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AIR POLLUTION POTENTIAL FROM ELECTROPLATING OPERATIONS

Philip Diamond

Environmental Health Laboratory
McClellan Air Force Base, California

April 1969

Report No. 69M-15
(Project No. E68-63)

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By

Philip Diamond

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13. ABSTRACT

Measurements were made of emission rates from electroplating operations considered to have maximum air pollution potential. Sampling was performed at McClellan and additional data from a previous survey at Hill Air Force Base was used. Values obtained were extremely low. Based on existing Federal standards, no collectors are specifically required for electroplating emissions. Experience of State and industry air pollution personnel, however, indicates that chrome plating and strong caustic emissions do require collectors.

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SECTION I

INTRODUCTION

As suggested in Hq AFLC (MCDPE) letter, 7 November 1968, a sampling study was undertaken to define the air pollution potential from electroplating operations. A Los Angeles County Engineering Manual published by the USDHEW (Ref. 1) defines the air pollution problem from electroplating as follows: "Most of the electrolytic plating and cleaning processes are of little interest from a standpoint of air pollution because the emissions are inoffensive and of negligible volume, owing to low gassing rates. Generally, air pollution control equipment is not required for any of these processes except the chromium plating process." Chromic acid mist emissions have caused problems by spotting car finishes in the vicinity of discharge ducts. Even though the concentrations are relatively low, they may still be high enough to cause property damage.

Mr. Schuman of the State of Michigan, Department of Health (Ref. 2) indicated that a collector is mandatory, based on his experience for chromic acid and alkali mists. In a personal discussion he indicated that he feels the alkali control requirement applies only to concentrated alkali emissions. He mentioned, for example, a 10 percent or more concentrated sodium hydroxide bath.

The direction provided by USAF (AFOCE) ltr, 9 Dec 66, Tables 11 and 12, are based on a now obsolete New York State Guide. This has been modified to the statute shown in Appendix I. "Environmental Ratings" of "B and C" as defined in Table II of Appendix I are usually assigned to areas surrounding plating shops according to I. Kingsley (N.Y. State Plans Review Engineer), and collectors are not normally required for plating discharges.

IBM Corporation's experience (Ref. 5) indicates that in the several IBM plating shops checked, the only fallout ever detected was chromic acid.

Emission figures for plating operations were not found in the literature surveyed (Ref. 3, 4, and 5) and contact with HEW, the Detroit Bureau of Industrial Hygiene, and New York State engineers disclosed that they were not aware of quantitative information available on plating discharge levels. No emission information was available from control equipment manufacturers. They generally report collector efficiency figures but do not indicate contaminant levels before and after scrubbing.

SECTION II

PROCEDURES

The plating and process tanks were selected for sampling on the basis of the following criteria:

1. A suitable and accessible sampling location was necessary. A straight run of duct away from elbows or constrictions and not requiring scaffolding was a minimum requirement.

2. Highest potential emission rates were anticipated (Ref. 6), based on emission tables published originally by New York State.

3. Plating, stripping, or cleaning operations were in progress in the tank during sampling.

4. Either a noticeable odor, irritation, or visible contaminant was perceived.

5. After selecting tanks which met most of the criteria outlined above, a pitot traverse was made at appropriate and accessible locations in the duct as far from a bend or obstruction as possible. The sampling procedure used was described by R. W. Sexton (Ref. 7). The point of average velocity was used to locate the sampling probe tip and isokinetic sampling was performed by adjusting the correct precalibrated pump sampling rate. A 1/4" I. D. pyrex probe with a 90° bend (opening facing into air stream) in series with an impinger containing 125 ml of appropriate sampling solution was used to collect samples.

Distilled water was used for sampling acids and bases and 0.1 N NaOH for cyanide sampling. M.S.A. tubes were used for NO_2 testing and surface sampling for HCN. The probe contents were carefully washed and added to impinger contents after sampling. A minimum sampling time of 10 minutes was used. If ventilation was inadequate, or proper sampling locations were not available, samples were taken above the tank liquid surface at a height of 10 - 15 inches above the point of maximum plating or stripping activity (as shown by bubble evolution or parts placement).

SECTION III

RESULTS

Results are summarized in Tables I and II below and bracketed values were samples taken above the same tank.

TABLE I

TANK SURFACE SAMPLES

Operation	Base*	Contaminant	Concentration
Silver Strike	M	HCN	12 ppm
Silver Plating	M	HCN	12 ppm
Cadmium Plating	M	HCN	2 ppm
Cadmium Barrel Plating	M	HCN	0 ppm
Cadmium Stripping	M	NO_2	0 ppm
Sulphuric Anodizing	M	H_2SO_4	0 ppm
Hard Chrome Plating	H	$CrO_3^=$	0.52 mg/m^3 0.28 mg/m^3
Hard Chrome Plating	H	$CrO_3^=$	0.14 mg/m^3 0.16 mg/m^3
Hard Chrome Plating	H	$CrO_3^=$	0.13 mg/m^3 0.18 mg/m^3
Hard Chrome Plating	H	$CrO_3^=$	0.34 mg/m^3 4.2 mg/m^3
Hard Chrome Plating	H	$CrO_3^=$	1.0 mg/m^3 1.1 mg/m^3

*M - McClellan AFB

H - Hill AFB

TABLE II

DUCT EFFLUENT SAMPLES

Operation	Tank Size	Average CFM/sq. ft.	Contaminant	Conc. mgm/m^3	Emission Factor lb/hr-ft^2 Tank Area
Hard Chrome Plating	4' x 8'	90	$CrO_3^=$	0.25	0.84 x 10^{-4}
Hard Chrome Plating	4' x 8'	80	$CrO_3^=$	$\left\{\begin{matrix}0.95\\0.18\end{matrix}\right.$	2.9 x 10^{-4} 0.54 x 10^{-4}
Hard Chrome Plating	4' x 8'	90	$CrO_3^=$	$\left\{\begin{matrix}0.73\\0.26\end{matrix}\right.$	2.50 x 10^{-4} 0.88 x 10^{-4}
Chrome Acid Anodizing (2 Ducts)	4' x 14'	80	$CrO_3^=$	4.0 2.2	Total 18.6 x 10^{-4}
Chrome Stripping	3' x 10'	60	$CrO_3^=$	0.2	.44 x 10^{-4}
Cadmium-HCl Tank	4' x 4'	135	HCl	70	354 x 10^{-4}
Silver Stripping	3' x 12'	40	NaOH HCN	140 0.24	210 x 10^{-4} .4 x 10^{-4}
Aluminum Bright Dip	5' x 14'	N.A.	NO_2 H_2SO_4	0 0	0 0

SECTION IV

DISCUSSION

Tank surface samples for chromic acid were taken at Hill Air Force Base in an industrial hygiene survey performed in February 1967. Our essential purpose in taking these particular samples was to provide an indication of the quantity of chromic acid mist escaping into the atmosphere and provide data for comparison with existing information. Ventilation rates varied from 85 - 400 cfm/ft^2.

The ventilation of the chrome plating tanks at McClellan AFB averaged only 85 cfm/ft^2, and the results of duct sampling are shown in Table II. Ventilation was poorly distributed on these tanks, and the results of surface samples taken for CrO_3 concentration ranged from 0.13 to 10.0 mgm/m^3.

Silver plating and cadmium plating tanks are cited in the literature (Ref. 6) as releasing no contaminants to the atmosphere. Sampling directly above these cyanide baths, we were unable to obtain concentrations of HCN above 12 ppm.

Cadmium stripping was performed with ammonium nitrate, and we were unable to find any NO_2 or NH_3 at the surface of the tank during the operation.

Results of samples taken directly above the sulphuric acid anodizing tank with anodizing in progress were negative for sulphuric acid.

The chromic acid anodizing tank sampled had two exhaust ducts, and the total CrO_3 emitted amounted to 0.10 pounds per hour. This value was significantly higher than the CrO_3 emission from the chrome plating tanks.

The only HCl tank in the plating shop that appeared to give off noxious fumes was the one in the cadmium area containing 50 - 55 percent by volume HCl where an emission rate of 0.57 pounds per hour was found.

The greatest emission of any contaminant obtained in the ducts sampled was 0.76 pounds of NaOH per hour from the silver stripping operation. Even this value is considerably below the New York State permissible limit of 10 pounds per hour.

Nickel plating involves no major health problems, and most baths can be operated without ventilation (Ref. 8). No air pollution problems should result from nickel plating.

We recognize that there are a number of variables which have affected the results obtained, and they must be taken into consideration if the results are to be applied to a new installation, i.e., the ventilation of the tank, freeboard, current density, cross-drafts, make-up air, etc. However, the results do indicate the order of magnitude of the concentrations to be expected and their relative insignificance from an air pollution standpoint.

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

1. Plating discharges (except for chromic acid, concentrated sodium hydroxide, or dilute sodium hydroxide with high current densities) are generally considered below levels which can constitute an air pollution problem from either a legal, aesthetic, or health standpoint.

2. Results indicate that the air pollution potential is negligible for almost all the plating and cleaning processes investigated.

3. A scrubber is recommended for silver stripping because of the relatively high concentration of strong caustic discharged.

4. Because of the car-spotting resulting from chromic acid discharges, a collector is recommended on chromic acid plating and chromic acid anodizing.

SECTION VI

REFERENCES

1. *Air Pollution Engineering Manual*, Air Pollution Control District, County of Los Angeles, complied and edited by John A. Danielson, 1967.

2. M. Schuman, "Designing Ventilation for Electroplating Plants," *Air Engineering* (7 July 1968), Vol 10, No. 7.

3. "Hazards in the Plating Industry," *Michigan's Occupational Health* (Winter 1965 - 1966), Vol II, No. 2.

4. D. Moore and I. W. Dyer, "New Way to Collect Plating Fumes," *Air Engineering* (April 1959).

5. "New Ventilation Design Cools Plating, Heat Treating Plant," *Heating, Piping and Air Conditioning* (September 1960).

6. Industrial Ventilation, *American Conference of Governmental Industrial Hygienists*, 9th Ed. Tables 5-5-5, 6.

7. R. W. Saxton, "Stack Sampling of Chemical mists and Vapors," Reprint No. 270-PB, American Air Filter Company.

8. L. E. Vager, "Hazards in the Plating Industry," *Michigan's Occupational Health* (Winter 1965-66), Vol. II, No. 2.

Appendix 1

Chapter IV Air Pollution Control

New York State Public Health Law

PART 187

CONTAMINANT EMISSIONS
FROM
PROCESSES, AND EXHAUST AND VENTILATION SYSTEMS

(Statutory authority: Public Health Law, §§ 1271, 1276)

Historical Note

Part added, filed Jan. 12, 1968 to be eff. Feb. 6, 1968.

Section 187.1 Applicability. This Part shall apply throughout the State of New York to contaminant emissions from processes, and exhaust and ventilation systems, except that when another Part applies to a specific air contaminant or a specific air contamination source, that Part shall take precedence and shall be applied in place of this Part.

Historical Note

Sec. added, filed Jan. 12, 1968 to be eff. Feb. 6, 1968.

187.2 Definitions. (a) *Environmental rating.* A rating indicated by the letter A, B, C or D, considers the environmental effects of an air contamination source. A rating takes into account properties and quantities of contaminants emitted; effects on human, plant, or animal life, or property; meteorological parameters, stack heights, characteristics of the community; and ambient air quality classification of the area in which the source is located or which it affects.

(b) *Emission rate potential.* The rate in pounds per hour at which air contaminants would be emitted to the outer air in the absence of air pollution control facilities or other control measures. The emission rate potential for cyclic operations shall be determined by considering both the instantaneous emission potential and the total emission potential over the time period of the cycle.

(c) *Emission source.* Any point at which air contaminants enter the outer air from processes, and exhaust and ventilation systems.

(d) *Exhaust and ventilation system.* Any system which removes and transports any gaseous or gas borne products from their point of generation to the outer air.

(e) *Permissible emission rate.* The maximum rate in pounds per hour at which air contaminants are allowed to be emitted to the outer air.

(f) *Process weight.* The total weight of all materials introduced into any specific process which may cause any discharge into the atmosphere. Solid fuels used in the process will be considered as part of the process weight, but liquid and gaseous fuels, uncombined water and combustion air will not.

(g) *Process weight per hour.* The total process weight divided by the number of hours in one complete operation from the beginning of a cycle to the completion thereof. For continuous processes, process weight should be determined on a daily basis.

Historical Note

Sec. added, filed Jan. 12, 1968 to be eff. Feb. 6, 1968.

187.3 Prohibitions. (a) No person shall cause, permit or allow the emission of air contaminants from an emission source resulting from an operation begun or modified, after the effective date of this Part, which exceeds the permissible emission rates specified in tables 2 and 3[‡], for the environmental rating as determined in accordance with table 1[‡].

(b) On January 1, 1971, or such later date as established by an order of the commissioner, the permissible emission rates specified in subdivision (a) shall become applicable to emission sources in existence on or prior to the effective date of this Part.

(c) The provisions of this section shall not be construed to allow or permit any person to emit air contaminants in quantities which alone or in combination with other sources would contravene any established air quality standards.

Historical Note

Sec. added, filed Jan. 12, 1968 to be eff.
Feb. 6, 1968.

187.4 Abatement. (a) The commissioner may require the person operating or maintaining emission sources to provide pertinent data concerning emissions so as to show compliance with the requirements of section 187.3.

(b) When required by the commissioner, the person operating or maintaining emission sources in operation before the effective date of this Part shall submit a detailed report including emission data, pertinent environmental factors and a proposed environmental rating so as to show conformity with this Part or proposed corrective measures and schedule for compliance. If this report is acceptable, the commissioner will so notify the person operating or maintaining the emission source. If the report is not acceptable, the commissioner will notify the person operating or maintaining the emission source as to the reasons together with an environmental rating that is acceptable and a time schedule for compliance. Upon petition to the commissioner within 30 days of such notice, the commissioner shall grant a hearing to the petitioner.

(c) Persons beginning or modifying operations after the effective date of this Part are required to submit to the commissioner or his representative, either prior to[*] or concurrently with submission of plans and/or specifications, an appraisal of the items mentioned in table 1[‡] in the form of a report including the proposed rating to be used for design purposes.

(d) The commissioner may seal any process equipment or prohibit any operation in accordance with a determination made under the provisions of section 1282 of article 12-A of the Public Health Law. The seal may be removed from the equipment only upon receipt of written notice from the commissioner.

Historical Note

Sec. added, filed Jan. 12, 1968 to be eff.
Feb. 6, 1968.

[‡] See Appendix 4.

[*] It is recommended that for large installations the report be submitted prior to submission of plans. Following approval of the preliminary report, final detailed plans and/or specifications will be completed and submitted to the commissioner or his representative for approval.

APPENDIX 4

TABLE 1

Environmental Rating

Rating	*Criteria*
A	Includes processes, and exhaust and ventilation systems where the discharge of a contaminant or contaminants results, or would reasonably be expected to result, in serious adverse effects on receptors or the environment. These effects may be of a health, economic or aesthetic nature or any combination of these
B	Includes processes, and exhaust and ventilation systems where the discharge of a contaminant or contaminants results, or would reasonably be expected to result, in only moderate and essentially localized effects; or where the multiplicity of sources of the contaminant or contaminants in any given area is such as to require an overall reduction of the atmospheric burden of that contaminant or contaminants.
C	Includes processes, and exhaust and ventilation systems where the discharge of a contaminant or contaminants would reasonably be expected to result in localized adverse effects of an aesthetic or nuisance nature.
D	Includes processes, and exhaust and ventilation systems where, in view of properties and concentrations of the emissions, isolated conditions, stack height, and other factors, it can be clearly demonstrated that discharge of the contaminant or contaminants will not result in measurable or observable effects on receptors, nor add to an existing or predictable atmospheric burden of that contaminant or contaminants which would reasonably be expected to cause adverse effects.

The following items will be considered in making a determination of the environmental rating to be applied to a particular source:

a) properties, quantities and rates of the emission
b) physical surroundings of emission source
c) population density of surrounding area, including anticipated future growth
d) dispersion characteristics at or near source
e) location of emission source relative to ground level and surrounding buildings, mountains, hills, etc.
f) current or anticipated ambient air quality in vicinity of source
g) latest findings relating to effects of ground-level concentrations of the emission on receptors
h) possible hazardous side effects of contaminant in question mixing with contaminants already in ambient air
i) engineering guides which are acceptable to the commissioner

TABLE 2

Usual Degree of Air Cleaning Required (1)
from
Processes, and Exhaust and Ventilation Systems
for
Gases and Liquid Particulate Emissions (Environmental Rating A, B, C and D)
and
Solid Particulate Emissions (Environmental Rating A and D)

	EMISSION RATE POTENTIAL (LB/HR)									
Environment Rating	Less than 1.0	1 to 10	10 to 20	20 to 100	100 to 500	500 to 1,000	1,000 to 1,500	1,500 to 4,000	4,000 to 10,000	10,000 and Greater
A	See Note (2)	99% OR GREATER								
B	*		90-91%	91-94%	94-96%	96-97%		97-98%	98-99%	99% or Greater
C	*		70-75%	75-85%	85-90%	90-93%		93-95%	95-98%	98% or Greater
D										

* Degree of air cleaning may be specified by the commissioner providing satisfactory dispersion is achieved.

(1) Where multiple emission sources are connected to a common air cleaning device, the degree of air cleaning required will be that which would be required if each individual emission source were considered separately.

(2) For an average Emission Rate Potential less than 1.0 lb/hr, the desired air cleaning efficiency shall be determined by the expected concentration of the air contaminant in the emission stream. Where it is uneconomical to employ air cleaning devices, other methods of control should be considered.

TABLE 3

Allowable Emissions
from
Processes, and Exhaust and Ventilation Systems
for
Solid Particulates (Environmental Rating B & C)

Process Weight (lb/hr)	Maximum Weight Discharge*** (lb/hr)
100	.50
500	1.46
1,000	2.30
5,000	6.70
10,000	10.80
25,000	20.00
50,000	31.80
75,000	42.00
100,000**	50.00
250,000**	58.20
500,000**	64.30
750,000**	68.40
1,000,000**	71.10
2,000,000**	78.30
5,000,000**	88.10

* In cases where process weight is not applicable (such as grinding and woodworking) the concentration of solid particulates in the effluent gas stream shall not exceed 0.3 lb/2000 lb of undiluted exhaust gas at actual conditions.

** For process weights in excess of 100,000 lb/hr, the permissible maximum weight discharge may exceed tabular value if the concentration of particulate matter in the effluent gas stream is less than 0.1 lb/1000 lb of undiluted exhaust gas at actual conditions.

*** To determine intermediate values of maximum weight discharge:
for process weights up to 100,000 lb/hr use $E = 0.024P^{0.665}$
for process weights in excess of 100,000 lb/hr use $E = 39P^{0.082}-50$
where E = maximum weight discharge in lb/hr; P = process weight in lb/hr