



Scientific Research and Consulting

MEMO

To: M. McCue, Evoqua Water Technologies LLC
From: S. Foster, CPF Associates, Inc.
Date: April 13, 2015
**Re: Evaluation of Sulfur Dioxide and Nitrogen Dioxide Emissions for the
Evoqua Water Technologies Carbon Reactivation Facility, Parker, AZ**

INTRODUCTION

At the request of Evoqua Water Technologies, an analysis of emission rates for sulfur dioxide (SO₂) and nitrogen dioxide (NO₂) was conducted for the Evoqua carbon reactivation plant outside of Parker, Arizona. The goals of the analysis were twofold: to identify SO₂ and NO₂ emission rates for the reactivation facility stack that would ensure protection of human health and to calculate the sulfur content in spent carbon feed corresponding to the health-protective SO₂ emission rates.

BACKGROUND

The Evoqua Water Technologies facility reactivates spent carbon which has been previously used to remove pollutants from water and air. The spent carbon is reactivated by heating it to very high temperatures under controlled conditions in a carbon reactivation furnace. The newly reactivated carbon is then reused as an activated carbon product. The carbon reactivation plant is located within the Colorado River Indian Tribes (CRIT) Reservation, in an industrial park owned by CRIT outside of the Town of Parker.

A comprehensive human health risk assessment was completed in March 2008 for the carbon reactivation plant as part of the facility's permitting activities under the Resource Conservation and Recovery Act (RCRA).¹ This assessment underwent extensive review by the U.S. Environmental Protection Agency (USEPA) and was conducted in accordance with a USEPA-approved workplan and following standard risk assessment methods established by USEPA.

The risk assessment evaluated many compounds that could potentially be emitted from the reactivation facility stack, including SO₂ and NO₂. Emission rates for most of the evaluated compounds, including SO₂ and NO₂, were based on stack gas measurements collected from the facility. The risk assessment results demonstrated that the potential risks associated with air emissions from the carbon reactivation facility stack, including those associated with SO₂ and NO₂, were below regulatory and other target risk levels for protection of human health.

¹ CPF Associates, Inc. Draft Risk Assessment for the Siemens Water Technologies Corp. Carbon Reactivation Facility in Parker, Arizona (July 30, 2007), and Response To USEPA Region IX Comments on the Draft Siemens Water Technologies Corp. Carbon Regeneration Facility Risk Assessment (March 13, 2008).

SO2 AND NO2 EMISSION RATES

In this analysis, emission rates for SO₂ and NO₂ were back-calculated from health-protective reference air concentrations using widely-accepted risk assessment methods. The approach involved identifying reference air concentrations for SO₂ and NO₂ from the USEPA and the California Environmental Protection Agency (CALEPA), and then back-calculating stack emission rates corresponding to these reference air concentrations using air dispersion modeling results. Air dispersion modeling was performed previously as part of the comprehensive risk assessment.

Emission rates were calculated for two averaging times (hourly and annual) to be consistent not only with the available health-based reference air concentrations but also with the methods used in the previously performed risk assessment. Additional information describing the calculations and inputs is provided in Attachment A.

The resulting health-protective emission rates are shown in Table 1 below. At these levels of emission, maximum downwind air concentrations would not exceed health-based criteria and thus adverse health effects would not be expected to occur.

Table 1
Health-Protective Emission Rates for the Carbon Reactivation Facility Stack

Compound	Maximum Hourly Emission Rate (based on acute short-term health effects) ^a			Annual Average Emission Rate (based on chronic long-term health effects) ^a		
	g/sec	lb/hr	Basis	g/sec	lb/hr	Basis
Sulfur dioxide (SO ₂)	3.8	30	NAAQS ^a	NA		
	13	100	CALEPA REL ^b			
Nitrogen dioxide (NO ₂)	3.6	29	NAAQS ^a	59	467	NAAQS ^a
	9.0	72	CALEPA REL ^b	NA		

NAAQS = U.S. National Ambient Air Quality Standard

CALEPA REL = California Environmental Protection Agency Acute Reference Exposure Level

NA = Not applicable

^a Based on the 1-hour average or annual average USEPA National Ambient Air Quality Standard.

^b Based on the California Environmental Protection Agency (CALEPA) 1-hour average air concentration below which adverse health effects are not anticipated to occur.

The emission rates in Table 1 are expected to be greatly underestimated (i.e., much lower than actually needed to protect public health) because of the use of several very conservative assumptions. These conservative assumptions include the following:

- The emission rates were calculated using maximum impact point air concentrations predicted by the air dispersion modeling. For example, the maximum hourly emission rates were derived using the maximum impact point 1-hour average air concentration. This maximum air concentration is associated with worst-case meteorological conditions and is the single highest result among the more than 43,800 hours modeled (i.e., using five years of meteorological data) at each of the more than 5,000 receptor grid locations evaluated beyond the facility boundary. This means that the health-protective maximum hourly emission rates have a substantial built-in margin of safety because they are derived for an extreme situation that is unlikely to occur.

C P F A S S O C I A T E S , I N C .

• 5404 Burling Road • Bethesda, MD 20814 • T: (301) 657-2686 • F: (301) 907-8230 •
www.cpfassociates.com

- The approach used to back-calculate emission rates from the 1-hour NAAQS is more health-protective than the method used by USEPA to determine compliance. The USEPA evaluates compliance with the 1-hour NAAQS based on the 99th percentile (SO₂) or 98th percentile (NO₂) of the 1-hour daily maximum concentrations averaged over three years. As noted above, the maximum hourly emission rates were derived based on only the single maximum 1-hour average air concentration which, at any given location, has about a 0.002% chance of occurring. The 99th and 98th percentiles of 1-hour daily maximums averaged over three years would be lower than the single highest 1-hour maximum used here. This means that the emission rates based on the 1-hour NAAQS are expected to be underestimated (i.e., higher health-protective emission rates would result if USEPA's compliance approach was used).

SULFUR CONTENT IN SPENT CARBON FEED

The weight percent of sulfur in spent carbon feed corresponding to the health-protective SO₂ emission rates was also calculated. This calculation was conducted using two spent carbon feed rates -- 2,760 lbs/hr, which is the feed rate under the facility's current RCRA interim status permit, and 3,049 lbs/hr which is the proposed feed rate in the facility's RCRA Part B permit application. The calculation also assumed complete conversion of sulfur to SO₂, and an SO₂ removal efficiency of 95% by the facility's wet scrubber air pollution control system. Additional information describing this calculation is provided in Attachment A.

The weight percent of sulfur in the feed that would, under worst-case conditions, result in maximum air concentrations equal to the 1-hour NAAQS and the 1-hour CALEPA acute reference concentration were calculated to be 10.9% and 36.6%, respectively (for a 2,760 lb/hr feed rate) and 9.8% and 33.1%, respectively (for a 3,049 lb/hr feed rate).

**ATTACHMENT A
ADDITIONAL INFORMATION**

The health-protective emission rates for SO₂ and NO₂, and weight percent of sulfur in the feed, were derived using well-accepted regulatory approaches for calculating air concentrations associated with stack emissions, the potential for adverse human health effects associated with inhalation exposure, and constituent feed rates for combustion facilities.

Calculation of Health-Protective Emission Rates

The equation used to calculate an air concentration associated with a stack emission rate is as follows:

$$CA_x = ER_x * UAC$$

where:

- CA_x = ambient air concentration of compound x (µg/m³)
- ER_x = emission rate of compound x (g/sec)
- UAC = unitized air concentration calculated from air dispersion modeling of the stack emission source assuming a 1 g/sec emission rate (µg/m³ per 1 g/sec)

Unit air concentrations (UACs) were obtained from the dispersion modeling performed to support the risk assessment for the reactivation facility.² The highest UACs from the dispersion modeling were conservatively selected for use, as these will result in the highest downwind air concentrations and, conversely, the most health-protective emission rates. Consistent with standard risk assessment methods, and the previously performed risk assessment for the facility, acute short-term exposures were addressed using the 1-hour average UAC while chronic long-term exposures were addressed using the annual average UAC.

- The maximum impact point 1-hour average UAC was 52 µg/m³ per 1 g/sec, predicted to occur at the closest developed location beyond the facility boundary (roughly 1,200 feet to the southwest of the stack) under worst-case meteorological conditions. This maximum air concentration was the highest single result among the more than 43,800 hours modeled (i.e., using five years of meteorological data) at each of the more than 5,000 receptor grid locations evaluated beyond the facility boundary. At the maximum impact location, the highest 1-hour average air concentration has about a 0.002% chance of occurring.
- The highest annual average UAC was 1.7 µg/m³ per 1 g/sec, predicted to occur roughly 1,000 feet to the north of the stack. This location is undeveloped with no commercial or residential use. If the UAC for the highest impact residential location was used to back-calculate a long-term health-protective emission rate instead, the resulting annual average NO₂ emission rate would be roughly 1.5 times higher than shown in Table 1.

The equation used to calculate the potential for non-cancer health effects from inhalation exposure to a compound is:

$$HQ_x = CA_x / RfC_x$$

² CPF Associates. 2007. Draft Risk Assessment for the Siemens Water Technologies Corp. Carbon Reactivation Facility in Parker, Arizona. July 30, 2007.

where:

HQ_x = hazard quotient for compound x

RfC_x = health-based reference air concentration for compound x (µg/m³)

Reference air concentrations (RfCs) for SO₂ and NO₂ were identified from USEPA and the California Environmental Protection Agency (CALEPA), as shown below.

Reference Air Concentrations for Sulfur Dioxide and Nitrogen Dioxide

Compound	Acute Inhalation Reference Concentration		Chronic Inhalation Reference Concentration	
	µg/m ³	Basis	µg/m ³	Basis
Sulfur dioxide	196	1-hour NAAQS ^a	NA	
	660	1-hour CALEPA REL ^b		
Nitrogen dioxide	188	1-hour NAAQS ^a	100	Annual NAAQS
	470	1-hour CALEPA REL ^b		

NAAQS = U.S. National Ambient Air Quality Standard

CALEPA REL = California Environmental Protection Agency Acute Reference Exposure Level

NA = Not applicable

^a Compliance with the NAAQS is evaluated based on the 99th (SO₂) or 98th (NO₂) percentile of 1-hour daily maximum concentrations averaged over three years. Comparison of the single maximum 1-hour average associated with stack emissions to the NAAQS, as done in this analysis, is health-protective, because the 99th or 98th percentiles of 1-hour daily maximums would be lower than the single highest 1-hour maximum.

^b The CALEPA acute, 1-hour average, reference concentration is set at a level at or below which adverse noncancer health effects are not anticipated to occur for a 1-hour exposure duration.

The regulatory criterion typically used to evaluate the likelihood of a non-cancer inhalation health effect is an HQ value of 1.0. An HQ >1 indicates that the air concentrations may be above the levels of concern for adverse health effects and generally triggers further evaluation. An HQ ≤1 indicates that adverse effects would not be expected to occur.

The equations presented above can be combined and rearranged to solve for an emission rate associated with a given HQ value:

$$ER_x = HQ * RfC_x / UAC$$

Emission rates associated with an HQ of 1.0 are shown above in Table 1.

Calculation of Sulfur Feed Rate

The relationship of sulfur in spent carbon feed to its emission rate can be calculated as follows:

$$ER_{SO_2} = (S_{wt\%}/100) * SCF * (1-RE) * (MW_{SO_2}/MW_S)$$

where:

ER_{SO₂} = SO₂ emission rate (lbs/hr)

S_{wt%} = Weight percent sulfur in spent carbon feed (%)

SCF = Spent carbon feed rate (2,760 lbs/hr or 3,049 lbs/hr)

RE = SO₂ removal efficiency (0.95)

MW_{SO₂} = Molecular weight SO₂ (64.07 g/mol)

MW_S = Molecular weight S (32 g/mol)

C P F A S S O C I A T E S , I N C .

• 5404 Burling Road • Bethesda, MD 20814 • T: (301) 657-2686 • F: (301) 907-8230 •

www.cpfassociates.com

The wet scrubber system at the plant was designed for 95% removal of SO₂. Based on input from Evoqua, the spent carbon feed rate was assumed to be either 2,760 lbs/hr (the feed rate under the facility's current RCRA interim status permit) or 3,049 lbs/hr (the proposed feed rate in the facility's RCRA Part B permit application). This calculation also conservatively assumed that 100% of the sulfur in the spent carbon feed would be converted to SO₂ in stack exhaust gas.

Rearranged, this equation can be used to calculate the weight percent sulfur associated with a specified SO₂ emission rate:

$$S_{wt\%} = \{ ER_{SO_2} * 100 * (MW_S / MW_{SO_2}) \} / \{ SCF * (1-RE) \}$$