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IN-DEPTH SURVEY REPORT
OF
GREENSBORO INDUSTRIAL PLATING
GREENSBORO, NORTH CAROLINA

SURVEY CONDUCTED BY:
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DATE OF SURVEY:
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Cincinnati, Ohio

PURPOSE OF STUDY: To evaluate engineering control technology used at Greensboro Industrial Plating, a hard chrome electroplating establishment.

EMPLOYER REPRESENTATIVES
CONTACTED: Mr. Robert Newsome, Owner

EMPLOYEE REPRESENTATIVES
CONTACTED: Non-Union

Abstract

An in-depth control technology survey was conducted at Greensboro Industrial Plating in Greensboro, North Carolina during January 26-30, 1981 and November 3-4, 1981. This company is involved in the hard chrome plating of steel and cast iron parts used in the lumber, textile and agricultural industries. Assessments of control technology, including ventilation design, control monitoring and work practices were made during the visit. Analyses of workplace air samples indicated that employee exposures to hexavalent chromium were controlled to 0.006 mg/m^3 and exposures to sulfuric acid were controlled to 0.40 mg/m^3.

Introduction

The National Institute for Occupational Safety and Health (NIOSH) is charged with the responsibility to conduct research and develop criteria for preventing exposure of workers to harmful chemical and physical agents. In response to this mandate, NIOSH has instituted a major effort to prevent occupational health problems through the application of control technology in the workplace. This control technology research program involves industry-wide engineering assessments in which effective options for the solution to occupational health problems are evaluated and documented.

NIOSH has initiated an assessment of engineering control technology in electroplating operations, where control measures exist for known chemical hazards, but a systematic study of their effectiveness has not been undertaken.

The Greensboro Industrial Plating facility was selected because it is a small scale, but high volume hard chrome plating operation with a well-designed ventilation system. Also, preliminary survey findings indicated good use of engineering controls for minimizing employee exposure to hexavalent chromium and sulfuric acid.

Facility Description

This electroplating facility is located in an industrialized city of the southern United States. The climate in this locale is usually warm and humid. Two separate surveys were conducted, one during January and the other during November when temperatures ranged from 49 to 69°F.

The plant occupies a 26 year-old building in an urban semi-industrial area of the city. Production is carried out over two shifts, six days per week. The workforce includes 21 production workers; of these, three were solely engaged in hard chrome plating during the period of interest, the first shift.

The operation involves hardchrome plating of steel and cast iron parts used primarily in the textile, lumber and agricultural industries. The parts range in size from small spindles (1/4" diameter x 3/4" long) to large pistons (10 1/2" diameter x 10" long).

Machine parts such as pumps and rollers are treated for wear with a thick chrome plate, while other parts (screws, nuts, bolts) only require a thin flash of chrome for corrosion protection.

Process Description

The parts to be plated arrive by truck at the receiving area, and are unloaded and transferred to the pretreatment area. If the part is oily or dirty, it is dipped in a cleaning tank containing an alkaline electro-cleaner for oil and dirt removal. If the part has a rough surface, it may be ground, polished with abrasives (abrasive belts, sand-blasting or compound polish), or tumbled in a tumbling barrel to produce a smooth surface. A hydrochloric acid dip may be required for surface scale removal. Surfaces which are not to be plated are then masked with tape.

Small parts are manually loaded on racks and then lowered into the plating tanks. Larger parts are carried by overhead hoist to the appropriate tanks and are subsequently lowered into the plating solution. Plating times can range from 30 minutes to several hours, depending on the plating thickness required.

After the desired chrome thickness is attained, the parts are removed either manually or by hoist, and water sprayed to rinse excess chromic acid, which drains back into the tank. After the parts are allowed to drip-dry they are de-racked, checked for smoothness and re-packed for shipping. All but one chrome plating solution contain 34 oz/gal chromic acid and 0.33 oz/gal sulfuric acid. The remaining tank contains 28 oz/gal chromic acid with a fluoride solution. All tanks are maintained at a temperature of 130^{O}F. Tanks are equipped with a heat exchange coil which supplies heat from a boiler. Cooling is accomplished by pumping cool ground water through the coils. All tanks are constructed of steel with either a lead or plastic liner. All of the tanks are equipped with two or three-sided exhaust hoods.

Plant Layout

The plant layout is shown in Figure 1. There are six hard chrome plating tanks, one cleaning tank and one rinse tank. Each tank is served by a separate rectifier or power generator. Tanks A, B, C and D are served by a fan inside the plating room and exhaust through a 20" duct in the roof. Tank E exhausts through a 21" duct through a fan outside on the roof. Tank F exhausts to an inside fan through a 14" duct in the roof. Exhausted air from tanks E and F is carried through mist eliminators which remove chromic acid from the airstream and return it to the tanks. There is no make-up air supply other than a central ceiling vent which houses a fan. The lack of supply air results in an airflow into the plating plant.

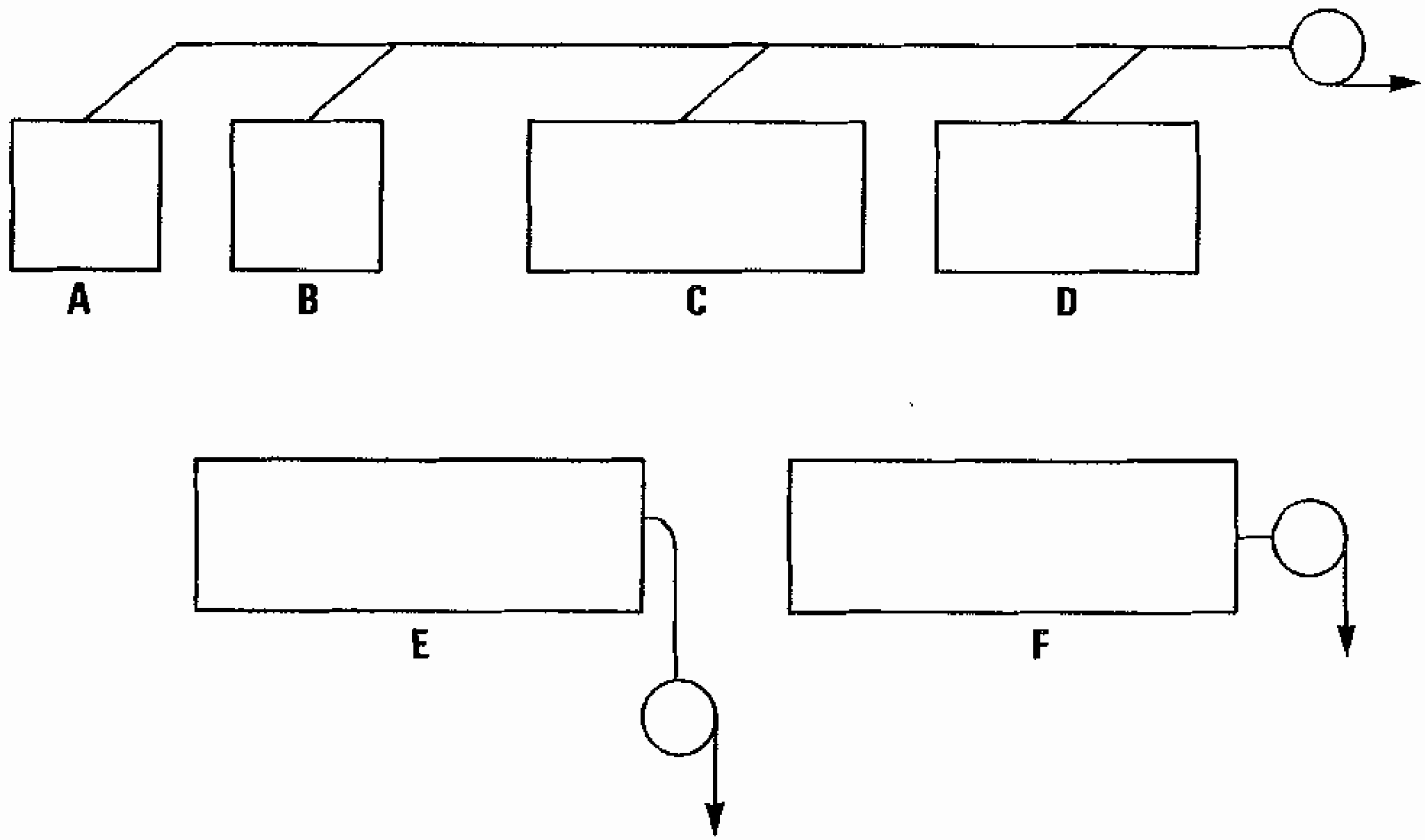

FIGURE 1: PLANT LAYOUT

Hazard Analysis

The primary hazards in the chrome plating operation are chromic and sulfuric acids. Chromic acid is introduced as chromium trioxide. Mists of hexavalent chromium compounds when inhaled can cause respiratory tract irritation, nasal septum ulceration and perforation, and chronic bronchitis. Skin contact with chromic acid may result in "chrome ulcers". Chromic acid mists may also discolor teeth and the tongue, and may cause severe eye injury[1,2,3].

Concentrated sulfuric acid can be highly irritating to the eyes and mucous membranes. Inhalation of sulfuric acid mists can result in pulmonary edema. Sulfuric acid in contact with skin tissue may cause burns and scarring.

Evaluation Procedure

Air Sampling

To assess control effectiveness, air samples were collected and ventilation measurements were taken. Personal, general area, and tank samples were analyzed for hexavalent chromium (CrVI) and sulfuric acid. Hexavalent chromium was collected using 37 mm diameter, 5 μm pore size polyvinylchloride filters in closed face cassettes, with MSA Model G personal sampling pumps operated at 2.0 L/min. After sampling, the filters were transferred from the cassettes to 20 ml vials as required by NIOSH analytical method No. P&CAM 319[4]. The samples were subsequently analyzed by diphenylcarbazide colorimetry at 540 nm[4].

Sulfuric acid was collected using 7 mm diameter silica gel tubes and DuPont 200 personal sampling pumps operated at 200 cc/min. The samples were analyzed by ion chromatography according to NIOSH Method No. P & CAM 310[4].

Ventilation Measurements

Air velocity and air flow measurements were made to evaluate the plant's engineering controls. Air velocities were measured using a TSI 1650 hot wire anemometer. Velocity measurements were taken in the vertical plane at the front and sides of each tank, and at the slots of the exhaust hoods. Velocities were averaged and the total volume of air discharged through each exhaust hood was determined.

Tank Evaluation

Tank B

Tank B, shown schematically in Figure 2, was evaluated only during the January survey. The tank dimensions are 4 ft. x 4 ft., and is ventilated along three sides with 1 1/2 inch slot hoods. Exhaust air flows to a 20 inch duct which also exhausts tanks A, C & D. (Tanks A and D were not evaluated). The ventilation for these tanks is provided by a 15 HP fan mounted inside the plant.

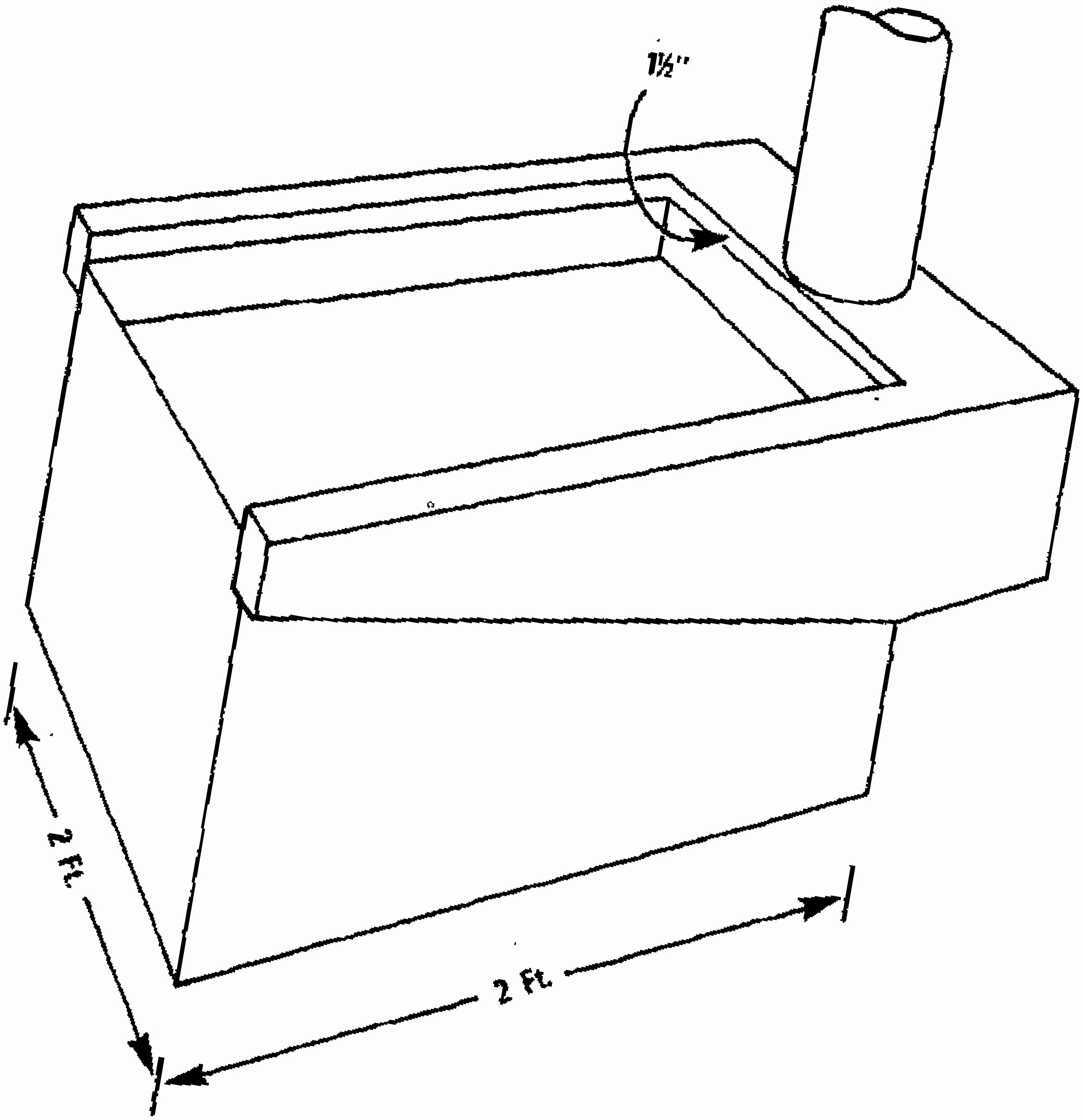

FIGURE 2: TANK B

Airflow Measurements

Airflow measurements for Tank B are presented in Table 1. Total airflow to the exhaust hood for Tank B was calculated to be 850 cfm, which corresponds to an exhaust rate of 55 cfm/ft^2.

Table 1

Airflow Measurements

Tank	Q Exhaust Air (cfm)	Q/A Exhaust Rate (cfm/ft^2)	ACGIH Recommendation (cfm/ft^2)
B (Jan)	850	55	250
C (Jan)	3030	100	250
E (Jan)	10,800	225	250
E (Nov)	11,730	240	250
F (Nov)	4500	60	250

Air Sampling Results

Air sampling data for Tank B are presented in Tables 2 and 3. The mean airborne concentration of CrVI was 0.66 mg/m^3. The mean concentration of sulfuric acid was 0.48 mg/m^3.

Table 2

Air Sampling Results - Hexavalent Chromium

Location	# Samples	Mean Concentration (mg/m^3)	Concentration Range (mg/m^3)
Tank B (Jan)	10	0.66	0.173 - 2.09
C (Jan)	9	0.039	0.015 - 0.079
E (Nov)	13	0.006	0.001 - 0.017
E (Jan)	4	0.007	0.0003- 0.0014
F (Jan)	12	0.087	0.009 - 0.340
F (Nov)	12	0.014	0.0003- 0.050
General Area (Jan)	4	0.017	0.009 - 0.031
General Area (Nov)	8	0.002	0.0004- 0.0047

Table 3

Air Sampling Results - Sulfuric Acid

Location	# Samples	Mean Concentration (mg/m^3)	Concentration Range (mg/m^3)
Tank B (Jan)	10	0.48	0.17 - 1.4
C (Jan)	8	0.30	0.13 - 0.36
E (Jan)	15	0.38	0.21 - 0.60
F (Jan)	23	0.82	0.53 - 1.28
F (Nov)	12	0.12	0.15
General Area (Jan)	4	0.18	0.15 - 0.27
General Area (Nov)	2	0.10	0.10

Discussion

A few of the chromium levels measured at Tank B in January approached and exceeded the OSHA Personal Exposure Limit (PEL) of 0.1 mg/m^3[5] and also exceeded the NIOSH recommendation of 0.025 mg/m^3. It is suspected that the background levels of CrVI in the plant were higher during the January survey when the plant doors were kept shut to conserve heat. (During the summer months, doors were kept open for natural, general dilution ventilation). The resulting lack of make-up air and a higher plating rate in January may explain the higher concentrations.

Additionally, the higher concentrations reported for Tank B could have resulted from faulty plenum design. The tank used 3-sided ventilation with air drawn across one-half of the tank, on the side closest to exhaust duct. This may have contributed to the low capture velocities measured at the front of the tank.

The ACGIH[6] recommends an exhaust rate of 250 cfm/ft^2 for free standing tanks with slot hoods exhausting chromic acid. The exhaust rate measured at Tank B was considerably less: 55 cfm/ft^2. An increased ventilation rate may be needed at this tank.

The mean sulfuric acid concentration 0.48 mg/m^3 was, less than 50% of the OSHA PEL of 1 mg/m^3.

Tank C

Tank C, shown in Figure 3, is located next to tank B. This tank measures 12 feet in length by 2 1/2 feet wide and is equipped with dual exhaust hoods along parallel sides of the tank. Exhaust air is discharged through a 20 inch duct to a larger duct carrying exhaust air from tanks A, B, C, and D. (Tank C was evaluated only during the January survey).

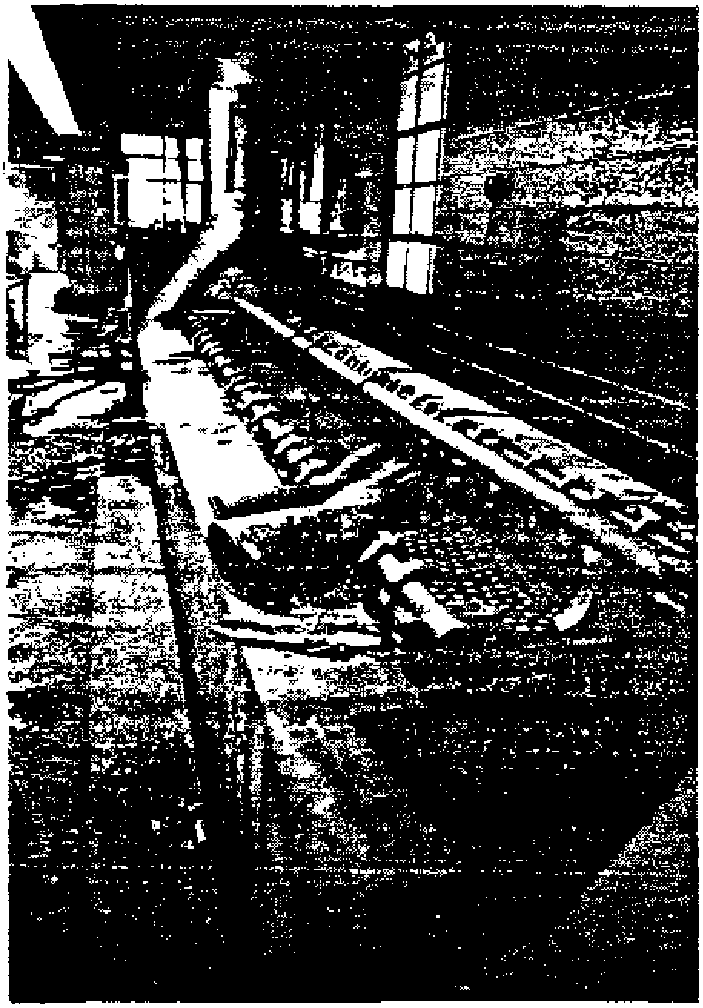

Figure 3. Tank C

Airflow Measurements

Airflow measurements for Tank C are presented in Table 1. Total airflow to the exhaust hood was 3030 cfm, with a corresponding exhaust rate of 100 cfm/ft^2.

Air Sampling Results

Airborne CrVI and sulfuric acid concentrations are reported for Tank C in Tables 2 and 3. The mean concentration of CrVI was 0.039 mg/m^3. Sulfuric acid samples averaged 0.30 mg/m^3.

Discussion

Chromium and sulfuric acid air sampling results for Tank C indicated much better contaminant control than for tank B. The exhaust rate (100 cfm/ft^2) was relatively better than that for Tank B, but still fell short of the ACGIH recommendation of 250 cfm/ft^2. The slightly improved exhaust rate at Tank C may be attributed to the tank's configuration and ventilation design. Unlike Tank B, Tank C is long and narrow with dually exhausting slot hoods along the length of the tank.

Tank E

Tank E, shown in Figure 4, is 12 feet long by 4 feet wide by 6 feet deep. It is equipped with four 6 foot long exhaust hoods with 2 inch wide slots extending along the length of the tank. Additionally, the rear tank edge has an 8 inch partial cover, inclined at a 45° angle extending from the top of the slot to the top of the rear anode bar. The partial cover is designed to reduce the effective surface area of the tank, thus increasing the velocity of air entering the hood. This tank also contained plastic balls to prevent excessive vapor evolution at the surface.

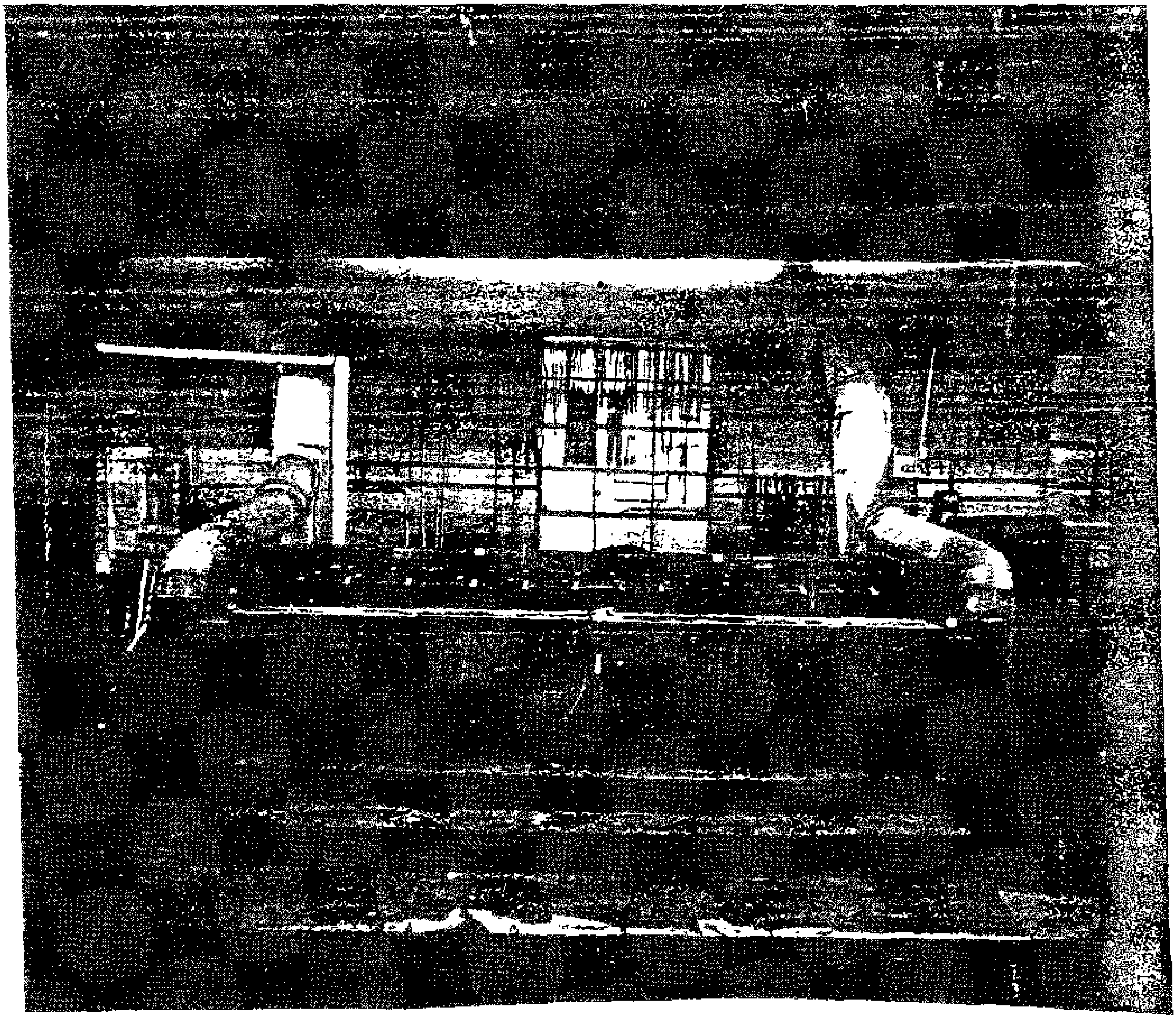

Figure 4 - Tank E

Airflow Measurements

Airflow measurements for tank E are reported in Table 1. Total air exhausted from tank E was 11,730 cfm. The tank exhaust rate was 240 cfm/ft^2.

Air Sampling Results

Airborne concentrations of chromium and sulfuric acid are reported in Tables 2 and 3. Mean concentrations of chromium were 0.006 mg/m^3 during January and 0.007 mg/m^3 during November. The mean concentration of sulfuric acid was 0.38 mg/m^3.

Discussion

Examination of the air flow rates for these tanks will indicate that the effective control at tank E is attributable to the high exhaust rate, (240 cfm/ft^2) which closely aligns the ACGIH recommended exhaust rate of 250 cfm/ft^2.

Tank F

Tank F is 21 feet long by 4 feet wide by 6 feet deep. It is equipped with 2-sided lateral exhaust hoods with 2 inch slots and with partial covers along the length of both sides. Plastic balls float on the surface to reduce vapor emission. Exhaust air is carried through a 14 inch diameter duct to the fan.

Airflow Measurements

Airflow measurements for Tank F are reported in Table 1. Total air exhausted from Tank F was 4500 cfm (60 cfm/ft^2).

Air Sampling Results

Airborne concentrations of chromium and sulfuric acid for Tank F are reported in Tables 2 and 3. The mean concentration of chromium was 0.087 mg/m^3 during January, and 0.014 during November. The mean sulfuric acid concentration was 0.82 mg/m^3 during January, and 0.12 mg/m^3 during November.

Discussion

Reported mean values for airborne chromium were within the OSHA PEL of 0.1 mg/m^3, although a few values were above the limit. This may be expected from a tank of this capacity exhibiting an exhaust flow of only 4500 cfm. The exhaust ventilation at this tank could be redesigned to improve the exhaust rate, and hence, the control velocity.

Personal Monitoring

Airborne concentrations of CrVI and sulfuric acid in the breathing zones of the platers are reported in Tables 4 and 5. These samples were collected over an 8-hour day shift. Mean concentrations of all personal exposures to CrVI were well below the OSHA PEL and less than 25% of the level recommended by NIOSH(7) for an 8-hour time-weighted average exposure. Mean concentrations of personal exposures to sulfuric acid were less than 50% of the OSHA PEL and the NIOSH recommended concentration.

Table 4

Employee Exposure - Hexavalent Chromium

Employee	Job Title	No. of Days Sampled	8-hr TWA Concentration (mg/m^3)	Range (mg/m^3)
A	Plater	4	0.004	0.001 - 0.009
B	Plater	4	0.006	0.001 - 0.014
C	Plater	2	0.001	0.001
Mean Exposure			0.004	
OSHA PEL[5]			0.100	
ACGIH TLV[8]			0.050	
NIOSH Rec[7]			0.025	

Table 5

Employee Exposure - Sulfuric Acid

Employee	Job Title	No. of Days Sampled	8-hr TWA Concentration (mg/m^3)	Range (mg/m^3)
A	Plater	4	0.433	0.109 - 0.903
B	Plater	4	0.421	0.107 - 0.967
C	Plater	2	0.128	0.110 - 0.145
Mean Exposure			0.327	
OSHA PEL[5]			1.0	
ACGIH TLV[8]			1.0	
NIOSH Rec[7]			1.0	

Conclusions

Experience has demonstrated that safe and healthful working environments within electroplating operations involving potentially harmful chemical agents can be achieved with the use of effective engineering control technology. The engineering controls in use at Greensboro Industrial Plating include double side draft ventilation hoods and 3-sided exhaust hoods for contaminant control. The 2-sided hoods were more effective for control of chromium than were the 3-sided hoods and the general dilution ventilation consisted of open doors and windows to allow entry of outside air during the warmer seasons. For tanks of the configuration present at this facility, with chromic acid as the major hazard of concern, the exhaust rate recommended by the ACGIH Ventilation Committee is 250 cfm/ft^2. This exhaust rate is recommended to achieve a control velocity of 150 ft/min. Only one of the tanks surveyed approached this exhaust rate. However, the air sampling data indicated that employee exposures were controlled within the OSHA PEL and the NIOSH recommended standard. It is possible that higher exhaust rates than those observed are required for higher production rates than those occurring at the time of the survey.

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