdiction, is also based on less than 100 percent. In a response to a CEC comment on the Palomar Energy Center, the San Diego Air Pollution Control District stated "*There is evidence to indicate a 50% assumption for* PM_{10} *is reasonable: not the least of which is acceptance of such on prior projects. Therefore the District will report the facility* PM_{10} *in the FDOC assuming 50% of the cooling tower water TDS is converted into* PM_{10}*.*"

As described in AP-42, because wet cooling towers provide direct contact between the cooling water and air passing through the tower, some of the water may be entrained in the air stream and carried out of the tower as drift. AP-42 also states that large drift droplets settle out of the tower exhaust stream and deposit near the tower. Other drift droplets may evaporate before being deposited in the area surrounding the tower and can produce PM10 emissions. AP-42 states that a "**conservatively high**" PM10 emission rate can be developed by assuming that all the drift forms PM10.

The assumption in the VV2 Project AFC is based on a more realistic assessment of cooling tower emissions. When studying aerosol physics, nebulizers are used to produce solid particles. When a 1,000 parts per million (ppm) solution is nebulized, a solid particle with a volume that is 0.001 times the original droplet volume will be produced.[1] Under these conditions, experience shows that a single particle will be produced. The size of the final aerosol particle depends on the volume fraction of solid material and the droplet diameter as follows:

---

[1] Hinds, William C., 1982. Aerosol Technology, Properties, Behavior and Measurements of Airborne Particles. John Wiley & Sons, Inc.

$D_s = D_d \times (F_v)^{1/3}$

Where:
D_s = diameter of solid particle
D_d = diameter of liquid droplet
F_v = volume fraction of solid material

This equation can be converted to calculate the resulting particle diameter for a cooling tower by accounting for the density of the particle. This equation is presented below:

$D_s = D_d \times (\rho_d/\rho_s \times TDS /1{,}000{,}000)^{1/3}$

Where:
D_s = diameter of solid particle
D_d = diameter of liquid droplet
ρ_d = density of droplet = 1 g/cm^3
ρ_s = density of solid particle = 2.2 g/cm^3 for sodium chloride
TDS = total dissolved solids, ppm

The above equation predicts the physical diameter of a particle formed from a cooling tower droplet. This equation assumes that a single particle will be formed when a droplet evaporates, because there is no evidence that multiple particles will be formed. In order to calculate PM10 emission, the aerodynamic diameter must be calculated as follows:[2]

$D_a = D_s \times (\rho_s)^{0.5}$

Several sources of data were considered to determine the droplet size of cooling tower drift. In order to be conservative, the size distribution that showed the greatest percentage of small droplets was used to calculate PM10 emissions. The droplet size distribution and the resulting particle size distribution are shown in Table DR5-1.

A chart showing the predicted particle size distribution based on the conservative droplet size is shown in Figure AQ5-1. This figure show that approximately 50 percent of the mass formed from evaporation of the drift droplets is expected to be in particles with an aerodynamic diameter of 10 microns or less, which supports the assumption that 50 percent of the particulate matter formed from evaporation of cooling tower drift will be PM10.

---

[2] http://www.epa.gov/eogapti1/module3/diameter/diameter.htm

Table DR5-1 Droplet Size Distribution and Calculated Solid Particle Size Distribution

Droplet Size(a) microns	Percent Mass Less Than Droplet Size(a)	Dry Particle Diameter(b)	
		Physical microns	Aerodynamic microns
15	20.0	2.0	2.9
35	40.0	4.6	6.8
65	60.0	8.5	12.7
115	80.0	15.1	22.4
170	90.0	22.4	33.2
230	95.0	30.2	44.9
275	98.0	36.2	53.6
525	99.5	69.0	102.4
700	100.0	92.0	136.5

(a) web.ead.anl.gov/bajatermoeis/documents/docs/BPPWG_AttachC_2003wet-dry_cooling_paper.pdf
(b) TDS = 5,000 ppm, particle density = 2.2 g/cm^3

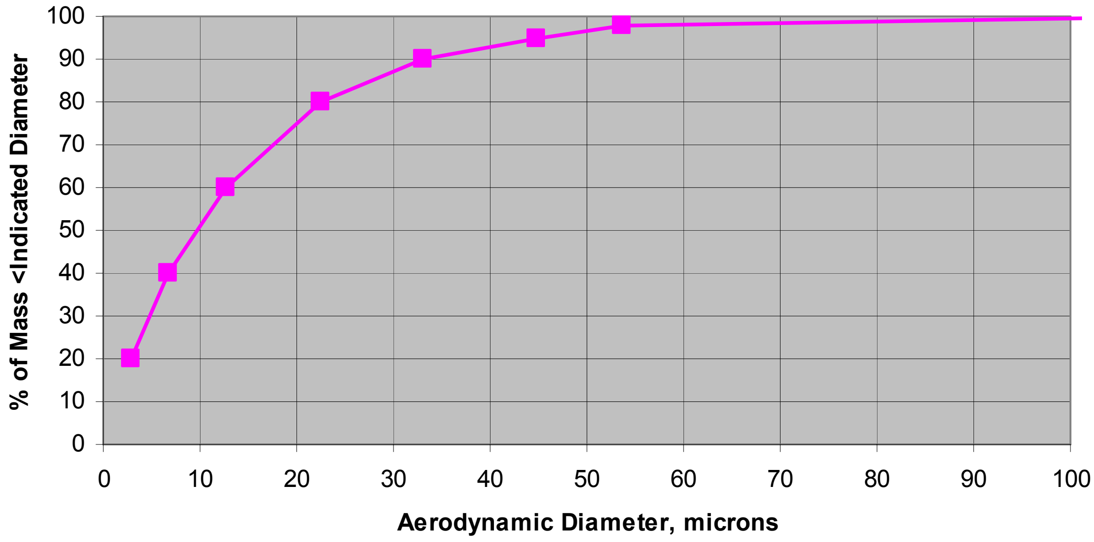


Figure AQ5-1 Calculated Soild Particle SIze Distribution

Calculating Realistic PM_{10} Emissions from Cooling Towers

Abstract No. 216 Session No. AM-1b

Joel Reisman and Gordon Frisbie
Greystone Environmental Consultants, Inc., 650 University Avenue, Suite 100, Sacramento, California 95825

ABSTRACT

Particulate matter less than 10 micrometers in diameter (PM_{10}) emissions from wet cooling towers may be calculated using the methodology presented in EPA's AP-42[1] , which assumes that all total dissolved solids (TDS) emitted in "drift" particles (liquid water entrained in the air stream and carried out of the tower through the induced draft fan stack.) are PM_{10}. However, for wet cooling towers with medium to high TDS levels, this method is overly conservative, and predicts significantly higher PM_{10} emissions than would actually occur, even for towers equipped with very high efficiency drift eliminators (e.g., 0.0006% drift rate). Such over-prediction may result in unrealistically high PM_{10} modeled concentrations and/or the need to purchase expensive Emission Reduction Credits (ERCs) in PM_{10} non-attainment areas. Since these towers have fairly low emission points (10 to 15 m above ground), over-predicting PM_{10} emission rates can easily result in exceeding federal Prevention of Significant Deterioration (PSD) significance levels at a project's fenceline. This paper presents a method for computing realistic PM_{10} emissions from cooling towers with medium to high TDS levels.

INTRODUCTION

Cooling towers are heat exchangers that are used to dissipate large heat loads to the atmosphere. Wet, or evaporative, cooling towers rely on the latent heat of water evaporation to exchange heat between the process and the air passing through the cooling tower. The cooling water may be an integral part of the process or may provide cooling via heat exchangers, for example, steam condensers. Wet cooling towers provide direct contact between the cooling water and air passing through the tower, and as part of normal operation, a very small amount of the circulating water may be entrained in the air stream and be carried out of the tower as "drift" droplets. Because the drift droplets contain the same chemical impurities as the water circulating through the tower, the particulate matter constituent of the drift droplets may be classified as an emission. The magnitude of the drift loss is influenced by the number and size of droplets produced within the tower, which are determined by the tower fill design, tower design, the air and water patterns, and design of the drift eliminators.

AP-42 METHOD OF CALCULATING DRIFT PARTICULATE

EPA's AP-42[1] provides available particulate emission factors for wet cooling towers, however, these values only have an emission factor rating of "E" (the lowest level of confidence acceptable). They are also rather high, compared to typical present-day manufacturers' guaranteed drift rates, which are on the order of 0.0006%. (Drift emissions are typically expressed as a percentage of the cooling tower water circulation rate). AP-42 states that "a *conservatively high* PM_{10} emission factor can be obtained by (a) multiplying the total liquid drift factor by the TDS fraction in the circulating water, and (b) assuming that once the water evaporates, all remaining solid particles are within the PM_{10} range." (Italics per EPA).

If TDS data for the cooling tower are not available, a source-specific TDS content can be estimated by obtaining the TDS for the make-up water and multiplying it by the cooling tower cycles of concentration. [The cycles of concentration is the ratio of a measured parameter for the cooling tower water (such as conductivity, calcium, chlorides, or phosphate) to that parameter for the make-up water.]

Using AP-42 guidance, the total particulate emissions (PM) (after the pure water has evaporated) can be expressed as:

$$\text{PM} = \text{Water Circulation Rate x Drift Rate x TDS} \qquad [1]$$

For example, for a typical power plant wet cooling tower with a water circulation rate of 146,000 gallons per minute (gpm), drift rate of 0.0006%, and TDS of 7,700 parts per million by weight (ppmw):

$$\text{PM} = 146{,}000 \text{ gpm x } 8.34 \text{ lb water/gal x } 0.0006/100 \text{ x } 7{,}700 \text{ lb solids}/10^6 \text{ lb water x } 60 \text{ min/hr} = \underline{3.38 \text{ lb/hr}}$$

On an annual basis, this is equivalent to almost 15 tons per year (tpy). Even for a state-of-the-art drift eliminator system, this is not a small number, especially if assumed to all be equal to PM_{10}, a regulated criteria pollutant. However, as the following analysis demonstrates, only a very small fraction is actually PM_{10}.

COMPUTING THE PM_{10} FRACTION

Based on a representative drift droplet size distribution and TDS in the water, the amount of solid mass in each drop size can be calculated. That is, for a given initial droplet size, assuming that the mass of dissolved solids condenses to a spherical particle after all the water evaporates, and assuming the density of the TDS is equivalent to a representative salt (e.g., sodium chloride), the diameter of the final solid particle can be calculated. Thus, using the drift droplet size distribution, the percentage of drift mass containing particles small enough to produce PM_{10} can be calculated. This method is conservative as the final particle is assumed to be perfectly spherical; hence as small a particle as can exist.

The droplet size distribution of the drift emitted from the tower is critical to performing the analysis. Brentwood Industries, a drift eliminator manufacturer, was contacted and agreed to provide drift eliminator test data from a test conducted by Environmental Systems Corporation (ESC) at the Electric Power Research Institute (EPRI) test facility in Houston, Texas in 1988 (Aull[2], 1999). The data consist of water droplet size distributions for a drift eliminator that achieved a tested drift rate of 0.0003 percent. As we are using a 0.0006 percent drift rate, it is reasonable to expect that the 0.0003 percent drift rate would produce smaller droplets, therefore, this size distribution data can be assumed to be conservative for predicting the fraction of PM_{10} in the total cooling tower PM emissions.

In calculating PM_{10} emissions the following assumptions were made:

- Each water droplet was assumed to evaporate shortly after being emitted into ambient air, into a single, solid, spherical particle.
- Drift water droplets have a density (ρ_w) of water; $1.0\ \mathrm{g/cm^3}$ or $1.0*10^{-6}\ \mu g/\mu\mathrm{m}^3$.
- The solid particles were assumed to have the same density (ρ_{TDS}) as sodium chloride, (i.e., 2.2 g/cm^3).

Using the formula for the volume of a sphere, $V = 4\pi r^3/3$, and the density of pure water, $\rho_w = 1.0\ \mathrm{g/cm^3}$, the following equations can be used to derive the solid particulate diameter, D_p, as a function of the TDS, the density of the solids, and the initial drift droplet diameter, D_d :

$$\text{Volume of drift droplet} = (4/3)\pi(D_d/2)^3 \quad [2]$$

$$\text{Mass of solids in drift droplet} = (\mathrm{TDS})(\rho_w)(\text{Volume of drift droplet}) \quad [3]$$

substituting,

$$\text{Mass of solids in drift} = (\mathrm{TDS})(\rho_w)\,(4/3)\pi(D_d/2)^3 \quad [4]$$

Assuming the solids remain and coalesce after the water evaporates, the mass of solids can also be expressed as:

$$\text{Mass of solids} = (\rho_{\mathrm{TDS}})\ (\text{solid particle volume}) = (\rho_{\mathrm{TDS}})(4/3)\pi(D_p/2)^3 \quad [5]$$

Equations [4] and [5] are equivalent:

$$(\rho_{\mathrm{TDS}})(4/3)\pi(D_p/2)^3 = (\mathrm{TDS})(\rho_w)(4/3)\pi(D_d/2)^3 \quad [6]$$

Solving for D_p:

$$D_p = D_d\ [(\mathrm{TDS})(\rho_w/\rho_{TDS})]^{1/3} \quad [7]$$

Where,

TDS is in units of ppmw
D_p = diameter of solid particle, micrometers (μm)
D_d = diameter of drift droplet, μm

Using formulas [2] – [7] and the particle size distribution test data, Table 1 can be constructed for drift from a wet cooling tower having the same characteristics as our example; 7,700 ppmw TDS and a 0.0006% drift rate. The first and last columns of this table are the particle size distribution derived from test results provided by Brentwood Industries. Using straight-line interpolation for a solid particle size 10 μm in diameter, we conclude that approximately 14.9 percent of the mass emissions are equal to or smaller than PM_{10}. The balance of the solid particulate are particulate greater than 10 μm. Hence, PM_{10} emissions from this tower would be equal to PM emissions x 0.149, or 3.38 lb/hr x 0.149 = 0.50 lb/hr. The process is repeated in Table 2, with all parameters equal except that the TDS is 11,000 ppmw. The result is that approximately 5.11 percent are smaller at 11,000 ppm. Thus, while total PM emissions are larger by virtue of a higher TDS, overall PM_{10} emissions are actually lower, because more of the solid particles are larger than 10 μm.

Table 1. Resultant Solid Particulate Size Distribution (TDS = 7700 ppmw)

EPRI Droplet Diameter (μm)	Droplet Volume (μm^3) [2][1]	Droplet Mass (μg) [3]	Particle Mass (Solids) (μg) [4]	Solid Particle Volume (μm^3)	Solid Particle Diameter (μm) [7]	EPRI % Mass Smaller
10	524	5.24E-04	4.03E-06	1.83	1.518	0.000
20	4189	4.19E-03	3.23E-05	14.66	3.037	0.196
30	14137	1.41E-02	1.09E-04	49.48	4.555	0.226
40	33510	3.35E-02	2.58E-04	117.29	6.073	0.514
50	65450	6.54E-02	5.04E-04	229.07	7.591	1.816
60	113097	1.13E-01	8.71E-04	395.84	9.110	5.702
70	179594	1.80E-01	1.38E-03	628.58	10.628	21.348
90	381704	3.82E-01	2.94E-03	1335.96	13.665	49.812
110	696910	6.97E-01	5.37E-03	2439.18	16.701	70.509
130	1150347	1.15E+00	8.86E-03	4026.21	19.738	82.023
150	1767146	1.77E+00	1.36E-02	6185.01	22.774	88.012
180	3053628	3.05E+00	2.35E-02	10687.70	27.329	91.032
210	4849048	4.85E+00	3.73E-02	16971.67	31.884	92.468
240	7238229	7.24E+00	5.57E-02	25333.80	36.439	94.091
270	10305995	1.03E+01	7.94E-02	36070.98	40.994	94.689
300	14137167	1.41E+01	1.09E-01	49480.08	45.549	96.288
350	22449298	2.24E+01	1.73E-01	78572.54	53.140	97.011
400	33510322	3.35E+01	2.58E-01	117286.13	60.732	98.340
450	47712938	4.77E+01	3.67E-01	166995.28	68.323	99.071
500	65449847	6.54E+01	5.04E-01	229074.46	75.915	99.071
600	113097336	1.13E+02	8.71E-01	395840.67	91.098	100.000

[1] Bracketed numbers refer to equation number in text.

The percentage of PM_{10}/PM was calculated for cooling tower TDS values from 1000 to 12000 ppmw and the results are plotted in Figure 1. Using these data, Figure 2 presents predicted PM_{10} emission rates for the 146,000 gpm example tower. As shown in this figure, the PM emission rate increases in a straight line as TDS increases, however, the PM_{10} emission rate increases to a maximum at around a TDS of 4000 ppmw, and then begins to decline. The reason is that at higher TDS, the drift droplets contain more solids and therefore, upon evaporation, result in larger solid particles for any given initial droplet size.

CONCLUSION

The emission factors and methodology given in EPA's AP-42[1] Chapter 13.4 *Wet Cooling Towers*, do not account for the droplet size distribution of the drift exiting the tower. This is a critical factor, as more than 85% of the mass of particulate in the drift from most cooling towers will result in solid particles larger than PM_{10} once the water has evaporated. Particles larger than PM_{10} are no longer a regulated air pollutant, because their impact on human health has been shown to be insignificant. Using reasonable, conservative assumptions and a realistic drift droplet size distribution, a method is now available for calculating realistic PM_{10} emission rates from wet mechanical draft cooling towers equipped with modern, high-efficiency drift eliminators and operating at medium to high levels of TDS in the circulating water.

Table 2. Resultant Solid Particulate Size Distribution (TDS = 11000 ppmw)

EPRI Droplet Diameter (μm)	Droplet Volume (μm^3) [2][1]	Droplet Mass (μg) [3]	Particle Mass (Solids) (μg) [4]	Solid Particle Volume (μm^3)	Solid Particle Diameter (μm) [7]	EPRI % Mass Smaller
10	524	5.24E-04	5.76E-06	2.62	1.710	0.000
20	4189	4.19E-03	4.61E-05	20.94	3.420	0.196
30	14137	1.41E-02	1.56E-04	70.69	5.130	0.226
40	33510	3.35E-02	3.69E-04	167.55	6.840	0.514
50	65450	6.54E-02	7.20E-04	327.25	8.550	1.816
60	113097	1.13E-01	1.24E-03	565.49	10.260	5.702
70	179594	1.80E-01	1.98E-03	897.97	11.970	21.348
90	381704	3.82E-01	4.20E-03	1908.52	15.390	49.812
110	696910	6.97E-01	7.67E-03	3484.55	18.810	70.509
130	1150347	1.15E+00	1.27E-02	5751.73	22.230	82.023
150	1767146	1.77E+00	1.94E-02	8835.73	25.650	88.012
180	3053628	3.05E+00	3.36E-02	15268.14	30.780	91.032
210	4849048	4.85E+00	5.33E-02	24245.24	35.909	92.468
240	7238229	7.24E+00	7.96E-02	36191.15	41.039	94.091
270	10305995	1.03E+01	1.13E-01	51529.97	46.169	94.689
300	14137167	1.41E+01	1.56E-01	70685.83	51.299	96.288
350	22449298	2.24E+01	2.47E-01	112246.49	59.849	97.011
400	33510322	3.35E+01	3.69E-01	167551.61	68.399	98.340
450	47712938	4.77E+01	5.25E-01	238564.69	76.949	99.071
500	65449847	6.54E+01	7.20E-01	327249.23	85.499	99.071
600	113097336	1.13E+02	1.24E+00	565486.68	102.599	100.000

Figure 1: Percentage of Drift PM that Evaporates to PM10

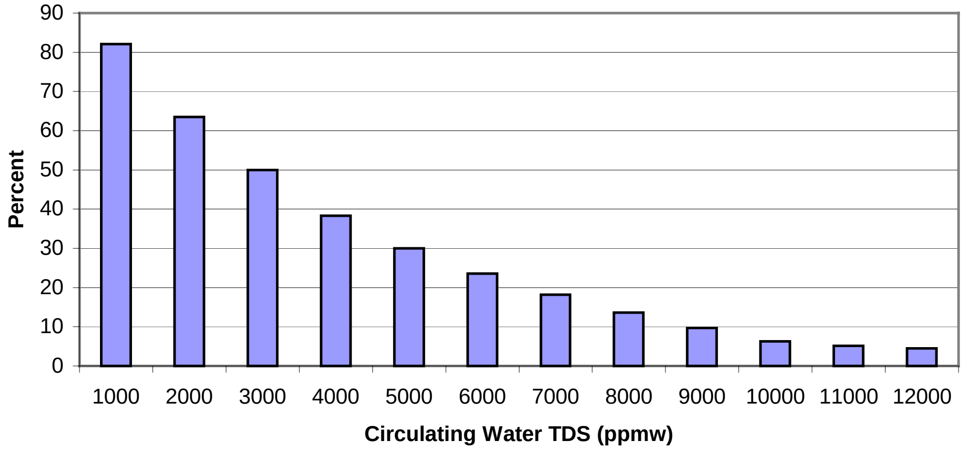
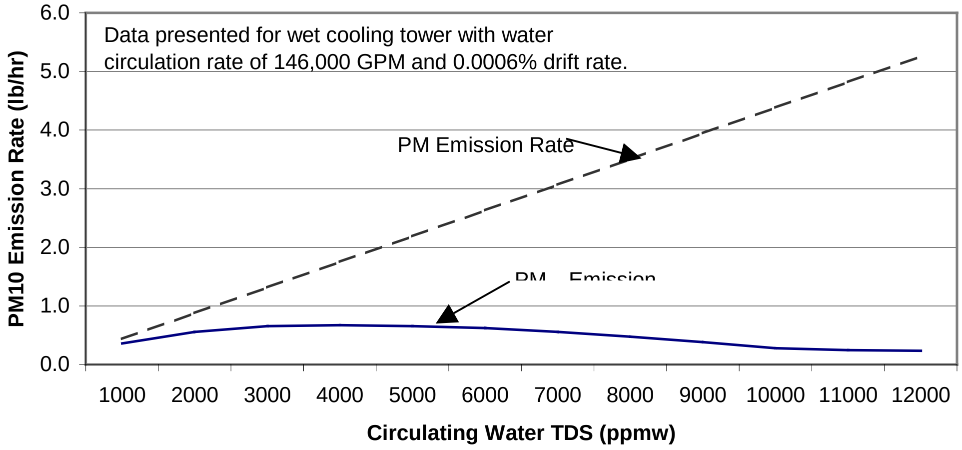


Figure 2: PM_{10} Emission Rate vs. TDS



REFERENCES

1. EPA, 1995. Compilation of Air pollutant Emission Factors, AP-42 Fifth edition, Volume I: *Stationary Point and Area Sources*, Chapter 13.4 Wet Cooling Towers, http://www.epa.gov/ttn/chief/ap42/, United States Environmental Protection Agency, Office of Air Quality Planning and Standards, January.

2. Aull, 1999. Memorandum from R. Aull, Brentwood Industries to J. Reisman, Greystone, December 7, 1999.

KEY WORDS

Drift
Drift eliminators
Cooling tower
PM_{10} emissions
TDS

PAPER NO: TP05-05
CATEGORY: ENVIRONMENTAL IMPACT

COOLING TECHNOLOGY INSTITUTE

ATMOSPHERIC EMISSIONS FROM EVAPORATIVE COOLING TOWERS

WAYNE MICHELETTI
WAYNE C. MICHELETTI, INC.

Presented at the 2005 Cooling Technology Institute Annual Conference
San Antonio, TX - February 28-March 3, 2005

ATMOSPHERIC EMISSIONS FROM EVAPORATIVE COOLING TOWERS

by

Wayne Micheletti
Wayne C. Micheletti, Inc.
977 Seminole Trail #300
Charlottesville, VA 22901-2824

Introduction

Evaporative cooling systems are common elements in many industrial processes, ranging from manufacturing to power production to refining. They are also important components in most of the HVAC systems used by large commercial, institutional and residential buildings. In all of these applications, the cooling tower acts as a heat rejection device primarily by evaporating a portion of the recirculated cooling water to the surrounding atmosphere. Promoting evaporation by maximizing the air-water interface and maintaining clean heat transfer surfaces through proper water treatment are major objectives in the design and operation of these systems. And since evaporative cooling towers can use large amounts of water, discussions of potential environmental issues usually focus on water intake or wastewater discharge concerns.

However, atmospheric emissions can also be important considerations that influence evaporative cooling tower design and operation. But because cooling towers are not typically thought of as "air pollution sources", many people may not fully understand which environmental regulations are relevant, which substances potentially may be identified as "pollutants", how emission rates are determined, and what control measures may be required. This paper discusses each of these issues in a general, but comprehensive manner so that cooling tower designers, owners and operators are better informed when making site-specific environmental evaluations and decisions.

Relevant Environmental Regulations

In the United States, atmospheric emissions from all stationary sources are generally regulated under the Clean Air Act (CAA) and the umbrella of subsequent Clean Air Act Amendments (CAAA). The U.S. Environmental Protection Agency (USEPA) has the authority for developing, implementing and enforcing these regulations. In many instances, the USEPA has delegated the responsibility for day-to-day implementation and enforcement of the regulations to corresponding state, regional and tribal agencies.

When the CAA was initially signed into law, the USEPA concentrated on improving or maintaining air quality by establishing ambient air standards for six criteria pollutants: carbon monoxide, lead, nitrogen oxides, ozone, particulate matter, and sulfur dioxide. In doing so, the Agency created two types of National Ambient Air Quality Standards (NAAQS). Primary standards set limits to protect public health, including the health of sensitive populations, such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation and buildings. The current primary and secondary NAAQS are summarized in Table 1.

While NAAQS are not emissions limitations on sources, they usually result in such limits being placed on source operations as part of a control strategy to achieve or maintain an ambient standard. Emissions standards are essentially limits on the amounts of criteria pollutants that can be emitted by a point source. State or local air regulatory agencies often define a point source based on the emission of a threshold amount of a given pollutant, as shown in Table 2. These agency definitions can vary (e.g., many states have lower emission thresholds), but point sources are typically large manufacturing or production plants and will most likely include all three types of emissions (process, fugitive and fugitive process). Within a given point source, there may be multiple emission points. This term should not be confused with point source, which is a regulatory distinction from area and mobile sources. Emission point refers to a single stack, vent or other discrete location of pollutant release (such as a cooling tower). Even though emissions limits are established for a point source, some state or local air regulatory agencies may require permit holders to inventory and report emissions from individual emission points as part of a point source permit.

Emission standards can be set in several different ways. The most straightforward emission standard is a simple limitation on the mass of a pollutant per unit time (e.g., pounds of pollutant per hour). Emission concentration standards limit the mass emissions of a pollutant per volume of air (e.g., grams per standard dry cubic meter). And, emission reduction standards limit the amount of current emissions relative to the amount of emissions before application of a pollution control measure (e.g., 50% reduction).

For two of the criteria pollutants (ozone and particulate matter), setting emission limits involves some special considerations. Ozone's critical role in the severity of photochemical smog has been recognized for years, placing it among the original six criteria pollutants. However, very little ozone is directly produced or released by human activities. For the most part, ozone is generated by the reaction of nitrogen oxides with hydrocarbons in the sunlight. Therefore, the NAAQS for ozone are usually translated into emission limits for nitrogen oxides and volatile organic compounds (VOCs), two other pollutants that are directly influenced by human activities. With certain exceptions, VOCs include any carbon compound that participates in atmospheric photochemical reactions. Some of the exceptions include carbon monoxide, carbon dioxide, methane, ethane and other organic compounds that have negligible photochemical reactivity. Hence, VOCs should not be confused with a broader class of chemicals referred to as Total Organic Compounds (TOCs) that do include methane, ethane, and several other less photochemically-reactive substances and particulates.

The NAAQS for particulate matter have evolved with time, meaning that corresponding emissions limits have as well. According to the USEPA, particulate matter is the generic term for a broad class of chemically and physically diverse substances that exist as discrete particles (liquid droplets or solids over a wide range of sizes). Particles may be emitted directly or formed in the atmosphere. The original NAAQS focused on particles with a nominal size of 25 to 45 micrometers (μm), referred to as Total Suspended Particles (TSP). In 1987, the NAAQS were revised to focus on particles with a mean aerodynamic diameter less than or equal to 10 μm (PM_{10}). In 1997, the USEPA further revised the revised NAAQS by: a) retaining the PM_{10} values for the purpose of regulating emissions of coarse-fraction particles, and b) developing new standards for fine-fraction particles with a mean aerodynamic diameter less than or equal to 2.5 μm ($PM_{2.5}$). By definition, then, any particulate matter with a mean aerodynamic diameter greater than 10 μm would not be classified as either PM_{10} or $PM_{2.5}$, so that the emission of such particulate matter would not be subject to either the PM_{10} or $PM_{2.5}$ NAAQS.

In addition to the original six criteria pollutants, Section 112(b) of the 1990 Clean Air Act Amendments listed 189 hazardous air pollutants (HAPs) of concern. These pollutants are generally emitted in smaller quantities than criteria pollutants, but may be reasonably anticipated to cause cancer, developmental effects, reproductive dysfunctions, neurological disorders, inheritable gene mutations or other chronically or acutely toxic effects in humans. HAPs include some relatively common substances (such as asbestos and chlorine), as well as numerous less common substances (such as 1,2-dibromo-3-chloropropane).

Unlike the criteria pollutants, HAPs have no ambient air quality standards. Instead, the USEPA has established two different sets of limits known collectively as the National Emissions Standards for Hazardous Air Pollutants (NESHAP). The first set consists of twenty-two emissions standards promulgated prior to the 1990 CAAA. These standards may be pollutant specific (e.g., vinyl chloride), source-category specific (e.g., benzene waste operations) or both pollutant and source-category specific (e.g., inorganic arsenic emissions from glass manufacturing plants). The second set (promulgated under Section 112(d) of the 1990 CAAA) is known as Maximum Achievable Control Technology (MACT) Standards and is based on the best demonstrated control technologies or practices in similar sources. MACT Standards are source category specific and each standard covers all the HAPs emitted by that category. NESHAP was the regulatory authority used by the USEPA to ban the use of chromium as a corrosion inhibitor in cooling water systems.

Aside from the Clean Air Act and subsequent amendments, which directly limit atmospheric emissions from stationary sources, other statutes or regulatory guidance may "indirectly influence" the need for improved emissions control or estimation. In the case of cooling towers, this type of indirect influence can be related to safety and health concerns (due to the possible presence of pathogens) or to potential toxics releases.

The pathogenic microorganisms that might be emitted from a cooling tower can be categorized into three broad groups: bacteria, parasites and viruses. In the case of cooling towers, undoubtedly the most well known pathogens are the multiple species of bacteria collectively known as *Legionella*. These bacteria tend to thrive at the range of water temperatures frequently found in many cooling systems. Hence, workers or other persons in the vicinity of a cooling tower may be exposed to drift, may inhale aerosols containing the *Legionella* bacteria, and may become infected with the illness. Unfortunately, the ubiquitous nature of *Legionella* makes it difficult to control entirely. Under the Safe Drinking Water Act (SDWA), the USEPA has established a Maximum Contaminant Level Goal (MCLG) of zero in potable water to reduce public exposure in showers, whirlpools and spas.[3] However, specific *Legionella* control in either industrial or HVAC cooling towers is not presently regulated by federal or state agencies. Nonetheless, many organizations (including the American Society of Heating, Refrigerating and Air Conditioning Engineers, the Association of Water Technologies, and the Cooling Technology Institute) have provided guidance on the design, location and operation of cooling towers to reduce the potential atmospheric emission of *Legionella* bacteria.

The increasing use of treated municipal effluent (often referred to as reclaimed water) as makeup to cooling towers may also introduce pathogens that might be emitted in the drift. But regulations on this type of use for reclaimed water have been slow in developing even though regulations for other reclaimed water uses (especially agricultural and recreational irrigation) are more widely established. In general, the USEPA has allowed water reclamation for nonpotable water use to proceed without proposing any regulatory standards. Similarly, few states have set any emission standards or limits. In 1992, five states regulated the general industrial use of reclaimed water: Hawaii, Nevada, Oregon, Texas and Utah; only one of these states (Hawaii) specifically regulated reclaimed water use in cooling towers.[4] Twelve years later, in 2004, nine states regulated the industrial use of reclaimed water: California, Florida, Hawaii, New Jersey, North Carolina, Oregon, Texas, Utah and Washington. With the exception of New Jersey, each of these states had specific regulations for reclaimed water use in cooling towers.[5] However, most of these state regulations focus primarily on the quality of reclaimed water used for cooling system makeup rather than on emissions from the cooling tower. But some state regulations have established setback requirements that limit the minimum distance from the cooling tower to the property line, presumably to address concerns from drift deposition.

Another relevant environmental regulation is the Emergency Planning and Community Right-to-Know Act (EPCRA). Under Section 113 of EPCRA, the USEPA has compiled the Toxics Release Inventory (TRI), a publicly available database that contains information on specific toxic chemical releases and other waste management activities obtained from facilities that meet established thresholds for manufacturing, processing or "otherwise use" of any of more than 600 chemicals and chemical categories. Since 1987, the TRI database has been updated annually by the USEPA using information submitted by manufacturing facilities.

Although EPCRA does not establish pollutant emission limits, it does require that emissions be measured or estimated each year. Even when the total annual release (including atmospheric emissions) of a specific toxic chemical does not exceed the threshold that would require reporting for the TRI database, EPCRA does require a manufacturing facility to archive measurement data and estimation calculations to demonstrate that reporting was unnecessary. Consequently, atmospheric emissions from cooling towers that are not regulated by permits may still need to be evaluated for TRI reporting purposes.

Potential Pollutants

Cooling towers can have three types of atmospheric emissions: water vapor (produced by the evaporation of cooling water in contact with air passing through the tower), drift (liquid droplets entrained in the exit plume from the tower) and volatile compounds (substances stripped from the cooling water by the air passing through the tower). Since water vapor is simply the gaseous form of H_2O, this emission is not considered objectionable from a potential pollutant perspective. However, depending upon atmospheric conditions and prevailing winds, the water vapor in a cooling tower plume can produce undesirable fogging or icing on nearby roadways or structures that may be problematic.

On the other hand, drift is not pure water, but is assumed to have the same composition as the cooling water passing through the tower. As such, drift will contain any impurities that may be present in the cooling water, making it a potential source of at least one criteria pollutant – particulate matter. In the case of cooling tower drift, environmental regulators have not been concerned so much with the number or actual size of the liquid droplets as with the salts that might precipitate from the dissolved solids in the droplets if the water evaporates. Depending upon site-specific industrial operations, the drift may also contain one or more of the Section 113 EPCRA compounds that must be considered when reporting or documenting annual emissions for the TRI database.

Certain VOCs (a precursor to ozone, which is a criteria pollutant) or HAPs (defined under NESHAP) may be stripped from the cooling water and exhausted in the cooling tower plume. For example, the USEPA has identified cooling towers in petroleum refineries as a potential source of VOCs (primarily hydrocarbons); blast furnace wastewater cooling towers in integrated iron and steel plants as a potential source of hydrogen cyanide (HCN); and cooling towers in coke production and byproduct processing as a potential source of benzene. Site-specific process operations will determine the introduction of these pollutants into the cooling water, as well as the potential emissions from the cooling tower.

Determining Emissions Rates

Atmospheric emissions from cooling towers can be either measured directly or calculated by material balance and/or an emission factor. When measured directly, the actual pollutant of concern is measured at or near the point of emission, usually the top of the fan stack for mechanical-draft towers. To account for variations across the exit plume and obtain meaningful results, multiple samples are typically collected at representative locations in the cross-section of the plume. Consequently, accurate field measurements of emissions in cooling tower plumes are complex, time-consuming and costly.

Several methods for directly measuring cooling tower drift have been used over the past twenty years. An isokinetic method codified by the Cooling Technology Institute as CTI ACT-140 is frequently used in estimating particulate emissions and seems to have found some acceptance with regulatory authorities. The technique draws a portion of the cooling tower outlet air at the fan stack exit plane into a collection apparatus (glass bead pack followed by a backup filter) at the same speed and direction as the local velocity in the cooling tower. The tube holding the glass beads is heated so that drift striking the beads will evaporate and deposit any dissolved solids. After a given test period, the solids collected on the glass beads and the backup filter are recovered by an acid wash and ultra-pure water rinses. The recovered solids are then analyzed for certain tracer elements (such as calcium, magnesium or sodium) that are likely to be present in the cooling water at concentrations high enough to enable a reliable calculation of the amount of liquid drift passed through the collection apparatus. An excellent summary of this drift measurement technique and the associated calculations can be found in the technical literature.[6]

Keeping in mind that CTI ATC-140 was originally developed as a means of assessing compliance with cooling tower manufacturers' drift guarantees, it's application as a tool for estimating potential pollutant emissions or determining compliance with environmental permits has certain limitations.

1. First, the method does not determine the size distribution of the drift droplets (which, in the case of particulate matter, can be important).

2. Second, the method cannot determine the size distribution of the particulate matter that is formed when the liquid phase of the drift droplet evaporates. This is critical because particulate emissions are regulated according to mean aerodynamic diameter and emissions limits only apply to particles with diameters less than or equal to 10 μm.

3. Third, the method cannot confirm the presence (or absence) of potential pollutants that do not precipitate or are not trapped in the collection apparatus when the liquid phase of the drift droplet evaporates (notably volatile and semi-volatile compounds such as hydrocarbons). However, at least one state (Texas) has suggested that a technique proposed in 1981 may have merit for determining VOC emissions from cooling towers.[7, 8]

Even so, CTI ATC-140 provides extremely valuable data on the total amount of cooling tower drift, which is important for calculating meaningful estimates of atmospheric emissions.

In the absence of direct measurement of a specific pollutant, an emission rate can be estimated by completing a material balance around a cooling tower or by applying emission factors derived from measurements and calculations made for similar cooling towers. Of these two approaches, a site-specific material balance is usually preferable because it will more closely reflect the actual design and operating conditions of a given tower and should provide a more accurate emission estimate. However, cooling towers may not be adequately instrumented and owner/operators may not have the resources for the sample collection and analyses necessary to obtain the data for a comprehensive material balance. Therefore, pollutant emission rates are most frequently estimated by using the simpler and more generic approach of emission factors.

Emission factors are numeric values that relate the release of given pollutant (such as particulate matter) from a given emission point (such as a cooling tower) to a given operating parameter (such as the recirculating water flow). As such, they provide a single composite value derived by correlating multiple source data obtained from emission points that are categorically the same, but may be designed or operated in widely different ways. The concept of emission factors was conceived by the California Air Resources Board and, subsequently, was accepted and promoted by the USEPA. To date, a number of emission factors have been developed for cooling towers, as shown in Table 3.

Although emission factors are intended to be representative, their reliability is inherently influenced by: a) the quantity and quality of the underlying database, and b) any associated assumptions. As one indication of reliability, the USEPA will often assign a rating to a published emission factor, ranging from A (Excellent) to E (Poor). Use of emission factors that have been assigned lower ratings can produce emission estimates that are unreasonably high, causing a cooling tower owner/operator to make unnecessary changes in order to comply with emission limits. Using the current USEPA emission factor to estimate particulate matter emission rates is a good example.

The USEPA emission factor for total liquid drift from a mechanical-draft cooling tower is 1.7 lb/10^3 gal of recirculating flow. This emission factor assumes a drift rate of 0.02 percent of the recirculating flow. Typical designs for new cooling towers specify drift rates between 0.0005 and 0.002 percent of the recirculating flow (one to two orders of magnitude lower than assumed by the USEPA). Even though the drift rate will vary from tower to tower due to drift eliminator installation and condition, and will tend to increase over the lifetime of a tower due to drift eliminator deterioration, the assumption inherent in the USEPA emission factor is still likely to overstate the actual amount of cooling tower drift.

The USEPA emission factor for particulate matter (PM_{10}) is also likely to overstate actual emissions because it is based, in part, on an overstated drift emission factor, as well as two other assumptions. The first assumption is that the recirculating water has a total dissolved solids (TDS) concentration of 11,500 ppm. The second assumption is that all of the total dissolved solids contained in the drift droplets will precipitate to form particulate matter having a mean aerodynamic diameter less than or equal to 10 μm (PM_{10}).

The first assumption will automatically overstate total particulate matter emissions for cooling systems in which the recirculating water TDS concentration is less than 11,500 ppm because a lower TDS means less salt to precipitate in the drift droplet. But this bias can be corrected by making an adjustment based on the ratio of the actual TDS concentration and the assumed TDS concentration. For instance, if the actual TDS concentration is 8,000 ppm, then the particulate matter emission factor should be reduced to 0.014 lb/10^3 gal of recirculating flow. If this revised emission factor is further adjusted in a similar manner to reflect the actual drift rate (as guaranteed by the tower manufacturer or as demonstrated with a field test) relative to the assumed drift rate, it should be possible to reduce the value even more. For the lower TDS recirculating water just described, if the actual drift rate is 0.002 percent of the recirculating flow, a more meaningful particulate matter emission factor would be 0.0014 lb/10^3 gal of recirculating flow. Hence, a cooling tower with these design and operating characteristics would have an estimated particulate matter emission rate almost fourteen times lower than predicted by the current USEPA emission factor.

The second assumption has an equally profound effect in overstating particulate matter emissions. In the absence of field data to indicate otherwise, the USEPA has stated:

> "a *conservatively high* [Agency's italics] PM_{10} emission factor can be obtained by (a) multiplying the total liquid drift factor by the total dissolved solids (TDS) fraction in the circulating water, and (b) assuming that, once the water evaporates, all remaining particles are within the PM_{10} range."

Even though the USEPA describes this method for estimating particulate matter emissions as *conservatively high*, it has still become the de facto means for establishing PM_{10} (and, more recently, $PM_{2.5}$) permit limits. But calculations based on drift droplet size distribution data suggest that most of the particulate matter formed by the precipitation of total dissolved solids when the drift liquid evaporates will have a mean aerodynamic diameter larger than or equal to 10 μm.[6, 13] As such, this particulate matter would not be regulated according to current PM_{10} or $PM_{2.5}$ NAAQS.

Using the drift droplet size spectrum shown in Figure 1 and assuming a particulate matter density of 2.36 gm/cm^3, the variations in particulate matter diameter for different recirculating water TDS concentrations can be calculated. The total amount of particulate matter that would have diameters less than 10 μm or 2.5 μm can also be calculated, as well as a corresponding emission factor. The results of these calculations are shown in Tables 4 and 5.

These results, clearly demonstrate the following:

- As the recirculating water TDS concentration increases, the maximum size (diameter) of a drift droplet capable of producing small particulate matter will decrease. Essentially, higher amounts of dissolved solids in the recirculating water will produce larger salt precipitates, so at greater TDS levels smaller drift droplets will create larger particles.

- As the recirculating water TDS concentration increases, the amount of small particulate matter formed as a percentage of the total particulate matter formed will decrease. Again, higher amounts of dissolved solids in the recirculating water will produce larger salt precipitates.

- As the recirculating water TDS concentration decreases, the small particulate matter emission factor decreases. Even though the percentage amount of small particulate matter formed in cooling systems with low TDS recirculating water is greater than in cooling systems with high TDS recirculating water, the total amount of dissolved solids available in the drift is so much less that the overall amount of small particulate matter produced and the associated emission factor are lower.

- Most importantly, the calculated PM_{10} and $PM_{2.5}$ emission factors shown in Tables 4 and 5 are at least an order of magnitude less than the small particulate emissions that would be calculated using the USEPA's *conservatively high* method. And even when the current USEPA particulate emission factor is adjusted for changes in drift rate and recirculating water TDS concentration, the calculated PM_{10} and $PM_{2.5}$ emission factors shown in Tables 4 and 5 are still noticeably less (see Figure 2). The fatal flaw in the USEPA's method is the assumption that all of the total dissolved solids in the drift become PM_{10} (or $PM_{2.5}$) particulate matter.

Environmental regulators continue to rely on the USEPA's method for estimating PM_{10} and $PM_{2.5}$ emissions, and cooling tower suppliers and owner/operators continue to accept the results when making design and operating decisions, even though there are technically sound reasons to believe this approach grossly overstates the actual small particulate matter emissions. In many ways, this illustrates one of the greatest dangers in using any generic emission factor – the quality of the underlying data and assumptions used to generate the emission factor are rarely understood or adjusted to more accurately represent actual site-specific conditions.

Emissions Control Measures

Atmospheric emissions from cooling towers can be controlled in two ways: 1) reduce the amount of drift (thereby reducing the amounts of any potential pollutants that may be present in the liquid drift droplets), and 2) reduce the concentrations of any potential pollutants in the recirculating water (consequently reducing the amounts of these components that might be discharged with the drift or volatilized in the cooling tower).

Drift reduction can be accomplished by properly installing and maintaining high-efficiency drift eliminators. Although the USEPA particulate matter emission factor is based on a drift rate of 0.02% of the recirculating water flow, much lower drift rates on the order of 0.0005% – 0.002% can be achieved. Care should also be taken to avoid overloading drift eliminators. Overloading can occur when the drift eliminators are installed too close to the water distribution system or when leaks in the distribution lines or a broken nozzle introduce too much water in a given region.

Quality control of the recirculating cooling water is essentially a matter of operations and good housekeeping. By operating at low cycles of concentration, constituents present in the makeup water or blown into the cooling tower will be purged from the system more readily. Aside from switching to a higher-quality (lower TDS) makeup water, this offers the best means for limiting the concentration of total dissolved solids in the drift and the particulate matter emissions from the tower. In situations with limited water resources, operation at higher cycles of concentration with makeup and/or sidestream water treatment has been suggested.[14] But the increased capital and operating expenses of these options would require careful technical and economic analyses to fully evaluate the site-specific suitability.

Good housekeeping involves consistent and proper treatment of the recirculating water (such as biocide addition to control microorganisms), as well as regular and adequate monitoring to detect and repair process equipment leaks that might introduce potential pollutants (such as hydrocarbons). Unfortunately, good housekeeping is rarely appreciated as an emissions control measure until a permit violation is identified and is frequently postponed in the pursuit of production targets.

Conclusions

Atmospheric emissions from cooling towers are becoming an increasingly important factor in the design and operation of industrial and commercial cooling systems. A number of environmental regulations may limit the emission of a variety of constituents, including particulate matter, volatile organic compounds and hazardous air pollutants. Directly measuring these atmospheric emissions is complex, time-consuming and costly. Therefore, generic emission factors based on certain cooling system characteristics or process operating conditions are commonly used to determine compliance with emission limits. However, estimates made using emission factors may not accurately predict actual emissions if the underlying data are limited or poor quality, or if the basic assumptions do not reflect site-specific conditions. The current USEPA emission factor for determining small particulate matter emissions from cooling towers is a good example of a "conservatively high" method that will generate overstated results. The most common measures for controlling atmospheric emissions from cooling towers include the proper installation and maintenance of high-efficiency drift eliminators and good control of the recirculating water quality. However, implementing any measure to reduce the emission of a specific pollutant should be based on a reliable determination of the actual existing emission rate and the anticipated emission rate reduction. Otherwise, an owner/operator may agree to environmental permit limits or undertake cooling tower design or operating changes that could be unnecessary and expensive.

References

1. U.S. Environmental Protection Agency web page http://www.epa.gov/air/criteria.html.

2. U.S. Environmental Protection Agency. Handbook for Criteria Pollutant Inventory Development: A Beginner's Guide for Point and Area Sources, EPA-454/R-99-037, Office of Air Quality Planning and Standards, Research Triangle Park, NC (September 1999).

3. U.S. Environmental Protection Agency. Legionella: Drinking Water Fact Sheet, Office of Water (September 2002).

4. U.S. Environmental Protection Agency and U.S. Agency for International Development. Guidelines for Water Reuse, EPA/625/R-92/004, Office of Water, Washington, DC (September 1992).

5. U.S. Environmental Protection Agency and U.S. Agency for International Development. Guidelines for Water Reuse, EPA/625/R-04/108, Office of Water, Washington, DC (September 2004).

6. Hennon, K.W., and D.E. Wheeler. "Cooling Tower Emissions Testing Using the Cooling Technology Institute Test Code – CTI ATC-140", *CTI Journal*, Vol. 25, No. 1, pp. 22-28.

7. Vernon, W.D., et.al. "A Device for Measuring Volatile Organic-Carbon Emissions from Cooling-Tower Water", *Journal of the Air Pollution Control Association*, Vol. 31, No. 12 (December 1981), pp. 1280-1282.

8. Texas Natural Resource Conservation Committee. Air Quality Permit Technical Guidance for Chemical Sources: Cooling Towers, Draft RG-108, Air Permits Division, Austin, TX (February 2001).

9. U.S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors (AP-42, 5th Edition, Vol. 1), Section 13.4 – Wet Cooling Towers (January 1995).

10. U.S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors (AP-42, 5th Edition, Vol. 1), Section 5.1 – Petroleum Refining (January 1995).

11. U.S. Environmental Protection Agency. National Emission Standards for Hazardous Air Pollutants (NESHAP) for Integrated Iron and Steel Plants – Background Information for Proposed Standards, Final Report, EPA-453/R-01-005, Section 3 (January 2001).

12. Pacific Environmental Services, Inc. Background Report for AP-42 Section 12.2 – Coke Production, prepared for the U.S. Environmental Protection Agency OAQPS/TSD/EIB, Research Triangle Park, NC.

13. Reisman, J. and G. Frisbie. "Calculating Realistic PM_{10} Emissions from Cooling Towers", *Environmental Progress*, Vol. 21, No. 2 (July 2002), pp. 127-130.

14. Baines, S. "How A Power Plant Air Permit Can Impact the Cooling Tower Circulating Water Treatment System Design", Presented at the 63rd Annual International Water Conference, Pittsburgh, PA (October 20-24, 2002).

Table 1 – Current National Ambient Air Quality Standards (NAAQS)[1]

Pollutant	Primary Standard	Averaging Time[A]	Secondary Standard
Carbon Monoxide	10 mg/m^3	8-hour once/year	None
	40 mg/m^3	1-hour once/year	None
Lead	1.5 µg/m^3	Quarterly Average	Same as primary
Nitrogen Oxides	100 µg/m^3	Annual Arithmetic Mean	Same as primary
Ozone	235 µg/m^3	1-hour (one day/year)	Same as primary
	157 µg/m^3	8-hour (avg. of 4th highest daily max. 8-hour avg.)	Same as primary
PM_{10}	50 µg/m^3	Annual Arithmetic Mean	Same as primary
	150 µg/m^3	24-hour	
$PM_{2.5}$	15 µg/m^3	Annual Arithmetic Mean	Same as primary
	65 µg/m^3	24-hour	
Sulfur Dioxide	78 µg/m^3	Annual Arithmetic Mean	
	364 µg/m^3	24-hour	
		3-hour once/year	1300 µg/m^3

A - Averaging times may be subject to special requirements.

Table 2 – Emissions Thresholds for Defining Point Sources[2]

Criteria Pollutant	Emission Threshold for Point Sources[A] (tons/year)
Carbon Monoxide	1,000
Lead or Lead Compounds	5
Nitrogen Oxides	100
Particulate Matter (≤ 10 μm)	100
Particulate Matter (≤ 2.5 μm)	100[B]
Sulfur Dioxide	100
Volatile Organic Compounds (VOCs)[C]	100

A - Emission threshold as stated in 40 CFR 51; Subpart Q 51.322.
B - Emission threshold as stated in 40 CFR 51; Subpart 51.025.
C - VOCs are not criteria pollutants, but are precursors of the criteria pollutant ozone.

Table 3 – Emission Factors for Cooling Towers[9-12]

Emission Parameter	Emission Factor	Rating
Total Liquid Drift		
• Induced-draft tower	0.020 % of recirculating water flow	D
	1.7 lb drift/10^3 gal of recirculating water flow	D
• Natural-draft tower	0.00088 % of recirculating flow	E
	0.073 lb drift/10^3 gal of recirculating water flow	E
PM_{10}		
• Induced-draft tower	0.019 lb/10^3 gal of recirculating water flow	E
VOCs (Petroleum Refinery)		
• Uncontrolled	6 lb/10^6 gal of recirculating water flow	D
• Controlled	0.7 lb/10^6 gal of recirculating water flow	D
Hydrogen Cyanide (Blast furnace wastewater cooling towers in integrated iron and steel plants)	0.08 lb HCN/ton of iron production	
Benzene (Coke production – uncontrolled)	0.41 – 0.49 lb/ton of coke product	

Note: Emission factor ratings range from A (Excellent) to E (Poor).

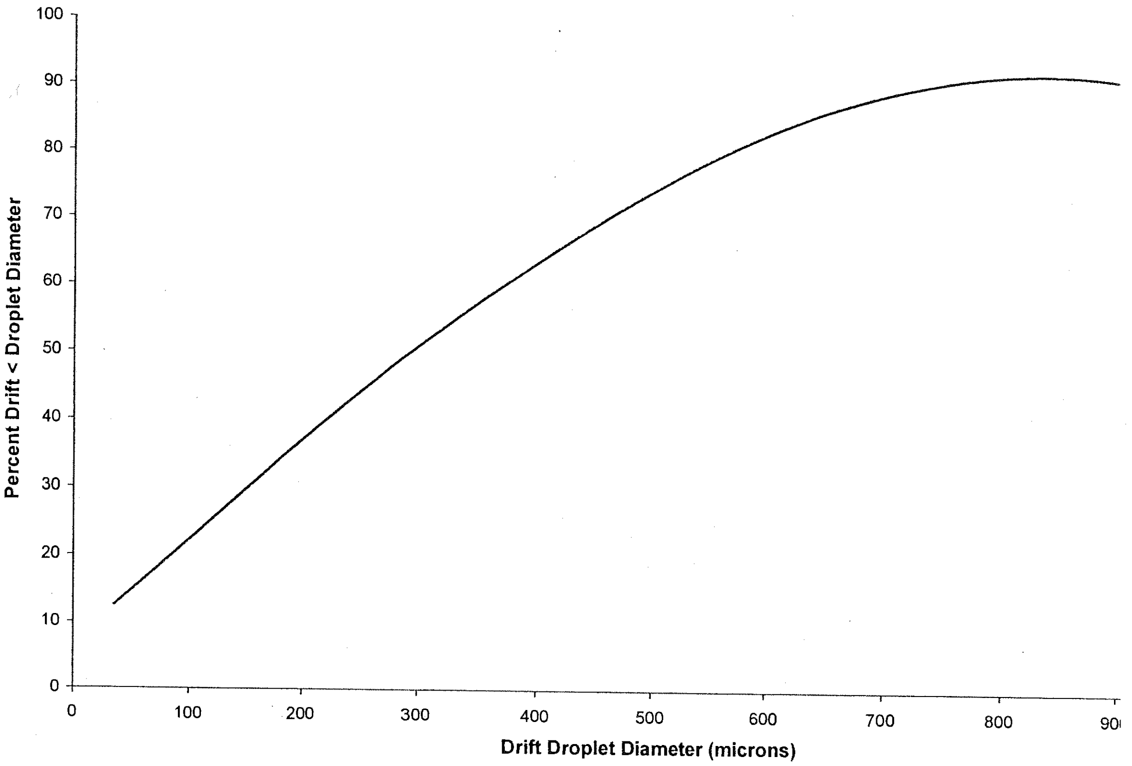


Figure 1 – Drift Droplet Size Spectrum[6]

Table 4 – Calculated PM_{10} Emission Factors as a Function of Recirculating Water TDS

Recirculating Water TDS (ppm)	Maximum Drift Droplet Diameter for PM_{10} Particulates (μm)	Percent Particulate Emission > 10 μm	PM_{10} Emission Factor (lb/10^3 gal of recirculating water flow)
500	168	68	0.00003
1000	133	73	0.00005
2500	98	78	0.00009
5000	78	81	0.00016
10000	62	83	0.00028
20000	49	85	0.00050
30000	43	86	0.00070

Note: Assumes spherical particulate matter having a density of 2.36 gm/cm^3 and 0.002% drift rate.

Table 5 – Calculated $PM_{2.5}$ Emission Factors as a Function of Recirculating Water TDS

Recirculating Water TDS (ppm)	Maximum Drift Droplet Diameter for $PM_{2.5}$ Particulates (μm)	Percent Particulate Emission > 2.5 μm	$PM_{2.5}$ Emission Factor (lb/10^3 gal of recirculating water flow)
500	42	86	0.00001
1000	33	88	0.00002
2500	25	89	0.00005
5000	19	90	0.00009
10000	15	90	0.00016
20000	12	91	0.00031
30000	11	91	0.00045

Note: Assumes spherical particulate matter having a density of 2.36 gm/cm^3 and 0.002% drift rate.

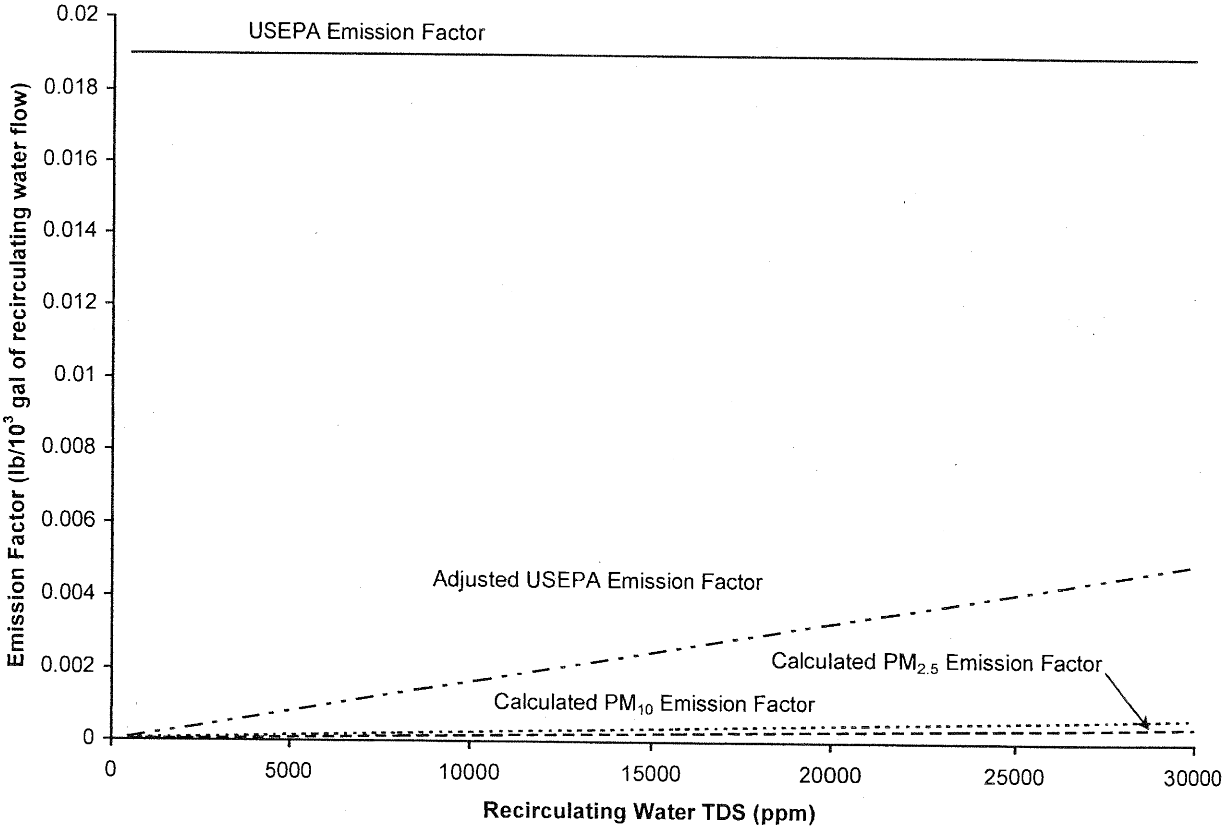


Figure 2 – Comparison of Particulate Matter Emission Factors

Soils and Water Resources (5-9)

Background: Industrial Water Supply

The Cosumnes Power Plant (CPP) receives industrial supply water from the Folsom South Canal, through a 66-inch pipeline still used by SMUD's Rancho Seco plant. CPP draws water from the large pipeline through a 12-inch line routed directly to the facility. The proposed amendment would eliminate a restriction on maximum instantaneous intake rate; however the amendment does not describe how the intake rates would change and how this might affect other users.

Data Requests

5. Please provide information showing the maximum water intake capacity of the plant.

Response:

SMUD contracts with the United States Bureau of Reclamation (USBR) for delivery via the Folsom-South Canal (FSC) of up to 60,000 acre-feet per year (AFY) of Central Valley Project water and 15,000 AFY of water made available pursuant to another agreement with the City of Sacramento. This water is dedicated to the operation of Cosumes Power Plant (CPP) and other uses at SMUD's Rancho Seco site. The water is pumped from the FSC via SMUD's FSC Pumping Station using one of three 20,000-gallon-per-minute pumps through a dedicated 66-inch pipeline that feeds Rancho Seco Reservoir and CPP. The pumping system is designed and operated to maintain the required reservoir level and provide water to CPP.

The water supply for CPP is diverted through a 12-inch pipeline off the 66-inch pipeline that feeds Rancho Seco Reservoir and is gravity fed to the CPP Cooling Tower and Service Water Makeup Tank. Each line is controlled by a makeup valve, which in turn is controlled by the plant's distributed control system (DCS).

The DCS system currently has an "electronic clamp" that limits the makeup between the two systems to 2,500 gallons per minute (gpm). Without the clamp, the design maximum flow is up to 2,600 gpm to the Cooling Tower and up to 3,845 gpm to the Service Water Makeup Tank, depending on the Rancho Seco Reservoir levels. CPP has also recently installed a single-pass water filtration system (OnePass) in preparation for the plant to accept water from the Sacramento River, which contains higher total dissolved solids (TDS) and total suspended solids levels. The OnePass system is designed with a maximum capacity of 2,750 gpm.

The Raw Water Head Loss Calculations for the CPP are included as Attachment DR5-1.

6. Please identify what the expected maximum flow rate would be for project operation, when it would occur, and how long it may be sustained.

Response:

The maximum flow rate for project operation is not expected to exceed 3,000 gpm. The maximum flow rate would occur on days when temperatures reach or exceed 90 degrees

Fahrenheit, generally during the months of June through September. Removal of references to a maximum flow condition would eliminate the need to curtail power during these high-temperature days. Therefore, as stated in the CPP Petition for Post-certification License Amendment, SFA is only requesting to remove the 2,500 gpm instantaneous limit to maximize generation during critical peak demand periods on high-temperature days. However, the project will still retain its total annual use limit of 2,650 AFY. The water use table from our annual CEC report (Attachment DR6-1) provides a summary of water use at CPP throughout the past 5 years.

7. Please discuss whether other users connected to the Folsom South Canal conveyance system will be affected by project operation at the maximum flow rate.

Response:

Because the water conveyance system was originally designed to deliver the total contracted volume noted in DR-5, the volume of CPP water use represents a relatively small fraction of the conveyance system capacity. Therefore, the proposed removal of the peak flow rate is not expected to have an impact on the one down canal user from SMUD's point of diversion.

8. Our original Staff Analysis indicates that SMUD has a water contract with the Bureau of Reclamation that expires in December 2012. Please discuss the status of the permit renewal and whether successful negotiation of this supply agreement would impact the proposed project water supply.

Response:

Municipal water service contractors like SMUD are entitled to renewal of their contracts by federal law. SMUD has executed a Binding Agreement to Renew its contract, and negotiations have occurred but are not yet complete. However, additional meetings are now being scheduled and both SMUD and the USBR intend to complete the negotiations timely. Please note that the document is a long-term contract rather than a permit.

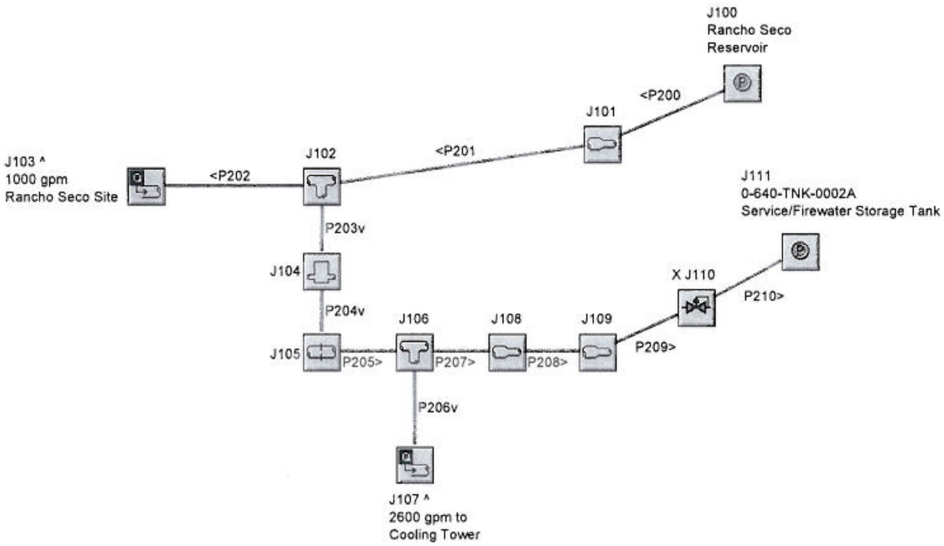
9. Please discuss whether any of the current water supply agreements used for the project would limit the proposed maximum flow rate.

Response:

As discussed in DR-7, SMUD contracts with the USBR for delivery via the FSC of up to 60,000 AFY of Central Valley Project water and 15,000 AFY of water made available pursuant to another agreement with the City of Sacramento. No water rights conditions are included in these agreements that would require a limitation on the instantaneous flow rate.

Attachment DR5-1
Raw Water Head Loss Calculations

Customer: SMUD
Project: Cosumnes Plant
System Code: 640
Description: Raw Water Headloss Calculation - AFT Fathom 5.0 Model Layout
Calculation No: CL/010325.0001-



General

```
Title: AFT Fathom Model
Analysis run on: 3/4/2011 9:00:26 AM
Application version: AFT Fathom Version 6.0 (2007.04.20)
Input File: P:\SMUD\010325\engrs\Mechanical\FATHOM\640 available head.fth

Execution Time= 0.09 seconds
Total Number Of Head/Pressure Iterations= 34
Total Number Of Flow Iterations= 3
Total Number Of Temperature Iterations= 0
Number Of Pipes= 11
Number Of Junctions= 12
Matrix Method= Gaussian Elimination

Pressure/Head Tolerance= 0.0001 relative change
Flow Rate Tolerance= 0.0001 relative change
Temperature Tolerance= 0.0001 relative change
Flow Relaxation=  (Automatic)
Pressure Relaxation=  (Automatic)

Constant Fluid Property Model
Fluid Database: AFT Standard
Fluid: Water at 1 atm
Max Fluid Temperature Data= 212 deg. F
Min Fluid Temperature Data= 32 deg. F
Temperature= 65 deg. F
Density= 62.34301 lbm/ft3
Viscosity= 2.53423 lbm/hr-ft
Vapor Pressure= 0.30169 psia
Viscosity Model= Newtonian

Atmospheric Pressure= 1 atm
Gravitational Acceleration= 1 g
Turbulent Flow Above Reynolds Number= 4000
Laminar Flow Below Reynolds Number= 2300

Total Inflow= 7,445 gal/min
Total Outflow= 7,445 gal/min
Maximum Pressure is 55.81 psia at Junction 103 Inlet
Minimum Pressure is 13.05 psia at Junction 111 Inlet
```

Valve Summary

Jct	Name	Valve Type	Vol. Flow (gal/min)	Mass Flow (lbm/sec)	dP Stag. (psid)	dH (feet)	P Inlet Static (ft. H2O std.)	Cv	K	Valve State
110	Control Valve	FCV	3,845	534.1	0.5012	1.158	92.52	5,430	0.3044	Opened By User

Pipe Output Table

Pipe	Name	Vol. Flow Rate (gal/min)	Velocity (feet/sec)	P Static Max (ft. H2O std.)	P Static Min (ft. H2O std.)	Elevation Inlet (feet)	Elevation Outlet (feet)	dP Stag. Total (ft. H2O std.)	dP Static Total (ft. H2O std.)	dP Gravity (ft. H2O std.)	dH (feet)	P Static In (ft. H2O std.)
200	Pipe	7,445	2.5552	75.35	33.80	239.0	197.0	-4.155E+01	-4.155E+01	-41.943	3.931E-01	33.80
201	Pipe	7,445	1.3200	128.72	75.40	197.0	143.0	-5.332E+01	-5.332E+01	-53.927	6.082E-01	75.40
202	Pipe	1,000	0.1773	128.73	128.73	143.0	143.0	3.722E-07	3.722E-07	0.000	3.727E-07	128.73
203	Pipe	6,445	7.4395	127.85	103.99	143.0	161.5	2.387E+01	2.387E+01	18.475	5.401E+00	127.85
204	Pipe	6,445	7.4395	104.33	103.25	159.0	159.0	1.082E+00	1.082E+00	0.000	1.083E+00	104.33
205	Pipe	6,445	7.4395	100.63	100.01	159.0	159.0	6.191E-01	6.191E-01	0.000	6.199E-01	100.63
206	Pipe	2,600	3.0012	99.97	99.97	159.0	159.0	1.257E-03	1.257E-03	0.000	1.259E-03	99.97
207	Pipe	3,845	4.4384	100.61	100.59	159.0	159.0	2.592E-02	2.592E-02	0.000	2.595E-02	100.61
208	Pipe	3,845	9.1193	99.39	97.67	159.0	159.0	1.719E+00	1.719E+00	0.000	1.721E+00	99.39
209	Pipe	3,845	15.6444	94.65	92.52	159.0	161.0	2.128E+00	2.128E+00	1.997	1.305E-01	94.65
210	Pipe	3,845	15.6444	89.37	30.10	163.0	208.0	5.926E+01	5.926E+01	44.939	1.435E+01	89.37

Pipe	P Static Out (ft. H2O std.)	P Stag. In (psig)	P Stag. Out (psig)
200	75.35	0.00	18.01
201	128.72	18.00	41.12
202	128.73	41.11	41.11
203	103.99	41.10	30.76
204	103.25	30.91	30.44
205	100.01	29.30	29.03
206	99.97	28.70	28.70
207	100.59	29.06	29.04
208	97.67	28.95	28.21
209	92.52	27.98	27.06
210	30.10	25.69	0.00

All Junction Table

Jct	Name	P Static In (psig)	P Static Out (psig)	P Stag. In (psia)	P Stag. Out (psia)	Vol. Flow Rate Jct Net (gal/min)	Mass Flow Rate Jct Net (lbm/sec)	Loss Factor (K)
100	Rancho Seco Reservoir	-0.04393	-0.04393	14.70	14.70	-7,445	-1,034.1	0.0000
101	Area Change	17.96927	17.99121	32.71	32.70	0	0.0	0.2337
102	Tee/Wye	41.05854	41.05854	55.81	55.81	0	0.0	See Losses
103	1000 gpm Rancho Seco Site	41.11022	41.11022	55.81	55.81	1,000	138.9	0.0000
104	20" Duplex Strainer	30.38494	30.53565	45.45	45.60	0	0.0	2.5018
105	Orifice	30.06660	28.92784	45.13	44.00	0	0.0	3.0581
106	Tee/Wye	28.86634	28.86634	43.73	43.73	0	0.0	See Losses
107	2600 gpm to Cooling Tower	28.64252	28.64252	43.40	43.40	2,600	361.1	0.0000
108	Area Change	28.91148	28.39115	43.74	43.65	0	0.0	0.7044
109	Area Change	27.64611	26.33571	42.90	42.68	0	0.0	0.3990
110	Control Valve	25.41332	24.04627	41.76	40.39	0	0.0	0.3044
111	0-640-TNK-0002A Service/Firewater Storage Tank	-1.64667	-1.64667	14.70	14.70	3,845	534.1	0.0000

Junction Loss Table

Jct	Pipe #	Pipe Dir.	Loss Factor (K)
102	P202	Out	36.98
	P203	Out	0.03621
	P201	In	0.000
106	P205	In	0.000
	P207	Out	-0.1767
	P206	Out	5.415

General

Title: AFT Fathom Model
Input File: P:\SMUD\010325\engrs\Mechanical\FATHOM\640 available head.fth

Number Of Pipes= 11
Number Of Junctions= 12

Pressure/Head Tolerance= 0.0001 relative change
Flow Rate Tolerance= 0.0001 relative change
Temperature Tolerance= 0.0001 relative change
Flow Relaxation= (Automatic)
Pressure Relaxation= (Automatic)

Constant Fluid Property Model
Fluid Database: AFT Standard
Fluid: Water at 1 atm
Max Fluid Temperature Data= 212 deg. F
Min Fluid Temperature Data= 32 deg. F
Temperature= 65 deg. F
Density= 62.34301 lbm/ft3
Viscosity= 2.53423 lbm/hr-ft
Vapor Pressure= 0.30169 psia
Viscosity Model= Newtonian

Atmospheric Pressure= 1 atm
Gravitational Acceleration= 1 g
Turbulent Flow Above Reynolds Number= 4000
Laminar Flow Below Reynolds Number= 2300

Pipe Input Table

Pipe	Name	Pipe Defined	Length	Length Units	Hydraulic Diameter	Hydraulic Diam. Units	Friction Data Set	Roughness	Roughness Units	Losses (K)	Junctions (Up,Down)	Geometry	Material
200	Pipe	Yes	500	feet	34.5	inches	Standard	0.0018	inches	1.548	100, 101	Cylindrical Pipe	Steel
201	Pipe	Yes	6500	feet	48	inches	Unspecified	0.0018	inches	0	101, 102	Cylindrical Pipe	Unspecified
202	Pipe	Yes	1	feet	48	inches	Unspecified	0.0018	inches	0	102, 103	Cylindrical Pipe	Unspecified
203	Pipe	Yes	600	feet	18.812	inches	Standard	0.0018	inches	1.173863	102, 104	Cylindrical Pipe	Steel
204	Pipe	Yes	80	feet	18.812	inches	Standard	0.0018	inches	0.5789315	104, 105	Cylindrical Pipe	Steel
205	Pipe	Yes	25	feet	18.812	inches	Standard	0.0018	inches	0.508	105, 106	Cylindrical Pipe	Steel
206	Pipe	Yes	1	feet	18.812	inches	Standard	0.0018	inches	0	106, 107	Cylindrical Pipe	Steel
207	Pipe	Yes	5	feet	18.812	inches	Standard	0.0018	inches	0.04	106, 108	Cylindrical Pipe	Steel

Pipe	Name	Pipe Defined	Length	Length Units	Hydraulic Diameter	Hydraulic Diam. Units	Friction Data Set	Roughness	Roughness Units	Losses (K)	Junctions (Up,Down)	Geometry	Material
208	Pipe	Yes	18	feet	13.124	inches	Standard	0.0018	inches	1.1	108, 109	Cylindrical Pipe	Steel
209	Pipe	Yes	2	feet	10.02	inches	Standard	0.0018	inches	0	109, 110	Cylindrical Pipe	Steel
210	Pipe	Yes	85	feet	10.02	inches	Standard	0.0018	inches	2.31309	110, 111	Cylindrical Pipe	Steel

Pipe	Size	Type	Special Condition
200	36 inch	schedule 40	None
201			None
202			None
203	20 inch	schedule 40	None
204	20 inch	schedule 40	None
205	20 inch	schedule 40	None
206	20 inch	schedule 40	None
207	20 inch	schedule 40	None
208	14 inch	schedule 40	None
209	10 inch	STD (schedule 40)	None
210	10 inch	STD (schedule 40)	None

Pipe Loss Table

Pipe	Total K	Elbow/Bend Smooth Flanged	Valve Butterfly	Valve Gate	Entrance/Exit Entrance	Entrance/Exit Exit	Other Tee
200	1.55	1 (0.17)	2 (0.6)		1 (0.78)		
203	1.17	7 (1.08)		1 (0.1)			
204	0.58	1 (0.12)	1 (0.3)				4 (0.16)
205	0.51	1 (0.17)	1 (0.3)				1 (0.04)
207	0.04						1 (0.04)
208	1.1						1 (1.1)
210	2.31	4 (0.78)	1 (0.49)			1 (1.0)	1 (0.04)

Area Change Table

Area Change	Name	Object Defined	Inlet Elevation	Elevation Units	Type	Geometry	Angle	Loss Factor
101	Area Change	Yes	197	feet	Conical	Expansion	50.	0.233674
108	Area Change	Yes	159	feet	Conical	Contraction	50.	0.7043517
109	Area Change	Yes	159	feet	Conical	Contraction	50.	0.3989933

Assigned Flow Table

Assigned Flow	Name	Object Defined	Inlet Elevation	Elevation Units	Special Condition	Type	Flow	Flow Units	Loss Factor
103	1000 gpm Rancho Seco Site	Yes	143	feet	None	Outflow	1000	gal/min	0
107	2600 gpm to Cooling Tower	Yes	159	feet	None	Outflow	2600	gal/min	0

Assigned Pressure Table

Assigned Pressure	Name	Object Defined	Inlet Elevation	Elevation Units	Initial Pressure	Initial Pressure Units	Pressure	Pressure Units
100	Rancho Seco Reservoir	Yes	239	feet	0.000	psig	0	psig
111	0-640-TNK-0002A Service/Firewater Storage Tank	Yes	208	feet	0.000	psig	0	psig

Assigned Pressure	Pressure Type	Balance Energy	Balance Concentration	(Pipe #1) K In, K Out
100	Stagnation	No	No	(P200) 0, 0
111	Stagnation	No	No	(P210) 0, 0

Control Valve Table

Control Valve	Name	Object Defined	Inlet Elevation	Elevation Units	Special Condition	Valve Type	Control Setting	Control Units	Pressure/ Head Type	Inlet Failure Type	Outlet Failure Type
110	Control Valve	Yes	161	feet	Fully Open - No Control	FCV	700	gal/min	N/A	Fully Open	N/A

Control Valve	Full Open Loss Type	Full Open Loss
110	Cv	5430

General Component Table

General Component	Name	Object Defined	Inlet Elevation	Elevation Units	Special Condition	Loss Model	Loss Value	Independent Variable	Ind. Variable Units	Dependent Variable
104	20" Duplex Strainer	Yes	161.5	feet	None	Resistance Curve	Variable	Vol. Flow Rate	gal/min	Pressure Loss

General Component	Dep. Variable Units	Loss Constant a	Loss Constant b	Loss Constant c	Loss Constant d	Loss Constant e
104	psid	0.2499999	-9.83333E-05	3.166666E-08	0	0

Orifice Table

Orifice	Name	Object Defined	Inlet Elevation	Elevation Units	Orifice Type	Flow Area Type	Dimension	Dimension Units	Loss Model	Loss Value
105	Orifice	Yes	159	feet	Sharp-Edged	Diameter	14	inches	K Constant	3.058096

Tee or Wye Table

Tee or Wye	Name	Object Defined	Inlet Elevation	Elevation Units	Tee/Wye Type	Loss Type	Angle	Pipes A, B, C
102	Tee/Wye	Yes	143	feet	Area Change	Detailed	90	202, 203, 201
106	Tee/Wye	Yes	159	feet	Sharp Straight	Detailed	90	205, 207, 206

Customer: SMUD
Project: Cosumnes Plant
System Code: 640/650 (Service/Firewater)
Description: Raw Water Headloss Calculation
Case: Phase 1 and 2 Considered

Headloss Calculations:

Calculation of Losses: see next sheet

Assumptions:

1. Assume Rancho Seco Reservoir minimum water elevation of 220' 0".
2. Assume Rancho Seco Reservoir maximum water elevation of 248' 6".
3. Assume Cosumnes site elevation of 152' 6".
4. Assume service water tank height of 32 feet ---> inlet elevation of 184' 6".
5. Assume cooling tower basin height of 5 feet ---> inlet elevation of 157' 6".
6. Assume max flowrate of 2600 gpm to cooling towers.
7. Assume max flowrate of 900 gpm to service water tanks.
8. Assume max flowrate of 1000 gpm to Rancho Seco site.

System Section Definitions:

1. 36" pipe from reservoir valve house to 48" pipe conn.
2. 48" pipe to branch tee (20") @ manhole (37+00).
3. 20" pipe to service water tank supply line tee.
4. 14" pipe to service water tanks supply lines.
5. 10" PB1 service water tank supply line.
6. 10" PB2 service water tank supply line.
7. 18" PB1 cooling tower makeup supply line.
8. 18" PB2 cooling tower makeup supply line.

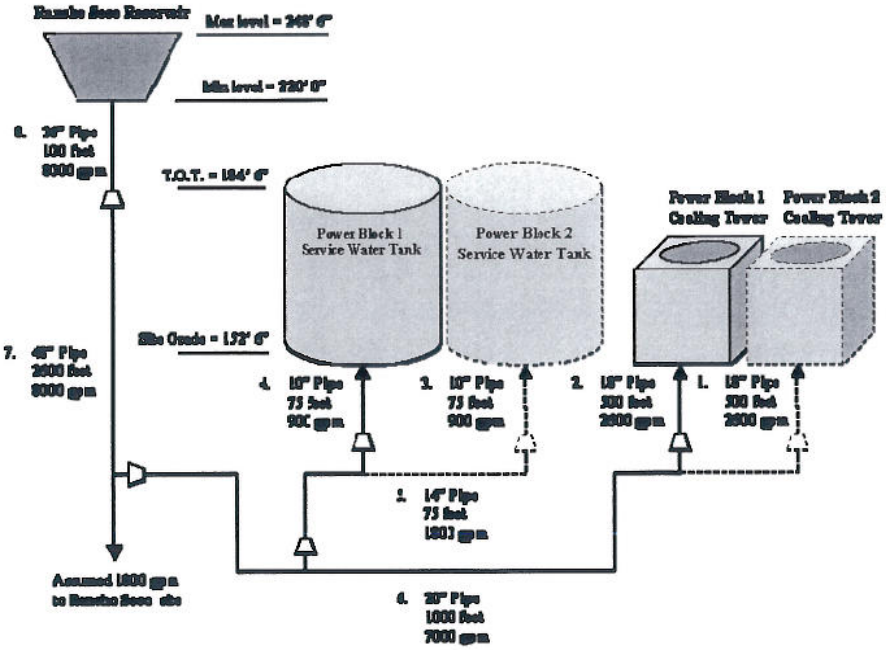
Available Head Calculations:

Min head avail. to serv. wtr. tanks (ft) = 35.5
Headloss to serv. wtr. tanks (ft) = 22.02
Excess head to serv. wtr. tanks (ft) = 13.48

Min head avail. to cooling tower basins (ft) = 62.5
Headloss to cooling tower basins (ft) = 22.51
Excess head to cooling tower basins (ft) = 39.99

Conclusion:

There is adequate head from Rancho Seco Reservoir to supply raw water for both the Phase 1 and future Phase 2 service/firewater storage tanks and cooling tower makeup without a need for raw water booster pumps.



Customer: SMUD
Project: Cosumnes Plant
System Code: 640/650 (Service/Firewater)
Description: Raw Water Headloss Calculation
Case: Phase 1 and 2 Considered

Calculation of Losses:

☐ ---> User Input

System Section	1	2	3	4	5	6	7	8
Inputs (Entered by User)								
System Design Conditions								
Flow Rate (gpm)	8000	8000	7000	1800	900	900	2600	2600
Design Pressure (psia)	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7
Design Temperature (°F)	100	100	100	100	100	100	100	100
Vapor Pres. of Water at Design Temp. (ft)	2.19	2.19	2.19	2.19	2.19	2.19	2.19	2.19
Pressure of Suction Source (ft)	-	-	-	-	-	-	-	-
Pipe Characteristics								
Pipe Material	Carbon Steel	Ductile Iron	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel	Carbon Steel
Pipe Schedule	5LX - STD	TC 1	20 - STD	40 - STD	40 - STD	40 - STD	40 - STD	40 - STD
Pipe ID (in)	35.250	49.640	19.250	13.250	10.020	10.020	17.250	17.250
Roughness (ft)	0.000150	0.000400	0.000150	0.000150	0.000150	0.000150	0.000150	0.000150
System Parameters								
Pipe Length (ft)	100	2,600	1,000	50	50	50	500	500
# of Pipe Entrances	1	1	1	1	1	1	1	1
# of 90 Degree Elbows	1	0	8	4	4	4	6	6
# of 45 Degree Elbows	0	7	0	0	0	0	0	0
# of 22.5 Degree Elbows	0	0	0	0	0	0	0	0
# of Tees--run	0	1	4	0	0	0	0	0
# of Tees--branch	0	0	1	0	0	0	0	0
# of Reducers--contracting	0	1	0	1	1	1	1	1
# of Reducers--enlarging	1	0	0	0	0	0	0	0
# of Butterfly Valves	2	4	2	2	2	2	2	2
# of Gate Valves	0	0	0	0	0	0	0	0
# of Ball Valves	0	0	0	0	0	0	1	1
# of Globe Valves	0	1	0	0	0	0	0	0
# of Swing Check Valves	0	0	0	0	0	0	1	1
# of Pipe Exits	1	1	1	1	1	1	1	1
Elevation Change (ft)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Static Suction Head (ft) --> neg. = Suction Lift	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Calculated Values								
Fluid Properties								
Density (lbm/ft3)	61.99	61.99	61.99	61.99	61.99	61.99	61.99	61.99
Absolute Viscosity (lbm/ft-sec)	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046	0.00046
Flow Conditions								
Velocity (ft/sec)	2.630	1.326	7.717	4.188	3.662	3.662	3.569	3.569
Reynolds number	1,046,359	743,033	1,676,553	626,335	414,119	414,119	694,919	694,919
Friction factor	0.01264	0.01381	0.01286	0.01452	0.01558	0.01558	0.01401	0.01401
Losses								
Head loss in pipe (ft)	0.046	0.237	7.418	0.179	0.194	0.194	0.965	0.965
Head loss @ Pipe Entrances (ft)	0.084	0.021	0.722	0.213	0.163	0.163	0.154	0.154
Head loss in 90 Degree Elbows (ft)	0.019	0.000	1.333	0.222	0.182	0.182	0.233	0.233
Head loss in 45 Degree Elbows (ft)	0.000	0.026	0.000	0.000	0.000	0.000	0.000	0.000
Head loss in 15 Degree Elbows (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Head loss in Tees--run (ft)	0.000	0.008	0.952	0.000	0.000	0.000	0.000	0.000
Head loss in Tees--branch (ft)	0.000	0.000	0.714	0.000	0.000	0.000	0.000	0.000
Head loss in Contracting Reducers (ft)	0.000	0.314	0.000	0.044	0.027	0.027	0.012	0.012
Head loss in Enlarging Reducers (ft)	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Head loss in Butterfly Valves (ft)	0.068	0.038	0.595	0.277	0.227	0.227	0.139	0.139
Head loss in Gate Valves (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Head loss in Ball Valves (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.008
Head loss in Globe Valves (ft)	0.000	0.128	0.000	0.000	0.000	0.000	0.000	0.000
Head loss in Swing Check Valves (ft)	0.000	0.000	0.000	0.000	0.000	0.000	0.139	0.139
Head loss @ Pipe Exits (ft)	0.107	0.027	0.925	0.273	0.208	0.208	0.198	0.198
Total Frictional Head Loss this section, hf (ft)	0.35	0.80	12.66	1.21	1.00	1.00	1.85	1.85
Total Elevation Change (ft)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Static Suction Head (ft)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Head Loss this section (ft)	0.35	0.80	12.66	1.21	1.00	1.00	1.85	1.85
Total Dynamic Head (ft) w/ 15% SF			5.00 (orifice plate)					29.57
Entered by user if applicable:								
For Pipe Entrance Calculation								
Is entrance flush?, Enter y or n:	n	n	n	n	n	n	n	n
For Elbow "K" Calculation								
Enter bend angle (e. g., 90):	90	90	90	90	90	90	90	90
Enter bend angle (e. g., 45):	45	45	45	45	45	45	45	45

Customer: SMUD
Project: Cosumnes Plant
System Code: 640/650 (Service/Firewater)
Description: Raw Water Headloss Calculation
Case: Phase 1 Considered

Headloss Calculations:

Calculation of Losses: see next sheet

Assumptions:

1. Assume Rancho Seco Reservoir minimum water elevation of 220' 0".
2. Assume Rancho Seco Reservoir maximum water elevation of 248' 6".
3. Assume Cosumnes site elevation of 152' 6".
4. Assume service water tank height of 32 feet ---> inlet elevation of 184' 6".
5. Assume cooling tower basin height of 5 feet ---> inlet elevation of 157' 6".
6. Assume max flowrate of 2600 gpm to cooling tower
7. Assume max flowrate of 900 gpm to service water tank.
8. Assume max flowrate of 1000 gpm to Rancho Seco site.

System Section Definitions:

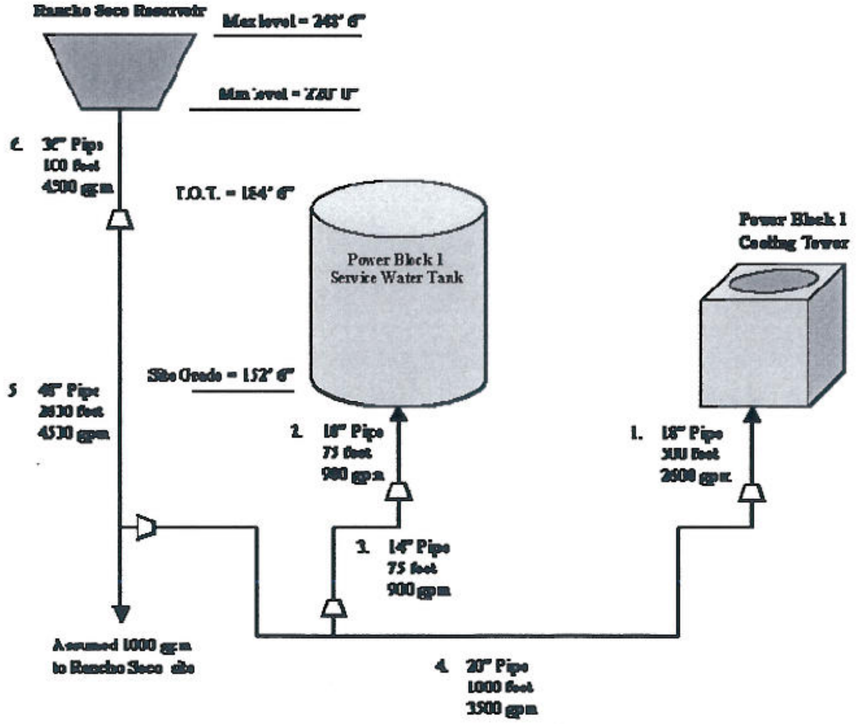
1. 36" pipe from reservoir valve house to 48" pipe conn.
2. 48" pipe to branch tee (20") @ manhole (37+00).
3. 20" pipe to service water tank supply line tee.
4. 14" pipe to service water tank supply line.
5. 10" PB1 service water tank supply line.
6. 18" PB1 cooling tower makeup supply line.

Available Head Calculations:

Min head avail. to serv. wtr. tank (ft) =	35.5	Min head avail. to cooling tower basin (ft) =	62.5
Headloss to serv. wtr. tank (ft) =	10.02	Headloss to cooling tower basin (ft) =	10.55
Excess head to serv. wtr. tank (ft) =	25.48	Excess head to cooling tower basin (ft) =	51.95

Conclusion:

There is more than adequate head from Rancho Seco Reservoir to supply raw water for the Phase 1 service/firewater storage tank and the cooling tower makeup without a need for raw water booster pumps.



Customer: SMUD
Project: Cosumnes Plant
System Code: 640/650 (Service/Firewater)
Description: Raw Water Headloss Calculation
Case: Phase 1 Considered

Calculation of Losses: ☐ ---> User Input

System Section	1	2	3	4	5	6
Inputs (Entered by User)						
System Design Conditions						
Flow Rate (gpm)	**4500**	**4500**	**3500**	**900**	**900**	**2600**
Design Pressure (psia)	**14.7**	**14.7**	**14.7**	**14.7**	**14.7**	**14.7**
Design Temperature (°F)	**100**	**100**	**100**	**100**	**100**	**100**
Vapor Pres. of Water at Design Temp. (ft)	**2.19**	**2.19**	**2.19**	**2.19**	**2.19**	**2.19**
Pressure of Suction Source (ft)	-	-	-	-	-	-
Pipe Characteristics						
Pipe Material	**Carbon Steel**	**Ductile Iron**	**Carbon Steel**	**Carbon Steel**	**Carbon Steel**	**Carbon Steel**
Pipe Schedule	**5LX - STD**	**TC 1**	**20 - STD**	**40 - STD**	**40 - STD**	**40 - STD**
Pipe ID (in)	**35.250**	**49.640**	**19.250**	**13.250**	**10.020**	**17.250**
Roughness (ft)	**0.000150**	**0.000400**	**0.000150**	**0.000150**	**0.000150**	**0.000150**
System Parameters						
Pipe Length (ft)	**100**	**2,600**	**1,000**	**50**	**50**	**500**
# of Pipe Entrances	**1**	**1**	**1**	**1**	**1**	**1**
# of 90 Degree Elbows	**1**	**0**	**8**	**4**	**4**	**6**
# of 45 Degree Elbows	**0**	**7**	**0**	**0**	**0**	**0**
# of 22.5 Degree Elbows	**0**	**0**	**0**	**0**	**0**	**0**
# of Tees--run	**0**	**1**	**4**	**0**	**0**	**0**
# of Tees--branch	**0**	**0**	**1**	**0**	**0**	**0**
# of Reducers--contracting	**0**	**1**	**0**	**1**	**1**	**1**
# of Reducers--enlarging	**1**	**0**	**0**	**0**	**0**	**0**
# of Butterfly Valves	**2**	**4**	**2**	**2**	**2**	**2**
# of Gate Valves	**0**	**0**	**0**	**0**	**0**	**0**
# of Ball Valves	**0**	**0**	**0**	**0**	**0**	**1**
# of Globe Valves	**0**	**1**	**0**	**0**	**0**	**0**
# of Swing Check Valves	**0**	**0**	**0**	**0**	**0**	**1**
# of Pipe Exits	**1**	**1**	**1**	**1**	**1**	**1**
Elevation Change (ft)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Static Suction Head (ft) --> neg. = Suction Lift	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Calculated Values						
Fluid Properties						
Density (lbm/ft3)	**61.99**	**61.99**	**61.99**	**61.99**	**61.99**	**61.99**
Absolute Viscosity (lbm/ft-sec)	**0.00046**	**0.00046**	**0.00046**	**0.00046**	**0.00046**	**0.00046**
Flow Conditions						
Velocity (ft/sec)	1.479	0.746	3.858	2.094	3.662	3.569
Reynolds number	588,577	417,956	838,277	313,167	414,119	694,919
Friction factor	0.01357	0.01476	0.01361	0.01570	0.01558	0.01401
Losses						
Head loss in pipe (ft)	0.016	0.080	1.962	0.048	0.194	0.965
Head loss @ Pipe Entrances (ft)	0.027	0.007	0.180	0.053	0.163	0.154
Head loss in 90 Degree Elbows (ft)	0.006	0.000	0.353	0.060	0.182	0.233
Head loss in 45 Degree Elbows (ft)	0.000	0.009	0.000	0.000	0.000	0.000
Head loss in 15 Degree Elbows (ft)	0.000	0.000	0.000	0.000	0.000	0.000
Head loss in Tees--run (ft)	0.000	0.003	0.252	0.000	0.000	0.000
Head loss in Tees--branch (ft)	0.000	0.000	0.189	0.000	0.000	0.000
Head loss in Contracting Reducers (ft)	0.000	0.099	0.000	0.011	0.027	0.012
Head loss in Enlarging Reducers (ft)	0.008	0.000	0.000	0.000	0.000	0.000
Head loss in Butterfly Valves (ft)	0.023	0.013	0.157	0.075	0.227	0.139
Head loss in Gate Valves (ft)	0.000	0.000	0.000	0.000	0.000	0.000
Head loss in Ball Valves (ft)	0.000	0.000	0.000	0.000	0.000	0.008
Head loss in Globe Valves (ft)	0.000	0.043	0.000	0.000	0.000	0.000
Head loss in Swing Check Valves (ft)	0.000	0.000	0.000	0.000	0.000	0.139
Head loss @ Pipe Exits (ft)	0.034	0.009	0.231	0.068	0.208	0.198
Total Frictional Head Loss this section, hf (ft)	0.11	0.26	3.32	0.32	1.00	1.85
Total Elevation Change (ft)	0.00	0.00	0.00	0.00	0.00	0.00
Static Suction Head (ft)	0.00	0.00	0.00	0.00	0.00	0.00
Head Loss this section (ft)	**0.11**	**0.26**	**3.32**	**0.32**	**1.00**	**1.85**
Total Dynamic Head (ft) w/ 15% SF			**5.00** **(orifice plate)**			**13.65**
Entered by user if applicable:						
For Pipe Entrance Calculation						
Is entrance flush?, Enter y or n:	n	n	n	n	n	n
For Elbow "K" Calculation						
Enter bend angle (e. g., 90):	**90**	**90**	**90**	**90**	**90**	**90**
Enter bend angle (e. g., 45):	**45**	**45**	**45**	**45**	**45**	**45**

Attachment DR6-1
CPP Water Use Summary

Water Res – 1 Water use Summary

Cosumnes Power Plant 2010 total water usage was 2,235.1 acre feet and a three year average of 2,225.5 acre feet. This is less than the 3 year average maximum allowable usage of 2,663 acre feet.

2006 to 2010 Monthly Water Usage for Cosumnes Power Plant in Acre Feet.

	2006	2007	2008	2009	2010
January	72.2	181.1	163.1	176.3	179.2
February	94.7	156.0	174.1	172.2	177.9
March	145.1	181.4	183.5	126.0	198.6
April	90.7	171.2	170.0	145.7	190.0
May	109.7	189.5	202.9	171.2	106.2
June	124.7	227.0	222.1	145.0	125.8
July	220.8	214.2	226.6	237.3	226.4
August	219.4	242.4	245.3	236.2	220.6
September	208.5	197.6	218.2	231.2	234.0
October	186.3	145.0	223.3	119.7	221.7
November	118.1	166.4	101.6	192.8	180.7
December	174.4	180.5	182.1	175.3	174.0
Yearly Total	**1,764.5**	**2,252.2**	**2,312.7**	**2,128.9**	**2,235.1**

Last Three Years' Average
= 2,225.5
Acre Feet Per Year.

Waste Management (10-11)

Background

A One Pass Filtration System has been added to the project water supply system for removal of TSS from the lower quality water now being delivered to the plant. Information presented in the 2009 amendment shows the treatment system could generate up to 225 lbs/hr. of waste. It is unclear how the project owner is managing this waste and whether the operation waste management plan has been updated to include this waste.

Data Requests

10. Please discuss whether the operation waste management plan has been updated to include management of the OnePass Filter system waste.

Response:

The Cosumnes Power Plant Waste Management Plan was last updated in April 2011 and includes management of the OnePass system waste. A copy of the current Waste Management Plan is included as Attachment DR10-1.

11. Please discuss whether there have been impacts related to management of the OnePass filter system waste.

Response:

As stated in the Petition to Amend, the OnePass system was designed and intended to operate only when the lower quality water is introduced into the Folsom South Canal. Since the system was installed, it has operated for approximately three months to support testing and improvements. During this period, the system has generated 127 tons of non-hazardous waste that was transported to a designated landfill. The truck traffic to transport the new perlite media into the station and waste perlite to the landfill consists of 42 round trips.

Attachment DR10-1
Cosumnes Power Plant
Waste Management Plan

	Cosumnes Power Plant Health, Safety, Environmental Procedure	Revision: 0 Issue Date: April 12, 2011
	Waste Management Plan	Review Cycle: NR Proc. No.: HSE 10.10

WOOD GROUP
POWER PLANT SERVICES

Health, Safety, and Environmental Procedure

Waste Management Plan

This procedure is the property of Wood Group Power Plant Services (WGPPS) and associated companies, including Wood Group Power Operations, Inc. (WGPO), WGPO (West), WGPO (Freeport), and any other WGPO Business Unit. This procedure shall be implemented as written at facilities that implement a quality management system where WGPPS has executed Operations & Maintenance contracts providing full care, custody and control.

Table of Contents

SECTION TITLE PAGE

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this *Waste Management Plan* is to provide general and specific instructions for collecting, storing and preparing shipments of non-hazardous and hazardous waste material. Handling of normal office trash (cardboard boxes, garbage, etc.) generated during normal business activities is not addressed in this document. This procedure is not intended as a substitute for sound and responsible operational practices, intelligent thinking, or experience.

2.0 SCOPE

This procedure applies to waste generated at the Cosumnes Power Plant (CPP).

3.0 REFERENCES

3.1 Contractor Plan

Univar USA, INC., Emergency Contingency Plan, Revised April 2010

3.2 Regulatory Requirements

Title 22, California Code of Regulation (Hazard Waste Management)
Accumulating Hazardous Waste at Generator Sites, California Environmental Protection Agency, Department of Toxic Substances Control, Fact Sheet, January 2002
California Energy Commission, Power Plant Certification Process, Laws, Ordinances, Regulations and Standards

3.3 Wood Group Power Plant Services - Health, Safety, and Environmental Guidelines:

1) ENV 3 Waste Management

2) ENV 4 Waste Minimization

3.4 Other Resources

Material Safety Data Sheets (MSDSs) applicable to the waste material.
Performance Requirements Univar USA, Inc., [Guidelines for] Waste Management Plan.

4.0 DEFINITIONS

4.1 Conditionally Exempt Small Quantity Generator (CESQG) - Hazardous waste generated on site by a CESQG facility does not exceed 100 kilograms (kg), or 220 pounds (lbs), in a calendar month. Waste management will be optimized at the CPP site as to be listed as a Conditionally Exempt Small Quantity Generator.

4.2 "Cradle to grave" - When applied to hazardous waste, this term implies that the generator is responsible for its proper final disposition.

4.3 Filter Cake/Salt Cake - Solids removed from a solid/liquid mixture by filtration. The residue ("filter cake" or "salt cake") remains on the filter and the filtrate passes through the filter.

4.4 Hazardous waste - Waste that is classified by the US EPA or by CA 14 CCR Chapter 3, Article 4, Section 17225.32 as hazardous, and requires special handling and disposal procedures.

4.5 Hazardous waste facility - A facility properly licensed and regulated to dispose of hazardous waste and meeting CA 14 CCR, Division, 7, Chapter 3, Article 5.7, Section 17367 requirements.

4.6 Hazardous waste generator - A facility that generates hazardous waste as part of it normal operation. CPP is a hazardous waste generator.

4.7 Hazardous waste hauler - A trucking or other transportation company licensed to transport hazardous waste material and meeting the requirements of Title 22 of the California Code of Regulations, Division 4.5, Chapter 13.

4.8 Large Quantity Generator (LQG) - A facility designated as an LQG generates more than 1000 kg (2200 lbs) of regulated hazardous waste or one kg (2.2 lbs) of acute hazardous waste per calendar month on site.

4.9 Non-hazardous waste - Waste that is not classified by the US EPA or by CA 14 CCR Chapter 3, Article 4, Section 17368 as hazardous and which has few or no restrictions when disposing.

4.10 One Pass Filter - A filter that removes suspended solids from the makeup water. The filter uses Perlite as the filter medium. Periodically the filter has to be backwashed, which washes the Perlite and suspended solids (perlite waste) off of the filter.

4.11 Paint - A broad category which includes oil-based and latex paints plus varnishes, lacquers and all other types of traditional finishes. It does not include thinners such as turpentine, ketones, mineral spirits, etc. Many local communities have very strict requirements for disposing of waste paints.

4.12 Satellite accumulation area - An area usually close to where the waste is generated and provided with properly labeled waste containers. CPP will not utilize satellite accumulation areas.

4.13 Small Quantity Generator (SQG) - To be designated a small quantity generator, the amount of regulated hazardous waste generated on site must not exceed 100 kg (220 lbs) or one kg (2.2 lbs) in a calendar month.

4.14 Waste storage area - An area that meets regulatory requirements for construction and location within the facility and where hazardous waste can be stored for the time allowed in accordance with regulatory guidelines. Section 7.1 gives some details of the storage site requirements.

5.0 RESPONSIBILITIES

5.1 The Facility Manager is responsible for the effective implementation of this procedure.

5.2 The O&M Manager is responsible for ensuring that plant personnel are properly trained and qualified, as required.

5.3 The Control Room Operator (CRO) is responsible for assigning a properly trained and qualified Operations and Maintenance Technician (OMT), as required.

5.4 All CPP employees are responsible to reduce waste as much as possible utilizing prudent purchasing, re-using products which have useful life and recycling.

6.0 LIMITS AND PRECAUTIONS

6.1 All waste/material handling should be done in accordance with the requirements found in the appropriate MSDS including use of recommended PPE and after discussion with your supervisor.

7.0 PROCEDURE

7.1 INTRODUCTION

The Cosumnes Power Plant (CPP) generates non-hazardous and hazardous waste during normal operations. Proper management of the waste generated is not only a regulatory requirement, it also emphasizes the value of Wood Group Power Operations philosophy of environmental stewardship.

All Wood Group-CPP team members shall read and understand this procedure and all other applicable training and operations material related to waste management. Information contained in this procedure will be updated periodically to ensure the information is current and applicable for its intended purpose.

The proper disposal of hazardous waste is the responsibility of the generator. If Wood Group-CPP contracts with a waste hauler or disposal facility and the contractor does not follow proper procedure, Wood Group-CPP could be liable for the negligence of the contractor. This concept is commonly referred to as “cradle to grave” responsibility and is part of the product’s life cycle assessment (LCA).

The largest constituent of waste generated at the CPP facility is the solid residue created from the pressure filter in the Zero Liquid Discharge (ZLD) System. The solids are mostly salts resulting from treating process water. Disposal of this residue (filter cake) is a component of Wood Group-CPP’s contract with Univar USA, Inc. Univar subcontracts with Ecology Control Industries (ECI) for waste hauling and emergency response services.

A “One Pass Filter” is used to remove suspended solids from the makeup water for the facility. The filter uses Perlite as the filter medium. Periodically the filter has to be backwashed, which washes the Perlite and suspended solids (perlite waste) off of the filter.

Proper waste management requires periodic inspection of the waste storage area and documentation of all inspections. The inspection log is an auditable legal document.

It is Wood Group Power Operation’s policy to conduct all of its business activities within all applicable regulations. Team members who willfully or through negligence violate any law, including laws pertaining to waste management, will be subject to disciplinary action.

7.2 WASTE DISPOSAL

Wood Group-CPP maintains a contract with Univar USA, Inc. for removal and disposal of hazardous and non-hazardous waste generated at the CPP facility. Frequency of disposal will be determined by the accumulated quantity and regulatory permitted storage time.

When a waste shipment is to be made, the containers will be sealed so that the no additional material can be added. The contracted waste handling vendor (Univar USA, Inc.) is then contacted for profiling of the waste and removal from site.

A qualified Wood Group-CPP team member will be present when the waste is transported from site. The Wood Group-CPP team member will carefully check the shipping manifest to ensure the proper items were loaded, and if qualified to do so, sign the manifest.

7.3 WASTE MANAGEMENT

Waste management is the process and application of procedures to handle hazardous and non-hazardous waste generate at the CPP property by Wood Group-CPP personnel and their contractors.

7.3.1 Waste Handling and Storage

Waste generated during the normal operation of the CPP facility must be stored in a designated area in approved and properly labeled containers.

The waste containers must be inspected weekly and the inspection documented. Inspection items will include:

- Condition of drums and other storage containers. Bulging containers (indicating reactions inside the containers) must be corrected (by venting) immediately. Leaking containers must be over-packed.
- Container labeling. All containers must be properly labeled. Special labels provided by the contracted waste handling vendor and showing the type of waste, the date placed in storage, the name of the waste generator and other required information must be clearly visible.
- Conditions of storage area. The area must be absent of trash. Containers containing non-compatible material must be separated by the required distance.

7.3.2 Contractor Waste Handling

Contractors must obtain approval from Wood Group-CPP for all chemicals, paints and other hazardous and non-hazardous material that are brought on site for use. Any waste generated by contractors must be removed and properly disposed of in accordance with this procedure. Wood Group-CPP will verify all disposal plans.

Contractors on the plant site are required to follow the same policies as Wood Group-CPP personnel. Wood Group-CPP is responsible for the actions of contractors concerning waste management.

7.4 WASTE REDUCTION

Wood Group CPP endorses efforts to reduce waste as much as possible. When reducing waste, three principles apply: reduce, re-use, recycle.

7.4.1 Reduce

Reducing the amount of waste generated starts with a thorough review of purchasing policies. Only the amount of material needed for the intended job will be ordered. It may require reducing the inventory kept in the plant to lessen the chance material will become outdated and thereby creating waste.

Sometimes it is possible to change a process or operation so that less waste is generated. For example, switching from a mineral oil to synthetic oil may allow more time between oil changes and reduce the amount of waste generated.

7.4.2 Re-use

Getting the most use of material not only reduces waste, it also makes good economic sense. Items that are changed routinely should be evaluated to make sure the maximum useful life is being obtained. For example, disposable air filters that are changed once a month can be evaluated to see if they could be used longer.

7.4.3 Recycle

Whenever possible material should be recycled. Items no longer suitable for the purpose it was purchased for may have some other use.

Recycling material may require some planning and changes in policy. Innovative thinking may lead to switching from a single-use product to one that can be used more than once or can be used for a different purpose after it is no longer fit for its primary use.

7.5 WASTE GENERATED AT CPP SITE

The waste generated at CPP will be classified and properly segregated in compliance with all applicable laws.

It is expect that the following waste will be generated at the facility:

7.5.1 Pressure Filter Cake/Salt Cake

Pressure filter cake is generated at the ZLD as part of operations. It is expected that two 20-cubic yards containers of this waste will be generated weekly. Univar USA has been contracted to remove and dispose of the waste residue.

During normal operation, Wood Group-CPP personnel to will arrange for the collection of the filter cake, follow the proper procedure for vendors entering plant property, and properly complete CALTRANS/DOT manifests.

7.5.2 Paints

The amount of paint kept on site will be minimal and is expected to be of “touch-up” quantity. Only the amount needed for a particular job will be ordered. When paint is no longer useable, it should be clearly labeled for profiling and disposal by the contracted disposal vendor. Cans that are empty and dry can be disposed of in normal refuse bins

7.5.3 Petroleum Based Solvents

Examples of petroleum based solvents include mineral spirits, ketones, and kerosene. These will be collected in containers properly labeled for this particular waste profile. Only solvents with the same profile number will be mixed together. Profile numbers for this waste will be determined by the contracted disposal vendor.

7.5.4 Chlorinated Solvent

Chlorinated and petroleum based solvents will not be used as degreasers at the CPP facility. Wood Group-CPP will use only bio-degradable degreasers at the CPP facility. Disposal of the biodegradable solvent will be managed by the contracted disposal vendor (Univar USA, Inc.).

7.5.5 Synthetic Lubricating Oil

Synthetic oils are sometimes used for lubricating and hydraulic control purposes. The synthetic oils shall not be mixed with mineral oils since different chemicals are used as the base for synthetic oil. Waste synthetic oil will be disposed of based on the profile provided by the contracted disposal vendor.

7.5.6 Mineral Lubricating Oil

Mineral oils are also used for lubricating and hydraulic control purposes. For the purpose of this document, lubricating greases are included in the mineral lubricating oil category. Waste oil can be generated by routine oil changes in pumps, gearboxes and other equipment. Waste mineral coil can also be generated by leaks captured by drip pans or oil in cans or other containers inadvertent contaminated by water or debris.

At CPP, waste oil is a California regulated waste stream and will be managed through the contracted disposal vendor.

7.5.7 Oil Filters

Oil filters should be drained as much as possible into approved containers and stored as CA regulated waste. Sometimes this may require punching holes in the filter housing. Disposal of the filters will be managed through the contracted disposal vendor.

7.5.8 Aerosol Cans

Efforts should be made to use the entire contents of aerosol cans. Holding the can in the position recommended on the product label will help ensure enough propellant is available to completely empty the can of its product.

Empty aerosol cans will be disposed of in approved labeled containers only and managed through the contracted disposal vendor.

7.5.9 Batteries

Batteries of most types are environmental hazards. Lead-acid batteries used in vehicles and portable power equipment should always be exchanged when a new battery is purchase. If the old battery can not be exchanged at the time of the purchase, a proper “core authorization” should be obtained so that the old battery can be turned in later.

Nickel-cadmium and lithium batteries that have a low potential for leakage can be collected in a container appropriate for the collection area. When a sufficient quantity is collected the waste batteries will be profiled and disposed of through the contracted disposal vendor.

Alkaline batteries are the common batteries used in flashlights and battery-powered instruments. To avoid generating excessive waste, batteries should be used until there is noticeable decease in power. An important exception is seldom used critical instrument where leaking batteries could cause damage. In such cases, the batteries should be replaced at appropriate time intervals, based on the expected life of the batteries.

All used batteries will be collected in approved, labeled containers and disposed of through the contracted disposal vendor.

7.5.10 Ethylene Glycol

Ethylene glycol is added to the Closed Cooling Water System. Waste ethylene glycol can be generated by leaks collected in drip pans and small quantities left in containers.

Ethylene glycol, even diluted with water is very hazardous to animal life and should be stored in appropriate metal or plastic containers and held for disposal by the contracted waste handling vendor.

7.5.11 Contaminated Fuels

Contaminated fuels are gasoline, diesel fuel, and other liquid fuels that have been contaminated with water or other material. Waste fuel should be placed in a properly marked container and held for disposal by the contracted waste handling vendor.

7.5.12 Acids

Some waste acids may be generated through laboratory operations or other process activities. All acid waste, liquid or solid, shall be placed in properly marked containers and held for disposal by the waste handling vendor.

7.5.13 Alkalis

Caustic soda or sodium hydroxide (NaOH) and ammonium hydroxide (ammonia in water, NH_4OH) are two strong alkalis used in the plant. Other alkalis may also be present in the plant. Alkaline waste, liquid or solid, will be placed in properly labeled containers and held for disposal by the contracted waste handler.

7.5.14 Empty Containers

Empty drums, buckets and other containers that were used to ship hazardous materials shall be held for disposal by the contracted waste handling vendor.

7.5.15 Lamps

Some lamps (light bulbs) require special disposal practices. These include metal vapors (low and high pressure sodium, mercury), halogen (metal halides), and fluorescent lamps.

Used lamps stored at the CPP facility will be stored in either their original containers or in approved disposal containers while being held for disposal by the contracted waste handling vendor.

7.5.16 Absorbent Material

Absorbent materials such as Pigs® and used spill cleanup kits are to be treated the same as the spilled material that was cleaned up. The used absorbents should be put in properly labeled containers, sealed and held for disposal in accordance with guidelines provided by the contracted waste disposal vendor.

Earth and aggregate removed as part of a spill clean up should be placed in 55 gallon drums and labeled properly. For larger spills where a contractor is involved, the containers must not leave the site without proper profiling and manifesting through the contracted waste disposal vendor.

7.5.17 Water Wash

Waste wash water from the Gas Turbine Generators (CTGs) is contaminated with detergent and oil and therefore can not be process in the plant. The waste water is collected in the gas turbine sumps, profiled, and removed from the site by the contracted waste handling contractor. The removal of waste wash water will require the contractor to provide a vacuum truck.

7.5.18 Oily Rags

Oily rags are generated by Wood Group-CPP and its contractors during maintenance activities. Oily rags are collected in properly labeled containers and routinely removed by a contractor for cleaning.

Oily rags are fire hazards and should be collected in metal drums with lids.

7.5.19 One Pass Filter Waste (Candle Filter)

The One Pass Filter is used to remove suspended solids from the makeup water for the facility. The filter uses Perlite as the filter medium. Periodically the filter has to be backwashed, which washes the Perlite and suspended solids (perlite waste) off of the filter.

The perlite waste is collected in a 20-yard roll-off. The 20-yard roll-off is designed to allow excess water to drain from the perlite waste. After the perlite waste is allowed to drain the majority of the liquid free material is then disposed of at a local landfill. CPP may in the future consider land application of the perlite waste. The perlite waste has been characterized as non-hazardous waste.

7.6 WASTE STORAGE

All hazardous and non-hazardous waste are stored in an approved central location. There are no satellite accumulation areas in the plant. Containers are provided for the storing the different types of waste expected to be generated at the CPP facility. Proper labeling is required for each container.

Regulations are specific about the type of containers than can be used. Drums with dents, excessive rust or peeling paint are not acceptable. For hazardous waste stored in drums, the drum must meet United Nations (UN) specification. Hazardous and non-hazardous waste containers will be provided by the contracted waste handling contractor (Univar USA).

7.7 EMERGENCY RESPONSE

In the event of a leak or spill that contaminates the ground or air, Wood Group-CPP will follow the procedure of the CPP Integrated Contingency Plan and immediately implement the Incident Control System.

Following rainstorms, the facility containments will be inspected for oil sheens and monitored for pH before dewatering. Based on the analysis, the water will be treated as rain water or properly profiled waste streams. A record will be maintained to indicate the rain event and the inspection of each containment.

7.8 RESOURCES

For information related to handling, storage and regulatory compliance of hazardous waste, Wood Group-CPP will defer to the contracted waste handling vendor, Univar USA. Univar personnel should be contacted in the following order:

Lynette Washington Sales, 323-837-7137
Steven Ojedia Technical Specialist, 408-307-7340
Lauran Goddard, Technical Specialist, 916-424-2134

8.0 <u>RECORDS</u>

8.1 Records generated as a result of this procedure shall be maintained in accordance with procedure QP-QCP-CQP, *Control of Quality Records.*

9.0 TRAINING REQUIREMENTS

9.1 Wood Group-CPP personnel that handle non-hazardous and hazardous waste will be properly trained including hazardous waste operator, DOT shipping manifest, and waste management awareness training. Some portions of the training must be repeated annually while others require only annual refresher courses. Some employees, because of their job duties, will receive more extensive training. Proper training documentation must be maintained as a regulatory requirement.

10.0 ATTACHMENT(S)

None