CHROME PLATING CONTROL DEMONSTRATION PROJECT STAFF REPORT

State of California
Air Resources Board

Stationary Source Division
September 1989

This report has been reviewed by the staff of the California Air Resources Board and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Air Resources Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ACKNOWLEDGMENTS

The staff of the Air Resources Board/Stationary Source Division express their appreciation and thanks to project participants whose diligence, perseverance, and support have been an asset to this project: Pete Ouchida, Dave Todd, and the source testing crew; Rupee Torre, and Linda Rabano of Monitoring and Laboratory Division; Ed Jeung of the Air and Industrial Hygiene Laboratory, Department of Health Services; Dean High of Pacific Environmental Services; Larry Cottone of Engineering Science/formerly with Pacific Environmental Services; Andy Smith of the U.S. Environmental Protection Agency; Robin Barker of Midwest Research Institute; Mike Reed of Electronic Chrome and Grinding; Susan B. Grant of Electrolyzing; Ray Bokleman of Chromal Plating Company; The Metal Finishing Association of Southern California; Monsanto Enviro Chem; CM & E Inc.; TRI-MER Inc.; CECO Filters Inc.; The South Coast Air Quality Management District; the San Diego County Air Pollution Control District; and the Bay Area Air Quality Management District.

Principal Author

Franklin R. Weintraub

Contributing Author

Gina Facca

Reviewed and Approved by

Clifford A. Popejoy, Manager, Process Evaluation Section
Donald J. Ames, Chief, Toxic Air Contaminant Control Branch
Peter D. Venturini, Chief, Stationary Source Division

Table of Contents

INTRODUCTORY SUMMARY

A. Overview

In February 1988 the Air Resources Board (ARB) adopted an airborne toxic control measure (ATCM) to control emissions of hexavalent chromium from chrome plating and chromic acid anodizing operations. The ATCM contains both an interim requirement (95 percent control or 0.15 mg/Amp-hr in 18 months) and a technology forcing requirement (99.8 percent control, or 0.006 mg/amp-hr in 48 months) for those platers who emit more than 10 lbs/year.

In response to this technology forcing requirement, the Metal Finishing Association of Southern California (MFASC) offered to carry out an 18-month demonstration project and requested ARB testing support. The Board accepted this proposal and directed ARB staff to participate in this project. This report is a summary and analysis of the data generated as a result of the demonstration project.

1. What was the project objective?

The project objective was to ascertain the achievability of the two compliance options available to large plating facilities (those emitting over 10 lb/year of hexavalent chromium): a mass-based emissions limit of an 0.006 mg/amp-hour or a 99.8 percent emission reduction requirement. A focus of this project was on the achievement of the 0.006 mg/amp-hour limit by reducing emissions both at the plating tank using process modifications, and using an "on the roof" conventional control device. The use of process modifications as a mechanism to reduce emissions at the source (the tank surface) prior to controlling stack emissions is more effective at reducing emissions than exclusive use of one of these methods. Additionally, capital equipment costs were compared to earlier estimates.

2. What is a "pollution prevention" approach, and why was it emphasized in this project?

A pollution prevention approach for hard plating facilities involves changes to the plating process, or process modifications, in order to reduce emissions from the plating tank. The Board requested that process modifications be evaluated as part of this project as a condition of ARB source testing support. Consequently, modifications to the plating process which had the potential to decrease emissions were examined. Tests on process modifications performed by Pacific Environmental Services (PES), the MFASC consultant, demonstrated that large emission reductions were possible by making simple process modifications. Those process modifications evaluated included the elimination of air agitation, and the use of floating polyballs and anti-mist additives.

The pollution prevention approach is desirable because it has been demonstrated to, when used with pollution control devices, achieve the lowest emission rate (i.e., lowest emissions of hexavalent chromium per amp-hour of plating done). Lower emissions mean lower potential public health impact. Therefore, both process modifications at the tank (such as elimination of air agitation, and the addition of floating polyballs or anti-mist additives) and a control device were employed for most of the plating tanks that ARB staff tested.

3. Who participated in the project?

The Metal Finishing Association of Southern California (MFASC), through its technical consultants Pacific Environmental Services (PES), were the project managers. The ARB staff furnished source test support and reviewed ongoing work. The South Coast (SCAQMD), San Diego (SDAPCD) and Bay Area (BAAQMD) districts reviewed ongoing work; the SCAQMD also participated in evaluating test methods.

4. What types of control devices were tested?

Two full-scale and two pilot-scale control devices were tested by ARB staff. Several process modifications were also included in the test program to determine the effect of these modifications upon emission reductions at the plating tank. Additionally, prior to ARB testing, PES performed a shakedown test to identify any equipment problems in need of correction.

5. What are the results?

Application of a pollution prevention approach incorporating a combination of process modifications and a control device, met and was below the 0.006 mg/amp-hour limit in 12 of 12 tests. Two additional tests in which a control device alone was tested on tanks without process modifications, met and exceeded the 99.8 control device percent alternative requirements.

The system performance with process modifications is shown in Figure 1. All tests incorporating process modifications and a control device had emission rates below 0.006 mg/amp-hour, thereby satisfying the ATCM requirements. In addition, in five of these tests, the percent removal efficiency met or exceeded the ATCM requirements.

Average performance for the two control devices tested on tanks without process modifications are shown in Figure 2. These devices both met the 99.8 percent control efficiency requirement.

FIGURE 1

Average System Emissions

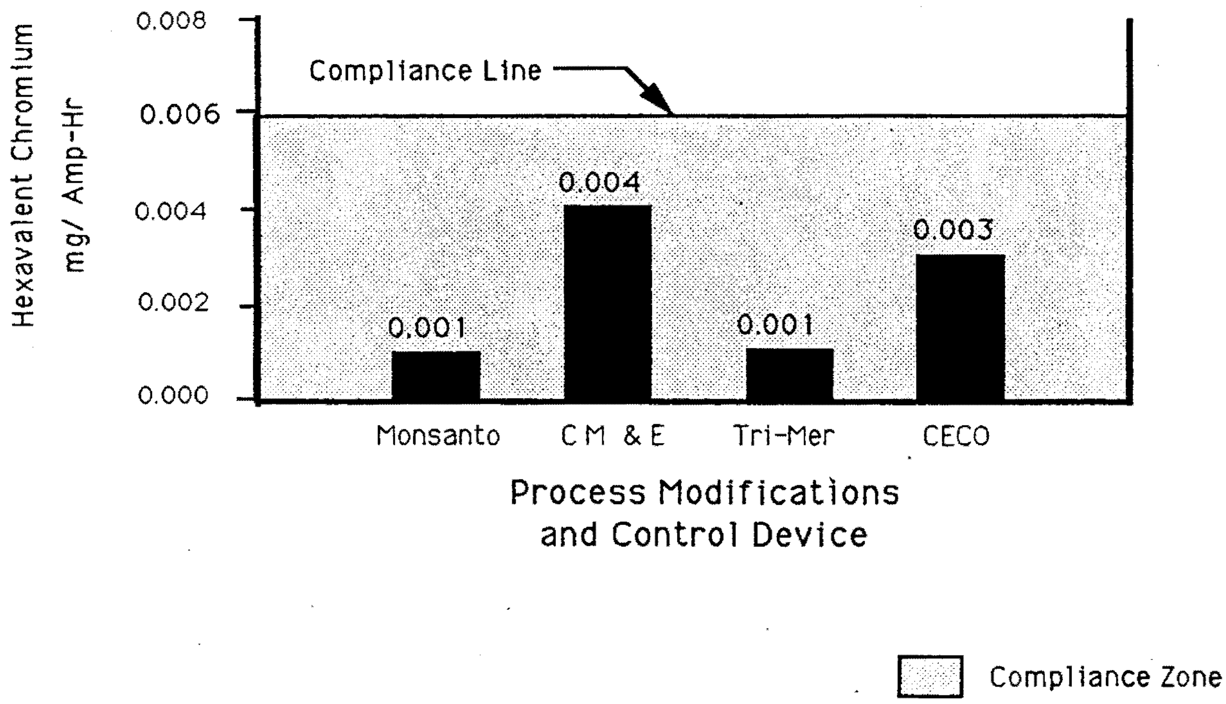
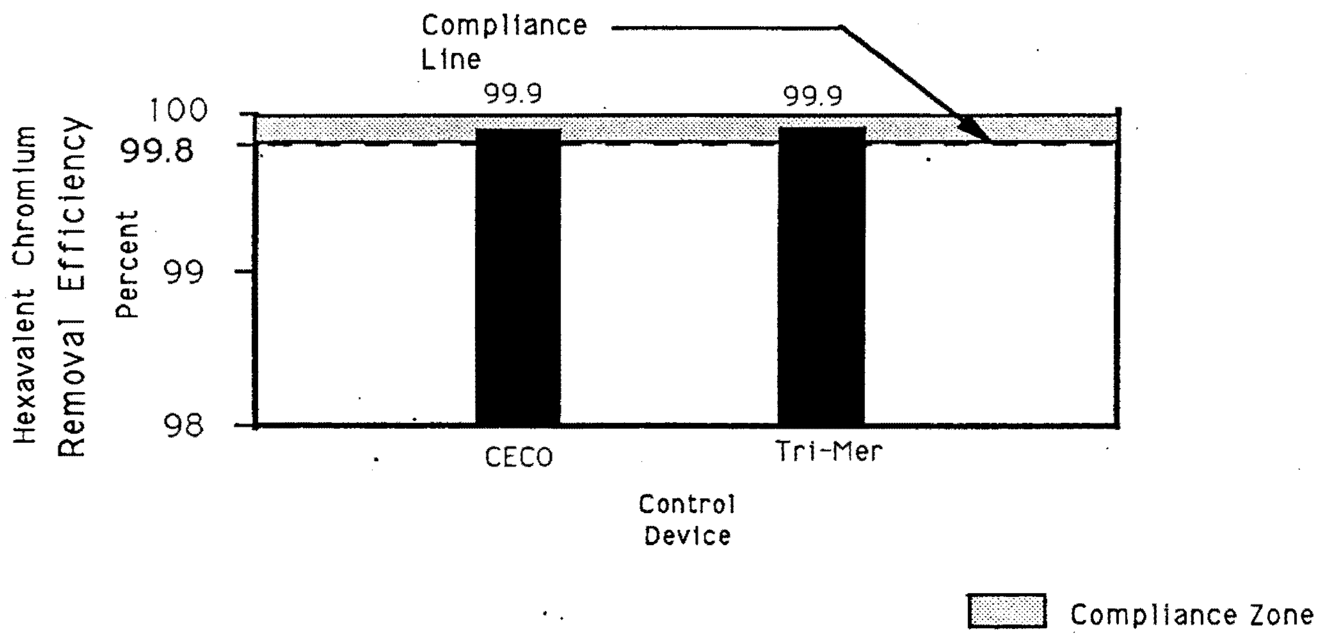


FIGURE 2

Control Equipment Performance
(w/o Process Modifications)



We evaluated general control equipment costs and found that our original estimates (cited in the 1988 ATCM technical support document) are within the range of costs for the control devices we tested.

B. Conclusion

Testing demonstrated that the requirements of the ATCM were consistently met on tanks both with and without process modifications. Consequently, we believe that the requirements of the ATCM are achievable and that no modification of the ATCM is necessary.

I. PROJECT DESIGN

1. What was the purpose of this project?

The project was designed to assess the achievability of the ATCM requirement of either 0.006 mg/amp-hour emission limit or 99.8 percent emissions reduction (control) for hexavalent chromium emissions from large hard chrome plating operations. The project included determining the potential role of process modifications upon emissions control, and the evaluation of commercially available pollution control devices appropriate to this application. Additionally, ARB staff compared capital equipment costs to earlier estimates.

2. Why was a pollution prevention approach emphasized?

A pollution prevention approach incorporating process modifications <u>and</u> a control device was emphasized because we believed it would result in the lowest emissions possible, and consequently the greatest benefit to public health. This emphasis means that the test results are focused on the achievability of the 0.006 mg/amp-hour limit over the achievability of the alternative requirement of 99.8 percent control.

3. Who participated in the project and what were the major tasks?

The MFASC, through its technical consultants, Pacific Environmental Services (PES), was the project manager. The ARB furnished source test support and reviewed ongoing work. Other participants and their roles are shown on Table 1.

Major project tasks included:

- Control equipment evaluation and selection
- Host site evaluation and selection
- Method evaluation testing
- Process modification testing
- Control equipment testing
- Interpretation of results/preparation of final report

4. What test method was used for control device testing?

The test method used for this project was a modified version of ARB method 425.

Several different techniques are currently available for the collection and measurement of hexavalent chromium from hard plating facilities. Three of these methods were simultaneously evaluated at a hard plating facility in October 1988 by the ARB, PES and SCAQMD test crews.

Table 1

CHROME PLATING CONTROL DEMONSTRATION
PROJECT PARTICIPANTS OTHER THAN MFASC/PES AND ARB

Participant	Project Role
Bay Area Air Quality management District (BAAQMD)	Reviewed Plan
Control Equipment Manufacturers	Reviewed plan, furnished control equipment
Host Sites	Furnished typical hard plating tanks for testing
San Diego Air Pollution Control District (SDAPCD)	Reviewed plan
South Coast Air Quality Management District (SCAQMD)	Reviewed plan, participated in test method evaluation
United States Environmental Protection Agency (EPA)	Provided technical consultation, observed testing

Subsequent to this testing, the parties involved agreed upon modifications to the ARB test method for chrome plating. This "consensus method" was used in the subsequent ARB control equipment testing. The modifications to 425 have been proposed for Board adoption in the fall of 1989. A separate detailed report on the testing and results has been prepared by ARB staff and was reviewed by project participants prior to preparation of this report.

II. RESULTS AND DISCUSSION

1. What types of control devices were tested?

Three types of devices were tested: two Brownian motion/inertial impaction collection devices; a reduced exhaust-flow/filtration device; and a flow acceleration/filtration device. Two of these devices were full scale and two were pilot scale. Those units selected for testing, host site test facilities, and the process modifications used during ARB-conducted testing, are shown in Table 2.

2. What are the final testing results?

The test results are summarized in Tables 3 and 4. ARB staff conducted a total of 14 tests for this project. Twelve of these tests, shown in Table 3, incorporated process modifications, and the two tests shown in Table 4, did not. Test results show that all 14 tests were in compliance with the ATCM by meeting one or the other requirement of the ATCM.

In some cases, both alternative requirements were met. The twelve tests which incorporated process modifications met the 0.006 mg/amp-hour requirement. Of these, five also met the 99.8 percent control requirement. The two tests of control device performance without process modifications, shown in Table 4, met the 99.8 percent control requirement.

All tanks incorporating process modifications and having a control device met the 0.006 mg/amp-hour limit, and some had emission rates that were much lower (0.001 mg/amp-hour). The combination of process modifications and a control device yielded lower emissions than did a control device only approach. The fact that all tested tanks incorporating process modifications met the 0.006 mg/amp-hour limit is very encouraging.

When both process modifications and a control device were used, low emission rates (less than 0.006) were achieved; in some cases the control device efficiency was below 99.8 percent. This suggests that it may be difficult for some facilities to achieve both the 0.006 mg/amp-hour emission limit <u>and</u> the 99.8 percent control (across a device). The ATCM does <u>not</u> require that both standards be met.

Figure 3 shows a comparison between emissions for the CECO and Tri-Mer devices which were tested on tank exhausts both with and without process modifications. Figure 3 shows that control device only emissions were further reduced by approximately 50 percent when both process modifications and a control device were used.

Table 2

Test Locations, Control Equipment and Other Information

Sampling Location	Electronic Chrome 9128 Dice Road Santa Fe Springs	Electrolyzing 1947 Hopper Ave. Los Angeles	Chromal Plating 1748 Workman St. Los Angeles	Chromal Plating 1748 Workman St. Los Angeles
Control Equipment Manufacturer	Monsanto	CM & E	Tri-Mer	CECO
Operating Principle	Fiber Bed Mist Eliminator, Brownian Diffusion	Reduced Flow, Filtration	Wet Packed Scrubber, Flow Accelerator	Inertial Impaction Brownian Diffusion
Pilot or Full-Scale	Pilot	Full Scale	Full Scale	Pilot
<u>Process Modifications Used During Testing</u>				
Sampling Dates				
a. Polyballs Only	January 23-27	January 30-Feb 3	February 14-17	February 21-24
b. Agitation Air Only			March 7	
c. Polyballs Plus Mist Suppressant			March 8-9	
d. None of a, b, or c				March 10

Table 3

System Emissions

Control Device	# of Tests	Range	Hexavalent Chromium Emissions mg/Amp-hr
Monsanto	3	0.0011-0.0017	0.001
CM & E	2	0.0040-0.0049	0.004
Tri-Mer	2	0.0002-0.0014	0.001
CECO	3	0.0028-0.0035	0.003
Tri-Mer	2	0.0005-0.0010	0.001

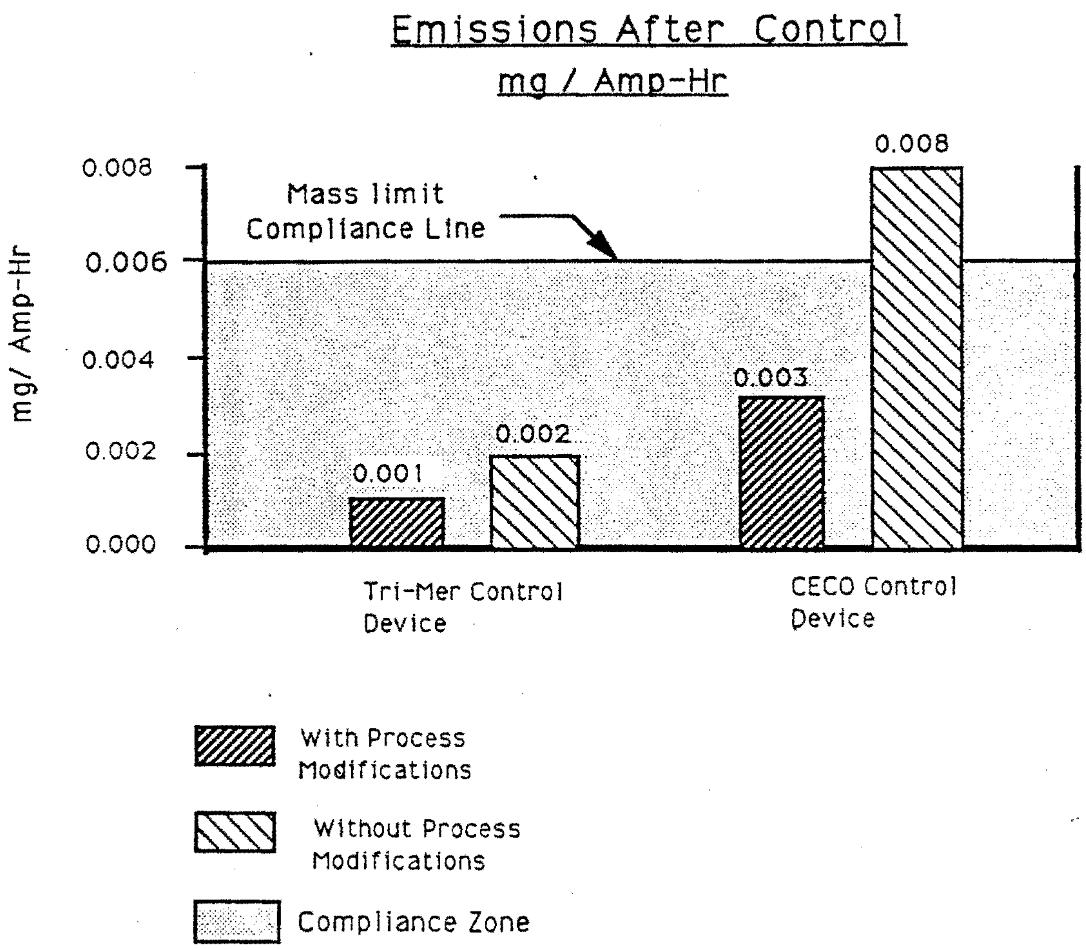
NOTE: Measured emissions are the result of both process modifications at the tank and a control device. All tests were run with polyballs and, for the first two devices listed, with no air agitation. The last of the Tri-Mer tests listed also included an anti-mist additive.

Table 4

Removal Efficiency
Control Device Only - No Process Modifications

Control Device	# of Tests	Hexavalent Chromium Emissions, mg/A-hr	Removal Efficiency, Percent
CECO	1	0.008	99.9
Tri-Mer	1	0.0018	99.9

FIGURE 3


Emissions After Control
mg / Amp-Hr
mg/ Amp-Hr
0.008
0.006
0.004
0.002
0.000
Mass limit
Compliance Line
0.001
0.002
0.003
0.008
Tri-Mer Control
Device
CECO Control
Device
With Process
Modifications
Without Process
Modifications
Compliance Zone

3. **Were the requirements of the ATCM met?**

The requirements of the ATCM were met for all hard plating tanks tested. The data shows that 0.006 mg/amp-hour was met in all cases by the use of both process modifications and an "off the shelf" control device. Of the tanks not employing process modifications, both were able to meet the 99.8 percent control requirement through the use of a control device only. Compliance with the ATCM by the percent control method may require site specific engineering. This is why a four year compliance time has been included in the ATCM.

It is important to note that the ATCM allows the facility operator a choice of compliance requirements, either 0.006 mg/amp-hour or 99.8 percent control. This allows a flexible approach to compliance based upon site specific conditions such as ability or desire to use process modifications to reduce emissions. In terms of reducing the public's exposure to hexavalent chromium emissions, the data available suggest that compliance with the 0.006 mg/amp-hour emission limit would result in lower emissions.

For those cases where uncontrolled emissions were equal to or greater than 14 mg/amp-hour, compliance with the 99.8 percent reduction option yields an emission rate which is 5 times higher than the 0.006 mg/amp-hour compliance option.

4. **Why didn't all control devices which achieved low mass emission values also achieve high removal efficiencies?**

A major focus of this project was to ascertain the role of process modifications upon emissions. The attainment of low mg/amp-hour mass emissions and high percent removal efficiencies are competing goals. High removal efficiencies are easier to obtain if the process itself results in high concentrations of hexavalent chromium in the exhaust stack. The mass of hexavalent chromium emitted by the plating process on a mg/amp-hour basis, tended to be lower when process modifications were used on the plating tanks. Consequently, a reduction of the hexavalent chromium emitted at the tank surface was emphasized over leaving the mass of hexavalent chromium emitted by the tank relatively high and achieving very high removal efficiencies across a control device.

When testing a control device which is attached to a tank employing process modifications (floating polyballs on the surface and no air agitation), the inlet loading (mass of hexavalent chromium per volume of exhaust air) to the control device is typically lower than without process modification. Since the inlet loading is lower and the mean particle diameter probably smaller, control devices of the type tested would be expected to remove a lower percentage of the pollutant than in a case where the inlet loading is higher. This phenomenon could cause a control device to exhibit less than optimum removal efficiency and yet result in low emission rates, and explains why some control devices were able to meet the mass limit but not the alternative removal efficiency requirement.

5. How do control equipment costs relate to estimates previously cited in the technical support document for the ATCM?

Estimates of general control equipment cost for the equipment we tested are similar in most cases to the estimates cited in the 1988 ATCM technical support document. We reevaluated equipment costs for each device for non-site-specific installation of a range of system sizes. In many cases, these estimated capital equipment costs were below the 1988 estimates, and in all cases were within 20 percent of the 1988 estimates. The appendix compares our current and previous cost estimates and is based upon recent conversations with equipment manufacturers.

III. ISSUES AND DISCUSSION

1. Can all platers use the process modifications?

Industry representatives have indicated to staff verbally that it may not be possible for every plater to use process modifications; the primary reason cited was potential adverse effects on product quality. Up until now, large hard platers have had no incentive to use process modifications in all cases. The incentive to reduce emissions at the tank is being emphasized by the Board and is currently being used successfully by many large hard platers and anodizers. No problems with product quality were reported to ARB staff by those platers using process modifications as part of the demonstration project.

Those platers who do not choose to (or cannot) use process modifications along with a control device to achieve compliance have the option of using the control efficiency approach. This option may require additional effort such as site-specific engineering. Data from the two tests performed on uncontrolled tanks demonstrates that 99.8 percent was achieved solely by a control device.

To account for site-specific circumstances which require additional effort to achieve compliance, the ATCM allows a four year compliance time.

2. Are platers given a direct emission credit for using process modifications?

Hard chrome platers who use process modifications are not given direct credit for emissions reductions at the source. The ATCM requires platers to control emissions to three particular levels based upon the lbs/year of hexavalent chromium they emit. These control levels and corresponding emission rates are shown below:

Hexavalent Chromium Emission Rate (lbs/yr) (Post Control)	Required Control Levels: Percent Removal		Required Control Levels: mg/amp-hour
Less than 2 (low emitting)	95	or	0.15
Greater than 2 but less than 10 (medium emitting)	99	or	0.03
10 or greater (high emitting)	99.8	or	0.006

The use of process modifications may allow some hard platers to move from the high to the medium emitting classification. For example, a decrease in hexavalent chromium emissions from over 10 lbs/year to below that amount may allow some platers to meet less stringent control requirements (0.03 mg/amp-hour or 99 percent control) using less costly equipment. The ATCM is structured to allow this approach and consequently provide indirect credit for the use of process modifications.

3. Why not lower the efficiency requirement from 99.8 to 99.5 percent as suggested by industry representatives?

There are several reasons why staff believe that the efficiency requirement should not be modified:

1. The current requirement in the ATCM, 0.006 mg/amp-hour, or 99.8 percent, was met in all 14 tests. The requirement for 0.006 mg/amp-hour has been met by using both process modifications and a control device, while 99.8 percent removal has been met by control devices tested on tanks with and without process modifications.

2. The ATCM currently allows industry two compliance options: 0.006 mg/amp-hour or 99.8 percent removal. Additionally, other compliance options may be possible provided they are no less stringent than the ATCM.

3. Because the existing ATCM requirements can be met, lowering them would result in increased emissions and increased potential adverse public health impact. For seven large hard plating facilities, lowering the percent removal requirement from 99.8 to 99.5 would potentially increase both hexavalent chromium emissions and cancer risk after control. Emissions would potentially increase 2 to 3 fold, while residual individual risks for the largest facility would more than double from 11-130 to 30-320 per million. This range of risk corresponds to the Department of Health Services' range in cancer potency factor of 12 to 146. The number of potential cancer cases, over a 70-year exposure attributable to emissions from the seven largest facilities would increase from 1-10 to 2-25 depending on the potency factor used.

4. Both the SCAQMD and the BAAQMD staffs have expressed opposition to reducing the stringency of the percent removal efficiency requirement. In fact, the BAAQMD rule has only the mg/amp-hour limit and does not include a percent efficiency requirement as a compliance option.

4. Will scale-up from pilot scale to full-scale devices be possible?

Both of the manufacturers who supplied pilot scale devices currently manufacture and sell full-scale devices suitable for this application. The development and testing of pilot-scale equipment prior to the development of full-scale devices is a common industrial practice.

The two pilot scale devices were tested by extracting only a portion of the main exhaust stream. This slipstream was extracted so that velocity and grain loading were similar to the main exhaust stream. A slipstream was required because the throughput of the pilot scale control devices was less than the main exhaust. Although some variability between the main and slipstreams in terms of grain loading was found, it was not considered to be significant. This variability was acceptable when compared to the magnitude other operational variables such as current and part surface area.

5. **How do preliminary PES shakedown test results compare with ARB test results?**

Prior to answering this question it is important to discuss the purpose for both types of testing. The PES testing, which preceeded ARB testing, consisted of a single test run and was designed to trouble shoot operational problems associated with particular control devices. This test was an indicator that the control devices were operating at design capacities. The ARB testing was a series of triplicate runs designed to provide measured performance data on a control device under typical facility operating conditions.

An evaluation of the PES screening results in comparison with the ARB test results indicate general agreement with one exception. The PES shakedown testing indicates that of the devices tested on tanks using process modifications, the 0.006 mg/amp-hour limit was met in three out of four facilities. In the case where the limit was not met, this may have been due to either a sampling problem or a control device problem, since both were encountered during this particular test run. The PES results indicate lower removal efficiencies than the ARB tests. Some possible explanations for these differences are:

1. Control devices when tested by PES may not have been operating under steady state conditions at the time of testing. ARB tests were generally conducted 1-2 weeks after the screening tests.

2. The test method used for the first Monsanto screening test was different than modified ARB test method 425. A test problem also occurred during the CM&E screening test.

3. Control devices were not operating correctly due to device-specific problems. This situation occurred during the screening test of the CECO device.

Staff does not believe that the variability in measured performance between the PES and ARB data is a significant issue. This is because of the differing purposes of the tests, and the fact that

ARB tests were done in triplicate and show a high degree of consistency.

6. **Under what circumstances would an alternative compliance approach for large hard chrome platers and anodizers be considered?**

Staff currently believes that the two existing compliance options (0.006 mg/amp-hour or 99.8 percent control) available to industry are achievable, verifiable, offer flexibility to both existing and new facilities. Staff does recognize, however, that because of site specific conditions some facility operators could benefit from alternative approaches to compliance. Alternative requirements-- such as using only process modifications without an emission collection system or control device, or the granting of cumulative emissions reductions credit for both process modifications and a control device--can be considered by districts in their rulemaking process.

Districts have the option of adopting rules which are different from the ATCM, as long as the district rule is no less stringent than the ATCM. When it is proposed, a district rule is submitted to ARB staff for review. If supporting evidence is sufficient to establish that the proposed rule is no less stringent than the ATCM, ARB staff will approve the rule.

7. **Can large hard plating shops comply with the ATCM, as written?**

The demonstration test data shows that using process modifications (floating polyballs and no air agitation) in combination with stack control devices results in compliance with the ATCM via the mg/amp-hour approach. Achievement of the 99.8 percent efficiency requirement on tanks without process modifications also has been shown. Facility compliance with the 99.8 percent will likely be more difficult in terms of initial achievability and long-term equipment performance and probably require site-specific engineering.

Staff concludes that compliance with the ATCM has been demonstrated in all 14 tests conducted at three typical plating shops using four different control devices and therefore recommends retaining the existing requirements of the ATCM.

APPENDIX

Table A

Estimated Capital Equipment Cost Comparison

System Size ACFM	Previous ($)[1] Capital cost Estimate	Monsanto[2] ($)	CM & E[3] ($)	CECO[4] ($)	Tri-Mer[5] ($)
100,000[6] (400 ft^2 tank area)[7]	1,400,000	1,643,750	886,250	512,500	753,750
40,000 (160 ft^2 tank area)	560,000	657,375	330,000	342,500	239,000
30,000 (120 ft^2 tank area)	420,000	493,000	247,500	257,500	132,750
20,000 (80 ft^2 tank area)	280,000	328,750	226,500	171,250	104,375
10,000 (40 ft^2 tank area)	140,000	163,750	135,250	151,250	70,875

These costs are general and not site specific

Notes:

1. Previously reported in the technical support document to Proposed Airborne Toxic Control Measure for Emissions of Hexavlent Chromium from Chrome Plating and Chromic Acid Anodizing Operations. January 4, 1988. Smaller systems were ratioed from this basis. Includes feight, taxes, installation and indirects via a capital cost factor of 2.33.
2. Costs for mist eliminator or filter elements and fiberglass tank housing were available from the manufacturer. A 2.33 capital cost factor was applied for auxiliary equipment, installation, and other contingencies. Includes a 25 percent retrofit adder and a cost of $31.25/ft^2 of tank area for floating balls.
3. Since this is a reduced flow system, these costs are based on a cost equivalent of 6.50-10.70$/cfm installed of a comparable high flow system. Costs from the manufacturer include fabrication and installation of tank cover, ducting, delivery, permit processing and source testing of the unit.
4. Costs are installed and based on a maximum of $12.00/cfm for a 10,000 cfm system to $4.00/cfm for a 100,000 cfm system. Approximately 30 percent is included for typical installation. Includes a 25 percent retrofit adder and a cost of $31.25/ft^2 of tank area for floating balls.
5. A 30 percent installation adder was cited by the manufacturer as appropriate. Costs shown are for capital equipment initial investment and installation. Includes a 25 percent retrofit adder and a cost of $31.25/ft^2 of tank area for floating balls.
6. 100,000 ACFM unit cost was calculated based on (2) 40,000 ACFM and (1) 20,000 ACFM units.
7. System size is based on an exhuast rate of 250 cfm/ft^2 of plating tank surface area.