

IN-DEPTH SURVEY REPORT #1

Honeywell, Incorporated  
Minneapolis, MN

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NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH  
Division of Physical Sciences and Engineering  
Engineering Control Technology Branch  
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PURPOSE OF SURVEY: To evaluate engineering control technology used in a captive plating and cleaning operation.

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STANDARD INDUSTRIAL CLASSIFICATION OF PLANT: 3822

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## ABSTRACT

An indepth control technology survey of plating and cleaning operations was conducted at the Honeywell (Golden Valley) residential division plant in Minneapolis, Minnesota. Honeywell plates only parts produced at this plant and these parts are used in control devices (heating thermostats and fan heat limit switches) and small air cleaning devices (light duty electrostatic precipitators). Four plating and cleaning lines were studied, including a manual line for chrome, an automatic zinc line, a manual silver line, and a manual barrel line for copper, nickel, bright nickel and tin. Primary airborne hazards were chromium VI, nickel, silver, cyanide, sulfuric acid, nitric acid, hydrochloric acid, and sodium and potassium hydroxides. The indepth study consisted of the assessment of the overall control system, primarily local exhaust ventilation and process automation.

## INTRODUCTION

This survey, conducted in the summer with outside daytime temperatures of 65 to 75°F, evaluated local exhaust ventilation and process automation in a captive plating and cleaning operation. Twenty-eight workers, covering two shifts, were employed in the plating shop. Small, irregular-shaped workpieces for electrical devices are cleaned and plated in one of five separate plating lines, occupying approximately 10,000 square feet of a 23.5 acre manufacturing area under roof. These separate plating lines consist of one automatic rack mechanism for low cyanide zinc plating; one automatic barrel arrangement for non-cyanide zinc plating; two separate manual lines - one for silver and one for chrome plating; and a manual barrel line for plating miscellaneous metals such as copper, nickel, bright nickel, and tin. Four of the five processes were selected for study based upon the unique control techniques employed and the hazard potential of substances used; these are: the low cyanide (automatic rack), manual chrome and silver lines, and the manual barrel line.

Each plating line was studied as a separate entity and is described independently.

## CASE STUDY A

### MANUAL CHROME LINE

#### INTRODUCTION

The cleaning tank and two electroplating tanks in the manual chrome line were studied. The cleaning tank contained a solution of sodium hydroxide and was equipped with a lateral exhaust ventilation system and a cover. The two plating tanks contained chromic acid and were ventilated using a push/pull technique. During the survey the chrome line was not in production so dummy loads were inserted in the tanks to simulate operations.

#### PROCESS

Parts for plating are transferred from the manufacturing area in large metal or wooden crates, brought into the plating area by a fork lift, and placed as close as possible to the plating line. The parts plated are primarily steel stampings; small, odd-shaped pieces used for electrical control devices.

The manual chrome line consists of an alkaline electrocleaner tank, a chrome strip tank, two chrome tanks, and intermediate rinse tanks. Only the alkaline cleaner and the two chrome tanks were evaluated. The electrocleaner solution contains sodium hydroxide and the chrome plating tanks contain chromic acid. Because there was no production on the chrome line during the survey, dummy loads were placed in the tanks to simulate regular operations.

#### HAZARD ANALYSIS

The primary hazards from the manual chrome line are sodium hydroxide and sulfuric acids. Sodium hydroxide (caustic soda) is a white solid, soluble in water, and can be inhaled as a dust or mist. It is capable of irritating the nose, producing pneumonitis, burning the eye or skin, and causing temporary loss of hair. Sodium hydroxide is very corrosive to body tissue, and chronic exposure to dilute solutions may result in dermatitis. Toxic effects are

limited to local tissue damage.<sup>1,2</sup> Chromic acid is chromium trioxide (chromic acid anhydride) and its aqueous solutions. Hexavalent chromium exists in solution with hydrogen ions and is considered to be in the noncarcinogenic form. Airborne hexavalent chromium compounds can cause irritation of the respiratory tract, ulceration and perforation of the nasal septum, epistaxis, skin ulceration, chronic asthmatic bronchitis, and eye injury. Chromic acid can cause cracks or breaks in the skin which are commonly referred to as "chrome holes" or "chrome ulcers", and chromic acid mist may also discolor the teeth and tongue.<sup>2-7</sup>

Sulfuric acid ( $H_2SO_4$ ) is a colorless, odorless liquid soluble in water and alcohol. Concentrated sulfuric acid can cause rapid damage to mucous membranes, is exceedingly dangerous to the eyes, and can burn and char the skin and mouth. Diluted  $H_2SO_4$  is irritating to the skin and may cause scarring of the skin and blindness. Inhaled sulfuric acid can cause etching of dental enamel and edema of the lungs and throat. Chronic exposure can lead to health problems such as emphysema and rhinorrhea.<sup>1,2</sup>

## EVALUATION

To determine the effectiveness of the controls used in the cleaning and chrome plating operations, area air samples were collected at fixed locations next to the cleaning and plating tanks and subsequently analyzed for sodium hydroxide, hexavalent chromium, and sulfuric acid. Samples for sodium hydroxide were collected using 37 mm closed-faced cassettes with teflon filters and MSA Model G personal sampling pumps operating at 1.5 Lpm. Sodium hydroxide was determined by analyzing for total sodium using atomic emission spectrophotometry (NIOSH Method S-381).<sup>8</sup> Hexavalent chromium was collected using closed-faced cassettes with 37 mm polyvinylchloride filters of 5  $\mu$ m pore size and MSA Model G personal pumps operating at 1.5 Lpm and analyzed colorimetrically by NIOSH Method No. P & CAM 169.<sup>9</sup> Sulfuric acid was collected using 7 mm diameter silica gel tubes and DuPont P-200 personal sampling pumps operating at 200 cc/m and analyzed using ion chromatography (NIOSH Method No. P & CAM 339).<sup>9</sup> Samples on the chrome line were collected from 1 to 5 hours.

Air velocity and total airflow were determined for each of the tanks. Control velocities were measured in the vertical plane at the front of the tank using a Kurz hotwire anemometer; total airflow was determined from air velocity at the slots in the exhaust hoods and total slot area.

#### ELECTRO CLEANING TANK CP2

Tank CP2 shown schematically in Figure 1, and on the right in Figure 2 contains sodium hydroxide (NaOH) electrocleaner solution of 8.0 oz/gal at a temperature of 150°F. The tank is 30 inches by 30 inches by 34 inches deep and contains 115 gallons of NaOH solution; the liquid level is 3-1/2 inches below the top of the tank.

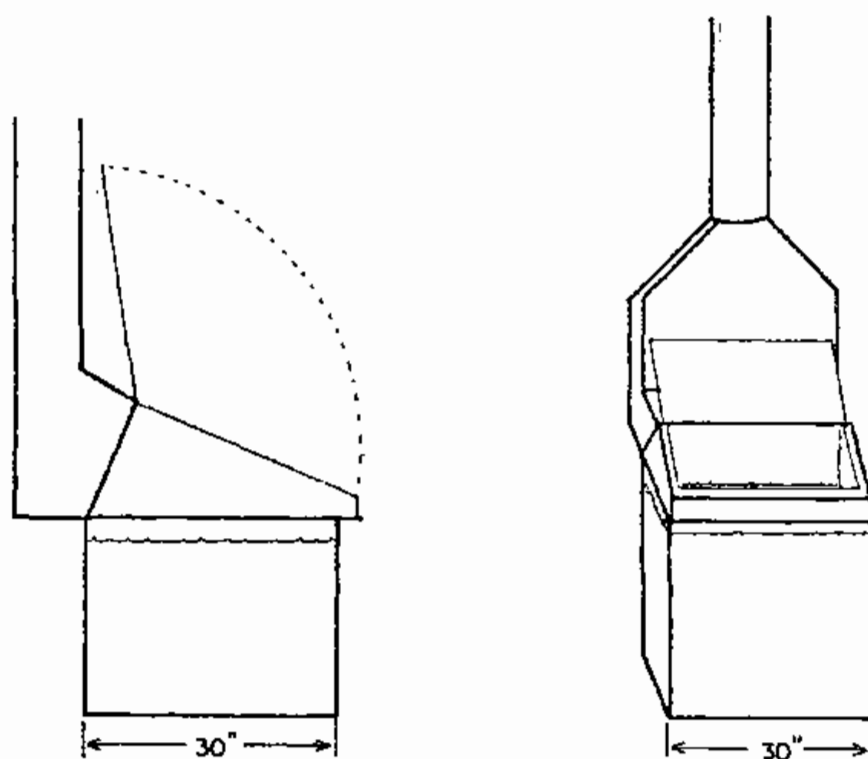


Figure 1. Tank CP2



Figure 2. Tank CP2.

The tank is equipped with a local exhaust hood and a cover. The exhaust air is vented through a 1 foot by 2-1/2 foot opening in the hood, through the plenum, and to a 9-inch diameter exhaust duct. The cover is lifted to allow loading and unloading of parts; a small gap between the cover and the tip edge of the tank allows ventilation air to be drawn across the tank when the cover is closed.

#### Airflow Measurements

Air velocity measurements were taken with the covers open and closed. Velocity measurements with the cover open are shown in Table 1. With the cover open, capture velocities ranged from 40 to 100 fpm across the front of the tank. With the cover closed, capture velocities along the front of the tank ranged from 200 to 450 fpm. Total airflow with the hood open was calculated to be 900 cfm or 140 cfm/ft<sup>2</sup>. Industrial Ventilation<sup>10</sup> recommended an airflow of 190 cfm/ft<sup>2</sup> for tanks (without covers) containing alkaline cleaning solutions at 160 to 210°F.



Table 1. Tank CP2 air velocity measurement (ft/min).

Distance From Exhaust Hood	2 in. from left	7-1/2 in. from left	Center	7-1/2 in. from right	2 in. from right
Face"	240	400	425	400	325
6"	120	160	240	170	150
13"	80	120	150	105	80
20"	40	80	90	80	40
Front lip of tank	40	50	100	40	40

### Air Sampling Results

Area samples for sodium hydroxide were taken at two locations along the front of the tank (approximately seven inches above the top of the tank). Six area samples were collected with no parts in the tank. The results in Table 2 show sodium hydroxide levels averaged  $0.02 \text{ mg/m}^3$  with no parts in the tank; however, when a dummy load was inserted in the tank, NaOH concentration averaged  $0.54 \text{ mg/m}^3$ . This higher value is due to one sample taken on the right side. Even with the tank operating, the concentrations were below the allowable limit of  $2.0 \text{ mg/m}^3$ . Although area samples can not readily be used to estimate compliance with the legal standard, they are a valuable indicator of the effectiveness of control system for the plating tanks.

Table 2. Air sampling results - sodium hydroxide ( $\text{mg/m}^3$ ).

Sample Location	No. of Samples	Sodium Hydroxide	Comment
Tank CP2 Mean	6	0.02	No parts in tank
Tank CP2 Mean	2	0.54	Dummy load inserted
OSHA PEL		2.0	
TLV		2.0	

## DISCUSSION

Electrolytic cleaning solutions containing sodium hydroxide have a moderate hazard potential and a medium mist evolution rate. For this type of solution Industrial Ventilation recommends a minimum control velocity of 75 fpm and a total exhaust rate of 190 cfm/ft<sup>2</sup>. This assumes no cover on the tank. The air sampling data shows that sodium hydroxide mists were very low with no parts in the tank and were satisfactorily controlled while the tanks were operating. Based on very limited data, a cover along with local exhaust ventilation may be necessary to control NaOH mist. The cover appeared to improve ventilation in two respects: it blocked the vertical rise of NaOH mist, and while closed, control velocities increased from an average of 50 fpm to an average 350 fpm.

### ELECTROPLATING TANKS CP5 and CP6

Chromic acid Tanks CP5 and CP6, shown in Figures 3 and 4, contain 31 oz/gal chromic acid and 0.2 to 0.3 oz/gal sulfate. The tanks are 36-inches by 30-inches by 44-inches-deep and are equipped with push-pull exhaust ventilation systems. Push air is supplied through 3.5-inch-diameter PVC pipes with 0.5-inch diameter orifices on 2-inch centers. The push air pipe manifold covers only about two of the three feet of Tank CP5, resulting in 11 supply air orifices along the front of Tank CP5 and 18 orifices along Tank CP6. The exhaust hood extends along the back of both tanks but is too short to cover the left six inches of tank CP5 and the right six inches of Tank CP6. The exhaust slot opening is approximately 6-inches high.

Exhaust air is vented through the plenum to a 14-inch-diameter duct. Fluid levels in both tanks were five inches below the top of the tanks. Bath temperatures were 110°F in CP5 and 130°F in CP6. During the sampling period dummy loads were placed in Tanks CP5 and CP6. On the right half of Tank CP6, there is a gap (approximately 12-square-inches) between the tank flange and the exhaust hood. Both tanks are air agitated and do not contain floating plastic balls.

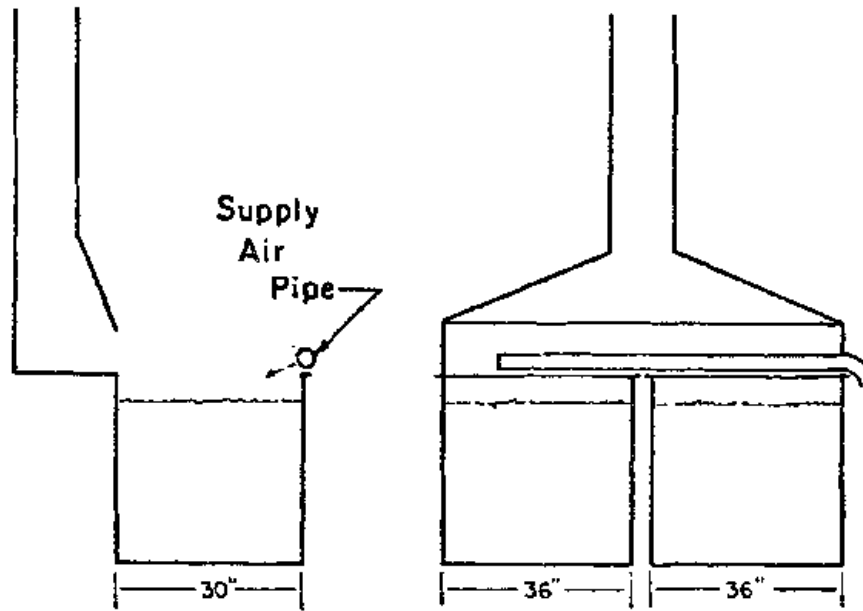


Figure 3. Tank CP5 and CP6.



Figure 4. Tank CP5 and CP6.

## CP5 AND CP6

### Airflow Measurements

Control velocities measured at the front of Tank CP5 averaged 50 fpm (Table 3) and ranged from less than 30 to 100 fpm. Total exhaust volume was approximately 900 cfm or 120 cfm/ft<sup>2</sup> (250 cfm/ft<sup>2</sup> is recommended by Industrial Ventilation for open surface tanks containing chromic acid). The amount of push air ( $q_0$ ) discharged for Tank CP5 was estimated to be 25 cfm. This discharge air jet entrains additional air as it moves to the exhaust hood. The quantity of discharge air plus entrained air reaching the exhaust hood is calculated to be 160 cfm (using Hemeon's formula presented in Table 3). According to Hemeon the exhaust rate ( $Q$ ) should always exceed the amount of induced air ( $q_x$ ) in a successfully operating push/pull system.  $Q$  exceeds  $q_x$  for tank CP5.

Control velocities for Tank CP6 averaged 30 fpm and ranged from 10 to 50 fpm. The total exhaust rate was 800 cfm or 110 cfm/ft<sup>2</sup>. The amount of push air ( $q_0$ ) discharged by the blower pipe of Tank CP6 was estimated to be 40 cfm, and the amount of induced air ( $q_x$ ) reaching the exhaust hood of Tank CP6 was calculated to be 260 cfm. The exhaust rate ( $Q$ ) of 800 cfm exceeded  $q_x$  and thus satisfied Hemeon's recommendations.

Table 3. Airflow measurements.

Tank	Q Exhaust Air (cfm)	Q/A Exhaust Rate (cfm/ft <sup>2</sup> )	Control Velocity (f/m)	$q_0$ Airflow From Blower Pipe (cfm)	$q_x^*$ Total airflow from blower pipe reaching exhaust hood	$Q > q_x$
CP5	900	120	50	25	160	Yes
CP6	800	110	30	40	260	Yes

\* $q_x$  is calculated from Hemeon's formula  $q_x/q_0 = 0.83 (X/W) 0.36$ .  
 $x$  = distance from blower pipe to exhaust hood;  $w$  = slot width (ft)<sup>9</sup>

## Air Sampling Results

Area air sampling results for Tank CP5 are shown in Table 4. Chromium VI concentrations taken along the front of the tank above the air blower ranged from 0.005 to 0.082 mg/m<sup>3</sup> and averaged 0.029 mg/m<sup>3</sup>. Four of five samples were less than the allowable limits for personal exposures of 0.05 mg/m<sup>3</sup> while one exceeded it (0.082 mg/m<sup>3</sup>).

Area samples for Tank CP6 showed chromium VI concentrations ranging from 0.08 to 1.62 mg/m<sup>3</sup> and averaged 0.56 mg/m<sup>3</sup>. Samples taken above the blower pipe (see Table 4) ranged from 0.08 to 0.22 mg/m<sup>3</sup> and averaged 0.14 mg/m<sup>3</sup>. Samples taken below the blower pipe, but above the lip of the tank ranged from 0.20 to 1.25 mg/m<sup>3</sup> and averaged 0.72 mg/m<sup>3</sup>. Two samples at the front center of the tank were 0.58 and 1.6 mg/m<sup>3</sup>.

Four sulfuric acid samples taken above the blower pipe on Tank CP6 ranged from 0.04 to 0.23 mg/m<sup>3</sup> and averaged 0.12 mg/m<sup>3</sup>. This is well below the allowable limit for personal exposures of 1.0 mg/m<sup>3</sup> sulfuric acid. No personal samples were collected on the chrome line because the tanks were not in production.

## DISCUSSION

A major reason for higher emissions from Tank CP6 is the higher chromium VI mist evolution due to the higher bath temperature, 130°F (CP6) and 110°F in CP5. The push/pull ventilation system at the exhaust volume used was inadequate for chromic acid solutions at 130°F. The same ventilation system on a CP5 tank was marginal but may be satisfactory with increased exhaust volumes.

Samples taken above and below the blower pipe on Tank CP6 show chromic acid levels much higher (5 times) below the pipe than above it. The blower should act like an ejector pulling room air from above and below the blower pipe and blowing it across the tank. However, because of the way the push air jet is directed, chromic acid mist is blown toward the anode bar and bounces back

into the gap between the push air pipe and the top edge of the tank. It appears supply (blower) air is increasing dispersion of chromic acid mist.

The existing push/pull system as designed and used is not recommended, however slightly higher exhaust volume, redirection of supply air jet, decreased supply air volume, extension of the exhaust hood along the length of the tank, and repair of the gap in the back of the tank should improve control of hexavalent chromium. Sulfuric acid mists from Tank CP6 were controlled satisfactorily.

Table 4. Air sampling results - Chromium VI and sulfuric acid.

Sample Location	No. of Samples	Chromium VI (mg/m <sup>3</sup> )	Sulfuric Acid (mg/m <sup>3</sup> )	Notes
Tank CP5 Mean	6	0.029	---	Dummy Parts
Tank CP6 above Mean	5	0.141	0.12	Dummy parts
Tank CP6 below Mean	7	0.715	---	Dummy parts
OSHA PEL		0.1	1.0	
ACGIH TLV		0.05	1.0	
NIOSH Recommended		0.025	1.0	

## CASE STUDY B

### AUTOMATIC RACK LINE

#### INTRODUCTION

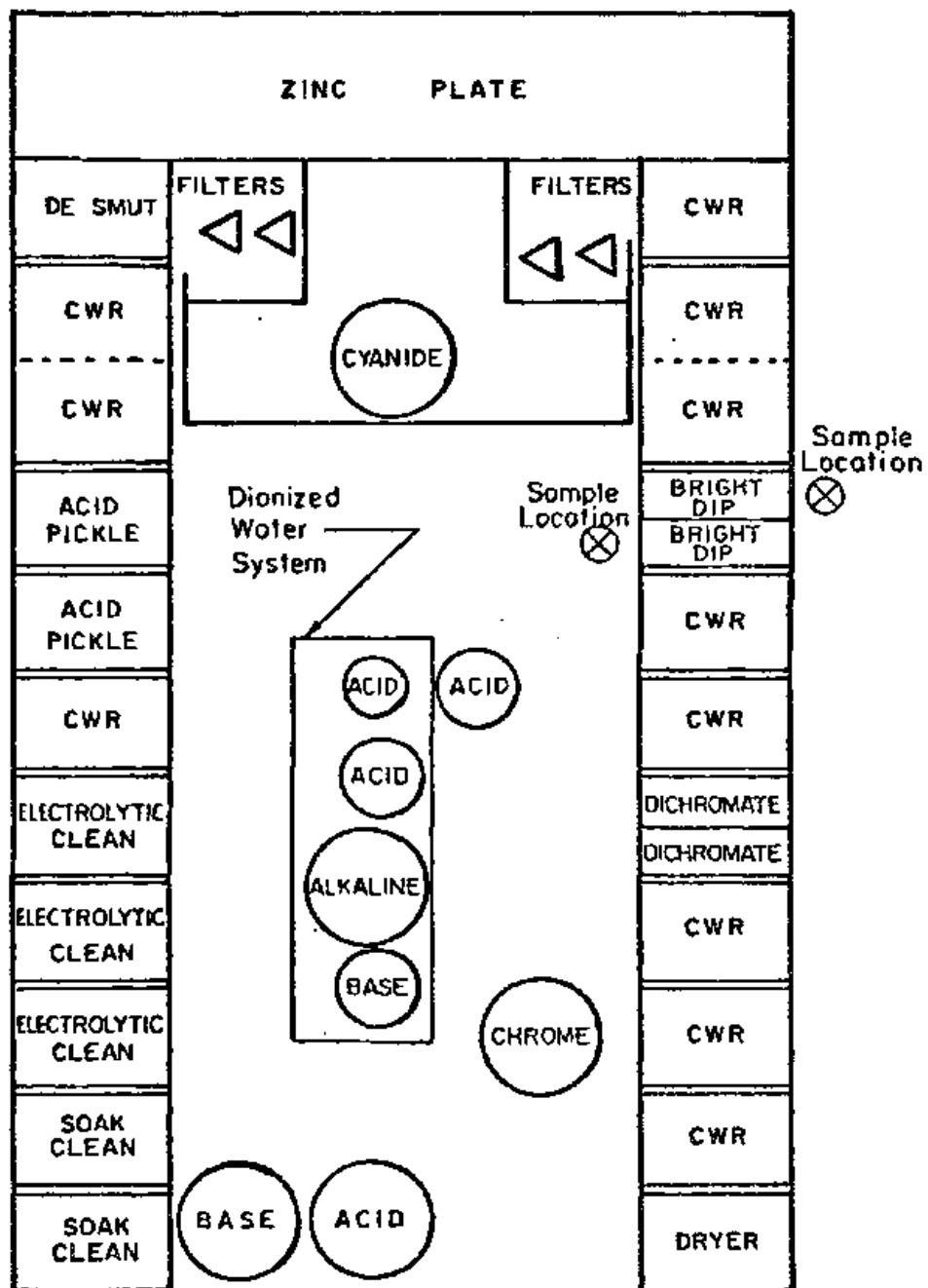
An automatic rack line for low cyanide zinc plating was evaluated. Although the zinc plating line is essentially automatic, except for the manual addition of chemicals to the tanks, the potential release of plating mists and fumes into the general work area is a major concern. Three tanks on the plating line were studied - one large tank containing a low cyanide zinc plating solution and two "bright dip" tanks containing primarily nitric acid. The zinc plating tank is equipped with local exhaust ventilation, but the two bright dip tanks have no local ventilation or other engineering controls. These tanks were evaluated to determine the effectiveness of engineering controls on the zinc tank as well as the need for controls on the "bright dip" tanks.

#### PROCESS

The automatic rack line shown in Figure 5 consists of a series of soak and electrolytic cleaners, acid pickle, de-smut, zinc plating bright dip, and dichromate tanks. Parts are hung by the workers at the open end of the horse-shoe-shaped plating line and taken off the racks at the end of the line. The line is completely automated; other than the occasional addition of chemicals to the tanks no one needs to work directly over or next to the tanks.

#### HAZARD ANALYSIS

The major potential hazards from the automatic rack line were cyanide, sodium hydroxide, nitric acid, and nitric oxides. The cyanides of principal concern include hydrogen cyanide (HCN) and simple salts of hydrogen cyanide, e.g., sodium, potassium, and copper cyanide, which may come in contact with an acid releasing HCN gas. HCN, when inhaled, or cyanide salts when ingested, can cause immediate collapse. High concentrations of cyanides can cause death due to chemical asphyxia at the cellular level and cessation of respiration. Lower concentrations can cause headaches, weakness, confusion, nausea, and vomiting.



RACKING / UNRACKING AREA

Figure 5. Automatic rack line.



Other effects are slow gasping respiration and eye and skin irritation.<sup>1,2,12</sup>

Sodium hydroxide (caustic soda) is a white solid, soluble in water, and can be inhaled as a dust or mist. It is capable of irritating the nose, producing pneumonitis, burning the eye or skin, and causing temporary loss of hair. Sodium hydroxide is very corrosive to body tissue, and chronic exposure to dilute solutions may result in dermatitis. Effects are limited to local tissue damage.<sup>1,2</sup>

Nitric acid is a colorless, yellow or red fuming liquid with an acrid, suffocating odor. It causes eye, mucous membrane and skin irritation; delayed pulmonary edema; pneumonitis; bronchitis; and dental erosion. Its extremely corrosive nature can produce burns and ulcers of the skin, eye, and mucous membranes.

Nitrogen dioxide is a dark brown gas that can irritate the eyes and nasal passages and produce an acid taste. Acute exposures may produce death preceded by symptoms of weakness, a cold feeling, nausea, abdominal pain, coughing, severe cyanosis, accelerated heart action, and convulsions. In some cases, nitrogen dioxide may produce dyspnea, cyanosis, vomiting, vertigo, and unconsciousness without pulmonary edema.

Nitrogen oxide (or nitric oxide) is a colorless gas that is rapidly oxidized in the presence of oxygen. Because it oxidizes to other oxides of nitrogen such as nitrogen dioxide (which is a much more serious hazard), it is a significant contaminant when found in the workplace. Methemoglobinemia may be caused by nitrogen oxide.<sup>1,2,12,13</sup>

#### EVALUATION

To determine the effectiveness of the controls or the need for controls, area air samples were collected for three consecutive days at fixed locations next to the zinc plating and "bright dip" tanks.

These samples were analyzed for total zinc, total sodium, particulate cyanide, and nitric and hydrochloric acids. Total zinc and total sodium were collected using closed-faced cassettes with 37 mm teflon filters and MSA Model G personal pumps operating at 1.3 to 1.5 Lpm. Particulate cyanide was collected using closed-faced cassettes with 37 mm polyvinylchloride filters and MSA Model G personal pumps at 1.3 to 1.5 Lpm. Nitric and sulfuric acid were collected using 7 mm diameter silica gel tubes and DuPont P-200 personal pumps operating at 200 cc/m. Filter samples were collected for 4 to 7 hours and tube samples from 6-8 hours.

Zinc was analyzed using atomic absorption spectrophotometry and sodium was determined by atomic emission spectrophotometry following NIOSH Method No. P & CAM 173.<sup>9</sup> Samples for particulate cyanide were analyzed using an ion specific electrode NIOSH Method S-250.<sup>8</sup> Nitric and hydrochloric acids were analyzed by ion chromatography (IC) according to NIOSH Method No. P & CAM 339.<sup>9</sup>

Air velocity and total airflow were determined for the canopy hood and slot hood of the zinc plating tank. Using a Kurz hot-wire anemometer, air velocities were measured in the vertical plane at the front of the tank across from the slot hood, at the slots in the exhaust hoods, and in horizontal planes below the canopy hood.

#### ZINC PLATING TANK

The zinc tank contains a low cyanide zinc plating solution consisting of 1 to 1.5 oz/gal zinc metal, 10 to 12 oz/gal sodium hydroxide, and 3 oz/gal or less total cyanide at a bath temperature of 85°F. The tank, shown schematically in Figure 6, is approximately 50 feet long by 5 feet, 4 inches wide and 5 feet deep, and holds 9,450 gallons of solution. In the plating operations the automatic rack machine lowers the racks into the solution at one end, moves the rack through the solution to the other end (slot hood end), and raises the rack out of the tank.

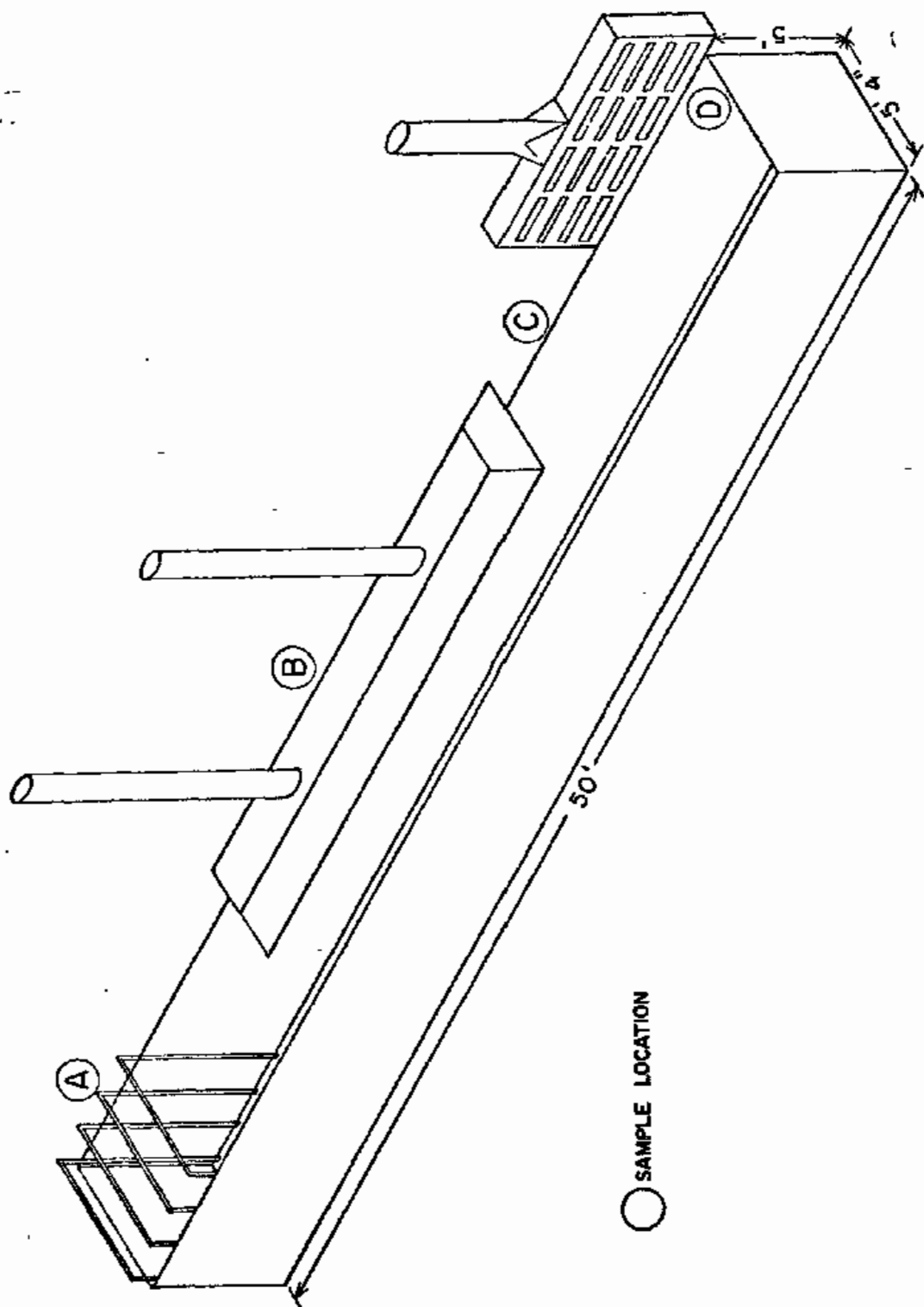


Figure 6. Zinc plating tank.



Figure 7. Slot exhaust hood.

#### Airflow Measurements

The zinc plating tank is ventilated with a canopy exhaust hood and a slot exhaust hood shown in Figures 6 and 7. The canopy hood is approximately 20 feet by 4 feet, and is located over the middle portion of the tank. The hood has two separate exhaust ducts. The average face velocity was 60 fpm. The total exhaust airflow of the canopy hood was calculated from the face velocity to be 4,800 cfm.

The canopy hood is approximately 30 inches above the tank. Measurements 20 inches below the hood and 10 inches above the tank show capture velocities averaging about 20 fpm, indicating the canopy hood acts only as a recovery hood capturing only mists and fumes that rise vertically into the hood.

The zinc tank is also equipped with a slot exhaust hood 9.5-feet-wide by 4-feet high with a 1-foot deep plenum. The hood has 16 slots, each 3-inches by 24-inches. The hood draws across the 5.3 foot width of the tank. Total airflow exhausted by the hood was calculated to be 3,200 cfm. The capture velocity measured at the front of the hood (across from the hood at 1 foot above

the tank edge) ranged from 10 to 45 fpm and averaged 30 fpm. The slot velocity averaged 400 fpm and the plenum velocity (vertical) was calculated to be 340 ft/min. Thus, the plenum velocity is 0.85 of the face velocity. The Industrial Ventilation<sup>10</sup> recommends the maximum air velocity in the plenum should be 0.5 the slot velocity or less for good air distribution. To achieve the ratio of 0.5 and improve air distribution, the slot areas would need to be reduced.

#### Air Sampling Results

Area samples for total zinc, total sodium, and particulate cyanide taken on the zinc plating tank are shown in Table 5. Samples were taken at 4 locations (see Figure 6) around the tank each day for three days. Levels for all substances sampled were near or below the detectable limit. Total zinc concentration averaged 0.005 mg/m<sup>3</sup>, sodium hydroxide concentrations averaged 0.08 mg/m<sup>3</sup> and all the particulate cyanide concentrations were less than 0.006 mg/m<sup>3</sup>.

Table 5. Air concentrations - zinc plating tank (mg/m<sup>3</sup>).

Location	Mean Total Zinc	Mean Total Sodium Hydroxide	Mean Particulate Cyanide	Number of Samples
AR 12-19 A*	0.006	0.11	< 0.006	3
AR 12-19 B*	< 0.004	0.02	< 0.006	3
AR 12-19 C*	0.005	0.10	< 0.006	3
AR 12-19 D*	0.004	0.08	< 0.006	3
Grand mean	0.005	0.08	< 0.006	
OSHA PEL	15.0	2.0 as NaOH	5.0 (skin) as CN	
NIOSH Recommended		2.0 (ceiling)	5.0 (ceiling)	

\*See Figure 6 for sample location.

## Discussion

The data indicates that mists and fumes from the zinc tank are well controlled with the present ventilation system. The ventilation system (the canopy hood and slot hood) may not be necessary for the low cyanide zinc system under normal operating conditions; however, the ventilation system may well be necessary to control noxious odors and as a precautionary measure in case cyanide is liberated through the inadvertent addition to the tank of a reactive chemical such as an acid.

## BRIGHT DIP TANKS

The two "Bright Dip" Tanks 23A and 23B, which were also evaluated, contained 1 percent (by volume) nitric acid and a proprietary chemical for brightening. The solutions were maintained at room temperature and a pH of 1.5 to 1.8. The two tanks were identical and each had a capacity of 350 gallons. The tanks were used alternately; as one tank filled up with nitric acid solution, the other would empty. There was no ventilation or other engineering controls associated with the two tanks.

## Air Sampling Results and Discussion

Six area samples for nitric acid and hydrochloric acid were taken at the "Bright Dip" Tanks, 23A and 23B. Two samples were taken each day for three days at sample locations shown in Figure 5. The results in Table 6 show an average nitric acid ( $\text{NO}_3$ ) level of  $0.05 \text{ mg/m}^3$  and hydrochloric acid ( $\text{HCl}$ ) level of  $0.14 \text{ mg/m}^3$ . These levels are greatly below the TLV for those substances. It is also possible that oxides of nitrogen are given off by the "Bright Dip" tanks; however, most of the  $\text{NO}_x$  would be converted to nitric acid in the sampling tube and would be included in the concentration for nitric acid.

Table 6. Air concentrations -  
bright dip tank (mg/m<sup>3</sup>).

	HNO <sub>3</sub>	HCl
	0.03	0.54
	0.03	0.16
	0.03	<0.006
	0.05	<0.006
	0.10	0.006
	0.05	0.006
Mean	0.05	0.14
OSHA PEL	5	7 (ceiling)
NIOSH Rec.	5	--

The results indicate that ventilation is not needed for this "Bright Dip" operation.

## CASE STUDY C SILVER LINE

### INTRODUCTION

Small electronic component parts, including limit switches and thermostat controls, are manually cleaned and silver plated over a copper base. The operations on this line are characterized by good work practices and a high rate of exhaust ventilation with resultant low employee exposure to plating bath vapors and mists.

### PROCESS DESCRIPTION

#### Operations

The silver plating process is performed manually by one plater. The unplated, small parts are typically received pre-boxed on pallets, and are manually transferred from the pallets to a bucket-type screen basket for precleaning.

The pretreatment process consists of several cleaning steps to prepare the base metal for plating. The layout plan and area sample locations of the silver plating line are shown in Figure 8. The pretreatment sequence follows:

1. Soak clean - parts are immersed in a hot caustic solution containing an alkaline cleaner to remove any traces of oil and grease.
2. Warm water rinse - alkaline cleaner is removed.
3. Acid dip ("pickle") - residual oxide film from the alkaline cleaner is removed.
4. Cold water rinse - acid is removed.
5. Cold water rinse - acid is removed.



# ⊗ Sample Locations

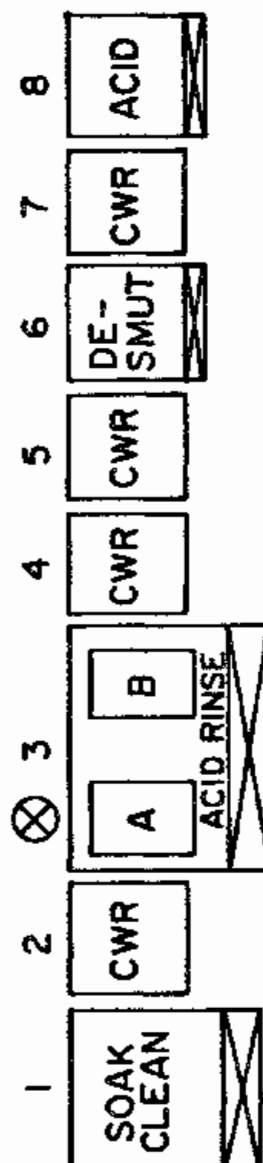
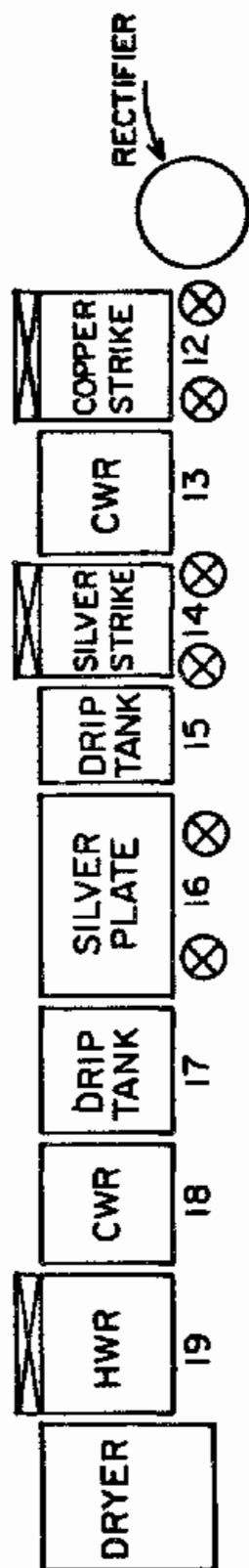


Figure 8. Manual silver line .

6. De-smut - caustic soda bath to remove films of smut resulting from the acid dipping step.
7. Cold water rinse.

Following the cleaning steps the parts are emptied from the screen basket to a horizontal barrel for plating. Direct current is distributed to the parts through horizontal dangles suspended from a current-carrying bar along the longitudinal axis of the barrel. The plating sequence follows:

1. Copper strike - assures adhesion of the silver to the base metal (approximately 3 to 5 minutes).
2. Cold water rinse.
3. Silver strike - gives main silver bath better adhesion (approximately 1 minute).
4. Silver plate - (approximately 30 minutes).
5. Cold water rinse.
6. Warm water rinse
7. Dry - parts are transferred from the barrel to a screen basket for oven-drying.

After drying, the parts are transferred from the screen basket to a paper-lined receptacle for transport.

#### Tank Description

There are 16 tanks on the silver line: 3 plating tanks, 4 cleaning tanks, and 9 rinse tanks. Plating Tanks 12 and 14 are served by the same rectifier while plating Tank 16 is served by a separate rectifier. All of the cleaning tanks

are equipped with local exhaust ventilation. Plating Tanks 12 and 14 are locally exhausted while Tank 16 is not.

#### Tank Constituents

The cleaning and plating baths contain a variety of constituents over a range of concentrations. All are operated at room temperature, with the exception of the copper strike, which is maintained at a temperature of 110°F. Constituents of the cleaning and plating solutions are identified in Table 7.

Table 7. Tank constituents.

Tank No.	Description	Constituents	Concentration
SP 3A	Acid pickle	Hydrochloric acid	35%/vol
SP 3B	Acid pickle	Nitric acid Sulfuric acid	30 % 30%
SP 6	De-Smut	Potassium cyanide Potassium Hydroxide	1 oz/gal 6 oz/gal
SP 12	Copper strike	Copper cyanide Potassium cyanide Potassium hydroxide Rochel-Tex	Copper metal: 3 oz/gal Cyanide: 1-1/2 oz/gal 8%/vol
SP 14	Silver strike	Silver cyanide Potassium cyanide Potassium carbonates (impurity)	Silver metal: 0.3-0.5 oz/gal Cyanide: 7-9 oz/gal 6 oz/gal
SP 16	Silver plate	Silver cyanide Potassium cyanide Potassium carbonates	Silver metal: 3 oz/gal Cyanide: 9 oz/gal 12-14 oz/gal

## HAZARD ANALYSIS

The primary hazards of the silver plating operation include mists of hydrochloric, nitric and sulfuric acid, caustic potassium hydroxide and cyanides.

The acid mists are all highly irritating to the eyes, skin, and mucous membranes. When in contact with skin and other body tissues these acids can produce dermatitis on repeated exposure, as well as burns and ulceration. Inhalation of acid mists can cause severe pulmonary irritation, including edema, pneumonitis, and bronchitis.

Potassium hydroxide is highly corrosive to body tissues. Dermatitis may result from repeated exposures to dilute solutions of liquids or mists.

Copper cyanide, potassium cyanide and silver cyanide, when in contact with acid, may release hydrogen cyanide gas. Hydrogen cyanide gas, when inhaled, or cyanide salts when ingested, can cause headache, nausea, asphyxiation, and death. Inhalation or ingestion of silver cyanide may cause argyria, a permanent discoloration or pigmentation of body tissues, especially the skin and eyes. Cyanide salts of any kind can cause immediate collapse.

## EVALUATION

Control effectiveness for the manual silver line was determined by the collection of air samples over a 3-day period. Personal samples for total cyanide, total copper, and total silver were collected each day during the day shift. Area samples were collected for the above substances plus nitric, hydrochloric, and sulfuric acid at fixed locations on the front lips of the plating tanks. Sample times were 2 to 5 hours.

Samples for cyanide, copper, and silver were collected on 37 mm, 5 micron polyvinyl chloride filters using MSA Model G and DuPont P-4000 personal sample pumps at a flow rate of approximately 1.5 L/min. The cyanide concentration was determined by leaching the filters with 10 mL 0.1 N sodium hydroxide (NaOH) and analyzed using a cyanide ion specific electrode NIOSH Method P & CAM 116<sup>9</sup>.

Following cyanide determination, the sample, including filter, were treated with nitric acid and perchloric acid and analyzed for copper and silver using atomic absorption spectrophotometry (AAS) according to NIOSH Method No. P & CAM 173.

Samples for nitric hydrochloric and sulfuric acid were collected using 7 mm diameter silica gel tubes and Dupont P-200 personal pumps operating at 200 cc/min and analyzed by ion chromatography (IC) according to NIOSH Method No. P & CAM 339.

Air velocity and total airflow was determined for each of the plating tanks. Air velocities were measured in the vertical plane in the front of the tank, at the centerline of the tank, and at the slots in the exhaust hoods.

### CLEANING TANK 3

Tank SP3, shown in Figure 9, is a (4' X 3') tank containing two smaller tanks (3A and 3B) suspended in a water bath. Tank 3A contains hydrochloric acid and Tank 3B contains a solution of nitric acid and sulfuric acid. The tanks were maintained at room temperature. The larger tank, SP3, (also shown in Figure 10) is equipped with a semilateral take-off slot hood. Contaminated air is exhausted from the plenum through an 8-inch duct to the fan.

### Airflow Measurements

Total airflow exhausted from Tank 3 was 900 cfm. At the front edge of the tank the capture velocity ranged from 25 to 100 ft/min and averaged 55 ft/min. This value is less than the ACGIH Industrial Ventilation recommendation of 75 to 100 ft/min for this type of hood and hazard classification. The exhaust rate for the entire surface of Tank 3 is  $71 \text{ cfm/ft}^2$ . The calculated exhaust rate for Tanks 3A and 3B would also be  $71 \text{ cfm/ft}^2$  for each tank surface; however, because Tanks 3A and 3B were 15-inches from the exhaust hood (see Figure 9), the actual exhaust rates across the surface of the two tanks were less. The actual exhaust rate across 3A and 3B is estimated to be approximately  $40 \text{ cfm/ft}^2$ .

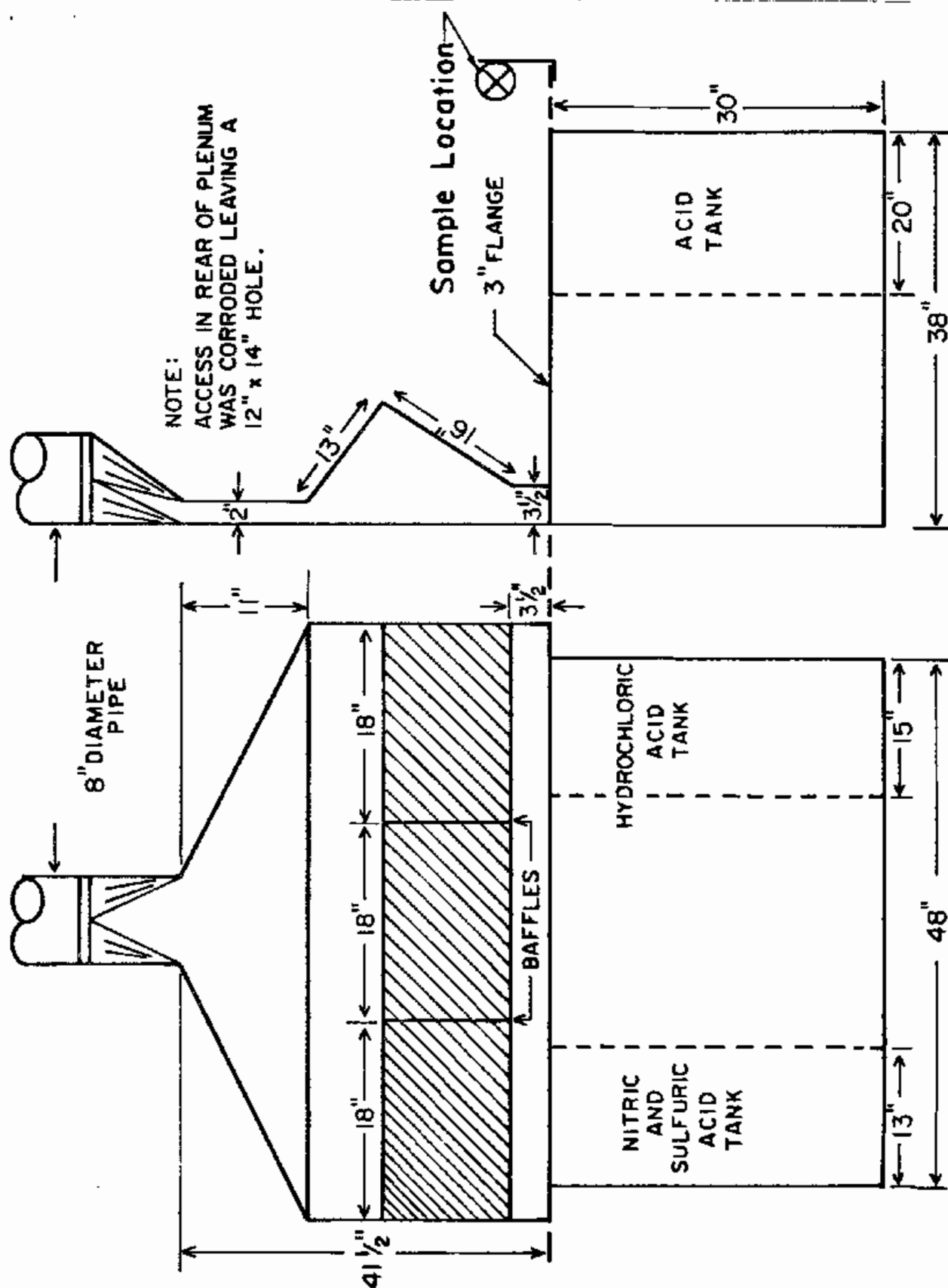


Figure 9. Acid tanks (SP3A and 3B).



Figure 10. Silver line - tanks SP1 and SP3.

#### Air Sampling Results

Mean concentrations reported for nitric acid and sulfuric acid were  $0.03 \text{ mg/m}^3$  and  $0.01 \text{ mg/m}^3$ , respectively. Chloride ion concentration was  $0.05 \text{ mg/m}^3$ . All concentrations reported were well within the OSHA PEL for these substances.

The sampling results indicate that the exhaust rate at Tank 3 is effective in controlling airborne acid mists. Although the control velocity does not meet the ACGIH Industrial Ventilation guidelines of 75 to 110 ft/min, the acid mists were well-controlled. The acid evolution rate was probably not great enough to require a control velocity greater than this value.

#### ELECTROPLATING TANKS 12 and 14

Tanks SP-12 and SP-14 (copper strike and silver strike) are shown in Figures 11 and 12. Each tank is equipped with a single slot ventilation hood with a center baffle. Tank SP-12 has a 9-inch slot and Tank SP-14 has a 6-inch slot.

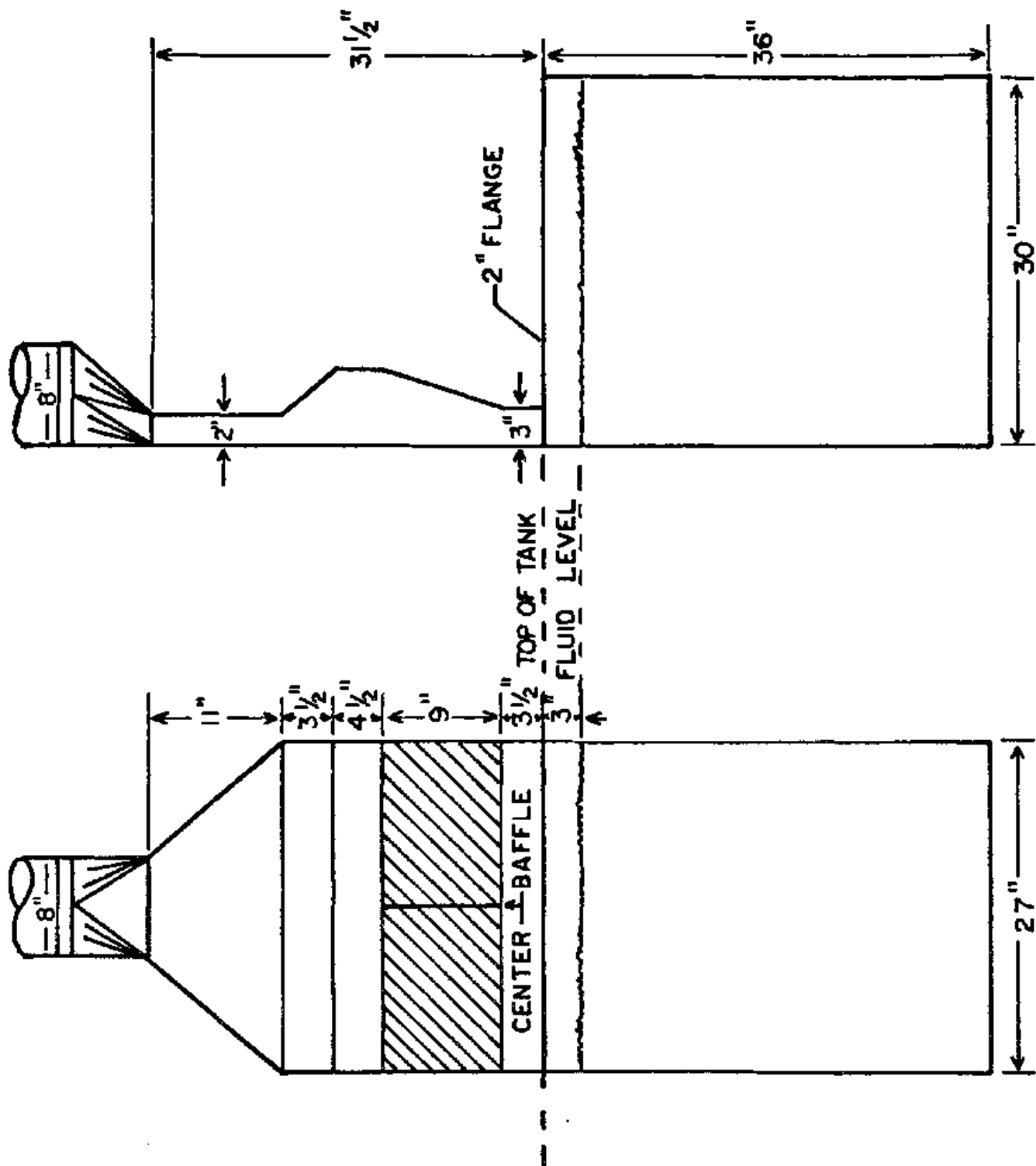


Figure 11. SP 12



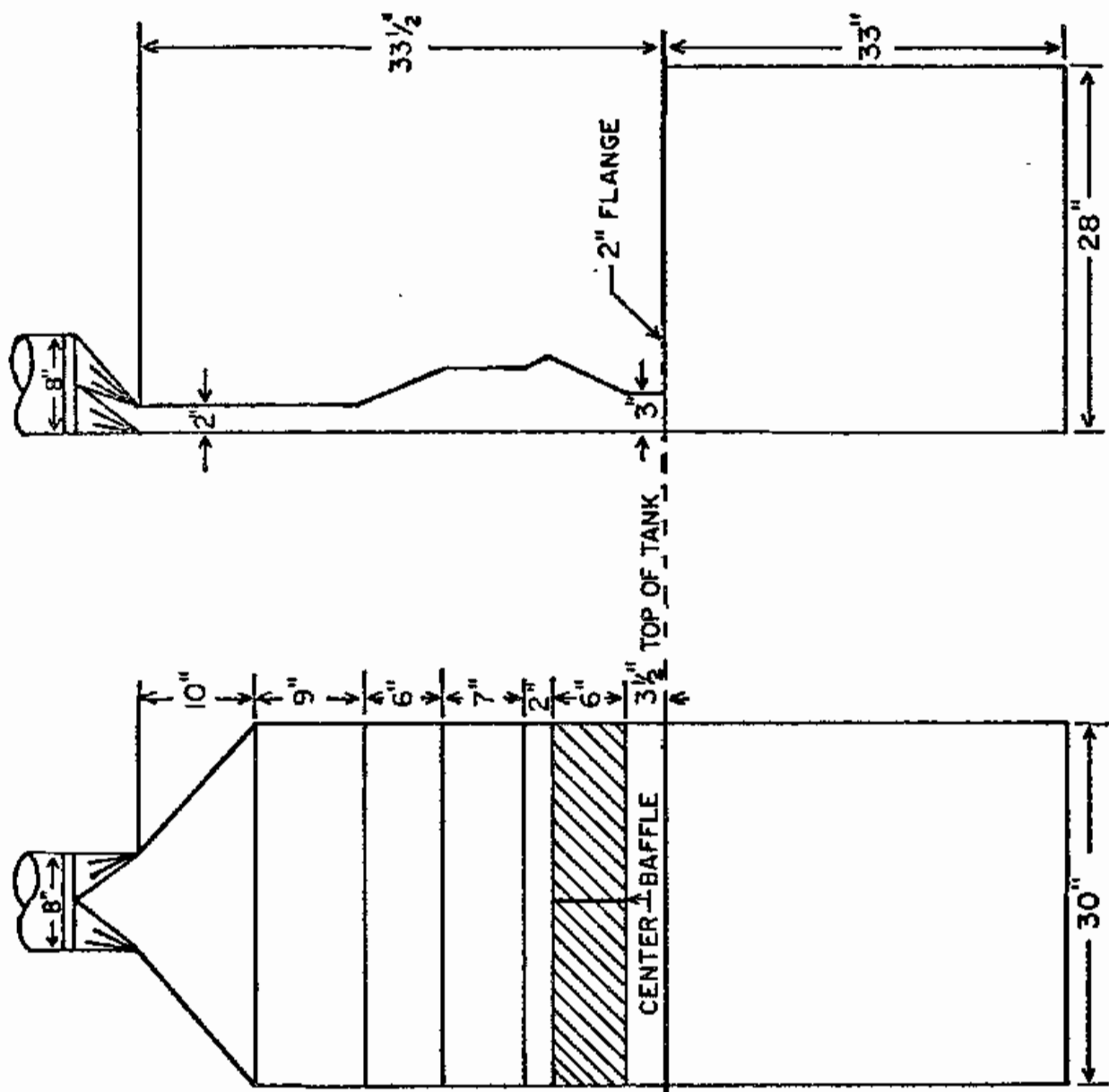


Figure 12. SP 14

Air is exhausted from the plenum through an 8-inch duct to the fan. Tank 12 operates at pH of 13.1 and temperature of 110°F and Tank 14 operates at pH of 10 to 11 and room temperature. Neither tank is agitated nor has plastic balls.

#### Airflow Measurements

##### Tank 12--

The capture velocity, measured 10 inches above the front edge of the tank varied from 0 to 40 fpm with the zero measurements obtained on the left side and center of the baffle. At 10 inches above the middle of the tank, the capture velocity averaged 25 fpm. The average slot velocities for the left and right sides of the baffle were 190 fpm and 150 fpm, respectively. It is suspected that an interferring draft may have disturbed the airflow at the front left edge of the tank, thereby directionally reducing the exhaust flow to the slot on this side. The total airflow to the slot hood was calculated to be 290 cfm (see Table 8).

##### Tank 14--

The capture velocity, measured 10 inches above the front edge of the tank, averaged 25 fpm. At 10 inches above the middle of the tank, the capture velocity averaged 70 fpm. The average slot velocities for the left and right sides were 590 fpm and 525 fpm. The total airflow to the slot hood was calculated to be 700 cfm.

Table 8. Airflow measurements.

Tank	Q Exhaust Air (cfm)	Q/A Exhaust Rate (cfm/ft <sup>2</sup> )	Control Velocity (f/m)
12	290	48	11
14	700	117	20

## Air Sampling Results

Personal and area sampling results for cyanide, copper, and silver are presented in Table 9. Mean concentrations for all samples were below the analytical method's limit of detection which, in this case, is less than 0.01 mg per filter. Therefore the concentrations reported were all less than the OSHA PEL for these compounds.

## Discussion

The sampling data indicated good control of the chemical hazards from Tanks 12 and 14. Contaminant control was effected by providing a sufficient rate of local exhaust to capture mists and vapors at or near their point of evolution.

Table 9. Workplace air concentrations.  
Silver line - Tanks 12, 14, and 16.

Date	Sample Location	No. of Samples	Mean 8-Hour TWA Concentrations (mg/m <sup>3</sup> )		
			Cyanide	Copper	Silver
8/12-14	Plater*	3	<0.01	<0.01	<0.008
8/12-14	Tank 12	3	<0.01	<0.01	--
8/12-14	Tank 14	3	<0.01	<0.01	<0.006
8/12-14	Tank 16	3	<0.01	--	<0.005
	OSHA PEL		5.0	1.0	0.01

\*Personal sample.

## ELECTROPLATING TANK 16

Tank SP-16 (silver plate) is 2.5 feet by 5-feet, has a capacity of 280 gallons, and is operated at a pH of 12 and room temperature. The tank is not equipped with local exhaust ventilation and is agitated only by the rotation of the barrel. Air sampling data shows the same airborne concentrations (0.01 mg/m<sup>3</sup>) for cyanide and silver as indicated for Tanks 12 and 14. These results are significantly below the OSHA PEL for these substances.

## DISCUSSION

The sampling results indicate that ventilation is not needed for SP-16, the silver plating tank. It may be surmised that the relatively high current densities required for the copper and silver strike operations warrant more extensive engineering control than is needed for the lower current silver plating tank. Although during normal operating conditions, fumes from Tank 16 are not a problem, it is recommended that ventilation be added to provide some protection in case a reactive chemical such as acid is inadvertently added to the tank and hydrogen cyanide released.

The sampling data demonstrate that the chemical hazards from Tanks 3, 12, and 14 were adequately controlled by the exhaust hoods in place. The control velocities at these tanks were not uniform suggesting disruptive cross currents in the building.

## CASE STUDY D

### MISCELLANEOUS BARREL LINE

#### INTRODUCTION

Nickel is barrel plated on miscellaneous small steel parts to provide a decorative and corrosion protective coating. Several preparatory steps are required -- precleaning, copper strike -- before the nickel plate is applied.

#### PROCESS DESCRIPTION

##### Operations

The miscellaneous barrel line is manually operated by a single plater. The parts to be plated undergo several pretreatment steps prior to the final nickel plating operation. The plater transfers small parts (armatures, hubs, and stop assemblies, clips, terminals, clamps, levers) from pallets to a 12-inch diameter screen basket. The screen basket is then manually lowered into the first cleaning tank.

The pretreatment process is as follows:

1. Soak clean - hot alkaline cleaner removes oil or solid soil from work-pieces.
2. Water rinse - alkaline cleaner is removed.
3. Acid pickle - residual oxide film from the alkaline cleaner is removed.
4. Cold water rinse.
5. Cold water rinse.
6. De-smut - caustic soda bath to remove films of smut resulting from the acid pickle step.

7. Cold water rinse.

8. Cold water rinse.

Following precleaning, the parts are loaded into a barrel for plating. The barrel is attached to a manually-operated hoist which travels along on overhead monorail and lowers the barrel into the plating bath. Direct current is applied to the parts through horizontal suspensions from a current-carrying bar at the longitudinal axis of the barrel.

The plating sequence is as follows:

1. Copper strike - improves bonding for nickel deposition (approximately 10 minutes).
2. Nickel plate - (approximately 90 minutes).
3. Bright nickel plate - gives bright finish.
4. Hot water rinse - manual, in screen baskets.
5. Dry - (approximately 5 minutes).

When dry, the parts are transferred to a paper-lined pallet for transport.

Figure 13 shows the layout plan and area sample locations of the miscellaneous barrel line.

#### Tank Description

There are 13 tanks on the miscellaneous barrel line: 3 plating tanks, 5 cleaning tanks, and 5 rinse tanks. All of the cleaning tanks (MS 1, 2, 4, 5, and 8) are ventilated. Plating Tanks MB-11 and MB-13 are equipped with slot exhaust hoods, while Tanks MB-15 and MB-18 are not locally exhausted.

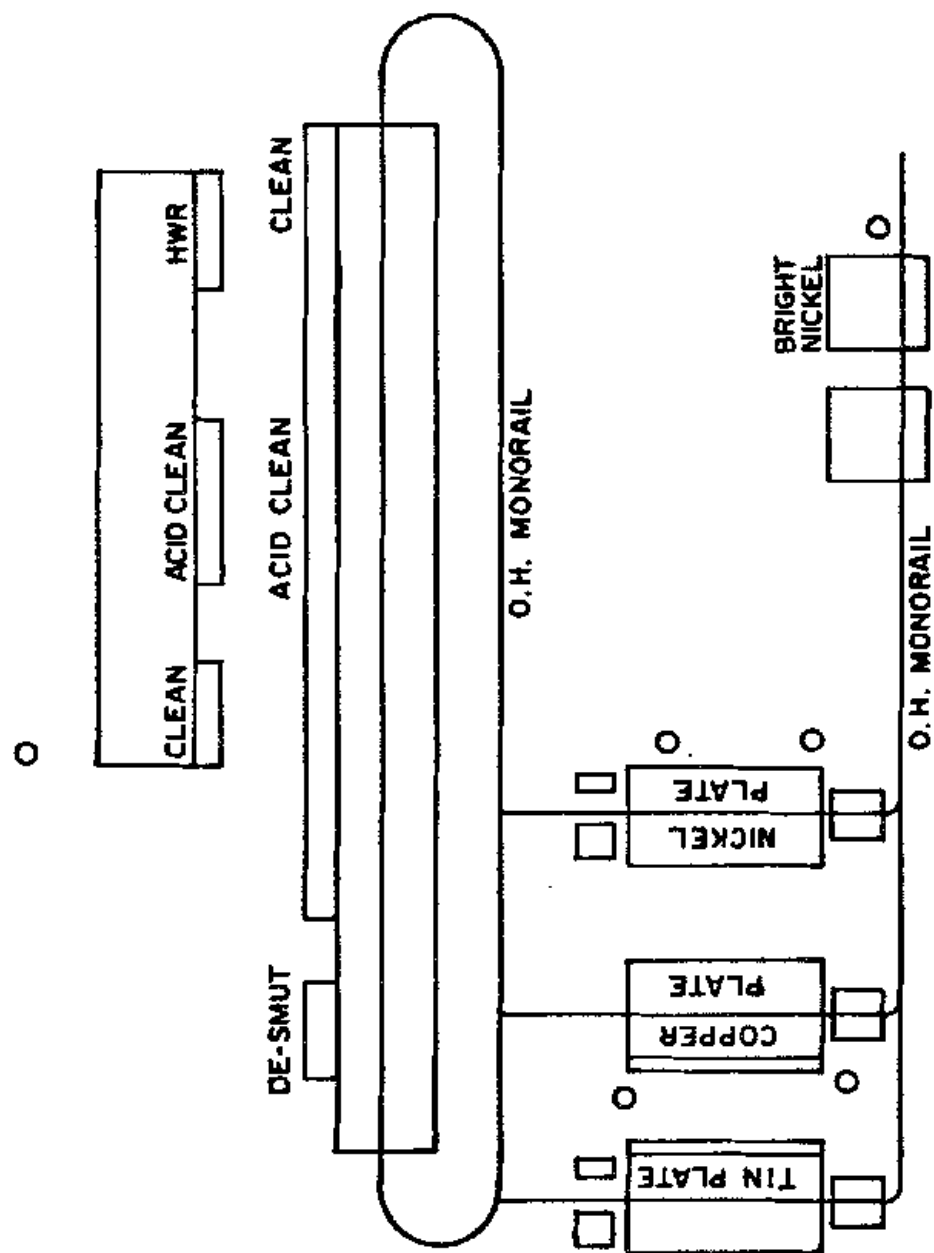


Figure 13. Miscellaneous barrel line.

Table 10. Tank constituents.

Tank No.	Description	Constituents	Concentration
MB-1, 2	Soak clean	Sodium hydroxide Potassium hydroxide Detergent Wetters, fillers, buffers	8 oz/gal
MB-4, 5	Acid pickle	Hydrochloric acid	17% vol.
MB-8	De-smut	Potassium hydroxide	
MB-11	Tin plate	Potassium stannate Potassium hydroxide	
MB-13	Copper strike	Copper cyanide Potassium cyanide Potassium hydroxide Rochelle salts Brightener (proprietary)	Copper metal: 3 oz/gal  Cyanide: 1-1/2 oz/gal
MB-15	Nickel plate	Nickel sulfate Nickel chloride Sulfuric acid Boric acid [Watts bath (grey)]	Nickel metal: 10 oz/gal.  5 oz/gal.
MB-18	Bright nickel	Nickel sulfate Nickel chloride Sulfuric acid Boric acid	Nickel metal: 10 oz/gal.  5 oz/gal.

## HAZARD ANALYSIS

The hazards associated with the miscellaneous barrel line can be grouped into the following categories: acids and alkalis, cyanides, and nickel compounds. The acids include hydrochloric and sulfuric, both highly irritating to the eyes, skin, and mucous membranes. Inhalation of acid mists may cause bronchitis, laryngitis, and pulmonary edema. Skin contact may cause ulcers and scarring upon repeated exposure. The alkalis, potassium hydroxide, and sodium hydroxide, are highly corrosive to body tissues and particularly irritating to the nose, eyes, and skin. Repeated exposures may cause dermatitis.<sup>1, 5</sup>



Copper and potassium cyanide, when in contact with acid, may release hydrogen cyanide gas. Hydrogen cyanide when inhaled can cause headache, nausea, asphyxiation, and death.<sup>1, 5</sup>

Nickel compounds can produce sensitization dermatitis, allergic asthma, pneumonitis, and cancer of the lung and nasal cavities. "Nickel itch" affects the fingers, hands, wrists, and arms.<sup>1, 5</sup>

## EVALUATION

To evaluate control effectiveness at the miscellaneous barrel line, air samples were collected and ventilation measurements were made. Personal samples for copper, nickel, and cyanide were collected during three 8-hour day shifts. Area samples for these substances plus potassium hydroxide and sulfuric and hydrochloric acid were collected at fixed locations approximately 10 inches above the front lip of each plating and cleaning tank. Samples were collected from 2.5 to 6 hours.

Samples from the copper, nickel, and cyanide were collected on 5 um pore size, 37 mm polyvinylchloride filters using MSA Model G personal sampling pump operated at 1.5 Lpm. Copper and nickel analysis was made by atomic absorption spectrophotometry according to NIOSH Method P & CAM 173<sup>9</sup>. Cyanide determination was made using a cyanide ion specific electrode according to NIOSH Method P & CAM 116.<sup>9</sup> Sulfuric acid (bright nickel bath) was collected on 0.8 um, 37 mm mixed cellulose ester filters using MSA Model G personal sampling pumps operated at 1.5 Lpm and analyzed by ion chromatography according to NIOSH Method P & CAM 268.<sup>9</sup>

Hydrochloric acid was collected using 7 mm diameter silica gel tubes and DuPont P-200 personal sampling pumps operated at 0.2 Lpm. Analysis was by ion chromatography according to NIOSH Method No. P & CAM 330.<sup>9</sup> Potassium hydroxide was collected on 37 mm Teflon filters using a MSA Model G personal sampling pump operated at 1.1 to 1.6 Lpm. Analysis was by atomic emission spectrophotometry according to NIOSH Method No. 173<sup>9</sup> (UBTL Method No. N173).

Slot and control velocity measurements were made along with total airflow determination for each of the plating and cleaning tanks equipped with exhaust hoods. Control velocities were measured in the vertical plane at the front of each tank using a Kurz hot wire anemometer. Total airflow was determined from slot velocities and slot areas.

#### CLEANING TANKS

Cleaning Tanks 1 through 8 (numbered from right to left) on the miscellaneous barrel line are pictured in Figure 14. Sampling and ventilation measurements were made on Tanks 2, 4, and 5. Tanks 2 (alkaline clean bath at 145°F), and 4 and 5 (acid clean bath at room temperature and a pH less than 1.0) have 12 inch by 1-1/2 inch multi-slotted hoods connected by a common plenum. The alkaline and acid tanks are separately exhausted through 12-inch ducts. Tank 2 is 6-feet by 4-feet by 2-feet, 8-inches; Tanks 4 and 5 are 3-feet by 4-feet by 2-feet, 8-inches.

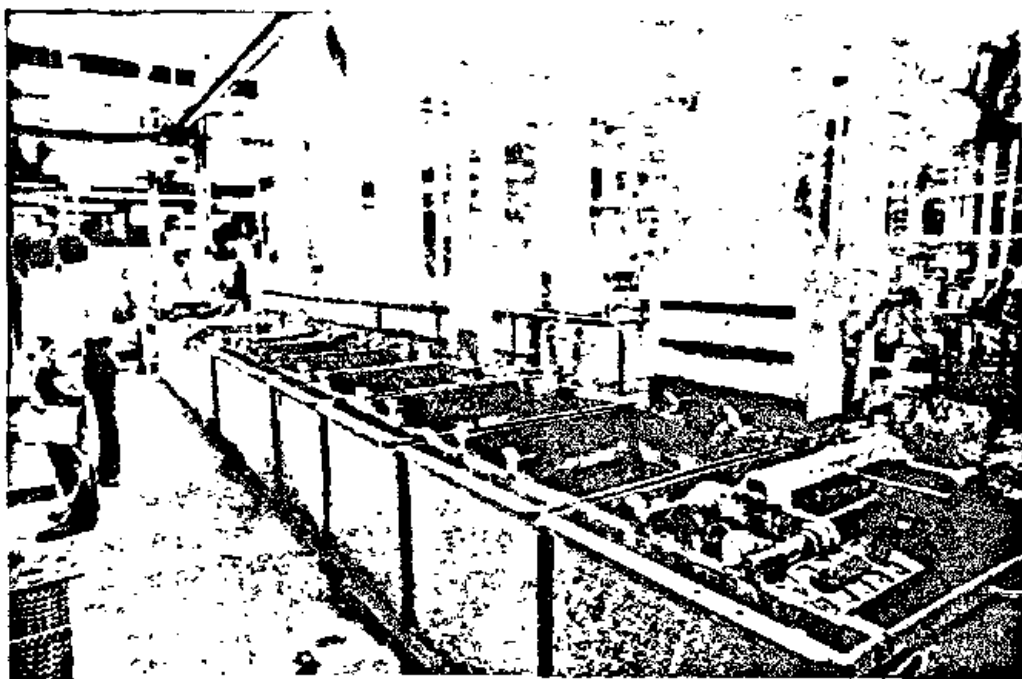


Figure 14. Cleaning tanks MB 1-8.

## Airflow Measurements

Airflow measurements for cleaning Tanks 2, 4, and 5 are presented in Table 11. Total air exhausted for Tanks 2, 4, and 5 was 1,900 cfm, 970 cfm, and 920 cfm, respectively. The exhaust airflow rates for these tanks were 80 cfm/ft<sup>2</sup>, 80 cfm/ft<sup>2</sup>, and 80 cfm/ft<sup>2</sup>. Control velocities at the sampling locations at the front of all three tanks was approximately 20 to 25 fpm.

Table 11. Airflow measurements.

Tank	Q Exhaust Air (cfm)	Q/A Exhaust Rate (cfm/ft <sup>2</sup> )	ACGIH Recommended Exhaust Rate (cfm/ft <sup>2</sup> )	Control Velocity (fpm)	Slot Velocity (fpm)
2	1,900	80	175	25	1,530
4	970	80	250	20	1,550
5	920	80	250	20	1,475
13	4,860	140	110	50	2,780

## Air Sampling Results

Air sampling results for the miscellaneous barrel cleaning line are presented in Table 12. Airborne concentrations of potassium hydroxide were below 0.02 mg/m<sup>3</sup>, and airborne levels of hydrochloric acid ranged from 0.01 to 0.80 mg/m<sup>3</sup> - all significantly below the OSHA PEL.

Table 12. Workplace air concentrations (mg/m<sup>3</sup>).

Location	KOH	HCl	CN	Cu	Ni	H <sub>2</sub> SO <sub>4</sub>
MB-2	<0.02	--	--	--	--	--
MB-4	--	0.22	--	--	--	--
MB-5	--	0.28	--	--	--	--
MB-13	--	--	<0.01	<0.01	--	--
MB-15	--	--	--	--	<0.006	--
MB-18	--	--	--	--	<0.004	0.01
Mean	<0.02	0.25	<0.01	<0.01	<0.005	0.01
OSHA PEL		7	5	1	1	1
ACGIH TLV	2	7	5	1	0.1	1
NIOSH			5 (ceiling)		0.015	1

### Discussion

The air sampling data indicate low levels of alkaline and acidic cleaning solution mists in the workroom air. These samples were taken to assess any emission of caustic hydroxide which may cause dermal or upper respiratory irritation. There is no regulatory limit for potassium hydroxide, however, the ACGIH TLV is 2.0 mg/m<sup>3</sup>.

The air sampling data suggest good contaminant control despite low control velocities at the front edge of each tank (Table 11). The calculated exhaust rates for Tanks 2, 4, and 5 were considerably less than the ACGIH Industrial Ventilation<sup>10</sup> minimum recommendation of 175 to 250 cfm. It is suspected that the control was interrupted by a competing air current produced by a fan blowing toward the front of the tanks. (The fan was installed to provide employee comfort.) Despite the low control velocities and interfering air current, the low levels of hydroxide and hydrochloric acid were evidence that these materials were easily controlled.

### Electroplating Tank 13

Plating Tank 13 (copper plate) is 9 feet long by 3-3/4 feet wide by 3 feet deep, operates at a pH of 13 and 110°F, is not air agitated, and contains no plastic balls. The exhaust hood has 14 slots, each 12 inches long by 1-1/2 inches wide. Exhaust air is vented through a plenum to two 14-inch ducts, to a common duct leading to the fan. The tank is shown schematically in Figure 15 and pictorially in Figure 16.

### Airflow Measurements

Control velocities at the front edge of Tank 13 averaged 50 fpm. This value is slightly lower than the ACGIH Industrial Ventilation recommendation of 75 to 100 fpm. However, the exhaust rate, computed to be 140 cfm/ft<sup>2</sup>, exceeds the ACGIH recommendation of 110 cfm/ft<sup>2</sup> for a tank of this width/length ratio.

### Air Sampling Results

Tank 13 air sampling results for cyanide and copper mists are shown in Table 12. Mean concentrations for each compound were less than 0.01 mg/m<sup>3</sup>. These levels are well below the OSHA PEL for these substances.

### Discussion

Cyanide and copper mist were easily controlled at this tank with local exhaust ventilation.

### Electroplating Tank 15

Plating Tank 15 (nickel plate) is 9-feet-long by 3-3/4-feet-wide by 3-feet-deep and operates at a pH of 3.8 to 4.2 and 110°F. Agitation results from barrel rotation only and no plastic balls are used. The tank is not equipped with local exhaust ventilation.

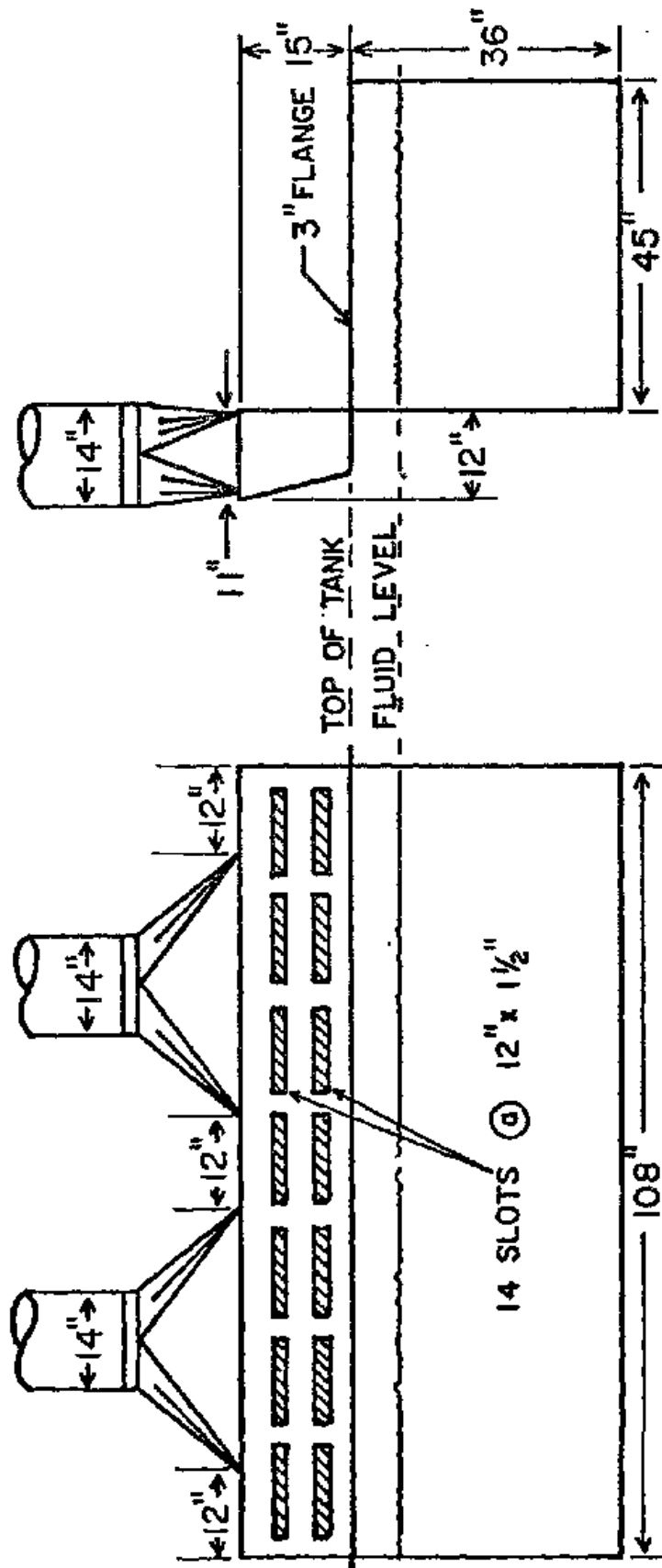


Figure 15. Copper plate - MB 13

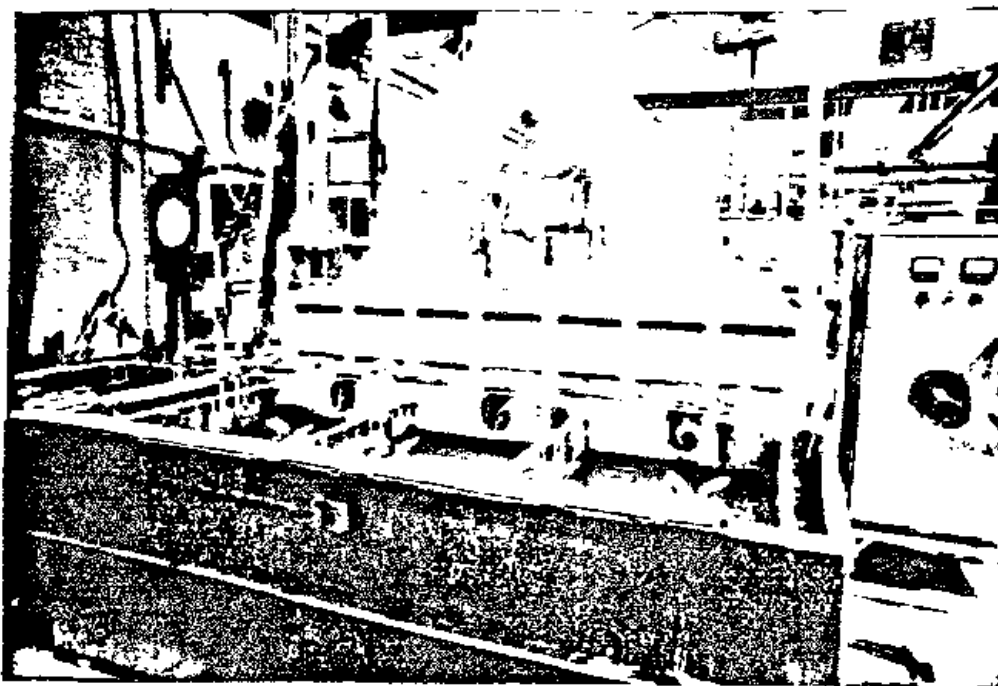


Figure 16. Tank 13 - copper plate.

#### Air Sampling Results

Air sampling results presented in Table 12 indicate very low ( $0.006 \text{ mg/m}^3$ ) concentrations of airborne nickel. These values are within the NIOSH recommended level for personal exposure to nickel of  $0.015 \text{ mg/m}^3$  and well below the OSHA PEL for nickel of  $1.0 \text{ mg/m}^3$ .

#### Discussion

The airborne nickel concentrations were sufficiently low to demonstrate that this substance was easily controlled without local exhaust ventilation.

#### Electroplating Tank 18

Tank 18 (bright nickel), measuring 3-feet, 8-inches by 4-1/2-feet by 3-feet, operates at pH 4 and a temperature of  $115^\circ\text{F}$ . Light agitation is provided by a filter pump. No floating plastic balls are used.. Tank 18 is not locally

ventilated. Air sampling data reflect very low levels of sulfuric acid mists ( $0.01 \text{ mg/m}^3$ ). Airborne nickel was well controlled, as indicated by the low concentrations reported ( $0.004 \text{ mg/m}^3$ ). A total of three samples each for sulfuric acid and nickel were taken during a one day period. This data suggests that local ventilation is not be required at this operation.

#### Employee Exposures

Platers on the miscellaneous barrel line were sampled during three 8-hour shifts. The sampling results are reported in Table 13. The data indicate very low exposures to cyanide, copper, and nickel. These low exposures further demonstrate the effective control of vapors and mists by this plant's ventilation system. The nickel levels were all below the NIOSH recommended level of  $0.015 \text{ mg/m}^3$ ; however it should be noted that at higher production rates nickel exposures greater than  $0.015 \text{ mg/m}^3$  may be possible.

Table 13. Employee exposures ( $\text{mg/m}^3$ ).

Plater	CN	Cu	Ni	No. of Samples
A	<0.01	0.06	< 0.011	2
B	<0.01	< 0.01	< 0.011	4
OSHA PEL	5	1	1	
ACGIH TLV	5	1	0.1	
NIOSH			0.015	



## SUMMARY

A safe and healthful working environment in electroplating operations depends upon the use of effective control technology, including good ventilation design and maintenance, good work practices and effective management. This captive electroplating shop employs good and effective techniques for minimizing employee exposures to potentially harmful chemical agents.

Personal samples taken at this plant show excellent low levels of exposure to cyanide, copper, nickel, and silver from copper, nickel, and silver electroplating operations. Area sample results for several of the plating tanks show excellent control of emissions using local exhaust ventilation. Cyanide and zinc emissions from a large automatic rack low-cyanide zinc plating tank and cyanide, copper and silver emissions from copper and silver cyanide strike tanks were controlled using local exhaust ventilation. Area sample results also showed essentially no metal mist or cyanide emissions from silver cyanide, nickel (Watts), and bright nickel plating baths not equipped with local exhaust ventilation; however, local exhaust ventilation is recommended for silver cyanide plating baths as a precaution in case acid were inadvertently added to the bath causing the release of hydrogen cyanide.

Three acid cleaning tanks and a caustic cleaning tank were well controlled with local exhaust ventilation. Hydrochloric acid levels for the three acid tanks averaged less than 1/20th the OSHA PEL and the hydroxide levels for the caustic tank averaged one-hundredth the OSHA PEL. However, a second caustic cleaning tank with local exhaust ventilation and a cover had higher (sodium) hydroxide levels equal to 1/4th the OSHA PEL. Area samples taken on a Bright Dip (nitric acid) tank without local exhaust ventilation showed low nitric acid levels averaging one-hundredth the TLV for nitric acid indicating there is no need to ventilate this tank.

The evaluation of a chrome plating tank operating at a 130°F equipped with puch-pull exhaust ventilation indicated inadequate control of hexavalent chromium emissions. Area sampling results show the average hexavalent chromium levels to be more than four times the OSHA PEL and almost 20 times the NIOSH recommended standard.

The occupational health hazards in the plating areas evaluated were well controlled with present techniques. Two recommendations to upgrade the operation are: (1) improve ventilation to the chromic acid plating tank as suggested in this report; and (2) repair and clean exhaust hoods and ducts with cracks, holes, and blockages on a more frequent basis.

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