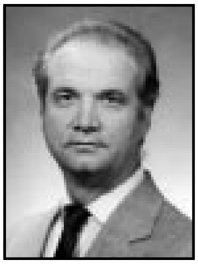

Advice & Counsel

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Ventilation Considerations For Chromium Plating Tanks

**Dear Advice and Counsel,
Despite the recent regulations on the process, my company is proceeding with the installation of a new hard chromium plating line. Could you provide guidance on plating equipment (especially ventilation and minimizing emissions)?**

Signed,
Hex Chrome Forever

Dear Hex Chrom**ium*** Forever,
*(*Harry Litsch says there's no such thing as chrome.)*
There are a number of excellent sources for most of the information you seek, including numerous articles published over the last 10 years in this journal by Myron Browning, CEF; J. Kraljic; H. Chessin; E.C. Knill & E.J. Seyeb Jr.; Dr. Ken Newby; and Allen R. Jones. Robert K. Guffie wrote a handbook on the subject—*The Handbook of Hard Chromium Plating* (Gardner Publications).

The literature is somewhat sparse on the subject of ventilation of a chromium plating tank, and I will not claim to be an expert on the subject. I have, however, collected some information over the years, so let's tackle the subject of what goes into a good ventilation system and how to minimize emissions from a chromium plating tank.

To meet strict EPA regulations on the amount of chromium that may remain in air discharged from a hard chromium plating process, plating tank(s) must be equipped with an efficient ventilation system, and an efficient method of removing chromic acid mist from the exhausted air.

The ventilation system and the mist elimination system should be designed together to optimize capture and removal of chromium. The following considerations will have an impact on emission levels and ventilation efficiency.

Process Control

First, look at the process and make any modifications that increase the efficiency of plating, because inefficiency leads to increased fume emissions. The following process modifications were evaluated in 1993 by the Metal Finishing Association of Southern California (MFASC) (contractor was Pacific Environmental Services) in response to regulations imposed on chromium emissions in that state.

Freeboard Modification

Freeboard is the distance between the surface of the plating solution and the lip of the plating tank. It makes common sense that if we provide added space above the emission point (the surface of the plating solution), we will provide an increased opportunity for the emitted particle to fall back to the solution by gravity, or impact the walls of the tank.

The MFASC report indicated a reduction of average hexavalent and total chromium emissions when the freeboard was increased from 6 in. to 12 (see Table 1).

Note, however, that an evaluation of freeboard on multiple tanks indicated an **increase** in emissions when freeboard was increased. This may be attributed to the difficulty in maintaining the same operating conditions on multiple tanks. In our opinion, increased freeboard should reduce emissions somewhat, and should also provide "room" to do other things, such as employ floating barriers or foaming agents.

Table 1
Air-agitated Plating Tank Emissions (mg/AH) vs. Freeboard Total Chromium/Hexavalent Chromium

Exhaust Rate	6 in. Freeboard	12 in. Freeboard
764 DSCFM	33.220/26.128	
924 DSCFM		25.074/14.416

% reduction = 24.5% total chromium, 42.5% hexavalent

At least 12 in. of freeboard should be designed into a new chromium plating tank.

Air Agitation

Air agitation of chromium plating solutions will add to the emission levels as the air bubbles burst at the surface of the plating solution, generating mist particles that are very similar to those generated by hydrogen gas.

The MFASC study indicated that a 5.6 percent reduction in emissions can be achieved by elimination of air agitation. Alternate methods of agitation (which serve mainly to maintain uniform solution temperature in deep tanks) include lift pumps and eductor systems.

Floating Barriers

Floating polypropylene balls have been used to control emissions for many years. They pose the problem of "traveling" from tank to tank, getting "stuck" in crevices of parts, and inhibiting evaporation of the solution (to make room for return of drag-out). Floating barriers are available in many shapes and sizes to reduce some of the travel and plugging problems. When they could be employed and kept in the tank, floating barriers were shown by the MFASC study to reduce emissions by 87 percent.

Foam Blankets/Wetting Agents

These products are very effective in reducing emissions between 93 and 98 percent, depending on operating conditions and the type of foaming agent/wetting agent used. The MFASC study indicated that a combined modification employing all of the above process modifications could achieve an emission reduction of 99.2 percent (Note: this was not enough to meet California emission standards). But let's look at additional ideas for improving the process, which were not part of the study.

Maintaining Solution Cleanliness

A conventional chromium plating solution containing 1 oz/gal (7500 ppm) of total metallic impurities can be expected to deliver a plating efficiency of around 9–10 percent, while the same solution containing 0.5 oz/gal (3500) ppm can deliver 12–14 percent efficiency. This may not sound like much, but it translates into a 20–40 percent reduction in gas (mist) production. A new plating tank should be designed to utilize continuous purification (removal) of metallic impurities. Consider ion exchange, membrane purification, or porous pot technologies for purification of chromium plating solutions.

Trivalent Chromium

High levels of trivalent chromium increase gas emissions by reducing plating efficiency. If the new plating tank will be used with low anode/cathode ratios (less than 2:1), consider designing continuous electrolysis into the system to oxidize trivalent back to hexavalent.

Analytical Control

The cathode efficiency of any chromium plating solution is closely tied to the ratio between the chromic acid and the sulfate content (typically 100:1 for a conventional solution and 200:1 for a mixed catalyst solution). Cathode efficiency is also closely tied to chromic acid concentration. A conventional plating solution, for example, is about 20 percent **less** efficient at 50 oz/gal than at 33 oz/gal of chromic acid. Frequent analysis and adjustment of this ratio will optimize plating efficiency. The efficiency of the plating solution can be estimated using a Hull cell.

Ventilation Design Considerations

Capture Velocity/Exhaust Rate

You can overdo a good thing. High exhaust rates may increase capture efficiency, but too high of an exhaust rate tends to "vacuum" out mist particles that ordinarily might fall back into the solution. The capture velocity needs to be balanced with the exhaust flow rate.

Figure 1[1] provides guidance (you'll need to optimize this for your specific installation). Note that for a tank two ft wide and four ft long, it takes about 225 cfm/ft^2 to achieve a capture velocity of 100 fpm (for chromium plating, a capture velocity of 150 fpm and exhaust rate of 3/5 dfm/ft^2 is required) with a lateral slot exhaust hood (no baffle), while the same capture velocity can be achieved with about 175 cfm/ft^2 if the exhaust hood has a baffle.

Table 2
Factors Influencing Hood Performance

- Construction, size, shape
- Minimize cross-drafts
- Velocity distribution across tank surface
- Position of hood relative to emissions
- Cross-drafts
- Physical/chemical characteristics of emissions
- Degree of enclosure
- Velocity contours of particulates

Addition or extension of side panels also significantly impacts exhaust flow-rate requirements by reducing cross-drafts. The side panels should be extended as far out from the exhaust hood as work practices allow.[2] Lower exhaust rates translate

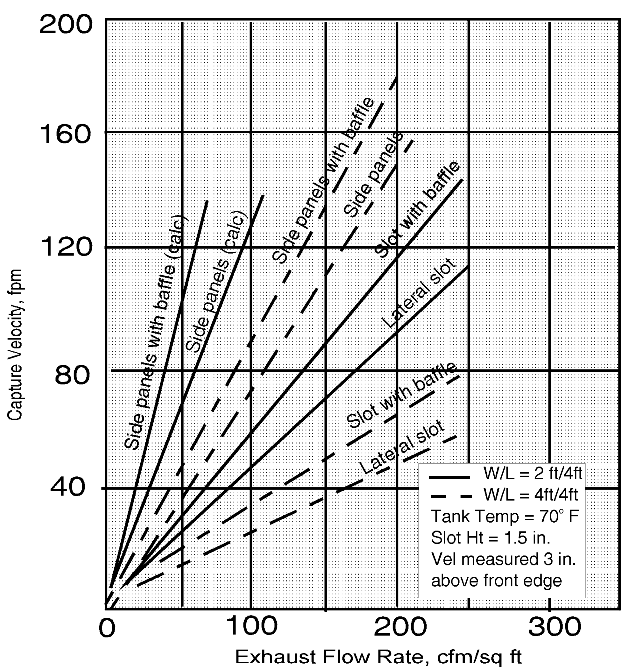


Fig. 1—Capture velocities for an open surface tank with single-slot lateral hood.

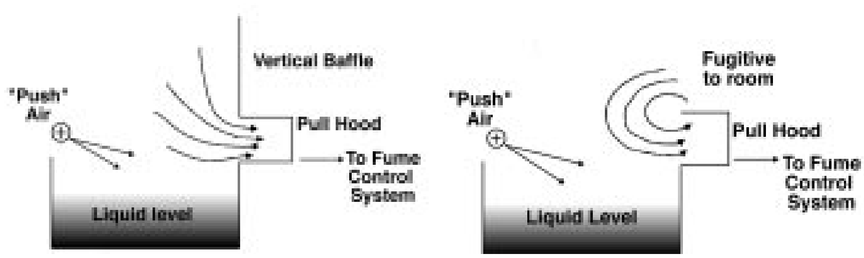


Fig. 2—Use of vertical baffle to improve "pull" distance.

into lower emissions (in some cases) and lower energy bills (in all cases), but be sure you remain within OSHA standards for worker exposure.

Hood Design

Table 2 provides factors affecting hood performance. Lateral exhaust hoods should be made of rigid PVC, and should employ a mesh pad section as a preliminary control device that returns captured mist to the tank during wash-down.

Exhaust hoods can be installed in downdraft or updraft configuration. Downdraft provides maximum access to the tank top, but prevents drainage of condensate and emissions back to the tank by gravity. Updraft ventilation should be used when possible, because gravity forces tend to work in favor of emission reduction.

If downdraft ventilation ducts are employed, note that a vertical baffle installed on the top of the duct (see Fig. 2) tends to maximize capture velocity over a greater distance across the width of the tank and the airspace above the tank. The height of this baffle should approach the width of the tank (assuming the baffle won't interfere with the travel of work over the tank), if ventilation is only from one side.

Cross-draft velocities at exhausted tanks should not be greater than 75 ft/min (0.4 m/sec) to avoid excessive fugitive emissions and disruption of mist capture by the exhaust hood.[3]

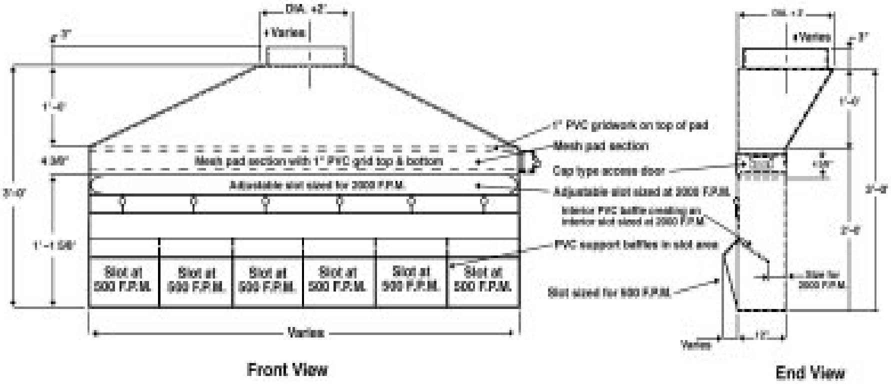


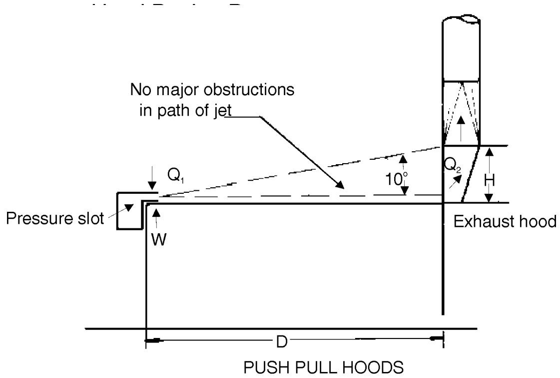
Fig. 3—Conceptual hood design (courtesy KCH Services Inc.)

On long tanks, the pull hood/plenum should be divided (see Fig 3, courtesy KCH Services Inc.) so that exhaust air is evenly drawn in along the length of the hood. The capture efficiency can be measured using a tracer gas or smoke testing.

Push/Pull Systems

Push/pull exhaust systems are often employed on tanks exceeding three ft in width, although double-pull, or four-sided pull can also be employed. One of the nicest examples of ventilation for a hard chromium plating tank that we have seen was at an aircraft maintenance facility operated by Northwest Airlines in Minneapolis, MN. The plating tanks in this facility employed **four-sided pull** ventilation, and all buswork and hardware was installed **above** the exhaust duct. Not only did this effectively capture emissions, but the buswork remained cleaner, longer.

Avoid push/pull systems on any tanks that are intended for use with a lot of hardware present between the push duct and the pull duct (see Fig. 4, courtesy of Ron Roberts, Lockwood Greene Engineers, Spartanburg, SC). Hard chromium plating operations often employ auxiliary anodes, cables, clamps, additional copper bus, etc., which act as barriers to both the pull and the



$$Q_1 = \frac{I}{D \times E} \times Q_2$$

where: D = length of Throw, feet
E = 2.0 for Throw < 8 ft.

Fig. 4—Hood design data.

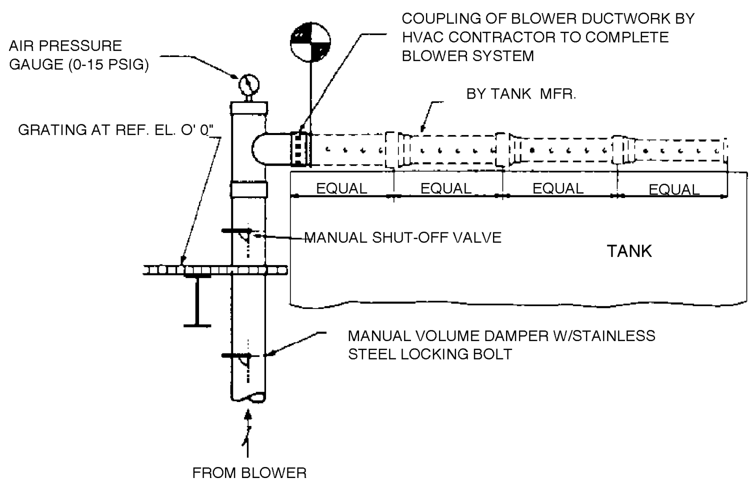


Fig. 5—Typical push-air system duct connection.

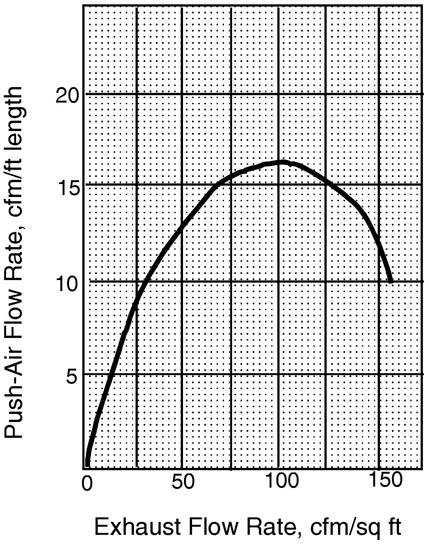


Fig. 6—Push-air flow rate required for minimum room emissions.

push. Since the push air is delivered at high velocity, it tends to cause high-speed collisions between the mist and the hardware on top of the tank, resulting in a high amount of fugitive emissions. We visited a one-year-old facility that spent millions of dollars on a modern hard chromium plating line that utilized push/pull ventilation. Thirty feet above the plating tanks, you could rub chromium plating solution off the catwalk railing!

Push Air Flow Rate

Excessive push air can disrupt emission capture. Slots are not as effective at pushing air and creating a curtain as jets (holes). The push jets should be directed to the center line of the tank's liquid surface.

A well-designed push air system is illustrated in Fig 5. Note the push pipe is reduced in size in equal sections across the tank to maintain an equal air velocity. Volume dampers and manual shut-off allow the operator to fine-tune the push, and to shut it off during immersion of a large part that will block the push air. Figure 6 provides guidance for the push air flow rate vs. the exhaust (pull) air flow rate.

One last comment: Design your ventilation system with as much flexibility as possible in terms of allowing you to adjust slot widths, hole sizes, etc., because fine tuning is almost always necessary. **P&SF**

References

1. Ron Roberts, Ventilation Engineer, Lockwood Greene Engineering, Spartanburg SC. (Mr. Roberts was also the source of tables and figures.)
2. *Electroplating Engineering Handbook*, Lawrence J. Durney, ed., 4th edition, page 642.
3. "Evaluation of Capture Efficiencies of Large Push-Pull Ventilation Systems with Both Visual and Tracer Techniques," Woods & McKarns, *AIHA Journal*, p. 1208 (December 1995).