A MEMBER OF THE ENVIRONMENTAL RESOURCES MANAGEMENT GROUP

Southeastern Universities Research Association-Continuous Electron Beam Accelerator Facility

Air Emissions Inventory

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ERM

1.0 *INTRODUCTION*

On 8 May 1995, Environmental Resources Management, Incorporated (ERM) conducted a site visit of the Southeastern Universities Research Association-Continuous Electron Beam Accelerator Facility (CEBAF) in an effort to produce an air emissions inventory outlining the facility's actual and potential air emissions. An inspection of the facility was performed, interviews were held with relevant facility personnel, and appropriate documents and data were collected.

The air emissions inventory was performed at the request of CEBAF to assess the facility's future regulatory requirements. The primary areas of investigation were the seven (7) natural gas boilers, cavity acid treatment, cavity cleansing, and fugitive emissions. Radionuclides were not included in the scope of this emissions inventory.

2.0 *DATA EVALUATION*

The process emissions for CEBAF have been outlined and described in detail in the following text and corresponding tables. All emissions are in terms of a weighted time average such as pounds per hour or tons per year. These terms were chosen to correspond with established emission factors and compliance parameters.

Information for the emissions inventory was collected from various sources including: permits and applications, registration updates, purchasing records, product inventories, waste summaries, and personnel interviews. The information was incorporated into the emissions summaries with data gaps addressed through conservative assumptions. All assumptions made in the emissions inventories are defined in detail.

Both potential and actual emissions are defined for all process areas. Potential emissions are defined as the maximum possible emissions discharged from a piece of equipment operating at 100% capacity for 24 hours per day, 7 days per week, and 52 weeks per year for a total of 8760 hours per year. Potential emissions are the basis for most regulatory requirements. Actual emissions are, as stated, the equipment's actual emissions. Normally, two or more years of actual emissions are used to assess the equipment's typical emissions as compared to its operating parameters to determine a normal operating emissions schedule for the piece of equipment.

2.1 *Natural Gas Boilers*

CEBAF has seven natural gas boilers located throughout the facility for the primary purpose of space heat. The boilers are all relatively small and are considered exempt from state air permitting requirements. The "AP-42" Emission Factors defined by the United States Environmental Protection Agency (USEPA) were used to establish criteria pollutant emission levels for the boilers. Both potential and actual boiler emissions were calculated and included in Tables 1 and 2 respectively. As indicated in Tables 1 and 2, the total criteria pollutant emissions from the boilers are small.

2.2 *Niobium Cavity Acid Bath*

CEBAF constructs cavities from niobium, a superconducting ductile metal, for use in the electron beam accelerator. During construction, the cavities are surface-cleaned and finished in an acid bath. An equal mixture of nitric, phosphoric, and hydrofluoric acids are used to remove approximately 2-4 mils of surface area to provide a smooth, polished surface. An exhaust system is located over the acid bath area which removes acid gases and NO_2 to a scrubber system. The collection efficiency of the scrubber on the acid gases is approximately 85% while the collection efficiency of NO_2 is nominal. For the purpose of this air emissions inventory, ERM assumed that NO_2 emissions are uncontrolled. NO_2 is the only criteria pollutant of concern in the acid bath process.

The Basic Acid Bath Reaction: $2\,Nb + 5NO_3^- \rightarrow Nb_2O_5 + \mathbf{5NO_2}$

Several calculations have been based on data supplied by CEBAF. Assumptions have been made to accept the validity of this data and to address any data gaps that may exist. Assumptions made for the Niobium Cavity Acid Bath process are indicated on Table 3a. According to the CEBAF air permit application dated 13 December 1988, the acid bath utilizes 30 gallons for two cavities and lasts one hour per cavity. The calculations in the application indicate that NO_2 emissions from the acid bath are 0.527 pounds per hour. According to CEBAF personnel, the acid bath treatment requires an additional hour between treatments to allow for acid temperature equalization resulting from a rather high exothermic reaction. Therefore, ERM assumed a rate of 0.527 pounds per two hours or 0.267 pounds per hour.

As indicated in CEBAF's Hazardous Waste Disposal Summary for the years April 1, 1993-March 31, 1995, ERM was able to estimate that approximately 500 gallons per year of acid solution were disposed as waste. It was

assumed that 100% of the acid solutions disposed of were incorporated in the cavity acid bath treatment.

According to Table 3, the NO_2 potential emissions from the niobium cavity acid bath are 1.15 tons per year. Considering the emissions level is based on the maximum potential production of 4380 cavities (1 cavity per 2 hours), the potential NO_2 emissions from acid bathing are insignificant.

2.3 *Cavity Cleansing*

After the cavities exit the acid bath they enter the cavity cleansing process. The cavities are cleansed to remove any remaining product and surface impurities. They are filled with four gallons of cleaning solutions (isopropyl alcohol and methanol) and attached to a vacuum. The cavities are then rinsed with distilled water and placed in storage. Since volatile solutions are used in the cleansing process, the primary pollutant of concern is VOC.

Assumptions made for the niobium cavity cleansing process are indicated on Table 4a. It is assumed that approximately 0.5 liters or 5% of the cleaning solution is lost through volatilization. Finally, since methanol is the most volatile cleansing solution it is used as the model solution in the emissions calculations.

Based on CEBAF's Hazardous Waste Disposal Summary Report for 1993-1995, the amount of cleaning solution disposed is approximately 725 gallons. Assuming that 5% of the solution volatilizes during cleaning, this 725 gallons is 95% of the total cleansing solution usage. These additional assumptions are indicated on Table 5a.

As indicated in Tables 4 and 5, the VOC emissions are small for a facility of CEBAF's size. With a cleansing solution usage rate at over 725 gallons per year, the potential VOC emissions are approximately 0.44 lbs per hour or 1.93 tons per year which makes the cleansing process an insignificant source.

Methanol is a USEPA designated hazardous air pollutant (HAP). Methanol usage was treated separately in the cavity cleansing calculations to determine HAP regulatory applicability. For potential emissions, methanol was assumed to be the sole cleansing solution. For actual emissions, ERM calculated that CEBAF used approximately 300 gallons of methanol per year for the years 1993-95. The total emissions from these calculations were insignificant. However, since adequate substitutes exist

for the cleansing of niobium cavities, for practical purposes, the usage of methanol should be discontinued.

2.4 *Fugitive VOC Emissions Discussion*

Fugitive emissions are those emissions not associated with a clearly identifiable means of conveyance (stack, vent, etc.). Fugitive emissions typically are released to the atmosphere through windows, doors, and exhaust fans and are difficult to measure. ERM was able to calculate the CEBAF's fugitive VOC and HAP emissions from information collected from CEBAF and directly from product vendors. The primary source of fugitive VOC and HAP emissions at CEBAF are spray cans; spray paints, flux remover, coatings, and welding sprays. As illustrated in Table 6, CEBAF's fugitive emissions are insignificant.

3.0 *PRELIMINARY REGULATORY ANALYSIS*

In the Hampton Roads area, a facility is considered a major source of air pollutants if the facility emits greater than 100 tons of any criteria pollutant or 250 tons of any combination of criteria pollutants. A source is also considered major if it emits 10 tons of any of the 189 designated federal hazardous air pollutants (HAP) or 25 tons of any combination of HAPs. If a source is defined as major, they are then subject to Title V Operating Permit requirements. Based on the air emissions inventory, CEBAF is considered a minor source and will not presently be subject to Title V requirements.

According to Title III of the 1990 Clean Air Act Amendments (CAAA), major and specific classified sources of hazardous air pollutants will be subject to maximum achievable control technology (MACT) for their HAPs emissions. MACT is defined as the average of the top 12% currently functioning control technology or the top 94 percentile. Thus, the MACT standard is significantly onerous for facilities with threshold HAP emissions. Based on the scope of this project, the radionuclide emissions were not included in this air emissions inventory. Radionuclides are a federally listed HAP and are regulated according to standards defined in 40 CFR Part 61 Subparts H and Q. ERM recommends that CEBAF assess its radionuclide emissions to determine its regulatory applicability to the above standards.

CEBAF incorporates several CFCs which are regulated under CAAA Title VI. According to Title VI, these CFCs are scheduled to be phased out by 1996. Title VI will not preclude CEBAF from consuming its current

surplus of CFCs however, since the production of these materials will have ceased, the supply available to the market will be drastically reduced. CEBAF will need to arrange with vendors substitute materials for current CFC use.

Finally, the Hampton Roads area is currently a marginal non-attainment area for ozone. The USEPA is considering adjusting the area's non-attainment status to moderate, more serious than marginal. The adjustment from marginal to moderate will occur, the question is when. When the adjustment occurs, both new and existing facilities will be subject to more stringent requirements for VOC and NOx emissions. CEBAF's current VOC and NOx emissions are insignificant and should not be affected by the non-attainment status adjustment.

4.0 RECOMMENDATIONS

As a result of this emissions inventory, ERM, Inc. recommends the following actions for CEBAF.

- Radionuclides are a federally listed HAP and are regulated according to standards defined in 40 CFR Part 61 Subparts H and Q. ERM recommends that CEBAF assess its radionuclide emissions to determine its regulatory applicability to the above standards.
- CEBAF applied for an air permit in 1988. The Virginia Department of Environmental Quality-Air Division stated that an air permit was not necessary at that time. Upon completion of the air emissions inventory, ERM concurs that an air permit is not necessary for CEBAF at this time. However, ERM does recommend that CEBAF maintain a copy of this air emissions inventory report on site for future use in negotiations with the VADEQ-Air Division.
- According to facility personnel, the use of methanol as a cavity cleansing solution has been discontinued. Methanol is considered a Federal air toxic as described in § 112 of the Clean Air Act. Removal of methanol from the cavity cleansing process should reduce future regulatory requirements.

5.0 SUMMARY

The air emissions inventory performed by ERM indicates that CEBAF is a minor source of air pollution (See Table 7). Therefore, CEBAF should not be subject to the air operating permit provisions of Title V of the Clean Air Act. However, it is possible that minor sources will be included in Title V

permitting activities in the future. ERM believes that this will not occur until after the year 2000. Also to ensure that CEBAF will not be subject to any restrictions in the near future, radionuclide emissions should be assessed to determine Title III regulatory applicability. The creation of the air emissions inventory will allow CEBAF to justify its minor source status to the Virginia Department of Environmental Quality and/or the U.S. Environmental Protection Agency and relieve CEBAF of unnecessary regulatory requirements.

TABLES

SURA-CEBAF

Air Emissions Inventory

Table 1
SURA-CEBAF Boilers
Potential Emissions-Uncontrolled

Ref No.	Boiler Type	Boiler Capacity (MMBtu/Hr)	TSP/PM-10		CO		NOx		Sulfur Dioxide		VOC	
			LB/HR	TON/YR	LB/HR	TON/YR	LB/HR	TON/YR	LB/HR	TON/YR	LB/HR	TON/YR
HB-1	Cleaver Brooks P-142-30	1.0000	0.0100	0.0300	0.0200	0.0900	0.1000	0.4400	0.0006	0.0030	0.0030	0.0100
HB-2	Cleaver Brooks P-142-30	1.0000	0.0100	0.0300	0.0200	0.0900	0.1000	0.4400	0.0006	0.0030	0.0030	0.0100
HB-3	Cleaver Brooks CB-760-60	3.0000	0.0200	0.0900	0.0600	0.2600	0.2900	1.2500	0.0020	0.0080	0.0080	0.0300
HB-4	Cleaver Brooks CB-760-60	3.0000	0.0200	0.0900	0.0600	0.2600	0.2900	1.2500	0.0020	0.0080	0.0080	0.0300
HB-5	Bryan F-450WG	0.4500	0.0030	0.0100	0.0090	0.0400	0.0400	0.1900	0.0003	0.0011	0.0012	0.0052
HB-6	Bryan CL-90WG	0.9000	0.0060	0.0300	0.0200	0.0800	0.0900	0.3800	0.0005	0.0022	0.0024	0.0100
HB-7	Bryan CL-90WG	0.9000	0.0120	0.0300	0.0200	0.0800	0.0900	0.3800	0.0010	0.0044	0.0048	0.0100
TOTAL POTENTIAL EMISSIONS			0.0810	0.3100	0.2090	0.9000	1.0000	4.3300	0.0070	0.0297	0.0304	0.1052

*Emissions determined by AP-42 emission factors

Table 2

SURA-CEBAF Boilers

Actual Emissions-Uncontrolled

Ref No.	Boiler Type	Boiler Capacity (MMBtu/Hr)	Annual Fuel Use (MM CU FT)	TSP/PM-10		CO		NOx		Sulfur Dioxide		VOC	
				LB/YR	TON/YR	LB/YR	TON/YR	LB/YR	TON/YR	LB/YR	TON/YR	LB/YR	TON/YR
HB-1	Cleaver Brooks P-142-30	1.0000	1.9000	14.2500	0.0071	39.9000	0.0200	190.0000	0.0950	1.1400	0.0006	5.2896	0.0026
HB-2	Cleaver Brooks P-142-30	1.0000	1.9000	14.2500	0.0071	39.9000	0.0200	190.0000	0.0950	1.1400	0.0006	5.2896	0.0026
HB-3	Cleaver Brooks CB-760-60	3.0000	8.6000	64.5000	0.0323	180.6000	0.0903	860.0000	0.4300	5.1600	0.0026	23.9424	0.0120
HB-4	Cleaver Brooks CB-760-60	3.0000	8.6000	64.5000	0.0323	180.6000	0.0903	860.0000	0.4300	5.1600	0.0026	23.9424	0.0120
HB-5	Bryan F-450WG	0.4500	0.7000	5.2500	0.0026	14.7000	0.0074	70.0000	0.0350	0.4200	0.0002	1.9488	0.0010
HB-6	Bryan CL-90WG	0.9000	1.4000	10.5000	0.0053	29.4000	0.0147	140.0000	0.0700	0.8400	0.0004	3.8976	0.0019
HB-7	Bryan CL-90WG	0.9000	1.4000	10.5000	0.0053	29.4000	0.0147	140.0000	0.0700	0.8400	0.0004	3.8976	0.0019
TOTAL ACTUAL EMISSIONS		24.5000		183.7500	0.0919	514.5000	0.2573	2450.0000	1.2250	14.7000	0.0074	68.2080	0.0341

*Emissions determined by AP-42 Emission Factors

Table 3

NOx Emissions from Niobium Acid Bath

Potential Emissions-Production and Maintenance

(5.2 Moles NOx/cavity) x (46 grams/Mole) x (1 kg/1000 g) x (2.205 lbs/kg) =	**0.527 lb/cavity**
(0.527 lb/cavity) x (1 cavity/2 hr) =	**0.264 lb/hr**
(8760 hr/yr) x (0.264 lb/hr NOx) x (1 ton/2000 lb)=	**1.156 ton/yr**

Actual Emissions-Production and Maintenance

(500 gal/yr solution) ÷ (30 gal/2 cavities) =	33.3 cavity/yr
Hourly NOx Emission Rate	**0.264 lb/hr**
(33.3 cavities/yr) x (1 hr/cavity) x (0.264 lb/hr NOx) x (1 ton/2000 lb)=	**0.004 ton/yr**

Table 3a: Assumptions for Acid Bath-NOx Emissions

- An average of 5.2 Moles of NOx/cavity is emitted during the niobium acid bath treatment.
- Acid Bath process will last approximately one hour per cavity.
- Approximately one hour must pass between acid bath treatments.
- Use of approximately 500 gallons of acid solution per year for the years 1993-95.
- Acid Bath batch process incorporates 30 gallons/batch; One batch equals two cavities.

Table 4
Cavity Cleansing

Potential VOC Emissions

Isopropyl Alcohol/Methanol
Specific Gravity: 0.7915

0.7915 x 8.34lb/gal x 1 gal/3.785 liters= 1.74 lb/liter

(1.74 lb/liter)x (0.5 liter) x 1 cavity/2 hr = **0.44 lbs/hr**

(8760 hr/yr) x (0.44 lbs/yr) x (1 ton/2000 lb) = **1.93 ton/yr**

Hazardous Air Pollutants (HAP)-Methanol

0.7915 x 8.34lb/gal x 1 gal/3.785 liters= 1.74 lb/liter

(1.74 lb/liter)x (0.5 liter) x 1 cavity/2 hr = **0.44 lbs/hr**

(8760 hr/yr) x (0.44 lbs/yr) x (1 ton/2000 lb) = **1.93 ton/yr**

Table 4a: Assumptions for Cavity Cleansing

- The cleansing solution with the largest specific gravity (Methanol: 0.7915) was incorporated for conservativeness.
- The Cavity Cleansing process lasts approximately 1 hour per cavity with 1 hour between treatments.
- An estimated 0.5 liters is spilled from each cavity; It is assumed that 100% of the spilled material is volatilized.
- Records from CEBAF Procurement state Methanol use ≈ 300 gallons/year.
- Methanol is listed as a federal hazardous air pollutant (HAP).

Table 5
Cavity Cleansing

Actual VOC Emissions

Cleansing Solution Usage

0.7915 x (8.34 lb/gal) x (725 gal/yr*)= **4785 lb/yr Designated Waste Cleansing Solutions**

VOC Emissions

(4785 lb/yr) x 5% volatilized*= **239 lb/yr* VOC Emissions**

* See Assumptions below for an explanation.

Hazardous Air Pollutants (HAP)-Methanol

(300 Gallons of Methanol) x (8.34 lb/gallon) x (0.7915) = 1980.00 lbs/yr

(1980.00 lbs/yr) x 5% volatilized = **99 lb/yr Methanol Emissions**

Table 5a: Assumptions for Cavity Cleansing-VOC Emissions

- The cleansing solution with the largest specific gravity (Methanol: 0.7915) was incorporated as a form of conservatism.
- Disposal of approximately 725 gallons of cleansing solution per year for the years 1993-95. (CEBAF Haz. Waste Disposal Summary)
- An estimated 0.5 liters of cleansing solution is lost through volatilization. (It is estimated that the volatilized product is equal to ≈ 5% of the total cavity volume).
- It is assumed that 100% of all solutions spilled are evaporated.
- Records from CEBAF Procurement state Methanol use ≈ 300 gallons/year.

Table 6
SURA-CEBAF
Fugitive Emissions

Volatile Organic Compounds (VOC)

The majority of fugitive VOCs originate from the use of aerosol sprays such as spray paint, flux removers, coatings, and welding sprays. Spray paints were by far the largest contributor to fugitive VOCs.

Spray Paint

(600 cans paint/yr) x (15 oz/can) x (1 lb/16 oz) x (90% volatiles) = 506 lbs/yr

Calculations were performed on all materials used to assess the fugitive emissions.
The remaining sources were nominal yet were added to the spray paint emissions for comprehensiveness.

Total VOC Emissions: **600 lbs/yr*** **0.30 tons/yr***

Hazardous Air Pollutants (HAP)

Chemical	CAS #	Annual Release*
Methylene Chloride	75-09-2	150.00
Xylene	106-42-3	150.00
Toluene	108-88-3	120.00
1,1,1-Trichloroethane	71-55-6	40.00
Ethyl Benzene	100-41-4	20.00
Methyl Ethyl Ketone	78-93-3	15.00
Hexane	110-54-3	0.50
1,4 Dioxane	123-91-1	0.30
Hydroquinone	123-31-9	0.04
Totals		**495.00 lb/yr*** **0.25 tons/yr***

*Numbers Rounded Up to Provide a Conservative Estimate

Table 7

SURA-CEBAF

Emissions Inventory

Process	TSP/PM-10				CO				NOx					Sulfur Dioxide				VOC				HAP			
	Potential		Actual		Potential		Actual		Potential		Actual			Potential		Actual		Potential		Actual		Potential		Actual	
	LB/HR	TON/YR	LB/YR	TON/YR	LB/HR	TON/YR	LB/YR	TON/YR	LB/HR	TON/YR	LB/HR	LB/YR	TON/YR	LB/HR	TON/YR	LB/YR	TON/YR	LB/HR	TON/YR	LB/YR	TON/YR	LB/HR	TON/YR	LB/YR	TON/YR
Natural Gas Boilers	0.08	0.31	183.75	0.09	0.21	0.90	514.50	0.26	1.00	4.33		2450.00	1.23	0.007	0.030	14.700	0.007	0.03	0.11	68.21	0.03				
Cavity Acid Bath Treatment									0.26	1.16	0.26		0.004												
Cavity Solution Cleansing																		0.44	1.93	239.00	0.12	0.44	1.93	99.00	0.05
Fugitive Emissions																		0.07	0.30	600.00	0.30	0.06	0.25	495.00	0.25
TOTAL EMISSIONS	**0.08**	**0.31**	**183.75**	**0.09**	**0.21**	**0.90**	**514.50**	**0.26**	**1.26**	**5.49**	**0.26**	**2450.00**	**1.23**	**0.007**	**0.030**	**14.700**	**0.007**	**0.54**	**2.34**	**907.21**	**0.45**	**0.50**	**2.18**	**594.00**	**0.30**