IN-DEPTH SURVEY REPORT:

CONTROL TECHNOLOGY FOR TRANS WORLD AIRLINES MAINTENANCE FACILITY

KANSAS CITY, MISSOURI

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Division of Physical Sciences and Engineering
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PLANT SURVEYED:	Trans World Airlines Maintenance Facility
SIC CODE:	471
SURVEY DATE:	October 27-29, 1981
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ABSTRACT

An in-depth control technology survey of plating and cleaning operations was conducted at the TWA Maintenance facility in Kansas City, Missouri. The maintenance shop plates and cleans all types of aircraft body and engine parts and ground equipment ranging in size from tiny washers to 10-feet long landing gear using a variety of chemical cleaning and platting baths. Nine plating and cleaning tanks were studied. These include silver plate, silver strike cyanide, copper strike cyanide, acid etch, nickel plate, cad,ium plate, hi-efficiency cadmium plate, cyanide, and degreaser tank. The primary airborne hazards were chromium VI, nickel, silver, cyanide, sulfuric acid, copper, cadmium, hydrogen fluoride, and tetrachloroethylene. The in-depth study consisted of the assessment of the overall control system, primarily local exhaust ventilation.

Environmental concentrations were fould to be within OSHA standards, with the exception of the vapor degreasing tank, despite a generally low levelof ventilation relative to tank size.

INTRODUCTION

The Engineering Control Technology Branch of the Division of Physical Sciences and Engineering, NIOSH, is conducting a research study to assess and document control methods for minimizing worker exposure in electroplating and cleaning operations. Exposures to plating tank mists and gases have been documented as a cause of a variety of health problems. These substances include chromium, cyanide, and sulfuric acid. Chromium exposure can cause irritation of the skin, mucous membranes, and respiratory tract resulting in skin ulceration and nasal septum perforation. High concentrations of cyanides can cause death, while lower concentrations can cause headaches, weakness, confusion, nausea, and vomiting. Sulfuric acid exposure is irritating to skin and may cause scarring of the skin and mouth, edema in the lungs, and blindness. This airline maintenance plating and cleaning shop was surveyed to evaluate local exhaust ventilation and tank covers.

Electroplating operations are located at the TWA maintenance base and are housed in a large brick building. The plating area is 5,500 square feet. Aircraft and engine parts and ground equipment, ranging in size from tiny washers to landing gear 10 feet long, are cleaned and plated. The 12-year old shop contains approximately 75 tanks for plating and cleaning. The maintenance base total employment is close to 5,000.

The plating shop operates two shifts with approximately 15 workers on the day shift and 3 workers on the evening shift. Day shift operates from 7:15 a.m. to 3:45 p.m. Employees have a large cafeteria located in a nearby building available to them. Plating processes include silver cyanide, copper cyanide, cad,ium cyanide, and chromic acid. Cleaning and stripping operations include tetrachloroethylene degreasers, sulfuric acid, nitric acid, hydrochloric acid and caustic solutions, and nickel cyanide strip. Plating tanks vary in area from 3 feet by 3 feet to 10 feet and are 2 1/2 feet to 10 feet deep. The degreaser units are 8 feet by 4 feet and 8 feet deep.

Tank 1 is a silver plating tank 2 feet by 8 feet by 2.5 feet deep equipped with three-sided exhaust ventilation. The exhaust slots are 1.5 inches wide on the Wast and West side and 1.75 inches on the South side. Fumes are exhausted through expanding-type plenums on the sides of the tank to a single plenum on the South side of the tank and is discharged to a laterial duct trough in the basement. There are no covers or other suppressants on this tank. The silver plate tank contains 46.2 gm/l of silver and is operated at 115°F temperature and a pH of 13. The silver plate solution is agitated by a filter pump and the liquid level maintained at 4 inches below the slot.

Tank 6 is a silver strike tank 3 feet by 3 feet by 2.5 feet deep equipped with three-sided exhaust ventilation. The exhaust slots are 1.6 inches on the West and South sides and 1.3 inches on the North side. Fumes are exhausted through expanding-type plenums on the sides of the tank to a single plenum on the West side of the tanks and is discharged to a lateral duct trough in the basement. There are no covers or other suppressants on this tank. The silver strike tank contains 2 gm/l of silver and 75 gm/l of cyanide and is operated at room temperature and a pH of 13. The silver strike solution is agitated by a filter pump and the liquid level maintained at 4 inches below the slot.

Tank 10 is a copper strike tank 3 feet by 3 feet by 2.5 deep equipped with three-sided exhaust ventilation. The exhaust slots are 1.5 inches on the North, South, and East sides. Fumes are exhausted through expanding-type plenums on the sides of the tank to a single plenum on the East side of the tank and is discharged to a laterial duct trough in the basement. There are no covers or other suppressants on this tank. The copper strike tank contains 34.9 gm/l of copper and is operated at 130°F temperature and a pH of 12.5. The copper strike solution is agitated by a filter pump and the liquid level maintained 4 inches below the slot.

Tank 19 is an acid etch tank 3 feet by 3 feet by 2.5 feet deep equipped with three-sided exhaust ventilation. The exhaust slots are 1.7 inches on the north and east sides and 1.5 inches on the south side. Fumes are exhausted through expanding-type plenums on the sides of the tank to a single plenum on the east side of the tank and is discharged to a lateral duct trough in the basement. There are no covers or other suppressants on this tank. The acid etch tank contains 35.2 oz/gal of sulfuric acid and is operated at room temperature. The liquid level is maintained at 4 inches below the slot.

Tank 25 is a nickel plating tank 5 feet by 8 feet by 5 feet deep equipped with three-sided exhaust ventilation. The exhaust slots are 1.75 inches on the south and west sides and 1.5 inches on the east side. Fumes are exhausted through expanding-type-plenums on the sides of the tank to a single plenum on the south side of the tank and is discharged to a lateral duct trough in the basement. There are no covers on other suppressants on this tank. The nickel plating tank contains 85.7 gm/l of nickel and is operated at 130^{o} temperature and a pH of 4. The nickel plate solution is agitated by a filter pump and the liquid level maintained 4 inches below the slot. The exhaust ventilation system on this tank malfunctioned during our visit and we were unable to take reliable ventilation measurements.

Tank 31 is a cadmium-cyanide plating tank 5 feet by 9 feet by 10 feet deep. This tank is not equipped with local exhaust ventilation and there are no covers or other suppressants on the tank. The cadmium-cyanide plating tank contains 20 gm/l of cadmium and 100 gm/l of cyanide and is operated at room temperature. The cadmium-cyanide solution is agitated by a air impeller and the liquid level maintained 4 inches below the tank lip. Air sampling data reflect levels for cadmium and cyanide below the detectable limit suggesting local exhaust ventilation may not be required at this operation.

Tank 53 is a cadmium-cyanide platingh tank 5 feet by 9 feet by 10 feet deep equipped with three-sided exhaust ventilation. The exhaust slots are 1.7 inches on the north and west sides and 1.9 inches on the south side. Fumes are exhausted through expanding-type plenums on the sides of the tank to a single plenum on the west side of the tank and is discharged to a lateral duct trough in the basement. There are no covers or other suppressants on this tank. The cadmium-cyanide palting tank contains 53 gm/l of cadmium and 90 gm/l of cyanide and is operated at room temperature. The cadmium-cyanide solution is agitated by a air impeller and the liquid level maintained 4 inches below the slot.

Tank 85 is a chrome plating tank 4 feet by 8 feet by 7 feet deep equipped with a three-sectional sliding cover and three-sided exhaust ventilation. The exhaust slots are 2 inches on the north, east, and south sides. Fumes are exhausted through expanding-type plenums on the east side of the tank and is discharged through three exhaust ducts to a lateral duct trough, equipped with a wet scrubber, in the basement. The chrome plating tank contains 33 oz/gal of chromium and is operated at 130°F temperature. The chrome plating solution is agitated by air and the liquid level maintained 4 inches below the slot.

Tank 117 is a vapor degreasing tank 5 feet by 8 feet deep equipped with a electrically operated roll-up cover and refrigerated cooling coils. This tank is not equipped with local exhaust ventilation. The vapor degreasing tank contains tetrachloroethylene and is operated at 250° temperature. The vapor level is maintained about 30 inches below the top of the tank.

Process Description

Parts brought into the plating area are cleaned and then dipped in a vat of hot wax to cover the part surfaces that will not be plated. After cooling, the wax is trimmed and the part brought into the plating area. Overhead hoists are used by platers to move large parts in and out of the tanks. Most parts plated are handled individually, although a small amount of barrel plating is done. Steam or cold water is used to heat or cool the solutions. The tanks are lined with an inorganic material (Koroseal).

Filters for cleaning the recirculating plating solutions are located above the floor. This permits easy maintenance of the filters.

Most of the plating and cleaning tanks are equipped with local exhaust ventilation. In addition, four of the chrome tanks have sliding covers. The local exhaust sytems vent from three sides of the tanks and exhaust downward through an exhaust tunnel in the floor of the building. The silver, copper, nickel, and chromic acid plating baths all have three-sided exhaust ventilation; however, only one of the two cadmium tanks is centilated. All except two of the chromic acid tanks have covers, including the four tanks with a sliding cover. A tetrachloroethylene degreaser tank is equipped with an electrically operated roll-up cover, and a refrigerator chiller. All the remaining cleaning tanks are equipped with local exhaust ventilation. A large make-up air unit supplies air to the plating shop.

Workers wear face shields when adding chemicals to baths, and the chemicals are added at a slow rate to prevent a violent reaction. Workers delivering chemical barrels to the plating area wear one-quarter face dust respirators. Some chemicals used regularly are kept near the plating tanks. The main chemical supply is stored in a detached building.

Protective equipment required in the plating area include safety glasses with side shields and safety shoes. The plating and cleaning tanks evaluated are as follows:

Silver plating bath is a manually operated 2 feet by 8 feet by 2 1/2 feet deep tank equipped with single-slot exhaust ventilation on three sides. The tank solution is maintained at room temperature and consists primarily of 46.2 gm/l silver.

Silver strike bath is a manually operated 3 feet by 3 feet by 2 1/2 feet deep tank equipped with single-slot exhaust ventilation on three sides. The tank solution is maintained at room temperature and consists primarily of 2.0 gm/l silver and 75.0 gm/l cyanide.

Copper strike bath is a manually operated 3 feet by 3 feet by 2 1/2 feet deep tank equipped with single-slot exhaust ventilation on three sides. The tank solution is maintained at 130^{o}F and consists primarily of 34.9 gm/l copper.

Acid etch bath is manually operated 3 feet by 3 feet by 2 1/2 feet deep tank equipped with single-slot exhaust ventilation on three sides. The tank solution is maintained at room temperature and consists primarily of 35.2 oz/gal sulfuric acid.

Nickel plating bath is a manually operated 5 feet by 8 feet by 5 feet deep tank equipped with single-slot exhaust ventilation on three sides. The tank solution is maintained at 130^{o}F and consists primarily of 85.7 gm/l nickel.

Cadmium-cyanide plating baths are manually operated 5 feet by 9 feet by 10 feet deep tanks with one equipped with single-slot exhaust ventilation on three sides. The tanks solutions are maintained at room temperature and consist primarily of 20.0 gm/l cadmium and 100.0 gm/l cyanide in the non-ventilated tank and 53.0 gm/l cadmium and 90.0 gm/l cyanide in the ventilated tank.

Chrome plating bath is a manually operated 4 feet by 8 feet by 7 feet deep tank equipped with a three-sectional sliding cover and single slot exhaust ventilation on three sides. The tank solution is maintained at 130°F and consists primarily of 33 oz/gal chromic acid.

Vapor degreasing tank is a manually operated 5 feet by 8 feet by 8 feet deep non-ventilated tank equipped with a electrically operated roll-up cover and refrigerated chiller. The tank solution is maintained at 250°F and consists of tetrachloroethylene.

The tank composition information is summarized in Table 1 and the location of these tanks are shown in Figure 1.

Table 1

Composition of Tank Solutions

Tank	Solution Description	Composition
1	Silver Plating Bath	46.2 gm/l Silver
6	Silver Strike	2.0 gm/l Silver 75.0 gm/l Cyanide
10	Copper Strike	34.9 gm/l Copper
19	Acid Etch	35.2 oz/gal. Sulfuric Acid
25	Nickel Plating Bath	85.7 gm/l Nickel
31	Cadmium-Cyanide Plating Bath	18-22 gm/l Cadmium 90-110 gm/l Cyanide
53	Cadmium-Cyanide Plating Bath	49-56 gm/l Cadmium 67-112 gm/l Cyanide
85	Chrome Plating Bath	33 oz/gal Chromic Acid
DG117	Vapor Degreasing Tank	Tetrachloroethylene

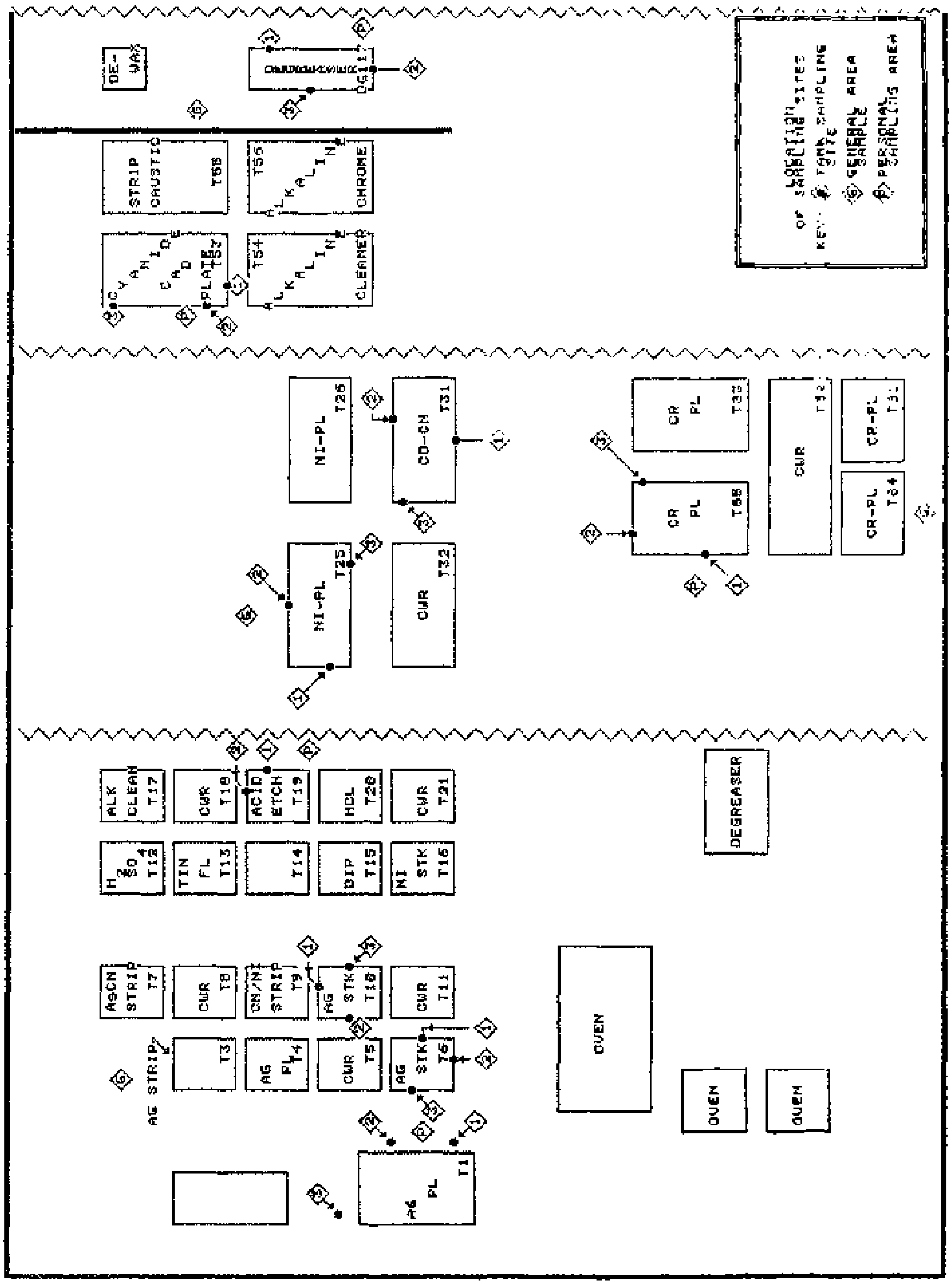

Figure 1. Tank and Sampling Site Locations.

Hazard Analysis

The primary hazards from the electroplating operation are chromium, sulfuric acid, silver, particulate cyanide, copper, nickel, hydrogen fluoride, cadmium, and tetrachloroethylene. These substances may be present in the air due to the generation of mist and vapors from the plating and cleaning bath. Workers also come in contact with the substances in liquid form when handling the parts being plated. All of the agents can act directly on the skin, the eyes, and the linings of the nose and throat. Chromium cyanide and hydrogen fluoride may also enter the body through the skin.

Much has been written on the potential health hazards of these substances. The following information is excerpted from the NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards. There is no attempt here to present all known data; merely some pertinent information in summary form. If more information is desired, please refer to the specific health guideline and the reference cited at its conclusion.

Chromic Acid

Chromic acid is an aqueous solution of chromium trioxide (CrO_3), a dark red, odorless solid. It may cause corneal injury if splashed in the eyes, and, if swallowed, stomach and kidney problems. From short-term exposure, chromic acid mist may cause severe irritation of the nose, throat, and lungs. Skin exposure may result in ulceration of the skin.

Repeated or prolonged exposure to chromic acid mist may cause ulceration and perforation of the nasal septum. Respiratory irritation may occur with symptoms resembling asthma. Liver damage with yellow jaundice has been reported. A skin rash may develop from prolonged contact or any allergic reaction. Erosion and discoloration of the teeth has been attributed to chromic acid exposure.

There is no positive evidence that chromic acid in the workplace has contributed to an increase in lung cancer, neither is there definitive evidence that absolves it. Papillomata of the oral cavity and larynx were found in 15 of 77 chrome platers exposed for an average of 6.6 years to chromic acid mist at air concentrations of 0.4 mg/m^3 chromium.

Annual medical examinations are advised. Emphasis should be placed on observation for changes in the mucous membranes of the upper respiratory tract, ulceration of the skin, and evidence of tumors of the respiratory tract and lungs.

The Occupational Safety and Health Administration (OSHA) has ruled that an employee's exposure to chromic acid and chromates (i.e. Chromium VI) shall not exceed at any time a ceiling concentration of 0.1 milligram of chromium per cubic meters of air. An employee's exposure to soluble chromic and chromous salts (i.e. total chromium) in any 8-hour work shift of a 40-hour work week shall not exceed the 8-hour time-weighted average of 0.5 mg/m^3.

NIOSH has recommended that the permissible exposure limit for non-carcinogenic chromium VI be reduced to 0.025 mg/m^3 averaged ocer a work shift of up to 10 hours per day, 40 hours per week, with a ceiling limit of 0.05 mg/m^3 averaged ocer any 15-minute period. Chromium trioxide is currently believed to be non-carcinogenic.

Sulfuric Acid

Sulfuric acid (H_2SO_4) can affect the body if it is inhaled or if it comes in contact with the eyes or skin. It can also affect the body if it is swallowed. The extent of the effects depends somewhat on how concentrated the acid is. Concentrated sulfuric acid destroys tissue through an extensive dehydrating action, while the dilute form is primarily an irritant due to its acid properties.

Sulfuric acid mist can severely irritate the eyes, nose, throat, and skin. Splashes of concentrated acid in the eyes or on the skin may cause blindness and severe burns. Repeated or prolonged exposure may cause erosion of the teeth, soreness of the mouth, and difficulty breathing. Chronic inflammation of the skin or irritation of the eyes may be caused by over-exposure to sulfuric acid.

The current OSHA standard for sulfuric acid is an 8-hour time-weighted average of 1.0 mg/m^3. NIOSH has recommended that the permissible exposure limit be 1.0 mg/m^3 averaged over a work shift of up to 10 hours per day, 40 hours per week.

Silver

Silver or soluble silver compounds generated during the electroplating process can affect the body if inhaled, swallowed, or comes in contact with the eyes or skin. Silver or soluble silver compounds can cause discoloration or blue-gray darkening of the eyes, nose, throat, and skin. Silver, once deposited in the body, is poorly excreted in the urine. The current OSHA standard for silver and soluble silver compounds is 0.01 mg/m^3 of air averged over an eight-hour workshift.

Cyanide

Cyanide can affect the body if it is inhaled, swallowed, or comes in contact with the eyes or skin. Sufficient cyanide may be absorbed through the skin, especially if there are cuts, to cause fatal poisoning. Inhalation or ingestion of cyanide salts on short term exposure may be rapidly fatal. Larger doses may cause the person to rapidly lose consiousness, stop breathing, and die. At lower levels of exposure, the earlier symptoms include weakness, headache, confusion, nausea and vomiting. Milder forms of intoxication may result only in weakness, dizziness, headache, and nausea. The dust of cyanide salts is irritating to the eyes, nose, and skin. Strong solutions of cyanide salts are corrosive and may produce ulcers. Effects from chronic exposure to cyanide are non-specific and rare. The current OSHA standard for cyanide is 5 mg/m^3 of air averaged over an eight-hour workshift. NIOSH has recommended that the permissible exposure limit be changed to a ceiling of 5 mg/m^3 of air averaged ocer a 10 minute period.

Copper

Copper dusts or mists can affect the body if inhaled, swallowed, or come in contact with the eyes or skin. Short-term exposure may cause a feeling of illness silimar to the common cold with sensations of chills and stuffiness of the head. Small copper particles may enter the eye and cause irritation, discoloration, and damage. Repeated or prolonged exposure may cause skin irritation or discoloration of the skin or hair.

The current OSHA standard for copper dusts or mists is 1 mg/m^3 of air averaged ocer an eight-hour workshift.

Nickel

Metallic nickel or soluble nickel compounds can affect the body if they are inhaled, swallowed, or come in contact with the eyes or skin. Nickel fumes are respiratory irritants and may cause pneumonitis. Skin contact may cause an allergic skin rash. Nickel and its compounds have been reported to cause cancer of the lungs and sinuses. Nickel itself is not very toxic if swallowed, but its soluble salts are quite toxic and, if swallowed, may cause giddiness and nausea. The current OSHA standard for nickel metal and soluble nickel compounds is 1 mg/m^3 of air averaged ocer an eight-hour workshift. NIOSH has recommended that the permissible exposure limit for nickel be reduced to 0.015 mg/m^3 averaged over a workshift of yp to 10 hours per day, 40 hours per week, and that nickel be regulated as an occupational carcinogen.

Hydrogen Fluoride

Hydrofluoric acid or hydrogen fluoride (HF) is a primary irritant of the eyes, skin, mucous membranes and lungs, and can produce chemical and dermal burns. Chronic exposure may result in nose bleeds. Fluoride burns can result in systemic poisoning by absorption of fluoride through the skin. Inhalation of high levels of elemental or acid fluorine can cause bronchospasm, pulmonary edema, gastrointestinal symptons, chest pain, lung damage, and death.

The current OSHA standard for hydrogen fluoride is 3 ppm or 2 mg/m^3 of air averaged over an eight-hour workshift. NIOSH has recommended that the permissible exposure limit be changed to 2.5 mg/m^3 of air averated over a workshift of not more than 10 hours per day, 40 hours per week, with a ceiling level of 5 mg/m^3 averaged over a 15-minute period.

Cadmium

Cadmium fume can affect the body if it is inhaled. Short-term exposure causes irritation of the nose and throat. If enough has been inhaled, after a delay of several hours, a person may also develop cough, chest pain, sweating, chills, shortness of breath, and weakness. Death may occur. Repeated or prolonged exposure may cause loss of sense of smell, ulceration of the nose, shortness of breath, kidney damage, and mild anemia. Exposure to cadmium fume has also been reported to cause an increased incidence of cancer of the prostrate in men.

The current OSHA standard for cadmium fume is 0.1 mg/m^3 of air averaged over an eight-hour workshift, with an acceptable ceiling level of 0.3 mg/m^3. NIOSH has recommended that the permissible exposure limit be reduced to a time-weighted average of 40 g/m^3 with a ceiling level of 200 g/m^3 for a 15-minute period.

Tetrachloroethylene

Tetrachloroethylene can affect the body if inhaled, swallowed, or comes in contact with the eyes or skin. Short-term exposure may cause headache, nausea, drowsiness, dizziness, incoordination, and unconsciousness. It may also cause irritation of the eyes, nose, and throat and flushing of the face and neck. In addition, it might cause liver damage with such findings as yellow jaundice and dark urine. The liver damage may become evident several weeks after the exposure. Prolonged or repeated over exposure to liquid tetrachloroethyulene may cause irritation of the skin. It might also cause damage to the liver and kidneys.

The current OSHA standard for tetrachloroethylene is 100 ppm or 678 mg/m^3 of air averaged over an eight-hour workshift, with a ceiling level of 200 ppm (1356 mg/m^3) and a maximum acceptable peak of 300 ppm (2034 mg/m^3) for five minutes in any three-hour period. NIOSH has recommended that the permissible exposure limit be reduced to 50 ppm (339 mg/m^3) averaged ocer a work shift of up to 10 hours per day, 40 hours per week, with a ceiling level of 100 ppm (678 mg/m^3) averaged over a 15-minute period.

Evaluation

To determine the effectiveness of the controls used in this electroplating operation, personal and area air samples were collected for the duraction of the workshift on three consecutive days. Breathing zone samples for hexavalent chromium, sulfuric acid, silver, cadmium, and particulate cyanide were collected on the day-shift production workers. These workers were in the plating area except during lunch and occasional short breaks. Breathing zone personal samples, both filter cassettes and silica gel tubes, were clipped to the collar, on the front side of the work shift. This placed them in the breathing zone, only a few inches below the fact, in a manner so as not to interfere with the workers activities.

Area samples were placed at fixed locations around the plating tanks. All but a few room air samples were positioned close to the edge of the tanks, above the slot if located on a ventilated side.

Personal and area samples for hexavalent chromium, silver, cadmium, and particulate cyanide and area samples for copper and nickel were collected using closed-face cassettes with 37 mm polyvinylchloride membrane filters of 5 um pore size and MSHA Model G personal pumps operated at a flow rate of 2 liters of air per minute. These samples were analyzed colorimetrically for using NIOSH method No. P&CAM173, by atomic absorption for cadmium using a modification of NIOSH Method No. S-312, by atomic absorption for particulate cyanide using NIOSH Method NO. S-250, by atmoic absorption for copper using NIOSH Method No. P&CAM 173, and by atomic absorption for nickel using NIOSH Method No. S-206.

Personal and area samples for sulfuric acid were collected using 7 mm diameter silica gel tubes and DuPont P-200 pumps operated at a flow rate of 200 cubic centimeters (cc) of air per minute. These samples were analyzed by ion chromatography for sulfuric aic using NIOSH Method No. P&CAM 339. Personal and area samples for tetrachloroethylene were collected using charcoal tubes per minute. These samples were analyzed by gas chromatography for samples for hydrogen fluoride were collected using liquid media samplers and MSA Model G personal pumps operated at a flow rate of 2 liters of air per minute. These samples were analyzed by ion chromatographjy for hydrogen fluoride using NIOSH Method No. 339.

Air velocities in front of the slot hoods and total air flow exhausted from each tank were measured, and dimensions were obtained for all tanks and ventilation systems.

Total air flow in each ventilation system was measured in the vertical duct by taking velocity readings for equal-area segments. Either a pittot tube or a hot-wire anemometer was used for these measurements. An estimate of the flow rate can be calculated by computing the average velocity and multiplying by the cross-sectional area of the flow at that point.

Air velocities were also measured for each tank at this slot and at the centerline of the tank or at some intermediate points. These measurements were taken using either a Sierra Model 440 or a Kurz Model 441 hot-wire anemometer. Slot air velocity measurements were taken at approximately one-foot intervals. Two readings were taken at each interval, one for the top half of the slot and one for the bottom half.

Since the velocity readings were taken for equal-area sections, an average slot velocity can be computed to adding all the velocity readings for each tank and dividing by the number of readings. An approximation of the volume flow rate may then be calculated by multiplying this average velocity by the total slot area for each tank.

Airflow Measurements

Airflow measurements for tanks 1, 6, 10, 19, 53 and 85 including exhaust volume and exhaust rate relative to the surface area of the tanks are shown in Table 2. Tank 31 (cadmium-cyanide plating) and Tank 117 (tetrachloroethylene degreaser) were not equipped with local exhaust ventilation. Tank 25 (nickel plating), although equipped with local exhaust ventilation slots on three sides, was affected by exhaust system malfunction during our visit and ventilation measurements were not taken.

Total exhaust volume and exhaust rate for Tank 1 were 1,779 cfm and 111 cfm/ft^2. Industrial Ventilation recommends adequate general room ventilation for free-standing open-surface tanks when silver plating.

Total exhaust volume and exhaust rate for Tank 6 were 782 cfm and 87 cfm/ft^2. Industrial Ventilation recommends 190 cfm for silver strike solutions in free-standing open-surface tanks not against a wall or baffle with hood along at least two parallel sides and tank width/length ratios of 1.00 to 2.00. The exhaust rate is equal to 46 percent of the recommended level. The three-sided hood provided fairly uniform exhaust ventilation with avrage slot velocities being 829 fpm on the North side, 979 on the West side, and 950 fpm on the South side.

Total exhaust volume and exhaust rate for Tank 10 were 1422 cfm/ft^2. Industrial Ventilation recommends 190 cfm for copper strike solutions in free-standing open-surface tanks not aganist a wall or baffle with hood along at least two parallel sides and tank width/length ratios of 1.00 to 2.00. The exhaust rate is equal to 83 per cent of the recommended level. The three-sided hood provided average slot velocities of 1248 fpm on the South side, 1638 fpm on the East side, and 1300 fpm on the North side. The slot velocities on the South and North sides were less than 80 percent of the velocity on the East side.

Table 2
Ventilation Airflow Relative to Surface Area of Tanks

Tank	Surface Area ft^2	Q Exhaust Air (CFM)	Q/A Exhaust Rate (CFM/Ft^2)	Recommended Exhaust Rate (CFM/Ft^2)
1	16.0	1779	111	Adequate general room ventilation
6	9.0	782	87	190
10	9.0	1422	158	190
19	9.0	1760	196	250
25	32.0	Exhaust Manlfunction		225
31	40.0	No Ventilation		Adequate general room ventilation
53	50.0	2921	58	Adequate general room ventilation
85	40.0	3244	81	250
117	40.0	No Ventilation		Dependent on operating conditions

Total exhaust volume and exhaust rate for Tank 19 were 1760 cfm and 196 cfm/ft^2 Industrial ventilation recommends 250 cfm for sulfuric acid solutions in free-standing open-surface tanks not against a wall or baffle with hood along at least two parallel sides and tank width/length ratios of 1.00 to 2.00. The exhaust rate is equal to 78 percent of the recommended level. The three-sided hood provided average slot velocities of 1342 fpm on the South side, 1733 fpm on the East side, and 1317 fpm on the North side. The slot velocities on the South and North sides were less than 80 per cent of the velocity on the East side.

Total exhaust volume and exhaust rate for Tank 53 were 2921 cfm and 58 cfm/ft^2. Industrial Ventilation recommends adequate general room ventilation for free-standing open-surface tanks containing cadmium-cyanide plating solutions.

Total exhaust volume and exhaust rate for Tank 85 were 3244 cfm and 81 cfm/ft^2. Industrial Ventilation recommends 250 cfm for chrome plating solutions in free-standing open-surface tanks not against a wall or baffle with hood along at least two parallel sides and tank width/length ratios of 0.5 to 0.99. The exhaust rate is equal to 32 per cent of the recommended level. The three-sided hood provided average slot velocities of 905 fpm on the North side, 1709 fpm on the East side, and 1109 fpm on the South side. The slot velocities on the North and South sides were 53 and 65 percent respectively of the velocity on the East side.

Air Sampling Results

Personal sampling results for hexavalent chromium, sulfuric acid, silver, cadmium, cyanide, and tetrachlorethylene are shown in Table 3. Mean concentrations for all personal samples were 0.0002 mg/m^3 for chromium VI, 0.067 mg/m^3 for sulfuric acid, <0.002 mg/m^3 for silver, 0.003 mg/m^3 for cadmium, <0.001 mg/m^3 for cyanide, and 107 mg/m^3 for tetrachloroethylene. Personal, tank, and general area sampling sites are shown in Figure 1. Silver exposures for the silver plating employee working around tanks T1 and T6 were all below the detectable limit of 0.002 mg/m^3. The standard for silvber is 0.01 mg/m^3. The acid etching employee working around Tank T19 had an average sulfuric acid exposure of 0.067 mg/m^3 for the three days samples. This concentration is 65.7 per cent of the OSHA PEL and NIOSH recommended level of 1.0 mg/m^3. The cadmium plating employee working around Tanks T31 and T53 had an average cadmium exposure of 0.003 mg/m^3 for the two days samples. This concentration is 3 per cent of the OSHA PEL of 0.1 mg/m^3 and less than 8 per cent of the NIOSH recommended level of 0.04 mg/m^3. Cyanide exposure for the cadmium plating employee working around Tanks T31 and T53 was less than the detectable limit of 0.001 mg/m^3. Chrome VI exposures for the chrome plating employee working around Tank T85 were all below the detectable limit of 0.0002 mg/m^3. The degreasing employee working around Tank DG117 had an average tetrachloroethylene exposure of 107 mg/m^3 for the two days samples. This concentration is 16 per cent of the OSHA PEL of 678 mg/m^3 and 32 per cent of the NIOSH recommended level of 339 mg/m^3.

Table 3
Employee Exposure (mg/m^3)

Job Description & Tank Number	Silver	Sulfuric Acid	Cadmium	Cyanide	Chrome VI	Tetrachloroethylene
Silver Plating T1,T6	< 0.002					
	< 0.002					
	< 0.002					
Acid Etching T19		0.106				
		< 0.047				
		< 0.047				
Cadmium Plating T31,T53			0.004			
			0.002			
				< 0.001		
Chrome Plating T85					< 0.002	
					< 0.002	
					< 0.002	
Degreasing DG117						130.0
						84.0
Mean	< 0.002	0.067	0.003	< 0.001	< 0.0002	107.0
Limit of Detection	0.002	0.004	0.002	0.001	0.002	10.0
OSHA PEL (29 CFR 1910)	0.01	1.0	0.10	5.0	0.100	678.0
ACGIH TLV (1981 TLV Book)	0.01		0.05	5.0	0.050	670.0
NIOSH Rec. (NIOSH/ OSHA Pocketguide)		1.0	0.04	5.0	0.025	339.0

Area samples are shown in Table 4 for silver and cyanide collected near Tanks T1 and T6, copper and silver collected near Tank T10, sulfuric acid and hydrogen fluoride collected near Tank T19, nickel collected near Tank T25, cadmium and cyanide collected near Tanks T31 and T53, chrome VI collected near Tank T85, and tetrachloroethylene collected near Tank DF 117.

Concentrations of silver and cyanide samples collected at Tanks T1 and T6 were all below the detectable limits of 0.002 mg/m^3 and 0.001 mg/m^3 respectively. Concentrations of copper and silver samples collected at and near Tank T10 were all below the detectable limit of 0.002 mg/m^3. Area samples for sulfuric acid collected at Tank T19 ranged from 0.053 mg/m^3 to 0.083 mg/m^3 with an average concentration for four area samples of 0.062 mg/m^3. All the values for sulfuric acid are far below the allowable limit of 1.0 mg/m^3. Although area samples can not readily be used to estimate compliance with the legal standard, they are a valuable indicator of control system effectiveness for plating tanks. Area samples for hydrogen fluoride collected at Tank T19 ranged from 0.14 mg/m^3 with an average concentration for four area samples of 0.167 mg/m^3. All the values for hydrogen fluoride are less than eight per cent of the allowable limit of 2.5 mg/m^3. Concentrations of nickel collected at and near Tank T25 were all below the detectable limit of 0.003 mg/m^3. Concentrations of cadmium and cyanide samples collected at Tanks T31 and T53 were all below the detectable limits of 0.002 mg/m^3 and 0.001 mg/m^3 respectively. Area samples for chrome VI collected at and near Tank T85 ranged from <0.0003 mg/m^3 to 0.13 mg/m^3 with an average concentration of 0.0137 mg/m^3 for the twelve samples. All the values for chrome VI are well within the allowable limits of 0.5 mg/m^3. Area samples for tetrachloroethylene collected at and near Tank DG117 ranged in concentration from 50 mg/m^3 to 1890 mg/m^3 with an average concentration of 552 mg/m^3 for the twelve full-shift samples. Tetrachloroethylene concentrations at the front of the tank (site 2) were approximately four times the levels at the middle of the tank (site 3), six times the levels near the rear of the tank (site 1) and 20 times the levels ten feet from the tank (site G). Samples taken at the front of the tank (site 2) were approximately three times the allowable limit of 670 mg/m^3 and six times the NIOSH recommendation of 339 mg/m^3. Samples taken at the middle of the tank (site 3) were approximately 80 per cent of the allowable limit and two timesthe NIOSH recommendation. This tank was equiped with a sliding cover and the higher levels at the front and middle of the tank can be attributed to the failure to adequately close the cover when the tank was not in use.

Table 4. Area Samples - Air Concentrations (mg/m^3)

Tank	Sample Site	Contaminate	10-27-81	10-28-81	10-29-81	Average
1	1	Silver	-	< 0.002	< 0.002	< 0.002
"	2	"	-	< 0.002	< 0.002	< 0.002
"	Average	"	-	< 0.002	< 0.002	< 0.002
"	3	Cyanide	-	< 0.001	< 0.001	< 0.001
"	Average	"	-	< 0.001	< 0.001	< 0.001
6	1	Silver	< 0.002	-	< 0.002	< 0.002
"	3	"	< 0.002	-	< 0.002	< 0.002
"	Average	"	< 0.002	-	< 0.002	< 0.002
"	2	Cyanide	< 0.001	-	< 0.001	< 0.001
"	Average	"	< 0.001	-	< 0.001	< 0.001
10	1	Copper & Silver	< 0.002	-	-	< 0.002
"	2	" "	< 0.002	-	-	< 0.002
"	3	" "	< 0.002	-	-	< 0.002
"	General area	" "	< 0.002	< 0.002	< 0.002	< 0.002
"	Average	" "	< 0.002	< 0.002	< 0.002	< 0.002
19	1	Sulfuric Acid	0.057	-	0.083	0.070
"	2	" "	0.056	-	0.053	0.054
"	Average	" "	0.056	-	0.068	0.062
"	1	Hydrogen Fluoride	0.19	-	0.14	0.165
"	2	" "	0.18	-	0.16	0.170
"	Average	" "	0.185	-	0.15	0.167
25	1	Nickel	< 0.003	< 0.003	< 0.003	< 0.003
"	2	"	< 0.003	< 0.003	< 0.003	< 0.003
"	3	"	< 0.003	< 0.003	< 0.003	< 0.003
"	General area	"	< 0.003	< 0.003	< 0.003	< 0.003
"	Average	"	< 0.003	< 0.003	< 0.003	< 0.003
31	1	Cadmium	-	< 0.002	< 0.002	< 0.002
"	2	"	< 0.002	-	< 0.002	< 0.002
"	3	"	< 0.002	-	< 0.002	< 0.002
"	Average	"	< 0.002	< 0.002	< 0.002	< 0.002
"	1	Cyanide	< 0.001	-	-	< 0.001
"	2	"	-	-	< 0.001	< 0.001
"	3	"	-	< 0.001	-	< 0.001
"	Average	"	< 0.001	< 0.001	< 0.001	< 0.001

Table 4. Area Samples - Air Concentrations (mg/m^3) (Cont'd)

Tank	Sample Site	Contaminate	10-27-81	10-28-81	10-29-81	Average
53	1	Cadmium	< 0.002	-	< 0.002	< 0.002
"	2	"	< 0.002	< 0.002	< 0.002	< 0.002
"	3	"	-	< 0.002	-	< 0.002
"	Average	"	< 0.002	< 0.002	< 0.002	< 0.002
85	1	Chrome VI	0.0003	0.013	0.002	0.0051
"	2	"	0.0003	0.0003	0.0003	0.0003
"	3	"	0.13	0.002	0.015	0.0490
"	General area	"	0.0003	0.0003	0.0003	0.0003
"	Average	"	0.0327	0.0039	0.0044	0.0137
117	1	Tetrachloroethylene	256	323	154	244
"	2	" "	1890	1398	1295	1528
"	3	" "	526	454	102	361
"	General area	" "	50	130	50	77
"	Average	" "	680	576	400	552

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