

Surface Finishing Safe Work Practices Manual

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alliance
An OSHA Cooperative Program

Disclaimer: Through the Occupational Safety and Health Administration (OSHA) and National Association for Surface Finishing (NASF) Alliance, NASF developed this manual for informational purposes only. It does not necessarily reflect the official views of OSHA or the U.S. Department of Labor.

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I. Introduction

Through the Occupational Safety and Health Administration (OSHA) the National Association for Surface Finishing (NASF) Alliance, NASF developed this manual to provide practical information on industry recommended work practices to improve safety and health in metal surface finishing facilities. The purpose of these work practices is to identify potential hazards associated with metal finishing operations and the precautions that should be adopted for the safety and health of all personnel involved in these processes. This manual identifies safe work practices that may reduce the potential for exposure to workers. Workplace safety and health checklists are also provided in Appendix A to assist owners and operators of metal finishing facilities in assessing what areas may need to be addressed to improve workplace safety and health.

Surface finishing facility owners should make this manual available to metal finishing managers, line supervisors and employees. It should be noted that the information contained in this manual is not necessarily mandatory, but rather suggested practices based on general industry standards. Accordingly, not all facilities will need to implement all of the work practices addressed in this document.

This document is also not a complete set of all of the work practices needed to ensure compliance with the applicable federal, state and local health and safety regulatory requirements. In many instances, facilities may have to do more to comply with the applicable regulatory requirements and should consult with local and state regulatory officials or experienced consultants on the specific requirements that may apply. To assist facilities in focusing efforts to improve workplace safety and health, a list of common OSHA citations for metal finishing operations is provided in Appendix B.

The NASF, OSHA and other organizations also have other resources, guidance and training to assist surface finishing employers in complying with the regulatory requirements. A list of compliance assistance resources that may be helpful for surface finishing facilities is provided in Appendix C.

II. Facility and Process Design

All metal finishing facilities and process lines should be designed to provide the safest working conditions possible. For existing operations, on-going inspections should be conducted to provide continuous improvement in safety. Where an inspection or near-miss indicates that there is an immediate threat to health or safety, action to control the hazard should be taken without delay.

For new and rebuilt lines, consideration should be given to allow for adequate space and access to the back of process lines where pumps and transfer piping are often installed. Bright lighting, especially for manual plating and maintenance operations is imperative.

1. Hazard Assessment

Before deciding on the type of engineering controls to use at the facility, an overall hazard assessment must be done to determine which method(s) would be most effective in reducing the exposures at the facility. Upon completion of the assessment, the facility should prepare a detailed report of findings and suggestions to improve existing engineering controls or implement additional measures to reduce exposures.

Keep in mind some facilities have multiple ventilation systems, and many different types of chemicals are used in surface finishing processes or production tanks. The optimal process temperature, chemical makeup, and process configuration of two different metal finishing operations can, and often do, vary widely. For this reason, an initial hazard assessment should be conducted to determine the most effective control methods.

III. Engineering and Work Practice Controls

Protecting employee health and safety are the primary objectives in an industrial metal finishing operation. Regulatory limits such as the Permissible Exposure Limit (PEL) and guidance such as Threshold Limit Value (TLV®) are used to define a healthy workplace environment. These exposure limits are found in the applicable OSHA regulations and American Conference of Governmental Industrial Hygienists (ACGIH®) Industrial Ventilation Manual, the 26th edition. To adequately protect workers from chemical exposures and injuries from occupational hazards at a metal finishing operation, facilities will need to control the air contaminants by first using engineering controls, which are the most effective approach, and second apply work practice controls. When these controls are infeasible, or do not completely control the hazard, facilities can provide further protection for employees through the use of appropriate PPE, including respirators. This section will address these three common control methods in the order of protectiveness.

Metal finishing facilities commonly use a variety of engineering controls to protect workers from exposures to air contaminants. These include local exhaust ventilation and general dilution ventilation, eductors, fume suppressants, surface tension reducers, rinse practices, and product substitution. This section will address each of these control methods.

1. Ventilation Systems

Industrial ventilation is a method of controlling worker exposures to airborne toxic chemicals or flammable vapors by exhausting contaminated air away from the work area and replacing it with clean air. The design and troubleshooting of industrial ventilation systems should be handled by qualified ventilation engineers or firms specializing in this field.

a. Types of Workplace Ventilation

The two common types of workplace ventilation used are local exhaust ventilation (LEV) or dilution (or general) ventilation.

Local exhaust ventilation captures contaminated emissions at or very near the source and should be exhausted to the outside (see example in Figure III-1). LEV systems are located as close as possible to the source of contamination to capture the contaminant before it is released into the work area. LEV is the preferred method to control air contaminants since it is more efficient and it eliminates the contaminants using lower exhaust flow volumes and therefore lower heating costs.

Dilution (or general) ventilation dilutes contaminated air in a whole building or room by supplying a large quantity of clean air and exhausting the contaminated air outside (see example in figure III-2). Dilution ventilation by itself should only be used if the toxicity of the contamination is low or if LEV is impractical such as in a confined space. When using dilution ventilation:

- Position exhausts as close to emission sources as possible;
- Use auxiliary fans for mixing;
- Make sure employees are upwind of the dilution zone; and
- Add make up air where it will be most effective.

The surface finishing industry uses both LEV and general ventilation. Some electroplating operations require the use of LEV to protect workers from exposures to contaminants (e.g., electroplating tanks). In other cases, general ventilation will be sufficient. To determine the appropriate ventilation for surface finishing operations, the facility should evaluate the facility airflow, assess the potential engineering controls, and design a ventilation system to minimize workplace exposures.

Figure III-1: Local Exhaust Ventilation (LEV)

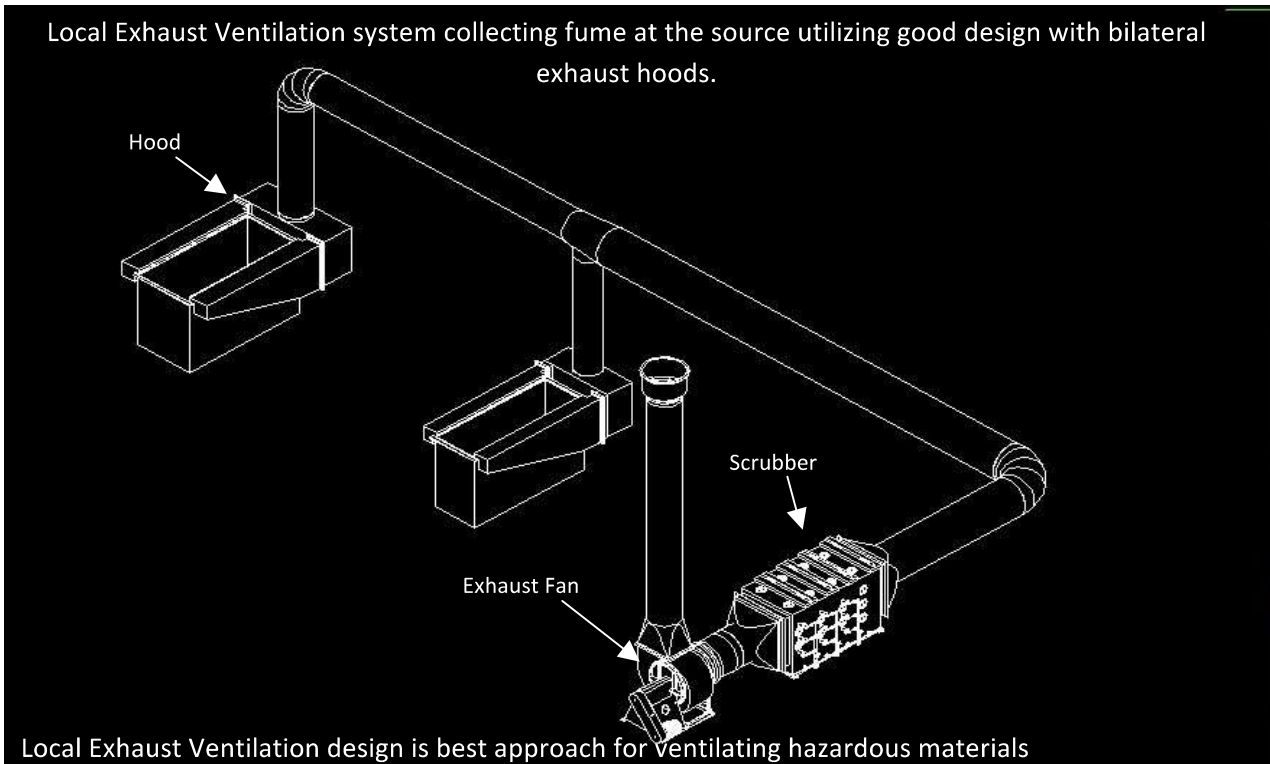


Diagram courtesy of KCH Services, Inc.

Figure III-2: General or Dilution Ventilation (Roof ventilators pulling outside air through building)

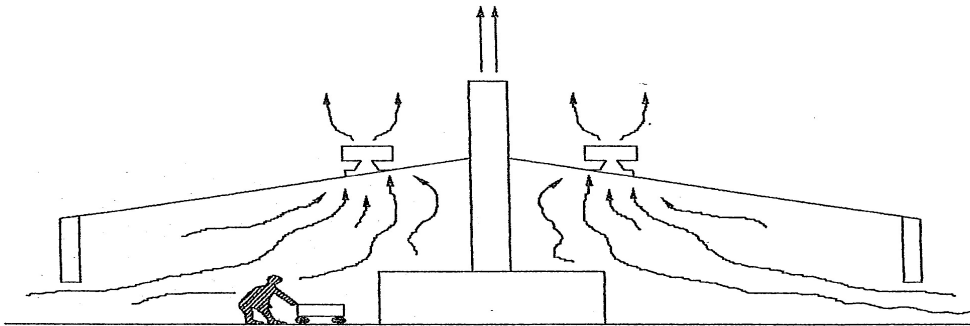


Diagram courtesy of KCH Services, Inc.

b. Balancing Makeup Air with Exhaust Air

LEV or dilution (or general) ventilation requires makeup air or the continued replacement of air being exhausted from the room or building. When makeup air is not provided, such as in the case of a closed building, then a negative pressure in the building is created, and this can impair the efficiency of the exhaust systems design. Low makeup air in regard to exhaust can disable pilot lights by reversing the flue gas in stacks. An indication that the makeup air system may be under-designed could be doors that are difficult to open and/or are slamming shut. One quarter inch of static pressure can create a 1,200 feet per minute (fpm) draft in a gap such as a door. Exhaust hood capture velocities are often designed less than 1,200 fpm. Illustrations of how to balance makeup air with exhaust air is provided below in Figure III-3.

Figure III-3: Illustration of slow and even distribution of return air/makeup air

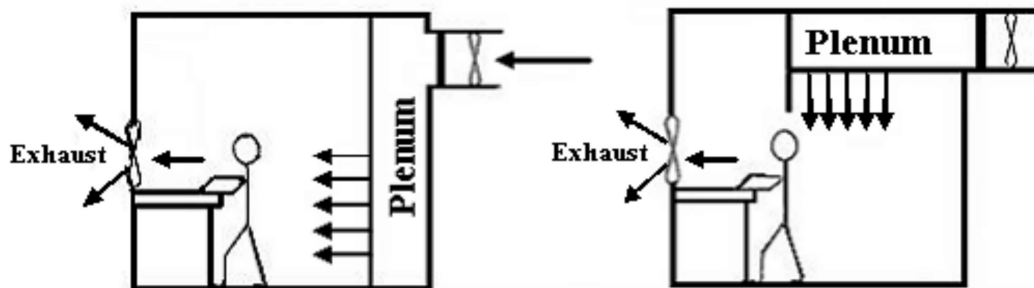


Diagram courtesy of KCH Services, Inc.

c. Assess Threat of Cross Drafts

Even distribution and slow air velocity provides the best approach when designing makeup or return air. Improper makeup air design can create interfering cross drafts in employee breathing zones.

d. Re-Entrainment of Exhausted Air

If the location and height of the exhaust stack is not selected properly, exhausted air and potential contaminants can be reintroduced into the building. The location of shipping doors, makeup air systems, other buildings, or other potential entrance points should be considered during the design phase. An example of how poor design of the ventilation system can lead to re-entrainment of exhausted air is provided below in Figure III-4.

Figure III-4: Poor design enables hazardous fumes to reenter facilities

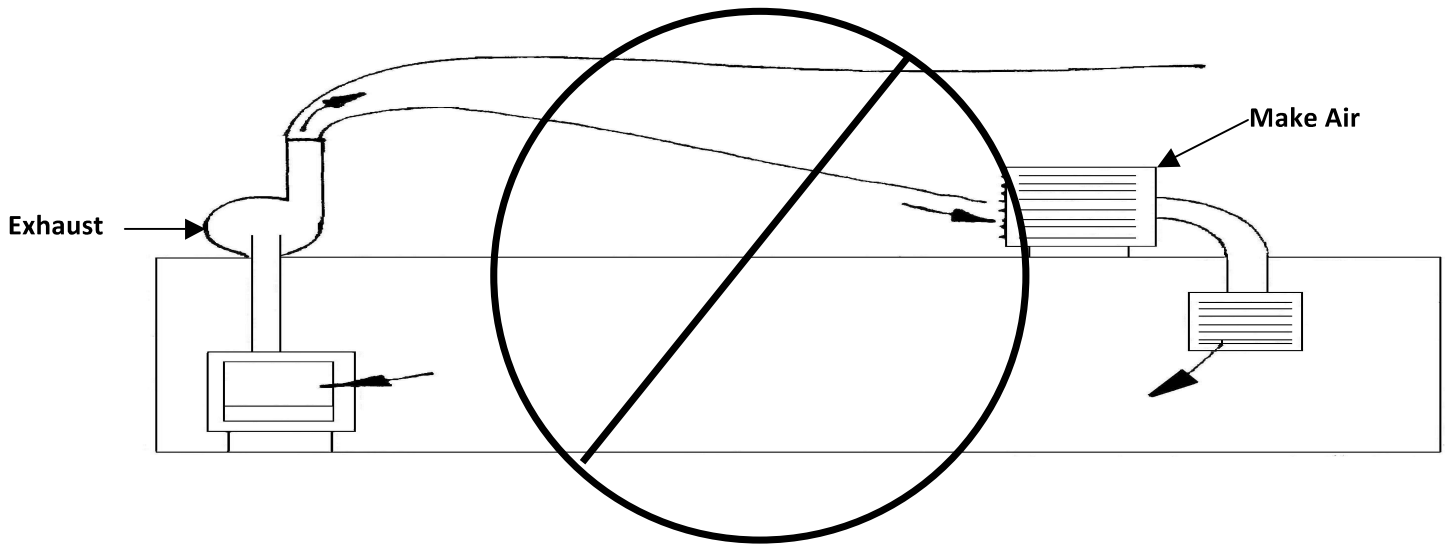


Diagram courtesy of KCH Services, Inc.

e. Effective Local Exhaust Ventilation Design

The most comprehensive LEV design can be found in the American Conference of Governmental Industrial Hygienists (ACGIH®) manual of recommended practice. According to the *Industrial Ventilation A Manual of Recommended Practice*, ACGIH® incorporates ANSI Z9 recommendation which has a scheduled review and acceptance process. The American National Standards Institute (ANSI) Z9 committee's revised manuals are periodically sent to the ACGIH® committee for review and acceptance. The latest ACGIH® Industrial Ventilation Manual, the 26th edition.

The ACGIH® and ANSI Z9 committees are made up of experienced professionals from universities, government agencies, and industry.

Several tables as well as other useful information in the ACGIH® Industrial Ventilation Manual can be used by facilities to design appropriate ventilation systems to control air contaminants.

Tables III-1 and III-2 below include ACGIH® recommendations that identify the categories of hazard potentials and the rate of gassing or misting for air contaminants. Table III-3 below also provides information to determine minimum control velocities in feet per minute (fpm) that can be used for effective ventilation of air contaminants.

Table III-1: Determination of Hazard Potential

HYGIENIC STANDARDS			
Hazard Potential	Gas and Vapor (ppm)	Mist (mg/m³)	Flash Point (degrees F)
A	0-10	0-0.1	—
B	11-100	0.11-1.0	Under 100
C	101-500	1.1-10	100-200
D	Over 500	Over 10	Over 200

Table III-2: Determination of Rate of Gas, Vapor or Mist Evolution

Rate	Liquid Temperature (F)	Degrees Below Boiling Point (F)	Relative Evaporation* (Time for 100% Evaporation)	Gassing**
1	Over 200	0-20	Fast (0-3 Hrs)	High
2	150-200	21-50	Medium (3-12 Hrs)	Medium
3	94-149	51-100	Slow (12-50 Hrs)	Slow
4	Under 94	Over 100	Nil (Over 50 Hrs)	Nil

* Dry time relation: Fast – Below 5, Medium – 5-15, Slow - 15-70, Nil – Over 70

** Rate of gassing depends on rate of chemical or electrochemical action, and therefore, depends on the material treated and the solution used in the tank and tends to increase with: 1. amount of work in the tank at any one time, 2. strength of the solution in the tank, 3. temperature of the solution in the tank, and 4. current density applied to the work in electrochemical tanks.

Table III-3: Minimum Control Velocity (fpm) for Undisturbed Locations

Class	Enclosing Hoods		Lateral Exhaust ¹	Canopy Hoods	
	One Open Side	Two Open Sides		Three Open Sides	Four Open Sides
A-1 & A-2	100	150	150	Do Not Use	Do Not Use
A-3 ² , B-1 & C-1	75	100	100	125	175
B-3, C-2 & D-1 ³	65	90	75	100	150
A-4 ¹ , C-3 & D-2 ³	50	75	50	75	125
B-4, C-4, D-3 ³ & D-4 – Adequate General Room Ventilation					

¹ Use aspect ratio to determine air volume.

² Do not use canopy hood for Hazard Potential A processes.

³ Where complete control of hot water is desired, design as next highest class.

f. Inspection and Maintenance of Ventilation Systems

Each facility should perform an initial detailed inspection and analysis of their existing ventilation system. An experienced ventilation technician or the facility's air flow evaluation team should analyze and inspect all components of the existing controls to ensure that they are operating at peak performance. Items for initial inspection may include:

- existing and potential controls for all sources of hazardous processes;
- exhaust and makeup air system;
- multiple static pressure readings;
- hood capture velocities;
- fume capture obstructions;
- identifying cross drafts; and
- cross reference collected data to design calculations.

Each facility should continue to monitor the ventilation system components monthly to ensure proper operation and efficiency. The components of the ventilation system that should be monitored include but are not limited to, fan bearings and belts as well as the condition of the fan wheel itself, composite mesh pad wash down systems, and wet-packed bed scrubber components such as nozzles, solenoids and "Y" strainers. An example of selected parts of a ventilation system is provided in Appendix D.

These parts should be examined to guarantee that the flow is within acceptable parameters maximizing the efficiency of your system. All pressure gauges should be inspected periodically to ensure there is little or no chance of debris building up within the lines and all gauges should be calibrated to ensure that the display pressure is accurate. These readings are vital not only for permit requirements, but also for predicting problems before they can become disasters. By taking these steps a facility owner or operator can be assured that its equipment will function properly with minimal unexpected downtime. By being aware of any problems that may arise, the facility can implement its action plan in time to reduce any loss of production.

Many ventilation systems in use today are not properly maintained and operated, which can lead to costly down time, potential increased workplace exposures, or excessive environmental emissions. A facility should conduct regular maintenance on its ventilation system. An example of regular maintenance tasks that a facility could implement is provided in Appendix E. If qualified employees in your facility are not available to provide and keep proper records and maintain system performance, then an outside firm may help.

A preventive maintenance agreement with an outside contractor is a good way to stay current with applicable regulatory requirements, quality control programs such as ISO 9000, and help to ensure the proper and effective operation of air control equipment. Most ventilation companies offer a preventive maintenance and repair service contract. Continued monitoring of the facility's engineered controls is accomplished with a service such as this. Qualified experienced technicians test, check, and record a wide variety of data that is then logged. The contractor would then provide a detailed copy of the Preventive Maintenance Agreement (PMA) report for the metal finishing facility. A sample PMA is provided below in Appendix F.

2. Use of Eductors to Minimize Air Contaminants in the Electroplating Tank

Many chemical baths are currently mixed via air agitation: air pipes bubble air into the tank to keep metal finishing process solutions mixed and to prevent them from settling. A potential adverse effect of this agitation is that air bubbles escape at the surface of the tank, resulting in misting and entrainment in the air. By using eductors (horn-shaped nozzles) in tanks, the flow from a pump to create solution movement below the surface without the use of air bubbles and the amount of misting and bubbling at the tank surface can be significantly reduced. An example of an eductor used in the surface finishing industry is in Figure III-5.

Figure III-5: Example of an Eductor Used in Metal Finishing Operations



Photo courtesy of Serfilco

Liquid pumped into the eductor nozzle exits at high velocity, drawing an additional flow of the surrounding solution through the eductor. This additional flow (induced liquid) mixes with the pumped solution and multiplies its volume five-fold. The source of the pumped liquid (input) can be a pump or filter chamber discharge.

Eductors are designed to multiply low pump flow to a larger volume of agitation by using the Venturi effect. For example, one 3/8" nozzle requires 7.5 gallons per minute (GPM) of pumped flow @ 10 psi 23 total dynamic head (TDH). The agitation rate will be 37.5 GPM @ 10 psi 23 TDH.

Use of eductors can provide a number of benefits for surface finishing operations:

- To minimize *workplace exposures* by reducing fume emissions by up to 90 percent below baseline.
- To reduce *energy consumption*, especially for all heated finishing baths. By having total movement of solutions in a tank, a more uniform heating is achieved and some heat is also generated by the constant recirculation of the solution. This more efficient process translates into less BTUs used.
- For *time savings* as eductors can increase the plating rate (amps/sqft) for most plating solutions which means less time in tank and a higher production rate.

While eductors can reduce potential workplace exposures, their use is not necessarily universally applicable for all surface finishing operations. This is especially true for some existing plating tanks where space constraints inside the tanks can make retrofitting the tank with eductors difficult for some finishing processes. In addition, tank access and parts removal can also present

some challenges when using eductors. Nonetheless, eductors provide an opportunity to reduce potential workplace exposures for surface finishing operations.

3. Fume Suppressants/Surface Tension Reducers

In some plating operations such as chromium plating, the efficiency of the plating process is relatively low, resulting in the formation and release of hydrogen in the form of small bubbles from the cathode. The breaking of these bubbles at the surface is responsible for the generation of chromic acid mist. A range of control systems are available to limit the release of the chromic acid mist into the workplace air. In many instances, the use of fume suppressants can significantly reduce emissions from plating tanks and substantially lower potential workplace exposure levels. The use of fume suppressants alone may not, however, be recommended for some operations when local exhaust ventilation is possible. Where a fume suppressant is used, it is important to ensure that the concentration is maintained at an effective level. This may require regular additions of the suppressant to the tank as well as regular surface tension measurements.

The use of fume suppressants and wetting agents to lower the surface tension of plating baths can also help to reduce potential workplace exposures. The materials can effectively help to minimize dragout from plating tanks and, thereby, reduce potential workplace exposures. Information about the chemicals contained in fume suppressants can be found on Material Safety Data Sheets. Should employers need additional information, they can contact their chemical suppliers/manufacturers.

4. Rinse Practices to Minimize Exposure

Most metal finishing operations utilize immersion rinsing techniques. However, as water reduction and other pollution prevention techniques are more often being used, it is common to find spray rinsing on a process line. The use of water can be greatly reduced by these techniques, but may contribute to airborne occupational exposures from the misting created by the spray. When possible, spray rinse should be done within the tank. If that is not possible, lower pressure spray nozzles may need to be used.

5. Product Substitution

One method to minimize the potential workplace exposure concerns associated with chemicals used in the surface finishing industry is to substitute less hazardous chemicals where practicable. One example of where the industry has focused extensive research is finding replacements for hexavalent chromium. A brief summary of those substitute technologies that have managed to gain some commercial application for hexavalent chromium is provided in Appendix G.

The surface finishing industry continues to support research and development efforts to identify commercially viable alternatives to hexavalent chromium plating chemistries and other potentially hazardous plating chemistries. To date, alternative technologies have not gained widespread commercial application due to: 1) the superior coating performance in decorative, functional and corrosion protection applications for hexavalent chromium plating, 2) cost effective applications,

3) broad and flexible ranges of use, and 4) strong customer/market preferences for hexavalent chromium plating. Surface finishing facilities should continue to examine and consider product substitution, where feasible and practical to provide a healthy, safe and viable working environment for surface finishing workers.

6 Exposure Monitoring for Air Contaminants

There are a variety of potential contaminants that may be found at electroplating shops (see Table III-4), and OSHA has workplace exposure standards for numerous air contaminants. To demonstrate compliance with these standards, employers must periodically monitor their employees' workplace exposures. Employers may be required to conduct initial monitoring of airborne concentrations and to conduct periodic exposure monitoring for all tasks where employee exposures may be above the applicable PEL and action levels.

The PELs are enforceable exposure limits promulgated by the Occupational Safety and Health Administration (OSHA). The PELs can be found in OSHA's Code of Federal Regulations (29 CFR 1910 subpart Z) for many of the chemicals used in surface finishing facilities. Other non-enforceable limits which can be used for guidance are: TLVs® are suggested, non-enforceable exposure limits and are established by the American Conference of Governmental Industrial Hygienists (ACGIH®) and National Institute for Occupational Safety and Health (NIOSH) Recommended Exposure limits (RELs).

Table III-4: Potential Contaminants in Electroplating Shops

<u>Metals</u>	<u>Acids</u>	<u>Other inorganics</u>	<u>Solvents and other organics</u>
Aluminum Cadmium Chromium Copper Lead Manganese Nickel Silver Zinc* Zinc compounds * fume or dust only	Hydrochloric acid* Nitric acid Phosphoric acid Sulfuric acid* * aerosol form only	Ammonia compounds Ammonium nitrate Chlorine Cyanide Cyanide compounds nitrates	Certain glycol ethers Ethylbenzene Formaldehyde Methyl ethyl ketone Methyl isobutyl ketone Tetrachloroethylene Trichloroethylene Toluene Xylene (mixed isomers)

Source: <http://www.nmfrc.org/compliance/tri.cfm>

A method for air sampling and analysis of metals that can be used is OSHA Method ID-125G – Metal and Metalloid Particulates in Workplace Atmosphere (ICP Analysis). This method and other analytical methods are available through OSHA's web site at www.osha.gov.

Facilities can conduct their own sampling, provided that they use the proper sampling equipment, filter media and follow the method, or they can use an outside consultant or insurance carrier to conduct or assist in the monitoring. During this sampling, a small calibrated pump is worn on the belt of the operator and is used to draw a representative air sample from the breathing zone of the employee and collected on a filter. An accredited laboratory with an outside approved quality control program should be used for analysis of the filter for the applicable air contaminant.

A. Hexavalent Chromium Exposure Monitoring Requirements

Exposure monitoring requirements that are applicable to surface finishing operations is the workplace exposure standard for hexavalent chromium: 29 CFR §1910.1026. On February 28, 2006, OSHA issued a standard that significantly lowered the limit on worker exposures to hexavalent chromium: 71 Fed. Reg. 10100 (2006). This new standard included monitoring, training and hygiene requirements for facilities with industrial processes that use hexavalent chromium, even in small quantities and/or concentrations. OSHA has also developed a *Small Entity Compliance Guide for the Hexavalent Chromium Standards* (OSHA 3320-10N, 2006) that has some helpful guidance for metal finishing facilities.

If hexavalent chromium is used in the workplace, the employer must monitor employee exposure to hexavalent chromium to determine if any employee is being exposed in excess of the PEL, 5 $\mu\text{g}/\text{m}^3$, as an eight-hour time-weighted average (TWA) (see Table III-5 for the PELs, TLVs® and RELs). For surface finishing operations, these processes include, but are not limited to:

- chromium electroplating,
- chromic acid passivation,
- hexavalent chromium conversion coating,
- chromic acid etching,
- chromic acid sealing of anodized and phosphated parts,
- wastewater treatment of hexavalent chromium containing rinsewaters, and
- welding or cutting of stainless steel.

Typical job tasks for surface finishing that may be monitored include, but are not limited to:

- metal finishing operations (*e.g.*, operators, un/rackers, supervisors),

- quality control monitoring and chemical additions (*e.g.*, lab techs),
- periodic tasks such as tank clean-out, liner replacement (*e.g.*, maintenance staff), and
- wastewater treatment of hexavalent chromium-containing process water and concentrates (*e.g.*, treatment operators).

Table III-5: Exposure Limits for Chromium (VI) Compounds

Organization	8-Hour Time-Weighted Average (TWA)
OSHA (enforceable) Chromium VI (general industry, Shipyards, and Construction) 29 CFR 1910.1026, 29 CFR 1915.1026, and 29 CFR 1926.1126	Permissible Exposure Limit (PEL): 5 µg/m ³ of air Action Level (AL): 2.5 µg/m ³ of air
ACGIH®- TLV® (non- enforceable)	50 µg/m ³ of air (water soluble Cr(VI) compounds) 10 µg/m ³ of air (insoluble Cr(VI) compounds)
NIOSH- REL (non-enforceable)	1 µg/m ³ of air (water soluble Cr(VI) compounds)* 1 µg/m ³ of air (insoluble Cr(VI) compounds)*

* for 10 hour TWA

Employers may chose between two options for performing exposure determinations: a scheduled monitoring option or a performance oriented option.

1. Scheduled Monitoring Option

a. Initial Monitoring

Employers who select the scheduled monitoring option must conduct initial exposure monitoring to determine exposure to Cr(VI) for each employee. This involves taking a sufficient number of personal breathing zone air samples to accurately characterize full shift exposure on each shift, for each job classification, in each work area. Monitoring results must indicate the employee’s time-weighted average exposure to airborne Cr(VI) over a typical 8-hour workday.

In some cases the employer will need to monitor all exposed employees, while in other cases it will be sufficient to monitor “representative” employees. Representative exposure sampling is permitted when a number of employees perform essentially the same job under the same conditions. For example, an employer may choose one welder to sample as a representative of several welders who work in a welding shop for determining exposure as long as all of the welders represented by the monitoring perform the same job under the same conditions.

b. Periodic Monitoring

Periodic monitoring is required if the initial monitoring shows that the employee’s exposure are at or above the Action Level (See Table III-6, below, for monitoring frequency.)

Table III-6: Monitoring Frequency	
<i>Exposure Scenario</i>	<i>Required Monitoring Activity</i>
Below the Action Level (< 2.5 µg/m ³)	No periodic monitoring required for employees represented by the initial monitoring
At or above the Action Level but at or below the PEL (2.5 µg/m ³ to 5 µg/m ³)	Monitor every six months
Above the PEL (> 5 µg/m ³)	Monitor every three months.

If initial monitoring shows exposures above the PEL, but subsequent periodic measurements indicate that exposures have lowered to levels at or below the PEL, but still above the Action Level, the employer may reduce the frequency of periodic monitoring to every six months. In addition, an employer may discontinue periodic monitoring for employees represented by monitoring results indicating that exposures have fallen below the Action Level if those results are confirmed by a second measurement taken at least seven days later.

c. Additional Monitoring

Additional monitoring is necessary when a workplace change may result in new or additional exposures to Cr(VI) or the employer has any reason to believe that new or additional exposures have occurred. These changes may include alterations in the production process, raw materials, equipment, personnel, work practices, or control methods used in the workplace.

2. Performance Oriented Option

The performance-oriented option allows the employer to determine the 8-hour TWA exposure for each employee on the basis of any combination of air monitoring data, historical monitoring data, or objective data sufficient to accurately determine current employee exposure to Cr(VI). This option is intended to allow employers flexibility in assessing the Cr(VI) exposures of their employees. Where the employer elects to use this option, the exposure determination must be performed prior to the time that the work operation commences and must provide the same degree of assurance that employee exposures have been correctly characterized as is provided under the scheduled monitoring option.

3. Monitoring Specifications

In determining each employee's workplace exposure to hexavalent chromium, employers may take either:

- personal breathing zone air samples for each employee exposed; or
- personal breathing zone air samples for one or more employees when the samples are representative of each employee's exposure, provided that sampling is conducted under the highest potential exposure.

Area monitoring is not an acceptable method for determining PEL compliance.

Personal breathing zone air samples are considered representative of an employee's eight-hour TWA if:

- the employee(s) sampled are in the same job classification;
- the employee(s) sampled are working in the same area;
- the employee(s) sampled work during the same work shift (if the employer can document that tasks and workplace conditions are similar during all work shifts, he/she only needs to determine the exposure level for one work shift); or
- the employee(s) sampled is expected to have the highest hexavalent chromium exposures of all employees in the group of employees represented by the samples collected.

OSHA ID-215 monitoring method requires that the sampling device must be calibrated in-line (*i.e.*, through the air filter media being used) for each monitor. The flow rate through each monitor must be two liters per minute (LPM). The air sampling media to be used is a 37 mm PVC filter badge, which is typically clipped to an operator collar and placed near his/her breathing zone. An approved primary calibration (*e.g.*, not a field rotameter) instrument must be used to verify the flow rate of two LPM through each filter. At least one blank (unused) cassette must be submitted for each lot of filters to be analyzed.

Before placing the monitor on the employee, the employer should explain why he/she is being tested, and indicate that the employee will be notified of the test results when they are available to the employer. The employees should also be instructed not to touch or remove the monitor at any time during the testing. They should wear the monitor during breaks and lunch periods. It is recommended that sampling be conducted for a full work shift. At a minimum, at least seven hours for each operator should be tested. For example, a maintenance operator may only have 30 minutes of exposure to chromic acid, but the monitor should be worn for the full work shift, unless the employer documents that no other exposures to Cr(VI) occurred during the remainder of the workshift.

4. Recordkeeping

Employers must establish and keep accurate records of all exposure monitoring data as well as the objective data used to support exemptions from initial monitoring requirements.

Employers must keep exposure monitoring records for 30 years. The records must include:

- the date of the measurement for each sample taken;
- the monitored operation involving hexavalent chromium exposure;
- the sampling and analytical methods used and evidence of accuracy by the lab;
- the number, duration, and results of samples taken;
- the worker's name, job classification, and exposure levels (where representative samples are used, identify all employees represented by the data and indicate which employees were above the action level and PEL); and
- any additional helpful general process information to include is type of metal finishing process (*e.g.*, hard chromium plating), the type of equipment (*e.g.*, manual, automatic hoist, *etc.*) and the type of ventilation (*e.g.*, bilateral, push-pull, enclosed hood, *etc.*).

B. General Monitoring Requirements

This guidance provides only general information on air monitoring requirements and should not be considered to be a complete summary for all monitoring requirements. For specific exposure monitoring requirements, please refer to the OSHA workplace exposure standards in Title 29 of the Code of Federal Regulations, Part 1910. The applicable standards can be accessed at OSHA's web site www.osha.gov.

IV. Personal Protective Equipment (PPE)

An initial hazard assessment for each job task for metal finishing operations must be properly conducted and documented. Once the hazard assessment is complete, recommendations on the appropriate level of PPE should be implemented.

This program should be reviewed regularly to ensure its ongoing adequacy, effectiveness, and accuracy, as well as to identify any opportunities for improvement. This can include a review of all related materials and records. All such reviews (whether changes were made or not) should be documented on the annual program review document.

1. PPE Hazard Assessment

The facility should assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of PPE. If such hazards are present, or likely to be present, the facility should:

- select, and have each affected employee use, the types of PPE that will protect the affected employee from the hazards identified in the hazard assessment;
- communicate selection decisions to each affected employee; and
- select PPE that properly fits each affected employee.

A PPE Assessment Survey (or equivalent) can be used to document this evaluation.

The facility should verify that the required workplace hazard assessment has been performed through a written certification that identifies the workplace evaluated; the person certifying that the evaluation has been performed; and the date(s) of the hazard assessment.

An example of a PPE Hazard Assessment for a metal finishing facility is provided below in Table IV-1.

Table IV-1: Sample PPE Hazard Assessment

Department	Description	Minimum PPE Required	Protection From Hazard(s)
NA	Entire Plant & Visitors	Safety Glasses Impervious Closed-Toe Shoes	Miscellaneous General Hazards from Manufacturing Operations
Plating	Plating Operator	Safety Glasses Slip & Chemical Resistant Shoes/Boots Chemical Resistant Gloves	Chemical Exposure Wet Floors Chemical Exposure
Plating	Chemical Additions	Safety Glasses & Face Shield Slip & Chemical Resistant Shoes/Boots Gloves/Apron	Chemical Exposure Wet Floors Chemical Exposure
Plating	Racking/ Unracking	Safety Glasses Closed-toe shoes Protective Gloves Ear Plugs (when drying parts)	Sharp Pieces Falling, Slipping Noise Exposure
Polishing	Polishing Operator	Safety Glasses Hard Hats ½ Mask Respirator Gloves/Apron Ear Plugs Safety Shoes	Particulate in Eyes, Lungs Flying parts Noise Exposure
Wastewater Treatment	Wastewater Treatment Operation	Safety Glasses Slip & Chemical Resistant Shoes/Boots Chemically Resistant Gloves Hearing Protection (optional)	Splashing of Wastewater & Chemicals Falling, Slipping Chemical Exposure Noise exposure
Shipping	Forklift Operators	Safety Glasses Hard Hats Safety Shoes	Flying Objects Falling Overhead Packages
Maintenance	Welding	Safety Glasses Face Shield w/Tinted Eye-Piece Leather Gloves Steel-Toe Safety Shoes	Fumes, Particulate Radiation Hot Objects Compression from Gas Cylinders
Maintenance	Electrical Work	Safety Glasses Leather Gloves Steel-Toe Safety Shoes	Fumes, Sharp Objects Sharp Objects, Shock Falling Tools, Sharp Objects
Maintenance	Chemical Handling/Spill Clean-Up	Safety Glasses Face Shield or Goggles Steel Toe Safety Shoes Chemical Resistant Gloves	Chemical Splashes, Fumes Chemical Splashes, Fumes Falling Containers, Slipping Skin Irritation

2. Selection of PPE

Selection of PPE should be based on several factors, including its ability to protect employees against the type and degree of hazard for which it is intended to be used. Other factors such as employee preferences, comfort, and attractiveness will be secondary considerations.

All equipment purchased after implementation of this program should meet applicable standards set forth by ANSI, American Society of Testing Materials (ASTM), or other appropriate organizations.

3. Defective Equipment

Defective or damaged PPE should not be used. Employees should report defective equipment to a supervisor, who will make a determination as to whether to repair or discard the equipment. Discarded equipment should be destroyed and/or labeled to ensure that other employees do not use it.

4. PPE Training and Communication

This section describes how this program should be communicated to employees, and how they should be trained in the required skills, procedures, *etc.* In all cases, training should be conducted by a suitably qualified person.

a. Timing of Training

Employees should receive training under the following circumstances.

- When they are initially assigned to an area, task, or activity to which this program applies.
- When changes in hazards, operations, materials, *etc.* make retraining appropriate.
- When employees' performance or other observation indicate a need for retraining.
- Refresher training should be provided annually.

b. Records

All employee training should be adequately documented. Training records should include:

- the names and job titles of all attendees;
- the name of the person conducting the training;
- the date, location and time of the session(s); and
- a brief description or outline of the material discussed.

Training records should be maintained at the facility for a minimum of three years beyond the training date.

c. Content of Training

The training session should address the following:

- when PPE is necessary;
- what PPE is necessary;
- how to properly don, doff, adjust, and wear PPE (including proper use and connection of fall protection equipment);
- the limitations of PPE; and,
- the proper care, maintenance, useful life, and disposal of PPE.

5. Protective Clothing

In general, operators working on a metal finishing process line should utilize a combination of the following: chemical-resistant shoes/boots, a chemical-resistant apron, chemical-resistant gloves, and safety glasses with side-shields or goggles.

For manual plating operations, a chemical resistant apron provides protection from dripping parts and accidental contact with tanks. Disposable Tyvek suits are also useful for protecting clothing during tank clean-outs and other similar tasks. If protective clothing is to be laundered for reuse, it must be bagged and labeled to ensure persons laundering these items are informed of hazardous chemical contamination (e.g., chromic acid).

As specified in the final rule for PPE payment, employers are required to provide for and pay for PPE (see 29 CFR 1910.132(h)).

a. Eye/Face Protection

It is recommended that employees should be provided with and required to wear eye/face protection where/when they are significantly exposed to hazards of:

- flying objects or particles,
- molten metal,
- liquid chemicals,
- acidic or caustic liquids,
- chemical gases or vapors, or
- potentially injurious radiant light.

All eye/face protection should meet the requirements of *American National Standards Institute (ANSI) for Occupational and Educational Eye/Face Protection, Z87.1*.

Employers should consider the following guidelines when selecting eye/face protection for their employees.

- Each employee who is exposed to splashing chemicals, flying particles or objects should wear eye protection which affords side protection. Clip-on or slide-on shields are acceptable.
- Employees who wear prescription lenses should wear eye protection that incorporates the prescription in its design or should wear eye protection designed to be worn over prescription lenses.
- Contact lenses are not to be considered protective lenses and are not recommended in corrosive environments.
- Eye/Face protection should be marked to clearly identify the manufacturer.

b. Head Protection

Employees should be provided with, and required to wear head protection, where/when they are significantly exposed to hazards of:

- falling objects,
- impact with fixed objects, or

- working with exposed electrical conductors which may contact the head.

While not all surface finishing operations may be required to provide head protection to its employees, facilities should consider this work practice where these hazards may be present in the workplace, even if it is not necessarily required.

Hardhats purchased prior to July 5, 1994 must comply with ANSI Z89.1-1969 or ANSI Z89.1-1986. Hardhats purchased after July 5, 1994 must comply with ANSI Z89.1-1986. Bump caps can be provided when employees are exposed to hazards involving impact with fixed objects.

- Class "G" hardhats should be issued to employees exposed to falling objects and/or contact with electricity up to 2,200 volts.
- Class "E" hardhats should be issued to employees exposed to falling objects and/or contact with electricity up to 20,000 volts.
- Class "C" hardhats should be issued to employees exposed to falling objects who have no exposure to electricity.

c. Foot Protection

Employees should be provided with, and required to wear foot protection, where/when they are significantly exposed to hazards of:

- falling or rolling objects (an example of foot protection is provided below in Figure IV-1);
- objects piercing the sole of footwear;
- electrical hazards to the feet; or
- chemical hazards to the feet (an example of boot protection used to protect workers from chemical hazards is provided below in Figure IV-2).

Figure IV-1: Example of Foot Protection Typically Used in Metal Finishing Operations



Photo courtesy of Scientific Control Laboratories, Inc.

Figure IV-2: Example of Foot Protection Typically Used to Protect Workers from Chemical Hazards in Metal Finishing Operations



Photo courtesy of Scientific Control Laboratories, Inc.

Protective footwear should comply with the new *American Society of Testing Materials (ASTM) Standards: F2412-05 (Standard Test Methods for Foot Protection) and F2413-05 (Standard Specification for Performance Requirements for Foot Protection)* in order to provide both impact and compression protection. Safety shoes can also be purchased that provide puncture, metatarsal, and electrical conductive or insulating protection.

Shoes/Boots with impact protection are required when carrying or handling materials such as packages, parts, or other heavy tools which could be dropped and for other activities during which objects might fall on feet. Slip-off/Kick-off shoes or boots are required in areas where employees handle molten metals.

Shoes/Boots with compression protection are required for activities involving skid trucks, bulk rolls, heavy pipes, or other objects which could roll onto employees' feet. Shoes/Boots with puncture protection are required where sharp objects such as nails, wire, tacks, screws, staples, etc. could be stepped on by employees, causing injury.

d. Hand Protection

Employees should be provided with, and required to wear, hand protection where/when they are significantly exposed to hazards of:

- cuts, lacerations, punctures, or abrasions;
- chemical burns;
- skin absorption of harmful substances; or
- temperature extremes.

Currently, there are no ANSI standards related to gloves and hand protection. The gloves provided must be appropriate for the operation. For example, manual plating operators' gloves should be elbow-length, and should be made of an impervious material such as Nitrile or PVC. Disposable latex gloves are generally not recommended for plating operators. Gloves should be sized appropriately to ensure that they do not reduce dexterity. Cotton linings can prevent heat discomfort from perspiration, and should be changed and washed daily for maximum comfort. A suitable place to store gloves when not in use should also be provided.

Gloves should be selected based on an evaluation of the performance characteristics (*i.e.*, chemical hazards, cut hazards, flame hazards, *etc.*) as required for appropriate protection when considering tasks to be performed, conditions present, duration of use, and the hazards or potential hazards identified. Consideration will be given to each specific application, how long it can be worn (chemical resistance or breakthrough time) and if it can be reused. Other factors to be considered should include the following:

- Will the glove provide the employee with the dexterity required to perform the job?
- Will the glove selected withstand the duration, frequency, and degree of exposure of the hazard and/or physical stresses that may be applied?
- Gloves to be used for protection against chemicals will be selected based on the toxic properties of the chemicals, relative to the tasks being performed, conditions presented, and duration of exposure.
- Gloves used for protection against mixtures/formulations will be selected based on the mixture component with the shortest breakthrough time.

Nitrile gloves are the most commonly used for manual plating operations, and an example is provided below in Figure IV-3.

Figure IV-3: Nitrile Gloves Commonly Used in Metal Finishing Operations



Photo courtesy of Scientific Control Laboratories, Inc.

6. Hearing Protection

Employers must provide hearing protection to all employees exposed to an eight-hour TWA of 85 dBa or higher. If there is a hearing loss, the levels for hearing protection may be lower. Hearing protectors can include disposable ear plugs or ear muffs. Where hearing protection is needed, facilities must also develop a Hearing Conservation Program that is consistent with the applicable regulatory requirements. More detailed information on hearing protection is available in the OSHA regulations at 29 CFR §1910.95.

7. Respiratory Protection

A respirator is a device designed to protect the wearer from inhaling harmful dusts, fumes, vapors, and gases. As previously stated, engineering control systems, such as adequate ventilation, should be used whenever possible to eliminate the need for respirators. Respirators should only be used as a "last line of defense," when engineering or administrative control systems are not feasible.

Respirators protect the user in two basic ways. The first is by the removal of contaminants from the air. Respirators that fall into this category are called air-purifying respirators. They include particulate respirators including approved filtering face pieces (or "dust masks"), which filter out airborne particles such as those generated by grinding, cutting, and sanding; and gas and vapor respirator (commonly referred to as "gas masks") which filter out vapors and gases such as acid gases. Other types of respirators protect by supplying clean respirable air from another source. Respirators that fall into this category are called atmosphere-supplying respirators. They include airline respirators, which use compressed air from a remote source; and self-contained breathing apparatus (SCBA), which include their own air supply. Respirators are further categorized as illustrated in Table IV-2.

Table IV-2. Types of Respiratory Protection






<p>Approved filtering facepieces (often called “dust masks”) can be used for some dusts, mists, welding fumes, and other particulates. They do not provide protection from gases or vapors. DO NOT USE FOR HEXAVALENT CHROMIUM; instead, select from the respirators below.</p>	
<p>Half-face respirators can be used for protection against most vapors, acid gases, dust or welding fumes. Cartridges/filters must match contaminant(s) and be changed periodically.</p>	
<p>Full-face respirators are more protective than half-face respirators. They can also be used for protection against most vapors, acid gases, dust or welding fumes. The face-shield protects face and eyes from irritants and contaminants. Cartridges/filters must match contaminant(s) and be changed periodically.</p>	
<p>Loose-fitting powered-air-purifying respirators (PAPR) offer breathing comfort from a battery-powered fan which pulls air through filters and circulates air throughout helmet/hood. They can be worn by most workers who have beards. Cartridges/filters must match contaminant(s) and be changed periodically.</p>	
<p>A Self-Contained Breathing Apparatus (SCBA) is used for entry and escape from atmospheres that are considered immediately dangerous to life and health (IDLH) or oxygen deficient. They use their own air tank.</p>	

Table courtesy of OSHA.

An example of a respirator that is commonly used in metal finishing operations is provided below in Figure IV-4.

Figure IV-4: Respirator Commonly Used in Metal Finishing Operations



Photo courtesy of Scientific Control Laboratories, Inc.

OSHA requires that all respirators used in the workplace be certified by NIOSH. Choosing the appropriate respirator depends on numerous factors, including but not limited to:

- What is the contaminant(s) of concern?
- What is the physical state of the contaminant(s) of concern - particulate, gas/vapor, or combination of particulate and gas/vapor?
- What is the expected concentration of the contaminant(s) of concern in the work place?
- What is the protection factor required?
- Is the respirator intended for use during fire fighting?
- Is the respirator intended for use in an oxygen-deficient atmosphere, i.e., less than 19.5% oxygen?
- Is the respirator intended for entry into unknown or IDLH atmospheres (e.g., an emergency situation)?
- Is there potential for eye irritation from the contaminant(s) of concern?

Many air-purifying respirators use cartridges to remove air contaminants. These cartridges are assigned a color, designating the type of contaminant they are designed to filter (see Table IV-3). It is important that employers select the appropriate cartridge for the contaminant(s) of concern. When making the selection, employers would need to match the respirator cartridge to the exposure environment. It is important to note that, if needed, air-purifying respirators can be equipped with a gas/vapor cartridge *in combination with* a particulate filter.

Table IV-3 - Cartridge Types

Cartridge Color	Contaminant
Olive	Multi-contaminant
White	Acid gas
Black	Organic vapors
Green	Ammonia gas
Yellow	Acid gas and organic vapors
Purple	Any particulates - P100
Orange	Any particulates – P95, P99, R95, R99, R100
Teal	Any particulates free of oil - N95, N99, or N100

Employers can refer to the following websites for further assistance in selecting the appropriate respirator(s) for their specific work environment(s) and exposure(s):

1. OSHA website - http://www.osha.gov/SLTC/etools/respiratory/respirator_selection.html
2. NIOSH website - <http://www.cdc.gov/niosh/docs/2005-100/>

Employers are responsible for ensuring that cartridges are periodically replaced in order to prevent breakthrough of the contaminant(s). Employers should consider the following factors in determining cartridge change-out schedules:

- The contaminant(s) the respirator is to protect against.
- The concentration of contaminant(s) in the work area.
- Frequency of use (e.g., is the respirator used continuously or intermittently throughout the shift?)
- Temperature, humidity and air flow through the cartridge or canister.
- Employees' work rates.
- The presence of other potentially interfering chemicals.

Employers should assume worst case conditions to avoid breakthrough earlier than anticipated. Employers can refer to the following OSHA website for assistance with respirator change-out schedules: http://www.osha.gov/SLTC/etools/respiratory/change_schedule.html

Employers should also follow manufacturer's instructions for respirator use, maintenance, and filter replacement. Employers must ensure that respirators are used in the context of a comprehensive respiratory protection program, as outlined in OSHA's Respiratory Protection Standard, 29 CFR 1910.134. A comprehensive respiratory protection program includes, but is not limited to, the following components as required by OSHA:

- Procedures for selecting respirators
- Medical evaluations of employees required to wear respirators
- Fit-testing for tight-fitting respirators
- Procedures for proper use of respirators in routine and emergency situations
- Procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing, discarding, and maintaining respirators
- Employee training on respiratory hazards and the proper use of respirators

- Program evaluation procedures
- Recordkeeping

It is particularly important that employees who need to wear respirators are medically evaluated to ensure that they can perform work tasks while wearing a respirator. Medical evaluation begins with a mandatory questionnaire, which is found in Appendix C of OSHA's Respiratory Protection Standard, 29 CFR 1910.134.

V. Facility Maintenance and Housekeeping

1. Inspection and Maintenance

Maintenance procedures should be arranged to suit individual work situations. Areas which require regular attention are:

- exhaust ventilation equipment,
- storage, handling and labeling of hazardous substances,
- critical plant and process control equipment,
- safety equipment,
- washroom and lunchroom facilities, and
- first aid equipment.

All items should be inspected by staff as part of their daily routine, and by maintenance or supervisors at least weekly.

Repairs or adjustments to process control or safety equipment should be carried out by qualified personnel only. The repair or adjustment of any safety-related equipment must be attended to as soon as it is found to be faulty.

2. Housekeeping

Good housekeeping at a metal finishing facility has a direct, positive impact on employee safety. Housekeeping should be the responsibility of all employees. Some suggested housekeeping measures should include, but are not limited to the following:

- maintaining dry, clean and clear aisle ways that are clearly marked and unobstructed (*e.g.*, no boxes, chemical containers, buckets, pallets in the way);
- cleaning up spills immediately;

- regularly wiping down equipment, emergency eyewash stations, work counters and other areas to prevent the accumulation of dust and other contaminants;
- keeping all chemical containers closed and labeled;
- emptying trash containers regularly;
- providing proper storage areas for production materials;
- minimizing the use of extension cords; and
- keeping eating areas and lockers room sanitary.

VI. General Employee Training

Effective training of employees is imperative for safe metal finishing operations. Classroom and on-the-job training must be completed [before starting an assignment?] or changes departments. Supervision by an experienced person is required until the employee gains adequate knowledge and experience to be able to do the job safely. Employers must ensure employees are either sufficiently experienced to do their work safely or are supervised by an experienced person. In addition, employees must be adequately trained in the safe use of equipment in the place of work, including protective clothing and equipment. A list of the common OSHA training requirements for metal finishing operations is provided below in Appendix H.

Employee training should include the following aspects:

- hazard communication - categories of hazards; review of chemicals being used, MSDSs and labeling; and operations in the work area where hazardous chemicals are present.
- the use and care of personal protective clothing and equipment (see Section IV);
- emergency action procedures for spills, first aid, fires, location of emergency eyewash stations and showers;
- the adverse health effects of the substances they are exposed to;
- the importance of good chemical hygiene practices; and
- any OSHA standards that apply to your workplace, where applicable.

APPENDICES

Appendix A: Workplace Safety and Health Checklists

In a well-operated plant the answer "yes" will be given to the following questions:

Daily Check

- | | | |
|--|-----|----|
| 1) Are aisles and passageways kept clean and dry? | Yes | No |
| 2) Is the floor washed? | Yes | No |
| 3) Are all spills cleaned up immediately? | Yes | No |
| 4) Are all aisles and exit routes free of obstructions? | Yes | No |
| 5) Is protective clothing worn by employees to prevent skin contact with hazardous substances? | Yes | No |
| 6) Is hearing protection provided and worn during noisy conditions? | Yes | No |
| 7) Is eye protection worn where splashing is a hazard? | Yes | No |
| 8) Is smoking actively discouraged in the work area and forbidden near plating tanks? | Yes | No |
| 9) Is air monitoring conducted properly when it is necessary? | Yes | No |
| 10) Are the emergency washing facilities operative? | Yes | No |

Weekly check

- | | | |
|--|-----|----|
| 1) Are floor holes, such as drains, covered? | Yes | No |
| 2) Have all employees who work near tanks been instructed about the relevant hazards and safe practices? | Yes | No |
| 3) Is appropriate personal protective equipment provided? | Yes | No |
| 4) Is the ventilation for open surface tanks working correctly? | Yes | No |
| 5) Is employee exposure to hazardous substances minimized? | Yes | No |
| 6) Do all containers — buckets, storage drums, tanks, etc. have a | | |

legible label stating their contents?	Yes	No
7) Are cyanides stored away from any possible contact with acids?	Yes	No
8) Are drum pumps used, where possible, to transfer liquids?	Yes	No
9) Are the respirators in use the correct type for the hazard?	Yes	No
10) Are respirators properly stored, cleaned, disinfected, and inspected?	Yes	No
11) Are eating areas and washrooms clean?	Yes	No
12) Is all electrical equipment safe and protected?	Yes	No
13) Have exposed wires, frayed cords, and deteriorated insulation been repaired or replaced?	Yes	No
14) Are fire extinguishers available and accessible?	Yes	No
15) Is storage available for each worker's gloves and respirators?	Yes	No
16) Are the hose connections of plating tanks secure?	Yes	No

Annual check

- | | | |
|--|-----|----|
| 1) Have the weekly checks been carried out? | Yes | No |
| 2) Are permanent aisles appropriately marked? | Yes | No |
| 3) In wet surface areas are walkways provided or non-slip materials used? | Yes | No |
| 4) Is management aware of the hazards presented by the substances used in the workplace? | Yes | No |
| 5) Have employees been instructed in safe work practices? | Yes | No |
| 6) Are spillage procedures and emergency phone numbers pinned up on the wall for easy reference? | Yes | No |
| 7) Have employees been instructed in emergency first aid procedures for cyanide poisoning? | Yes | No |
| 8) Is there some means of instantly rinsing the eyes in areas where acid or alkali splashes may occur? | Yes | No |
| 9) Are sources of water for quick drenching available where corrosive materials are used? | Yes | No |
| 10) Is at least one employee per shift a qualified first aider? | Yes | No |
| 11) Are first aid supplies readily available, inspected and maintained? | Yes | No |
| 12) Are medical personnel readily available for advice and consultation on matters of employee health? | Yes | No |
| 13) Are employees involved in electroplating given periodic medical check-ups? | Yes | No |

- | | | |
|--|-----|----|
| 14) Where there is a suspected noise problem, have noise levels been measured? | Yes | No |
| 15) If engineering controls cannot reduce noise to safe levels has an attempt been made to limit employee exposure? | Yes | No |
| 16) Do junction boxes, switches and electrical fittings comply with the current electrical regulations? | Yes | No |
| 17) Are fire extinguishers fully charged and kept in well sign-posted places? | Yes | No |
| 18) Is lighting sufficient to illuminate detail in the plating process, contamination on surfaces and tripping hazards on the floor? | Yes | No |
| 19) Do all employees have access to MSDSs, these guidelines and any other relevant safety information? | Yes | No |
| 20) Have the standards of operation relating to safety been received? | Yes | No |

Appendix B: Common OSHA Citations for Metal Finishers

3471 Electroplating, Plating, Polishing, Anodizing, and Coloring

Listed below are the standards which were cited by **Federal OSHA** for the specified SIC during the period October 2006 through September 2007. Penalties shown reflect current rather than initial amounts. For more information, see [definitions](#).

Standard	#Cited	#Insp	\$Penalty	Description
Total	478	69	225960	
19100134	59	22	18458	Respiratory Protection.
19101200	55	27	16738	Hazard Communication.
19101026	24	7	10288	Chromium VI
19100147	22	10	7091	The Control of Hazardous Energy (lockout/tagout)
19100303	22	16	11535	General Requirements (Electrical Equipment).
19100305	22	16	14665	Wiring methods, components, and equipment for general use.
19100151	18	18	10013	Medical services and first aid.
19100124	17	14	11548	Dipping and Coating Operations
19100023	16	10	11224	Guarding floor and wall openings and holes.
19100107	15	7	8168	Spray finishing using flammable and combustible materials.
19100132	15	12	12045	General requirements (PPE).
19100212	14	13	8946	General requirements for all machines.

19100095	13	7	3906	Occupational noise exposure.
19100146	13	8	8156	Permit-required confined spaces
19100178	13	8	9703	Powered industrial trucks.
19100219	12	6	4563	Mechanical power-transmission apparatus.
19100022	10	9	5225	General requirements (Walking, working surfaces).
19100304	9	6	6390	Wiring design and protection.
19040029	8	7	1200	Forms.
19100242	8	8	3045	Hand and portable powered tools and equipment, general.
19100253	8	6	2036	Oxygen-fuel gas welding and cutting.
19101028	8	1	5500	Benzene.
19100133	7	7	1724	Eye and face protection.
5A0001	7	5	9430	General Duty Clause, OSH Act
19100141	6	6	1623	Sanitation.
19100037	5	5	1758	Maintenance, safeguards, and operational features for exit routes.
19100157	5	5	263	Portable fire extinguishers.
19100179	5	3	1650	Overhead and gantry cranes.
19101000	5	3	3100	Air contaminants.
19100184	4	3	1700	Slings.
19100213	4	1	1688	Woodworking machinery requirements.

19100106	3	2	820	Flammable and combustible liquids.
19100120	3	2	3200	Hazardous waste operations and emergency response.
19040002	2	2	0	Partial exemption for establishments in certain industries.
19100176	2	2	1050	Handling materials - general.
19100215	2	2	1095	Abrasive wheel machinery.
19100307	2	2	800	Hazardous (classified) locations (Electrical Equipment).
19100333	2	1	500	Selection and use of work practices (Electrical Equipment)
19100335	2	2	437	Safeguards for personnel protection (Electrical Equipment).
19040004	1	1	0	Recording criteria.
19040032	1	1	0	Annual summary.
19100027	1	1	563	Fixed ladders.
19100036	1	1	375	Design and construction requirements for exit routes.
19100101	1	1	341	Compressed gases (general requirements).
19100110	1	1	225	Storage and handling of liquefied petroleum gases.
19100145	1	1	1500	Specifications for accident prevention signs and tags.
19100243	1	1	750	Guarding of portable powered tools.
19100254	1	1	495	Arc welding and cutting.
19100332	1	1	437	Training (Electrical Equipment)
19100334	1	1	0	Use of equipment (Electrical Equipment).

Appendix C: List of Compliance Assistance Resources

NASF

- 1) Electroplating Engineering Handbook, 4th Edition, Lawrence J. Durney (editor) 1984
- 2) Management Manual, National Association of Metal Finishing (NAMF/NASF), 3rd Edition 2000
- 3) American Electroplaters and Surface Finishers (AESF) Foundation Training Courses (NASF website at www.nasf.org)
 - Electroplating and Surface Finishing
 - Environmental Stewardship
 - OSHA Safety and Compliance
 - Regulatory Compliance

OSHA

- 1) Small Entity Compliance Guide for Hexavalent Chromium Standard (OSHA 3320-10N, 2006)
- 2) Hexavalent Chromium Webpage (<http://www.osha.gov/SLTC/hexavalentchromium/index.html>)
- 3) Compliance Assistance Specialists (http://www.osha.gov/dcsp/compliance_assistance/cas.html)
- 4) New Compliance Assistance Products (http://www.osha.gov/dcsp/compliance_assistance/new_ca_products.html)
- 5) OTI courses (see <https://learninglink.dol.gov/dol/user/site/browseCatalog.do>)
- 6) Web-Based Compliance Assistance (http://www.osha.gov/dcsp/compliance_assistance/index.html#Compliance%20Assistance%20Resources)
- 7) Web-Based Industry Specific (http://www.osha.gov/dcsp/compliance_assistance/industry.html)
- 8) OSHA Respiratory Protection Standard Webpages:
(<http://www.osha.gov/SLTC/respiratoryprotection/index.html>)
(<http://www.osha.gov/SLTC/etools/respiratory/index.html>)
http://www.osha.gov/SLTC/etools/respiratory/change_schedule.html
http://www.osha.gov/SLTC/etools/respiratory/respirator_selection.html
- 9) OSHA Small Entity Compliance Guide for the Respiratory Standard (<http://www.osha.gov/Publications/secgrev-current.pdf>)

NIOSH

- 1) Hexavalent Chromium Information (<http://www.cdc.gov/niosh/topics/hexchrom/>)
- 2) Respiratory Selection website: (<http://www.cdc.gov/niosh/docs/2005-100/>)
- 3) Health Hazard Evaluations
 - Mercil Plating Company (<http://www2a.cdc.gov/hhe/select.asp?PjtName=403&bFlag=0&ID=3>)
 - Marsh Plating Corporation (<http://www2a.cdc.gov/hhe/select.asp?PjtName=371&bFlag=0&ID=9>)
 - Summit Finishing Company
(<http://www2a.cdc.gov/hhe/select.asp?PjtName=7400&bFlag=0&ID=11>)
 - Modern Plating Corporation
(<http://www2a.cdc.gov/hhe/select.asp?PjtName=9864&bFlag=0&ID=13>)
 - Industrial Platers, Incorporated
(<http://www2a.cdc.gov/hhe/select.asp?PjtName=967&bFlag=0&ID=18>)

Appendix D: Selected Parts for Ventilation System (Sample)

Fan:

Serial #:21349

Rated Static Pressure:4"

Fan Wheel Size: 27" wheel

Wheel Material: Coated Steel

Motor RPM: 1750

Wheel RPM: 2700

Bearings Model:Sealmaster

Belt Size: B-68 (x's 2)

Wheel Sheave Size: 285V70

Motor Sheave Size: 285V70

CFM: 13,171

Total Tested Static Pressure: 1.4"

Fan Vibration (Mils.): 3.4 mils

Fan Rotation: Clockwise

Motor Horsepower: 20 HP

Motor Voltage: 230/460

Bearings Make: NP-31

Fan Shaft Size: 1 15/16"

Sheaves Center to Center: 26"

Scrubber: Hedron 200-14D

Packing Media: 2" Saddles

Mesh Configuration:

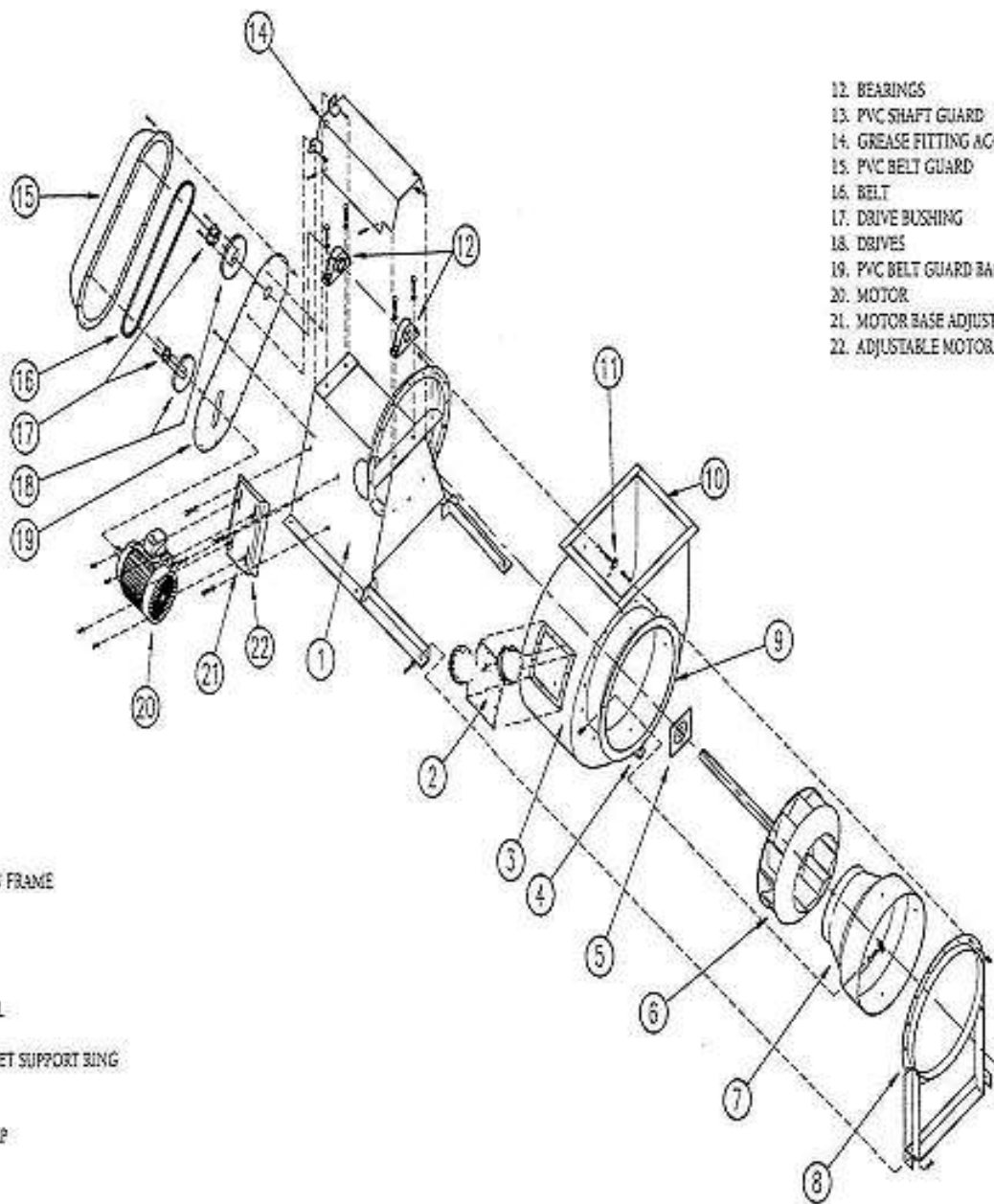
Spray Nozzles: Delavan #2 (16)

Mist Eliminator: Chevron

Mesh Size:

Outlet Transition Diameter: 57X57into28

* Base Line Numbers



- 12. BEARINGS
- 13. PVC SHAFT GUARD
- 14. GREASE FITTING ACCESS HOLE
- 15. PVC BELT GUARD
- 16. BELT
- 17. DRIVE BUSHING
- 18. DRIVES
- 19. PVC BELT GUARD BACK PLATE
- 20. MOTOR
- 21. MOTOR BASE ADJUSTING BOLT
- 22. ADJUSTABLE MOTOR BASE

- 1. EPOXY COATED STEEL FAN FRAME
- 2. PVC ACCESS DOOR
- 3. PVC HOUSING
- 4. PVC DRAIN COUPLING
- 5. KOROSEAL SHAFT SEAL
- 6. FRP COATED STEEL WHEEL
- 7. PVC INLET CONE
- 8. EPOXY COATED STEEL INLET SUPPORT RING
- 9. PVC INLET FLANGE
- 10. PVC OUTLET FLANGE
- 11. PVC PROTECTIVE BOLT CAP

NH - SERIES BLOWER PARTS LISTS

Appendix E: Maintenance Schedule for Ventilation Equipment

Daily Maintenance Tasks:

- Check Static Pressure Across Crucial Components
- Check Make up Water Rates
- Check Sump Levels

Monthly Maintenance Tasks:

- Check Belts on Exhaust Fan
- Grease Bearings
- Inspect All Supply and Drain Plumbing for Any Obstructions or Buildup
- Check Spray Nozzles Patterns for Any Indication of Debris in the Line
- Assess Any Buildup in Hoods or Ductwork
- Note All Static Pressures to Insure Proper Efficiencies Across Mist Eliminators and Packing Media

Quarterly Maintenance Tasks:

- Inspect Fan Wheel for Any Damage
- Check Balance of Fan Wheel
- Check Condition and Integrity of All Mist Eliminators and Packing Media
- Check Tightness of All Hardware
- Check Condition and Integrity of All Gasket Material Associated with Equipment
- Inspect All Steel Structures for Corrosion or Fatigue

Other Maintenance Tasks as Needed:

- Remove and Either Clean or Replace Composite Mesh Pads When Static Pressures Become Too High
- Remove and Either Clean or Replace Packing Media When Needed
- Calibrate Magnahelic Gauges, pH and ORP Analyzers as Recommended by Manufacturer
- Some Hazardous Air Pollutants May Require Daily Logging of System Flow and or System Readings

Appendix F: Sample Preventive Maintenance Agreement for Ventilation System

PREVENTIVE MAINTENANCE AGREEMENT

This maintenance agreement dated the _____ day of _____ between ABC, Inc. and _____ covers the following system(s): [Job Number _____ and Description of Existing Systems].

The purpose of this agreement is to provide periodic inspection of the system(s), indicated in this agreement, in order to diagnose current possible future problems. The particulars of this agreement are as follows:

- 1) This periodic maintenance agreement commences in [month] of [year] and continues in effect for a period of one (1) year.
- 2) ABC agrees to furnish a services representative to perform two (2) maintenance visits over the period of one (1) year from the date indicated in this agreement.
- 3) Each visit by a ABC Service Representative will be for a period of up to nine (9) hours, to be arranged between the hours of 8:00 a.m. to 5:00 p.m., Monday through Friday, excluding holidays.
- 4) _____ will provide a maintenance representative to accompany the ABC Services Representative for the purpose of assisting with inspections, repairs, and exposure to proper preventive maintenance techniques.
- 5) A mechanical and instrumentation inspection will be performed on the system(s) covered by this agreement. This inspection is to include the following:

Mechanical Inspection

A – FANS

- 1- Inspect Wheel for Wear
- 2- Inspect shaft condition
- 3- Inspect bearings and collars
- 4- Inspect drive belts for wear
- 5- Inspect all hardware for tightness and corrosion

- 6- Inspect sheave alignment
- 7- Check and record RPM
- 8- Inspect all welds

B – SCRUBBERS

- 1 – Inspect packing for pluggage
- 2 – Inspect all welds
- 3 – Inspect recirculation system
- 4 – Inspect ball valves for leakage
- 5 – Inspect unions for leakage
- 6 – Inspect for clogged nozzles
- 7 – Inspect for spray header orientation
- 8 – Inspect mist eliminator section
- 9 – Inspect mesh pads for pluggage
- 10 – Inspect mesh pads for fit
- 11 – Inspect recirculation pump
- 12 – Inspect, verify and adjust differential gauges.

C – HOODS AND DUCTWORK

- 1 – Inspect all hood welds
- 2 – Inspect all dampers
- 3 – Inspect all duct hangers
- 4 – Inspect all hood support
- 5 – Inspect all duct welds
- 6 – Inspect all in-line control devices

D – ELECTRICAL INSPECTION

- 1 – Inspect solenoid operation
- 2 – Inspect pH probes and meters
- 3 – Inspect ORP probes
- 4 – Inspect sump heater

- 6) All operating parameters will be reviewed and appropriate adjustments and calibrations will be performed.
- 7) The ABC Service Representative will provide labor to replace parts necessary to bring the covered system(s) within proper operating parameters (up to the amount specified in the agreement).
- 8) Parts will be supplied either from _____ spare parts, or purchased from ABC.
- 9) The ABC Representative will make recommendations for the replacement of additional parts, which cannot be addressed at the time of the scheduled visit.
- 10) The ABC Service Representative will make recommendations for additions to the spare parts inventory.
- 11) If requested by _____ the ABC Service Representative will provide operator and/or maintenance training during the scheduled visit. This will be considered as part of the scheduled time indicated in this agreement.
- 12) Labor charges for service visits beyond the two (2) scheduled annual visits will be charged the normal rate of _____. This includes labor provided at the time of the scheduled visits, which exceeds the time indicated in this agreement.
- 13) _____ will provide adequate operating and/or down time, at the time of the scheduled visit, to allow for completion of the provisions of this agreement.
- 14) This agreement involves labor only. All parts are to be taken from _____ stock, or purchased from ABC.
- 15) The purchase price of this agreement is \$ _____ due 30 days from the date of this agreement acceptance.
- 16) Either ABC or _____ may terminate this agreement for any reason provided it has given the other party 30 days advance written notice of its intent to terminate. In the event that either party terminates this agreement in accordance with this paragraph, ABC will promptly refund the pro-rated portion of the annual fee for any outstanding maintenance visits.

The following parties have agreed to the conditions of this agreement.

ABC, Inc.

Signed: _____

Title: _____

Surface Finishing Company

Signed: _____

Title: _____

Appendix G: Product Substitution Options for Hexavalent Chromium

A brief summary of those substitute technologies that have managed to gain some, albeit some, commercial application for hexavalent chromium is provided below.

1. Decorative Trivalent Plating has been commercially available for approximately 20 years. It is essentially limited to decorative applications. Trivalent chromium has obtained a small market share in the US, primarily because it allows a greater number of parts per rack, and because it affords a reduced tendency for "white wash" rejects from the chromium plating bath, and, finally, because it facilitates air permitting for new plating shops or new decorative plating installations in existing installations.

Trivalent chromium processes are available in either sulfate or chloride based electrolytes. The sulfate electrolyte offers a lower make-up cost, but it is typically limited to depositing chromium coatings of 5 to 7 millionths of an inch thick. The chloride electrolyte compensates for its higher make-up cost by allowing a thickness of 10 to 12 millionth of an inch to be applied, which results in deposits that more closely resemble hexavalent chromium in color.

Both trivalent chromium electrolytes are technically more difficult to operate than hexavalent chromium, but this is not a serious limitation. As mentioned above, there remain some color match problems with deposits from trivalent chromium electrolytes, particularly when the chemistries are not well maintained. The color match problem is the main reason the automotive industry has not yet fully qualified trivalent chromium as a replacement for hexavalent chromium, and until the automotive companies grant full approval for the use of trivalent chromium, this will remain a serious limitation in the expansion of trivalent chromium processes for the US decorative chromium plating industry.

An additional disadvantage of trivalent chromium is that the cost of the replenishment chemistries for either type of electrolyte is significantly higher than for hexavalent chromium. There are also only a very few quality suppliers for the chemistry and the technology training, as opposed to hexavalent chromium, which is widely available as both a commodity or a proprietary plating bath chemistry.

2. Functional Trivalent Plating. Many research and development groups around the world have been working for many years to try to develop a functional trivalent chromium chemistry. A recent review of the current status and the problems holding back this chemistry to date was given by Dr. Kenneth Newby at the May 24-27, 2004 4th International Chromium Colloquium held in St. Etienne, France. The paper was entitled, *What Seems to be Holding Back Functional Trivalent Chromium Plating*. The most significant problem cited was the inability of trivalent chromium chemistries to obtain both good wear and good corrosion resistance at the same time, which is a primary attribute of hexavalent chromium deposits.

3. High Velocity Oxygen Fuel (HVOF) technology injects a powder, for example a Tungsten Carbide – Cobalt mixture, into a hot, supersonic, oxygen fueled torch that accelerates the powder onto the part to be coated. It provides a relatively rapid deposit build up. The most significant attribute is that the substrate is not subject to hydrogen embrittlement as can be the case with chromium plating. This saves significant turn around time in those instances where this is important.

HVOF is significantly more expensive than chromium plating from the perspective of capital cost for equipment and for labor both during deposition and for later grinding operations and productivity. Robots that are used must be monitored and can only work on one part at a time. Most chromium plating is done with many parts on a rack and with relatively less labor compared to HVOF, except for loading and unloading the chromium plating racks.

One of the significant technical limitations to HVOF is that it can only operate on a line of sight basis. In other words, the substrate must be in front of the robotic gun. Hence inside diameters of a manufactured part are very difficult, if not impossible, to coat using HVOF.

HVOF is probably the most developed alternative to functional hexavalent chromium plating. Other than the increased labor demands, productivity concerns and high capital investment needed, the major shortcoming is that the deposits are only approved for a very limited number of applications -- predominately U.S. Department of Defense ("DOD") applications where cost is not typically the controlling variable. To date, efforts to get the technique and deposit approved in other industries such as automotive have been limited, if they exist at all. These concerns, coupled with the limitations discussed above, effectively means that HVOF as a commercially viable alternative to hard chromium plating is at best many years away, if at all.

4. Electroless Nickel Boron Alloys. Virtually every "known" or "under development" wet chemistry, whether it is electroplating or electroless plating, has been evaluated as a potential functional chromium alternative. Of all the potential wet chemistries that have been evaluated, only electroless nickel boron has had any commercial success, and even that has been very limited due to the extremely high cost of applying this technology, which includes approximately one percent by weight of boron into the coating. This alloy offers excellent corrosion protection, as well as outstanding wear resistance, but has not gained widespread commercial application due to the high cost associated with it.

There are two reasons for the very high deposition cost. First, because all electroless plating processes coat parts wherever the solution contacts the parts, expensive masking materials must be used to prevent solution contact on the areas where deposition is not needed. This is in stark contrast to hexavalent chromium plating where the limited covering power of the electrolyte is actually an advantage in preventing deposition in unwanted areas of parts. A second reason for the extremely high deposition cost is because the additives that are needed to apply the nickel boron coatings are quite expensive and generally have an additional royalty fee associated with them as well. For these reasons, electroless nickel boron alloys have been used almost exclusively on small parts that frequently have small holes that require plating, and where the extra cost of plating non-critical areas is not significant.

5. Dry Process Alternatives. These are also a variety of “dry processes” (e.g., PVD, CVD, Ion Beam Deposition, Brush Plating, Laser Cladding, Explosive Bonding, Ion Implantation) that are being examined as potential replacements for hard or functional chromium plating applications. None of these processes have reached commercial success of any significant consequence, although each can claim specific, limited applications for which the technology offers some environmental and performance advantages compared to hard chromium plating. Significant cost and application limitations must be overcome before any of these technologies will increase the relatively small “niche” market share they currently enjoy. Additionally, these technologies all (with the exception of brush plating) require a substantial capital investment, which is a significant limiting factor, particularly for the many small businesses that currently operate chromium plating processes.

6. Trivalent Passivates. While it is true that *in certain applications* trivalent passivates have made great strides in providing corrosion protection that matches the protection that hexavalent materials provide, these trivalent materials are significantly more expensive to use in production. The make-up cost of trivalent passivates is as much as ten to twelve times the cost of hexavalent materials. Additionally, the trivalent materials have a significantly shorter operating life, because they are considerably less tolerant to the presence of dissolved metals such as zinc and iron, compared to hexavalent materials. Finally, many trivalent passivates operate at elevated temperatures and are therefore much more energy intensive than the hexavalent materials.

In addition, trivalent passivates cannot be used as drop-in replacements for all post-treatment applications. For example, there are no trivalent passivates that provide reliable performance that is equivalent to hexavalent olive drab chromates, which are required for many military and aircraft applications. Furthermore, until recently there were no reliable substitute trivalent materials that would produce a true black finish on conventional zinc plated deposits. This is no longer the case. Finishers now have several chemical options from which to choose, all of which will provide a true black finish that offers corrosion protection that is at least on par with what the hexavalent chromates provided in the past.

Appendix H: Common OSHA Training Requirements for Metal Finishers

REGULATION	WHO SHOULD BE TRAINED	FREQUENCY
Hazard Communication 29 CFR 1910.1200	All employees working with hazardous materials.	Review upon employee hiring/Full program within 60 days of hire. No Annual training required by Hazard Communication Standard Only for initial and for new hazards introduced. .
Control of Hazardous Energy (Lockout/Tagout) 29 CFR 1910.147	Employees performing lockout/tagouts for controlling hazardous energy.	Annually for "authorized employees" and before employee performs an energy-isolating required job task, whenever job tasks or processes change, or employer believes inadequacies exist in program
Electrical Safety 29 CFR 1910.303	Employees working with electrical systems.	Same as above.

<p>Personal Protective Equipment (PPE) 29 CFR 1910.132</p>	<p>All employees are required to wear PPE, including eye protection, foot protection, hand & head protection, etc.</p>	<p>Before employee dons any PPE, whenever job tasks or processes change, or employer believes inadequacies exist in program.</p>
<p>Respirator Use 29 CFR 1910.134</p>	<p>All employees are required to wear respirators</p>	<p>Annually w/ Fit Testing Medical Evaluation upon employee hiring <u>and as needed thereafter.</u></p>
<p>Hearing Conservation 29 CFR 1910.95</p>	<p>Employees exposed to greater than 85 dBA in an 8-hr workday, based on area noise tests or employees wearing hearing protection.</p>	<p>Annually, with audiometric exams.</p>

<p>Powered Platform Operation (Forklift Safety) 29 CFR 1910.178</p>	<p>All forklift drivers</p>	<p>Upon employee hiring and job task changing. Due every three years</p>
<p>Bloodborne Pathogens 29 CFR 1910.1030</p>	<p>All supervisors or employees that are assigned first aid duties</p>	<p>Upon employee hiring & annually thereafter. Employees that are not trained are not allowed to respond.</p>
<p>Emergency Action Plan & Evacuation 29 CFR 1910.38</p>	<p>All employees</p>	<p>Upon employee hiring & whenever plan changes, or employer believes re-training is needed.</p>