California Environmental Protection Agency
AIR RESOURCES BOARD

STAFF REPORT: INITIAL STATEMENT OF REASONS FOR PROPOSED RULEMAKING

AIRBORNE TOXIC CONTROL MEASURE TO REDUCE EMISSIONS OF HEXAVALENT CHROMIUM AND NICKEL FROM THERMAL SPRAYING

Stationary Source Division
Measures Assessment Branch

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State of California
AIR RESOURCES BOARD

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Public Hearing to Consider

ADOPTION OF THE PROPOSED AIRBORNE TOXIC CONTROL MEASURE TO REDUCE EMISSIONS OF HEXAVALENT CHROMIUM AND NICKEL FROM THERMAL SPRAYING

To be considered by the Air Resources Board on December 9, 2004, at:

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State of California
AIR RESOURCES BOARD

PROPOSED AIRBORNE TOXIC CONTROL MEASURE TO REDUCE EMISSIONS OF HEXAVALENT CHROMIUM AND NICKEL FROM THERMAL SPRAYING

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ACRONYMS

AB	Assembly Bill
APC	Air Pollution Control
APCD	Air Pollution Control District
AQMD	Air Quality Management District
ARB	Air Resources Board
ASM	American Society for Metals
ATCM	Airborne Toxic Control Measure
AWS	American Welding Society
BAAQMD	Bay Area Air Quality Management District
BACT	Best Available Control Technology
BL	Barrio Logan
Cal/OSHA	California Occupational Safety and Health Administration
CAPCOA	California Air Pollution Control Officers' Association
CAS	Chemical Abstract Service
CATEF	California Air Toxic Emission Factors
CCR	California Code of Regulations
C.E.	Control Efficiency
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CRF	Capital Recovery Factor
HAP	Hazardous Air Pollutant
HCAT	Hard Chrome Alternatives Team
HEPA	High Efficiency Particulate Abatement
HRA	Health Risk Assessment
HSC	Health and Safety Code
HVOF	High Velocity Oxy-Fuel
ISOR	Initial Statement of Reasons
ITSA	International Thermal Spraying Association
MW	Molecular Weight
NEC	Not Elsewhere Classified
NESHAP	National Emission Standards for Hazardous Air Pollutant
NIOSH	National Institute for Occupational Safety and Health
OEHHA	Office of Environmental Health Hazard Assessment
OSHA	Occupational Safety and Health Administration
PD	Protected Data
PEL	Permissible Exposure Limit
PM	Particulate Matter
PM_{10}	Particulate Matter with an aerodynamic diameter less than or equal to 10 microns
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter less than or equal to 2.5 microns
PTA	Plasma Transferred Arc
REL	Reference Exposure Level

ACRONYMS

SCC	Source Classification Code
SCAQMD	South Coast Air Quality Management District
SDAPCD	San Diego County Air Pollution Control District
SFO	San Francisco Airport
SIC	Standard Industrial Classification
SRP	Scientific Review Panel
SWA	Sales-Weighted Average
TAC	Toxic Air Contaminant
T-BACT	Best Available Control Technology for Toxics
T.E.	Transfer Efficiency
TSP	Total Suspended Particulate
ug	Microgram
ug/m3	Micrograms per Cubic Meter
U.S. EPA	United States Environmental Protection Agency

EXECUTIVE SUMMARY

I. INTRODUCTION

This executive summary presents the Air Resources Board (ARB/Board) staff's *Proposed Airborne Toxic Control Measure (proposed ATCM) to Reduce Emissions of Hexavalent Chromium and Nickel from Thermal Spraying*. The proposed ATCM would require thermal spraying facilities that use materials containing chromium or nickel to have the best available control technology (BACT) and obtain an air permit, if they have not already done so. The proposed ATCM would not specifically eliminate the use of materials containing chromium or nickel and it would not require these materials to be reformulated. If approved by the Board, the proposed ATCM will be sent to the air pollution control and air quality management districts (air districts) to be implemented and enforced. The local air districts may implement the proposed ATCM as approved by the Board, or adopt an alternative rule that is at least as stringent as the proposed ATCM.

II. BACKGROUND

1. What is thermal spraying?

Thermal spraying (or metal spraying) is a process in which materials are heated to a molten or nearly molten condition and are sprayed onto a surface to form a coating. Materials can be heated by combustion of fuel gases (similar to welding) or by using electricity. Thermal spraying includes processes such as flame spraying, plasma spraying, high velocity oxyfuel (HVOF) spraying, and twin wire electric arc spraying. Thermal spraying can be used in a wide variety of industries for numerous applications. In addition, thermal metal spraying can be a replacement for some hard chromium electroplating processes. Some thermal spraying materials contain chromium and nickel compounds and the use of these materials can create emissions of hexavalent chromium and nickel.

2. Why is the staff proposing an ATCM for thermal spraying?

There are potential serious health risks associated with thermal spraying, as there are with hard chromium electroplating. As a result, the Board directed staff to investigate the health risks associated with thermal spraying activities, and to propose an ATCM if warranted.

The ARB identified hexavalent chromium and nickel as toxic air contaminants (TAC) in 1986 and 1991, respectively. The ARB identifies and controls TACs under the authority of the California Toxic Air Contaminant Identification and Control Program (Air Toxics Program) established by Assembly Bill 1807 (AB 1807) and set forth in Health and Safety Code (HSC) sections 39650 through 39675. Both hexavalent chromium and nickel were determined to be human carcinogens without an identifiable threshold exposure level below which no significant adverse health effects are anticipated. Nickel was also deemed to have acute health impacts.

Hexavalent chromium is a very potent carcinogen relative to other TACs. For example, hexavalent chromium is second only to dioxins in terms of carcinogenic potency, and is 24,000 times more potent than perchloroethylene and 5,000 times more potent than benzene. Although nickel is a much less potent carcinogen than hexavalent chromium, short-term exposure to relatively low concentrations of nickel can result in acute health impacts.

The Board has adopted three ATCMs for hexavalent chromium. These are the chrome plating and chromic acid anodizing ATCM in 1988, an ATCM prohibiting the use of hexavalent chromium in cooling towers in 1989, and an ATCM prohibiting the use of hexavalent chromium in motor vehicle coatings in 2001. None of these ATCMs address hexavalent chromium emissions from thermal spraying. The chrome plating ATCM is currently being updated, and is scheduled for Board consideration in 2005.

There are currently no federal or local air district rules that specifically regulate thermal spraying operations. Some districts have permitted these operations and through the permits have required controls. Other districts have not required such permits. Therefore, no uniform method of regulating thermal spraying operations currently exists statewide.

3. What actions did staff take to consult with interested parties?

As part of our outreach program, staff made extensive contacts with air districts, industry and facility representatives as well as other affected parties through public workshops, meetings, telephone calls, and mail-outs. Major outreach activities included:

- Forming an ARB/District Working Group and conducting three conference calls with group members;
- Forming an ARB/Industry Working Group and conducting four conference calls with group members;
- Creating an ARB Thermal Spraying website and maintaining a List-Server to automatically update interested parties about proposed ATCM developments;
- Providing copies of draft surveys to working group members to obtain their input and recommendations;
- Conducting a survey by mail and e-mail for 42 thermal spraying material manufacturers in the United States and Canada;
- Conducting a survey by phone, FAX, and e-mail for facilities in California identified as potentially conducting thermal spraying operations;
- Preparing and making available for review, on ARB's website, the survey reports for the manufacturers survey and the facility survey;

- Making a presentation at the International Thermal Spray Association's regional meeting on April 2, 2004, in San Diego;
- Mailing workshop notices and posting workshop materials on ARB's website;
- Conducting three public workshops which allowed for participation by phone;
- Conducting site visits to three thermal spraying operations to better understand the thermal spraying processes and facility layouts; and
- Preparing fact sheets regarding the development of the proposed ATCM and making them available to industry associations, potentially affected facilities, and the public.

4. How does this proposed ATCM relate to ARB's goals on community health and environmental justice?

The ARB is committed to evaluating community impacts of proposed regulations, including environmental justice concerns. It is ARB's goal to reduce or eliminate any disproportionate impacts of air pollution on low-income areas and ethnically diverse populations so that all individuals in California can live, work, and play in a healthful environment. The proposed ACTM will reduce exposure to hexavalent chromium and nickel in California communities with affected facilities, including those with low-income and ethnically diverse populations.

To address environmental justice and general concerns about the public's exposure to hexavalent chromium emissions, the proposed ATCM establishes criteria for the operation of new thermal spraying facilities that use materials containing chromium or nickel. New facilities would be required to install High Efficiency Particulate Abatement (HEPA) filters (or equivalent), and could not operate in, or within 500 feet of, the boundary of a residential or mixed use zone. In addition, new facilities would be required to undergo a site-specific analysis to ensure adequate protection of public health. We believe these criteria are necessary for new thermal spraying facilities because hexavalent chromium is a potent carcinogen, and short-term exposure to nickel causes acute health impacts.

III. EMISSIONS AND POTENTIAL HEALTH IMPACTS

1. How much hexavalent chromium and nickel is emitted from thermal spraying facilities?

Thirty-seven of the 51 thermal spraying facilities in California use materials that contain chromium or nickel. We used ARB survey data to estimate the range of statewide emissions of hexavalent chromium and nickel from these thermal spraying facilities. The actual emissions estimate (the lower end of the range) is based on actual material usage reported by individual thermal spraying facilities. The maximum potential emissions estimate is based on the results of our 2003 manufacturer survey, which reflects total material sales during 2002. According to our 2003 manufacturer survey, 90 tons of thermal spraying materials containing chromium or nickel were sold or distributed in California during 2002.

Actual emissions of hexavalent chromium are estimated to be 9.4 pounds (based on 2003 facility data) and the maximum potential emissions are estimated to be 66 pounds (based on 2002 material sales data.) Actual emissions of nickel are estimated to be 105 pounds (based on 2003 facility data) and the maximum potential emissions are estimated to be 740 pounds (based on 2002 material sales data). The difference between the estimates of actual emissions and maximum potential emissions may be due to the following factors: 1) materials sold in one year may be used over multiple years; 2) some materials sold to California distributors may be redistributed out of State; and 3) some businesses that conduct thermal spraying may not have been captured by the ARB facility survey. Consequently, actual and maximum potential emissions represent the range of estimated emissions from thermal spraying. Table ES-1 provides a summary, by air district, of the estimated actual emissions of hexavalent chromium and nickel from thermal spraying facilities in 2003. These data were used to estimate the potential cancer risk for each thermal spraying facility in California.

Table ES-1: Estimated Actual Emissions of Hexavalent Chromium and Nickel*

District	No. of Affected Facilities	Hexavalent Chromium Emissions (lbs/yr)	Nickel Emissions (lbs/yr)
Bay Area AQMD	6	1.5	22.2
Feather River AQMD	1	0.04	0.3
South Coast AQMD	18	7.6	70.1
San Diego County APCD	7	0.3	6.4
San Joaquin Valley APCD	3	0	6.0
Ventura County APCD	2	0	0.01
Total	37	**9.4**	**105**

*Based on 2003 emissions data reported by facilities in the 2004 ARB Thermal Spraying Facility Survey.

2. What are the potential health impacts from exposure to hexavalent chromium and nickel emissions from thermal spraying facilities?

Exposure to hexavalent chromium and nickel may result in increased cancer risks and health risks from other non-cancer impacts, such as respiratory irritation, nasal and skin ulcerations, allergic sensitization, asthma complications, and birth defects. To assess potential health impacts, we evaluated health risks for the thermal spraying facilities identified in our facility survey. First, we conducted air dispersion modeling using data from four actual thermal spraying facilities that represented a range of operating conditions. We then used the results of that modeling and facility-specific actual emissions data to estimate health risks for thermal spraying businesses throughout the State.

The methods used in this risk assessment are consistent with the Tier 1 analysis presented in the Office of Environmental Health Hazard Assessment (OEHHA) Air Toxics “Hot Spots” Program Risk Assessment Guidelines, the Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments. The air dispersion models that were used have been approved by the U.S. Environmental Protection Agency, and are recommended by ARB for use in risk assessments.

Estimated potential cancer risks from hexavalent chromium and nickel exposure ranged from less than one per million up to approximately 300 per million for most facilities, with one facility having a potential cancer risk of 2,800 per million. For more than half of the 51 thermal spraying facilities in California, our analysis indicated potential cancer risks of less than one per million for near-source receptors where the maximum concentrations are expected to occur.

We are working with the South Coast Air Quality Management District (SCAQMD) to address the impacts from the facility with a potential cancer risk of 2,800 per million as soon as possible, and in advance to adoption and implementation of the proposed ATCM. The SCAQMD has notified this facility that it is subject to the AB 2588 program requirements, and must perform a health risk assessment. The facility will be conducting a source test to quantify their emissions for use in the health risk assessment.

We also evaluated non-cancer health impacts, including acute impacts from short-term exposure to nickel and chronic impacts from long-term exposure to hexavalent chromium and nickel. The primary non-cancer health impacts from thermal spraying are potential acute impacts from short-term exposure to nickel emissions. The potential for acute or chronic non-cancer health impacts is expressed in terms of a hazard quotient for a single TAC or a hazard index for multiple TACs. Typically, a hazard quotient or hazard index greater than one is considered unacceptable. Our analysis indicated that nickel emissions from thermal spraying facilities could result in an acute hazard quotient greater than one. Our evaluation of acute health impacts only included nickel, because hexavalent chromium does not have an established acute reference exposure level.

Our analysis also indicated that long-term exposure to hexavalent chromium and nickel emissions from a small number of high use thermal spraying facilities could result in a chronic hazard index greater than one. All but a few facilities are expected to have chronic hazard indices less than one. The highest estimated chronic hazard index for a specific facility was approximately two.

IV. SUMMARY OF THE PROPOSED AIRBORNE TOXIC CONTROL MEASURE

1. Who must comply with the proposed ATCM?

The proposed ATCM applies only to thermal spraying facilities in California that use materials containing chromium, chromium compounds, nickel, or nickel compounds. The proposed ATCM does not apply to portable thermal spraying operations that are used for 30 or less consecutive days for field applications at offsite locations.

2. What does the proposed ATCM require?

The proposed ATCM establishes emission standards that reflect the use of best available control technology (BACT). The proposed ATCM applies only to thermal spraying facilities in California that use materials containing chromium, chromium compounds, nickel, or nickel compounds. The proposed ATCM does not regulate the sale or composition of thermal spraying materials.

The proposed ATCM specifies control efficiency requirements for point sources and volume sources. The requirements increase in stringency with increasing emissions. Emissions must be determined by the calculation methods specified in the proposed ATCM or by using source test data that has been approved by the local air district. The proposed ATCM specifies the test methods to be used when conducting an emissions source test.

The proposed ATCM establishes requirements for new and modified thermal spraying operations that are more stringent than the requirements for existing operations. January 1, 2005, is the cutoff date in the proposed ATCM for distinguishing between existing operations, and new and modified operations. For example, a facility is considered "new" if it begins initial operations on or after January 1, 2005. A facility is considered "modified" if it undergoes a physical modification on or after January 1, 2005, that requires an application for an authority to construct and/or a permit to operate. We are proposing this cutoff date for two reasons. First, we want to minimize the potential for existing facilities to modify their operations prior to the ATCM's effective date in order to avoid the more stringent requirements for modified operations. Secondly, we want to minimize the potential that companies considering construction of a new thermal spraying facility will begin initial operations before the ATCM's effective date in order to avoid the more stringent requirements that apply to new operations. The January 1, 2005, cutoff date will also provide such companies adequate notice of the ATCM requirements before they undertake the expense of construction.

The air districts must implement and enforce the proposed ATCM or adopt an equally effective measure. The earliest the air districts could enforce the proposed ATCM for new facilities would be when the Office of Administrative Law approves it. The effective date for existing facilities to comply with the proposed ATCM is January 1, 2006.

a. What are the requirements for existing facilities?

Existing facilities are defined as those in existence before January 1, 2005. These facilities must use air pollution control devices that meet control efficiencies ranging from 90 percent to 99.97 percent. The control efficiency requirements increase in stringency with increasing emissions. The proposed ATCM also establishes maximum hourly emission limits for nickel. The maximum hourly nickel limit is 0.1 lb for point sources (sources with a stack), and 0.01 lb for volume sources (sources without a stack). The control efficiency requirements are designed to ensure that the maximum potential cancer risk is less than ten in a million. The maximum hourly nickel limits are designed to ensure that the acute hazard quotient from nickel emissions does not exceed one. These facilities must also use an enclosure and ventilation system that complies with designated operating standards. In addition, recordkeeping and regular monitoring are required to ensure the proper operation of the ventilation system and control device. All existing facilities that use materials containing chromium or nickel must submit an initial emission inventory and obtain a permit from their local air district.

A remotely located existing facility that uses products that contain chromium, chromium compounds, nickel or nickel compounds, may be able to comply with the proposed ATCM without installing additional controls if it meets all of the following criteria:

- facility emits less than 0.5 lb/yr of hexavalent chromium;
- facility is located at least 1,640 feet (500 meters) from a sensitive receptor;
- facility is equipped with an air pollution control device that achieves at least 90 percent control efficiency;
- facility submits an emissions inventory to the air district each year; and
- facility undergoes a site-specific analysis by the air district that demonstrates adequate protection of public health.

These criteria are designed to ensure that the potential cancer risk to the nearest sensitive receptor is less than ten in a million. A facility that meets the above listed criteria would undergo an annual review by the air district to ensure that the criteria continue to be met.

b. What are the requirements for modified facilities?

Modified facilities are thermal spraying operations that undergo a modification on or after January 1, 2005. Modifications can include production increases that result in increased emissions or equipment changes that require a permit modification. Modified facilities will be required to use an air pollution control device that achieves 99.97 percent control efficiency down to 0.3 microns (e.g., a HEPA filter). Modified facilities must comply with this requirement upon initial startup. If a facility already has a HEPA filter that achieves this control level, no additional upgrades are required after a modification.

c. What are the requirements for new facilities?

New facilities are thermal spraying operations that have an initial startup on or after January 1, 2005. This does not include the addition of a new permit unit at a facility that existed before January 1, 2005. New facilities must use an air pollution control device that achieves 99.97 percent control efficiency down to 0.3 microns (e.g., a HEPA filter). New facilities must also comply with a maximum hourly nickel limit of 0.1 lb. In addition, a new facility cannot operate unless it is located outside of a residential or mixed use zone and is located at least 500 feet from the border of a residential or mixed use zone.

All new facilities would also be subject to a site-specific analysis by the local air district to ensure adequate protection of public health. This type of analysis is already being done in many air districts as part of their permitting process for sources of TACs. These requirements are designed to address overall health impact and environmental justice concerns. New facilities must comply with the proposed ATCM upon initial startup.

d. What exemptions are allowed?

If an existing facility has very low emission levels (e.g., less than 0.001 lb/yr of hexavalent chromium and less than 0.3 lb/yr nickel), it may qualify for an exemption from installing additional controls. These facilities would be required to obtain a permit and report emissions annually to the air district.

3. What is the basis for the proposed ATCM?

The proposed ATCM is based on our evaluation of BACT for reducing hexavalent chromium and nickel emissions from thermal spraying operations, in consideration of health risk and cost. In evaluating BACT, we analyzed information from ARB’s 2003 thermal spraying material manufacturer survey and ARB’s 2004 thermal spraying facility survey. Based on this information and discussions with air districts, industry and control equipment manufacturers, we determined that suitable control devices are readily available and widely used. Further, the application of BACT, as proposed by staff, will result in potential cancer risk levels being reduced to less than three in a million for the nearest sensitive receptor. The non-cancer health impacts will be reduced to acceptable levels because both the acute hazard quotient for nickel and the chronic hazard index for hexavalent chromium and nickel will not exceed one.

4. Are the proposed standards technologically feasible?

Yes. The proposed ATCM standards are technologically feasible based on information from the ARB's 2004 thermal spraying facility survey, discussions with thermal spraying equipment providers, and manufacturers of air pollution control devices.

Most thermal spraying facilities already use control devices to minimize particulate emissions. In addition, many facilities have already installed HEPA filters, which are the most effective control devices available.

5. What alternatives to the proposed ATCM did staff consider?

California Government Code section 11346.2 requires the ARB to consider and evaluate reasonable alternatives to the proposed ATCM. We considered two alternatives to the proposed ATCM. The alternatives were evaluated in terms of applicability, effectiveness, enforceability, and cost/resource requirements. No action was the first alternative considered. The no action alternative was not acceptable because it would not address the public health risk posed by hexavalent chromium and nickel emissions from thermal spraying facilities.

The second alternative was to require that all thermal spraying facilities install HEPA filters if they use materials containing chromium or nickel. We determined that this alternative would be excessively burdensome and costly for facilities that have a minimal benefit for public health due to their low emissions. However, this alternative would be slightly more effective than the proposed ATCM in reducing emissions of and exposure to hexavalent chromium and nickel. Health and Safety Code (HSC) section 39666 requires consideration of cost and risk. Because of the very low risk reduction and high cost, this alternative was not selected.

6. What does the law require ARB to do to protect public health?

HSC section 39666 requires the ARB to adopt ATCMs to reduce emissions of TACs. When adopting ATCMs for TACs without a Board-specified threshold exposure level, HSC section 39666 requires the ATCM to reduce emissions to the lowest level achievable through the application of BACT or a more effective control method. The proposed ATCM is consistent with this requirement. To determine BACT, we evaluated the proposed control measure and alternatives to the proposed control measure. The proposed ATCM requires control technology that is technologically feasible and will provide the greatest reduction in exposure and risk at the lowest cost of any of the alternatives identified.

V. POTENTIAL IMPACTS OF THE PROPOSED AIRBORNE TOXIC CONTROL MEASURE: HEALTH, ECONOMIC AND ENVIRONMENTAL

1. What businesses and public agencies will be affected by the proposed ATCM?

The proposed ATCM is expected to impact 37 thermal spraying facilities, including 34 businesses, two federal government facilities, and one local government facility. Twenty-six of the 34 businesses have fewer than 100 employees and could be considered small businesses. Only three of the 37 impacted facilities are dedicated thermal spraying operations whose primary business is providing thermal spraying services. Twenty of the 37 facilities are job shops that provide machining and coating services to various industries. Ten are manufacturers whose products include aerospace components, gas turbines, printing equipment, electronics, and automotive parts. Four facilities conduct onsite maintenance and repair for their own military equipment, aircraft, and water treatment systems.

Twenty-four of the 37 affected facilities already have HEPA filters or other control devices that are expected to qualify as BACT under the proposed ATCM. For these 24 facilities, the requirements of the proposed ATCM will include: developing an emissions inventory; obtaining or modifying permits; improving ventilation system monitoring; and maintaining additional records.

Six of the remaining 13 facilities would be required to install control devices under the proposed ATCM. However, four of these facilities may choose to eliminate or reduce their thermal spraying operations rather than install additional controls. These 13 facilities would also be required to comply with requirements for emissions inventories, permitting, monitoring, and recordkeeping. Although we expect one public agency to be affected, it will only experience minor impacts from recordkeeping and monitoring since it is already permitted and equipped with a HEPA filter.

2. How would the proposed ATCM reduce risk to public health?

The proposed ATCM requires the use of air pollution control devices at thermal spraying facilities that will reduce hexavalent chromium emissions by nearly 80 percent overall (7 to 50 lbs/year), and reduce nickel emissions by 51 percent overall (54 to 377 lbs/year). Emissions from currently uncontrolled facilities would be reduced by over 99 percent. The facility with the greatest emissions would be required to install a HEPA system achieving over 99.9 percent control efficiency. As a result, the potential cancer risk to the nearest sensitive receptor from these facilities would be reduced from current levels to less than three potential cancer cases per million. In addition, neither the acute hazard quotient from exposure to nickel nor the chronic hazard index from exposure to hexavalent chromium and nickel would exceed one.

Another benefit of the proposed ATCM would be reduced worker exposure. The proposed ATCM would require the use of enclosures and ventilation systems that will pull contaminated air away from the worker and transport it to a control device. As a result, worker exposure to hexavalent chromium and nickel emissions from thermal spraying would be greatly reduced.

3. What is the total cost of the proposed ATCM?

ARB staff estimates the total cost of the proposed ATCM to affected businesses to range from $672,000 to $1,195,000 in initial capital and permitting costs, and $55,000 to $94,000 in annual recurring costs. The total annualized cost of the proposed ATCM ranges from $150,000 to $257,000. The annual cost for facilities that would not be required to install additional controls ranges from $600 to $850 per facility. The annual cost for facilities that would be required to install additional controls ranges from about $5,000 to $55,000 per facility. The annualized costs are based on the conservative assumption that air pollution control devices will have a 10 year useful life and blowers will have a five year useful life. If the equipment has a longer useful life, the annual costs will decrease.

These cost estimates are based on discussions with thermal spraying facilities, local air districts, filter manufacturers, and hazardous waste disposal companies.

4. What are the expected economic impacts of the proposed ATCM on businesses?

Most of the affected businesses will be able to absorb the costs of the proposed ATCM with no significant adverse impacts on their profitability. This finding is based on the staff's analysis of the estimated change in "return on owner's equity" (ROE). Generally, a decline of more than ten percent in ROE suggests a significant adverse impact on profitability. For 31 of the 37 affected businesses, the decline in ROE is 0.1 to 4.6 percent. For the six businesses that may need additional controls, the expected decline in ROE is 16 to 68 percent. One facility could have a higher decline in ROE, depending on the number of control systems they choose to install. However, the higher decline in ROE would result from a business decision to add more control systems than necessary to comply with the ATCM (see Chapter VII for additional discussion). Four of these six businesses may choose to eliminate or reduce their thermal spraying operations rather than installing control devices. However, such a decision would have only a small impact on these entities because thermal spraying provides less than five percent of their gross annual revenue and their employees spend less than one hour per day conducting thermal spraying.

We expect the two remaining businesses to install new control devices. One of these businesses which does small amounts of thermal spraying, indicated it would pass the cost of controls on to its customers to minimize the cost impacts.

However, the overall cost impact to its customers is not expected to be significant. The other business is a large dedicated thermal spraying facility. This facility has a gross annual revenue of nearly $10 million and the annual cost of compliance would amount to approximately 0.6 to 1.7 percent of their gross annual revenue, depending on the number of booths they choose to upgrade. Overall, we do not expect a significant increase in cost for products that require thermal spraying because most businesses will be able to absorb the cost of the proposed ATCM.

We do not expect the proposed ATCM to have a significant impact on employment; business creation, elimination or expansion; and business competitiveness in California. ARB staff also expects no significant adverse fiscal impacts on any local or State agencies. For the one public agency impacted by the proposed ATCM, we estimate the costs to be approximately $600 per year.

We do not expect manufacturers of thermal spraying materials to incur any costs, because the proposed ATCM does not regulate material formulations. However, it is possible that some thermal spraying facilities will choose to discontinue their use of materials that contain chromium and nickel, rather than install control devices. It is not expected that this potential decline in material usage will have a significant economic impact, because our research indicates that only facilities with very low usage levels are considering the elimination of chromium and nickel-based materials.

5. What are the expected environmental benefits of the proposed ATCM?

The proposed ATCM would reduce hexavalent chromium emissions by nearly 80 percent overall (7 to 50 lbs/yr), and would reduce nickel emissions by 51 percent overall (54 to 377 lbs/yr) from thermal spraying operations in California. These reductions will occur in six air districts, with the greatest benefits occurring in the SCAQMD and BAAQMD.

Some thermal spraying facilities generate hazardous waste in the form of metal sludge from water curtain booths. The proposed ATCM is expected to result in a small decrease in the quantity of metal sludge disposed as hazardous waste, as some water curtain booths are upgraded to more efficient dry filter systems.

The proposed ATCM's requirements for locating and controlling new thermal spraying facilities would also help to address environmental justice concerns about exposing the public to sources of hexavalent chromium emissions.

6. Are there any potential negative environmental impacts?

No significant adverse environmental impacts are expected to occur as a result of adopting the proposed ATCM. Some thermal spraying facilities generate hazardous waste in the form of contaminated filter media. Although, the proposed ATCM is expected to cause an increase in the disposal of filters as hazardous waste, the increase is not expected to be significant.

7. How are the AB 2588 "Hot Spots" requirements and the ATCM interrelated?

ARB staff is currently developing amendments to the Air Toxics “Hot Spots” Emission Inventory and Criteria Guidelines Regulation to address thermal spraying operations. These amendments would align with the proposed ATCM requirements to avoid duplicative requirements and ensure that potential risks are evaluated and mitigated where necessary. The amendments to the Air Toxics “Hot Spots” Emission Inventory and Criteria Guidelines Regulation are expected to be considered by the Board in 2005.

VI. NEXT STEPS

If the proposed ATCM is adopted, the local air districts must implement and enforce the ATCM. However, if an air district wishes to adopt an alternative regulation, it has 120 days to propose and six months to adopt a regulation that is at least as stringent as the proposed ATCM. Thermal spraying facilities would need to be in compliance by January 1, 2006.

VII. RECOMMENDATION

We recommend that the Board adopt the proposed ATCM contained in Appendix A. The proposed ATCM would require the use of BACT for thermal spraying facilities that use materials containing chromium or nickel. The proposed ATCM would also require facility owners or operators to conduct regular monitoring and inspections to ensure that control devices are operating properly. Benefits from the proposed ATCM include a reduction in public exposure and health risk, due to reduced emissions of hexavalent chromium and nickel from thermal spraying operations. In addition, the proposed ATCM would result in reduced workplace exposure.

I. INTRODUCTION

I.A. OVERVIEW

Thermal spraying (or metal spraying) is a process in which materials are heated to a molten or nearly molten condition and are sprayed onto a surface to form a coating. Materials can be heated by combustion of fuel gases (similar to welding) or by using electricity. Thermal spraying includes processes such as flame spraying, plasma spraying, high velocity oxyfuel (HVOF) spraying, and twin wire electric arc spraying. Thermal spraying can be used in a wide variety of industries for numerous applications. In addition, thermal spraying can be a replacement for some hard chromium electroplating processes. There are potential serious health risks associated with thermal spraying, as there are with hard chromium electroplating. As a result, the Air Resources Board (ARB or Board) directed staff to investigate the health risks associated with thermal spraying activities.

The ARB staff identified thermal spraying as a source of emissions of hexavalent chromium and nickel. Both of these compounds are classified as toxic air contaminants (TACs). Hexavalent chromium is a very potent carcinogen, relative to other carcinogens. For example, the cancer potency factor for hexavalent chromium is second only to dioxins in terms of carcinogenic potency and is 24,000 times more potent than perchloroethylene. Although nickel is a much less potent carcinogen than hexavalent chromium, short-term exposure to relatively low concentrations of nickel can result in acute health impacts. To reduce the potential health risks associated with these TACs, ARB staff has developed a proposed airborne toxic control measure (ATCM). This Initial Statement of Reasons (ISOR) describes the ATCM development process and provides information on the following items:

- Regulatory authority;
- Identification of TACs;
- Control of TACs;
- Physical characteristics of TACs;
- Description of thermal spraying operations;
- Manufacturer and facility survey data;
- Air emissions from thermal spraying operations;
- Ambient concentration, exposure and health risk assessment; and
- Proposed ATCM and its health, economic, and environmental impacts.

I.B. REGULATORY AUTHORITY

The ARB's statewide air toxics program was established in the early 1980's. Assembly Bill (AB) 1807 (Tanner, Chapter 1047, statutes of 1983), *The Toxic Air Contaminant Identification and Control Act,* created California's Toxic Air Contaminant Identification and Control Program (Air Toxics Program) to reduce the public's exposure to air toxics. This law is codified in Health and Safety Code (HSC) sections 39650 through 39675.

AB 2588 (Connelly, Chapter 1252, statutes of 1987), *Air Toxics "Hot Spots" Information and Assessment Act,* supplements the Air Toxics Program by requiring a statewide air toxics inventory, notification of people exposed to a significant health risk, and facility plans to reduce these risks.

I.C. TOXIC AIR CONTAMINANT IDENTIFICATION

The identification phase of the Air Toxics Program requires that the ARB, with the participation of other State agencies, evaluate the health impacts of, and exposure to, substances and to identify as TACs those substances which pose the greatest health threat. The ARB's evaluation is made available to the public and is formally reviewed by the Scientific Review Panel (SRP) established under HSC section 39670. Following ARB's evaluation and SRP review, the Board identified hexavalent chromium as a TAC at its January 1986 Board hearing. The Board, at its August 1991 Board hearing, identified nickel as a TAC. Both compounds were determined to be human carcinogens without an identifiable threshold exposure level below which no significant adverse health effects are anticipated. Nickel was also deemed to have acute health impacts.

I.D. CONTROL OF TOXIC AIR CONTAMINANTS

1. Airborne Toxic Control Measures

Once a compound has been identified as a TAC, the Board is required to prepare a report on the need and appropriate degree of regulation for the compound, and adopt regulations to reduce emissions of the compound, per HSC section 39665. These regulations are called Airborne Toxic Control Measures (or ATCMs.) In this document, we use the terms ATCM, regulation, and control measure interchangeably. Since hexavalent chromium and nickel don't have Board-specified threshold exposure levels, California law requires this ATCM to be based on best available control technology (BACT) or a more effective control method where cost and risk are taken into consideration.

The Board has adopted three ATCMs to reduce emissions of hexavalent chromium:

- 1988 - *Hexavalent Chromium Airborne Toxic Control Measure for Chrome Plating and Chromic Acid Anodizing Operations (*ARB, 1998a);
- 1989 - *Airborne Toxic Control Measure for Hexavalent Chromium For Cooling Towers* (ARB, 1989); and
- 2001 - *Airborne Toxic Control Measure for Emissions of Hexavalent Chromium and Cadmium From Motor Vehicle and Mobile Equipment Coatings*.

***** The Chrome Plating and Chromic Acid Anodizing ATCM is currently being updated and is scheduled for Board consideration in 2005.

None of the existing hexavalent chromium ATCMs address emissions from thermal spraying operations. Therefore, ARB has developed the proposed *Airborne Toxic Control Measure for Emissions of Hexavalent Chromium and Nickel Compounds from Thermal Spraying*. The determination to control these emissions is based on the potential risk to human health from the use of thermal spraying materials containing chromium and/or nickel. Thus, this ATCM focuses on a relatively small segment of the materials that are used in the thermal spraying industry. The proposed ATCM was developed in cooperation with the local air districts, the affected industry, and other interested stakeholders.

2. Hexavalent Chromium Control Plan

In February 1988, the Board approved a hexavalent chromium control plan (control plan) (ARB, 1988). The purpose of this control plan was to set forth the overall course of action for controlling sources of hexavalent chromium. While the control plan listed chromium-electroplating facilities as sources to control, it did not specifically consider the control of hexavalent chromium from thermal spraying. However, facilities have begun to use thermal spraying as an alternative for hard chromium electroplating processes.

3. AB 2588 "Hot Spots" Program

The AB 2588 Air Toxics "Hot Spots" Information and Assessment Act was enacted in September 1987. Under the AB 2588 program, stationary sources are required to report the types and quantities of certain substances that their facilities routinely release into the air. The goals of this program are to collect emission data, identify facilities having localized impacts, ascertain health risks, notify nearby residents of significant risks, and reduce risks to public health. Some local air districts have found that thermal spraying facilities pose a community health risk due to hexavalent chromium emissions. These facilities are being addressed through the AB 2588 “Hot Spots” Program. The ARB staff plans to amend the "Hot Spots" regulation to include thermal spraying as a listed category. This would require all thermal spraying facilities to prepare and submit emissions inventories to their local air districts.

4. California Air District Rules

There are currently no local air district rules that specifically regulate thermal spraying operations. Some districts have permitted these operations and these permits have required control devices. Other districts have not required permits for thermal spraying operations, because the quantities of pollutants emitted fall below their general permitting thresholds.

Some districts have special permitting rules for facilities that emit toxic pollutants. These rules establish the health risk levels that trigger the need for installation of Best Available Control Technology for Toxics (T-BACT). The South Coast Air

Quality Management District has Rule 1401 (New Source Review of Toxic Air Contaminants) and Rule 1402 (Control of Toxic Air Contaminants from Existing Sources) to control toxic emissions. Rule 1401 applies to air permits for new, relocated, or modified sources that emit TACs. If the increase in cancer risk from a modification does not exceed one in a million, T-BACT controls are not required to obtain an air permit. If the increase in cancer risk is between 1 and 10 in a million, T-BACT controls are required to obtain an air permit. In addition, the cancer burden must not exceed 0.5 cases. Under Rule 1402, the action risk level is 25 in a million for cancer risk, a cancer burden of 0.5, or a total acute or chronic hazard index of 3.0 for any target organ system at any receptor location. Acute or chronic hazard index is the ratio of the estimated level of exposure over a specified period of time to its acute or chronic reference exposure level. Existing facilities that exceed the action risk level must develop risk reduction plans and implement measures to reduce risks to below the action level.

The San Diego County Air Pollution Control District (SDAPCD) has Rule 1200 (Toxic Air Contaminants – New Source Review) and Rule 1210 (Toxic Air Contaminant Public Health Risks – Public Notification and Risk Reduction) to control toxic emissions. If the increase in cancer risk does not exceed one in a million, T-BACT controls are not required to obtain an air permit. If the increase in cancer risk is between 1 and 10 in a million, T-BACT controls are generally required to obtain an air permit. If the increased cancer risk is greater than 10 and up to 100 in a million, it may still be possible to get an air permit if a facility can meet specific conditions.

The Bay Area Air Quality Management District (BAAQMD) does not have a specific rule for toxics permitting. However, BAAQMD's permitting policy is generally consistent with the SCAQMD and SDAPCD toxics new source review rules. All permit applications for new or modified sources are screened for emissions of TACs and sources that may present significant health risks are required to install T-BACT to minimize TAC emissions.

5. National Emission Standards for Hazardous Air Pollutants

In the federal Clean Air Act Amendments of 1990, the United States Environmental Protection Agency (U.S. EPA) identified chromium compounds and nickel compounds as Hazardous Air Pollutants (HAPs). Both compounds were known to have, or may cause adverse effects on human health and/or the environment. In 1992, AB 2728 (Tanner, Chapter 1161, statutes of 1992) specified that ARB must, by regulation, identify as TACs, the 189 substances identified by the federal government as HAPs.

For certain designated source categories, U.S. EPA has developed specific regulations called National Emission Standards for Hazardous Air Pollutants (NESHAPs). Thermal spraying is not one of the designated categories; therefore, no NESHAP regulation exists for this source category. However, the

U.S. EPA has identified metal spraying as a process that could potentially be regulated in the future under their Urban Air Toxics program (EPA, 2002.)

I.E. PUBLIC OUTREACH

1. Outreach Efforts

The ARB staff has made extensive efforts to ensure public participation throughout the two-year ATCM development process. ARB's public outreach program involved interaction with:

- thermal spraying materials manufacturers and their associations;
- thermal spraying facility operators and their associations;
- California's air pollution control and air quality management districts;
- air pollution control agencies in other states;
- environmental/pollution prevention and public health advocates; and
- other interested parties.

These entities participated in the development and review of two surveys conducted by ARB staff: the 2003 Thermal Spraying Materials Survey (materials survey) and the 2004 Thermal Spraying Facilities Survey (facility survey). The ARB staff also coordinated conference calls, working group meetings, and three public workshops. Through these efforts, ARB staff obtained information on the use and emissions of hexavalent chromium, nickel, and other chemicals of concern in thermal spraying materials. All parties were given opportunities to express their concerns, both in public and in private meetings. As part of ARB's outreach program, staff made extensive personal contacts with industry and facility representatives, as well as other affected parties through meetings, telephone calls, and mail-outs.

<u>Outreach Activities Included</u>:

- Forming an ARB/District Working Group and conducting three conference calls with group members;
- Forming an ARB/Industry Working Group and conducting four conference calls with group members;
- Creating an ARB Thermal Spraying website and maintaining a List-Server to automatically update interested parties about ATCM developments;
- Providing copies of draft surveys to working group members to obtain their input and recommendations;
- Conducting a survey by mail and e-mail for 42 thermal spraying material manufacturers in the United States and Canada;

- Conducting a survey by phone, FAX, and e-mail for facilities in California identified as potentially conducting thermal spraying operations;
- Making a presentation at the International Thermal Spray Association's regional meeting on April 2, 2004, in San Diego.
- Mailing workshop notices and posting workshop materials on ARB's website;
- Conducting three public workshops which allowed for participation by phone;
- Conducting site visits to three thermal spraying operations to better understand the thermal spraying processes and facility layouts; and
- Preparing fact sheets regarding the development of the ATCM and making them available to industry associations, potentially affected facilities, and the public.

2. Public Involvement

As described below, affected industries, other government agencies, and organizations have been actively involved in the ATCM development process. In addition to conducting three public workshops, ARB has implemented other measures to increase the general public's awareness of and participation in this process.

The ARB staff have made ATCM information available via the ARB website at: (http://www.arb.ca.gov/coatings/thermal/thermal.htm**)** and have established a thermal spraying list server to automatically inform subscribers of modifications to any of the thermal spraying web pages.

Thermal spraying materials manufacturers and industry representatives have actively participated in the development of this ATCM. The industry has provided technical information, has commented on the materials survey, the facility survey, and the proposed regulatory language. Industry involvement included:

- numerous telephone conversations with staff;
- completion of the materials survey;
- completion of the facility survey; and
- participation in conference calls and workshops.

Local air districts have been actively involved in the ATCM development process. In addition to the ARB/District Working Group, the ARB staff has coordinated with the California Air Pollution Control Officers Association (CAPCOA) Toxics Subcommittee. Districts provided data on the thermal spraying facilities in their areas and information on their permitting requirements for the thermal spraying industry.

Also, staff obtained information on regulatory requirements in other states, contacting air pollution control agencies to obtain information on permitting and emission calculations for thermal spraying operations.

3. Data Collection Tools Used To Assist in Report Preparation

Efforts to obtain data for this ATCM included conducting surveys of air districts, thermal spraying material manufacturers, and thermal spraying facilities.

District Survey

On November 20, 2002, ARB staff solicited the input and participation of each air district via a written request to all Air Pollution Control Officers. To assist in ATCM development, ARB staff requested information regarding thermal spraying facilities, material usage, emissions data, and risk assessment information.

Manufacturer Survey

In May 2003, ARB staff mailed the materials survey to thermal spraying manufacturers throughout the United States and Canada. The materials survey included thermal spraying materials containing hexavalent chromium, nickel, and other chemicals of concern. The materials survey requested data on sales, chemical composition, type of thermal spraying process, customer industry identification, and customer location. The materials survey was distributed to 42 companies and the response rate was 90 percent (%).

Facility Survey

In January 2004, the ARB staff telephoned, mailed and FAXed a survey to facilities throughout California identified as using a thermal spraying process. The facilities were identified through information provided by the local air districts, industry organizations, internet searches, and telephone directories. The data collected included information on thermal spraying processes, pollution control devices, material usage, and operating parameters.

REFERENCES

ARB, 1988. Air Resources Board. "Proposed Hexavalent Chromium Control Plan". 1988.

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ARB, 1989. Air Resources Board. "Proposed Hexavalent Chromium Control Measure For Cooling Towers". 1989.

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EPA, 2002. Environmental Protection Agency. "Description of New Source Categories that are Listed for Future Regulatory Development", EPA memorandum from Barbara Driscoll to Urban Strategy Docket, November 18, 2002.

II. PHYSICAL CHARACTERISTICS, SOURCES AND AMBIENT CONCENTRATIONS OF HEXAVALENT CHROMIUM AND NICKEL COMPOUNDS

This chapter summarizes general information on the physical properties, sources, emissions, ambient and indoor concentrations and atmospheric persistence of hexavalent chromium and nickel. The information is derived from the Toxic Air Contaminant Identification List Summaries, unless otherwise noted (ARB, 1997). This chapter also includes information from the following documents:

- Staff Report: Initial Statement of Reasons for Proposed Rulemaking – Identification of Hexavalent Chromium as a Toxic Air Contaminant (ARB,1985);
- Proposed Hexavalent Chromium Control Measure for Cooling Towers (ARB, 1989);
- Staff Report: Initial Statement of Reasons for Proposed Rulemaking – Identification of Nickel as a Toxic Air Contaminant (ARB, 1991);
- Proposed Airborne Toxic Control Measure for Emission of Toxic Metals From Non-Ferrous Metal Melting (ARB, 1992); and
- Airborne Toxic Control Measure for Emissions of Hexavalent Chromium and Cadmium from Motor Vehicle and Mobile Equipment Coatings: Initial Statement of Reasons for Proposed Rulemaking Executive Summary/Staff Report (ARB, 2001).

II.A. HEXAVALENT CHROMIUM AND HEXAVALENT CHROMIUM COMPOUNDS

1. Physical Properties

Chromium is an odorless, steel-gray, hard metal that is lustrous and takes a high polish. It is extremely resistant to corrosive agents. Chromium can exist in water in several different states, but under strongly oxidizing conditions may be converted to the hexavalent state and occur as chromate anions. Chromium is soluble in dilute hydrochloric acid and sulfuric acid, but is not soluble in nitric acid or strong alkalis or alkali carbonates. Table II-1 contains information on the physical properties of chromium.

Chromium metal is not found in nature, but is produced principally from the mineral chromite (chrome ore). Chromite contains chromium in the +3 oxidation state, or chromium (III). Chromium combines with various other elements to produce compounds, the most common of which contain either trivalent chromium (Cr^{+3}, the +3 oxidation state), or hexavalent chromium (Cr^{+6}, the +6 oxidation state). Trivalent chromium compounds are sparingly soluble in water, while most hexavalent chromium compounds are readily soluble in water. Chromium forms a number of compounds in other oxidation states; however, those of +2 (chromous), +3 (chromic) and +6 (chromates) are the most important.

Table II-1: Physical Properties of Hexavalent Chromium	
Synonyms:	Chrome VI, Cr^{+6}
Atomic Weight:	51.966
Atomic Number:	24
Valences:	1 – 6
Boiling Point:	2642 °C
Melting Point:	1900 °C
Vapor Pressure:	1 mm Hg at 1616 °C
Specific Gravity:	7.14

(ARB, 1997)

2. Sources

Thermal spraying is a source of hexavalent chromium emissions. Thermal spraying involves spraying molten or nearly molten materials to form a coating. Thermal spraying materials rarely contain hexavalent chromium as an ingredient. However, hexavalent chromium can be present as a contaminant or it can be created during the thermal spraying process. Based on ARB's 2003 Thermal Spraying Materials Survey (ARB, 2004), the most common use of chromium in thermal spraying is as part of a metal alloy (Cr, CAS# 7440-47-3). Other forms of chromium used in thermal spraying materials are chromium carbide (Cr_3C_2, CAS# 12012-35-0), chromium oxide (Cr_2O_3, CAS# 1308-38-9); and trivalent chromium (Cr^{+3}, CAS# 16065-83-1).

Chromium electroplating is another source of hexavalent chromium emissions. In the chromium electroplating process, an electrical charge is applied to a plating bath containing an electrolytic salt (chromium anhydride) solution. The electrical charge causes the chromium metal in the bath to fall out of solution and deposit onto various objects placed into the plating bath. The desired thickness of the metal layering determines the type of chromium electroplating process. Decorative chromium plating is the application of thin layers of chromium to a surface (e.g., faucets and automotive wheels). Hard chromium plating applies a substantially thicker layer on surfaces that require greater protection against corrosion and wear (e.g., engine parts and industrial machinery). Hexavalent chromium emissions appear as a mist from the plating bath during the electroplating process.

Hexavalent chromium is a permanent and stable inorganic pigment used in paints, rubber, and plastic products. The most commonly used form of hexavalent chromium pigment is lead chromate. The spraying of chromated paints is a source of hexavalent chromium emissions. Hexavalent chromium emissions can also occur from firebrick lining of glass furnaces. Other stationary sources of hexavalent chromium emissions are electrical services, aircraft and parts manufacturing, and steam and air conditioning supply services.

3. Emissions

Statewide hexavalent chromium emissions from stationary sources in 2002 are estimated to be about 1,085 pounds, based on data supplied under the Air Toxics “Hot Spots” Program. Statewide hexavalent chromium emissions from thermal spraying operations in 2002 are estimated to range from nine to 66 pounds. The nine pounds per year estimate represents actual emissions based on facility reports of material usage. The 66 pounds per year estimate is a maximum potential emissions quantity based on materials sales reported to ARB by thermal spraying material manufacturers.

4. Natural Occurrence

Chromium is a naturally occurring element found in rocks, animals, plants, soil, and in volcanic dust and gases (ARB, 1997). Trivalent chromium is a component of most soils. In areas of serpentine and peridotite rocks, chromite is the predominant chromium mineral. Deposits of five to ten percent chromite have been found in beach sands and streams in several California counties. Also, chromium has been found in non-serpentine areas of California at concentrations as high as 500 parts per million (ARB, 1997).

Chromium in soil is generally in an insoluble, biologically unavailable form, mainly as the weathered form of the parent chromite or as the chromium (III) oxide hydrate. Weathering and wind action can transport chromium from the soil to the atmosphere. Generally, such mechanical weathering processes generate particles greater than ten micrometers in diameter, which have significant settling velocities. The extent to which natural sources of chromium contribute to measured ambient chromium levels in California is not known. Ambient chromium derived from soil is expected to exist as trivalent chromium (ARB, 1997).

5. Ambient Concentrations

Chromium compounds and hexavalent chromium are routinely monitored by the statewide ARB air toxics network. The monitoring results indicate that hexavalent chromium concentrations have declined in recent years. The statewide mean concentration of hexavalent chromium has decreased from 0.27 nanograms per cubic meter (ng/m^3) in 1992 to 0.101 ng/m^3 in 2002. For hexavalent chromium ambient monitoring, the limit of detection has also decreased from 0.2 ng/m^3 in 1992 to 0.06 ng/m^3 in 2003. Therefore, the mean concentrations for 2003 are based on more precise measurements of ambient concentrations. Monitoring results below the limit of detection are assumed to be one-half the limit of detection or 0.1 ng/m^3 prior to 2003 and 0.03 ng/m^3 since 2003.

Table II-2 shows the hexavalent chromium mean concentration at various monitoring sites in local districts with thermal spraying facilities (ARB, 2004a).

Table II-2: Hexavalent Chromium Mean Concentration in Local Air Districts with Thermal Spraying Facilities

District	ARB's Air Toxics Network Monitoring Site	Year	Mean Concentration (ng/m^3)
Bay Area Air Quality Management District	Fremont-40733 Chapel Way	2003	0.045
	San Francisco-10 Arkansas St.	2003	0.145
	San Jose-156B Jackson St.	2003	0.098
	San Jose-120B North 4th St.	2000	0.13
	Concord-2975 Treat Blvd.	1999	0.10
	San Pablo-759 El Portal	1999	0.10
	Richmond-1144 13th St.	1996	0.13
San Diego County Air Pollution Control District	Calexico-1029 Ethel St.	2003	0.088
	Chula Vista-80 E. J St.	2003	0.063
	El Cajon-Redwood Ave.	2003	0.038
San Joaquin Valley Air Pollution Control District	Bakersfield-5558 California Ave.	2003	0.053
	Stockton-1601 E. Hazelton St.	2003	0.13
	Fresno-3425 N. 1St St.	2003	0.05
	Modesto-814 14th St.	1999	0.10
	Modesto-1100 I St.	1997	0.11
	Bakersfield-225 Chester Ave.	1993	0.21
South Coast Air Quality Management District	Azusa-803 Loren Ave.	2003	0.09
	Los Angeles-1630 N. Main St.	2003	0.07
	Riverside-5888 Mission Blvd.	2003	0.348
	Burbank-228 W. Palm Ave.	2002	0.123
	N. Long Beach-3648 North Long Beach Blvd.	2002	0.078
Ventura County Air Pollution Control District	Simi Valley-5400 Cochran St.	2003	0.06

Data on ambient concentrations of hexavalent chromium indicate that hexavalent chromium comprises 3 to 8 percent of total ambient chromium concentrations. Chromium in ambient air has been reported to contain principally respirable particulates, with a mass median diameter of about 1.5 to 1.9 micrometers (ARB, 1997).

6. Indoor Sources and Concentrations

The extent of exposure to airborne chromium in the indoor environment, other than in the workplace, is not known. There are no direct consumer uses of chromium that could lead to indoor emissions of chromium compounds. Although cigarettes are known to contain chromium, the intake of chromium from smoking is not known (ARB, 1997).

In a field study conducted in Southern California, investigators collected particles (PM_{10}) inside 178 homes and analyzed the samples for selected elements, including chromium. Two consecutive 12-hour samples were collected inside and immediately outside of each home. Chromium was present in measurable amounts in less than 25 percent of the indoor or outdoor samples (ARB, 1997).

A study in Southern California measured chromium inside vehicles during the summer of 1987 and winter of 1988. An average chromium concentration of 12 ng/m^3 and a maximum concentration of 41 ng/m^3 were measured (ARB, 1997).

7. Atmospheric Persistence

Atmospheric reactions of chromium compounds were characterized in field reaction studies and laboratory chamber tests. These results demonstrated an average experimental half-life of 13 hours (ARB, 1997). Physical removal of chromium from the atmosphere occurs both by atmospheric fallout (dry deposition) and by washout and rainout (wet deposition). Measurements have shown that most chromium deposition occurs through wet deposition. Chromium particles of less than five micrometers (aerodynamic equivalent) diameter may remain airborne for extended periods of time, allowing long distance transport by wind currents. Consequently, meteorological conditions can play a significant role in the dispersion of chromium emitted from some sources (ARB, 1997).

II.B. NICKEL AND NICKEL COMPOUNDS

1. Physical Properties

Nickel is a silvery white metal that retains a high polish. Nickel is malleable, ductile, ferromagnetic, corrosion resistant and a good conductor of electricity and heat. Nickel compounds range from quite soluble in water to practically insoluble in water. The most common oxidation state of nickel is the divalent form (Ni^{2+}). Nickel acetate, bromide, chloride, iodide, nitrate and sulfate are soluble in water. Nickel oxides, hydroxides, sulfides, arsenide, chromate, carbonate, phosphate and selenide are insoluble in water. Properties for nickel compounds vary depending on the particular compound. See Table II-3 for information on the physical properties of nickel.

Table II-3: Physical Properties Of Nickel

Synonyms:	Raney Alloy, Raney Nickel
Atomic Weight:	58.69
Atomic Number:	28
Valences:	2 and 3
Boiling Point:	2730 ^{o}C
Melting Point:	1453 ^{o}C
Vapor Pressure:	1mm at 1,810 ^{o}C
Specific Gravity:	8.9

(ARB, 1997)

2. Sources

Thermal spraying is a source of nickel emissions. Thermal spraying involves spraying molten or nearly molten materials to form a coating. Many thermal spraying materials are nickel-based and may contain a combination of nickel with chromium, cobalt, and other toxic air contaminants. Some materials contain more than 90% nickel and a small percentage of another metal (e.g., aluminum.) Based on the ARB's 2003 Thermal Spraying Materials Survey (ARB, 2003), the most common use of nickel in thermal spraying is as part of a metal alloy (Ni, CAS# 7440-02-0).

Nickel is normally used in the manufacture of various metal alloys. Generally, nickel is alloyed with iron, copper, chromium, aluminum and zinc. Nickel and nickel compounds are used in electroplating, ceramics, welding, jewelry and coins. Nickel is also used for manufacturing corrosion-resistant alloys and the production of catalysts and batteries (ARB,1991.)

Nickel acetate is used as a hydrogenation catalyst. It is an intermediate in the formation of other nickel compounds, and is used as a sealant in aluminum manufacturing and in electroplating. Nickel carbonate is used as a purification intermediate in refining nickel; and as a catalyst in the petroleum, plastic and rubber industries (ARB, 1991.)

Fuel combustion (residential oil, distillate oil, coke and coal) accounts for the majority of statewide emissions of nickel. Particles that result from combustion are characteristically less than one micrometer (μm) in diameter, while large particles (greater than 10 μm) are likely to arise from dust and fugitive emissions. Nickel has also been discovered or identified in vehicle exhaust (ARB, 1997.)

3. Emissions

Statewide emissions of nickel and nickel compounds from stationary sources in 2002 are estimated to be at least 54 tons per year, based on data supplied under the Air Toxics “Hot Spots” Program.

The statewide emissions of nickel and nickel compounds from thermal spraying are estimated to range from 105 to 740 pounds in 2002. The 105 pounds per year estimate represents actual emissions based on facility reports of material usage. The 740 pounds per year estimate is a maximum potential emissions quantity based on raw materials sales reported to ARB by thermal spraying raw material manufacturers.

4. Natural Occurrence

Nickel is present in the earth’s crust at 0.018 percent and is found in ores (sulfides, arsenides, antimonides and oxide or silicates). The most prevalent forms are nickel sulfate and oxides. Primary sources are chalcopyrite, pyrrhotite, pentlandite, ganierite, nicolite, and millerite. Nickel and nickel compounds comprise 0.03 percent of the particulate matter in the atmosphere. Nickel powders are deposited as meteoritic dust from the stratosphere. Sources of natural emissions of airborne particles containing nickel are included in soil, sea spray, volcanoes, forest fires and vegetation. Wind erosion and volcanic activity contribute 40 to 50 percent of the atmospheric nickel from natural sources (ARB, 1991.)

5. Ambient Concentrations

ARB’s statewide air toxics network regularly monitors nickel and nickel compounds. Identified as a TAC in June 1991, ARB estimated that emissions of nickel and nickel compounds result in a population-weighted annual concentration of 7.30 ng/m^3 (ARB, 1991). The statewide mean concentration of nickel compounds has remained relatively stable at 4.1 ng/m^3 in 1992 to 4.5 ng/m^3 in 2002. For nickel monitoring, the limit of detection has decreased from 2 ng/m^3 in 1992 to 1 ng/m^3 in 2003. Therefore, the mean concentrations for 2003 are based on more precise measurements of ambient concentrations.

Table II-4 shows the mean concentration of nickel and nickel compounds at various monitoring sites in local districts with thermal spraying facilities (ARB, 2004b).

Table II-4: Nickel Mean Concentration in Local Air Districts with Thermal Spraying Facilities

District	ARB's Air Toxics Network Monitoring Site	Year	Mean Concentration (ng/m^3)
Bay Area Air Quality Management District	San Francisco-10 Arkansas St.	2002	4.2
	San Jose-120B North 4th St.	2001	4.6
	Fremont-40733 Chapel Way	2000	2.3
	Concord-2975 Treat Blvd.	1999	3.3
	San Pablo-759 El Portal	1999	2.2
	Richmond-1144 13th St.	1996	3.1
San Diego County Air Pollution Control District	Calexico-1029 Ethel St.	2003	3.5
	Chula Vista-80 E. J St.	2003	3.8
	El Cajon-Redwood Ave.	2002	3.2
San Joaquin Valley Air Pollution Control District	Bakersfield-5558 California Ave.	2003	3.3
	Stockton-1601 E. Hazelton St.	2002	6.1
	Fresno-3425 N. 1St St.	2002	2.2
	Modesto-814 14th St.	1999	2.3
	Modesto-1100 I St.	1997	2.4
	Bakersfield-225 Chester Ave.	1993	4.8
South Coast Air Quality Management District	Azusa-803 Loren Ave.	2002	12.5
	Burbank-228 W. Palm Ave.	2002	5.6
	Los Angeles-1630 N. Main St.	2002	6.4
	N. Long Beach- 3648 North Long Beach Blvd.	2001	7.4
	Riverside-5888 Mission Blvd.	2002	5.4
Ventura County Air Pollution Control District	Simi Valley-5400 Cochran St.	2002	2.6

6. Indoor Sources and Concentrations

Tobacco smoke is an indoor source of nickel. A single cigarette contains one to three micrograms (*µg)* of nickel and a portion of that nickel becomes airborne during smoking (ARB, 1991.) Other sources of indoor airborne nickel emissions include house dust and the use of consumer products containing nickel (ARB, 1997.)

In a field study in Southern California, investigators collected particles (PM_{10}) inside 178 homes and analyzed them for selected elements, including nickel. Two consecutive 12-hour samples were collected inside and immediately outside of each home. Nickel was present in measurable amounts in less than 10 percent of the indoor or outdoor samples (ARB, 1997).

7. Atmospheric Persistence

For nickel and nickel compounds, the atmospheric half-life and lifetime are estimated to be 3.5 to 10 days and 5 to 15 days, respectively. Nickel particulate is removed from the atmosphere by wet or dry deposition. The nickel associated with atmospheric pollutants is almost always detected in particulate matter. Nickel is continuously transferred between air, water and soil by natural, chemical and physical processes such as weathering, erosion, runoff, precipitation, and stream and river flow (ARB, 1991).

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III. SUMMARY OF THERMAL SPRAYING OPERATIONS

This chapter provides a general overview of thermal spraying operations and a brief description of the materials used in these operations.

III.A. OVERVIEW

Thermal spraying (or metallizing) is a process in which metals are deposited in a molten or nearly molten condition to form a coating. Typical coating thickness ranges from 25 to 11,000 micrometers and bond strengths can range from 5,000 – 45,000 pounds per square inch (psi) (Gansert, 2003). Coating materials can include pure metals, metal alloys, carbides, oxides, ceramics, and ceramic metals (cermets). The material is usually in the form of a powder or wire, but there are some applications where a ceramic rod is used. Powders are manufactured in a variety of mesh particle sizes, usually finer than 120 mesh (125 microns) (AWS, 1985).

Energy sources include use of an oxyacetylene flame and an electric arc. Once the material becomes molten, it is delivered to the surface with air or gas pressure. The coating is formed by building up layers of molten droplets that flatten and solidify, thereby forming a mechanical bond to the surface. During the deposition process, the part surface remains much cooler than the molten material, rarely exceeding 250°F -300°F. Therefore, thermal spraying can be a suitable coating technique for substrates that cannot tolerate high temperatures.

For more severe service, a thermally sprayed coating may be sealed with a thin conventional organic coating (paint) or silicone. In many cases, thermally sprayed surfaces are machined to provide the desired finish.

Thermal spraying began in Europe in the early 20th century and was introduced in the United States in the 1920s. During World War II, the use of thermal spraying increased significantly as a method for repairing parts in industrial equipment. The use of thermal spraying has steadily increased over the years and the thermal spraying market was estimated to be greater than two billion dollars in 2000 (ITSA, 2003).

Thermal spraying is conducted at a variety of facilities. Some businesses conduct thermal spraying as a service to other businesses, while others use thermal spraying at their own manufacturing and repair facilities (e.g., aerospace rework). Most of the businesses in California are machine shops or job shops that provide thermal spraying services to other businesses. Smaller businesses will generally use the relatively low-cost thermal spraying technologies (e.g., twin-wire electric arc spraying and flame spraying), while larger businesses may invest in more expensive technologies (e.g., High Velocity Oxygen Fuel (HVOF)) and robotically-controlled application methods.

III.B. THERMAL SPRAYING PROCESSES

Table III-1 summarizes the primary types of thermal spraying processes that are in use. Each of these processes is described in greater detail in the following sections.

Table III-1: Thermal Spraying Processes

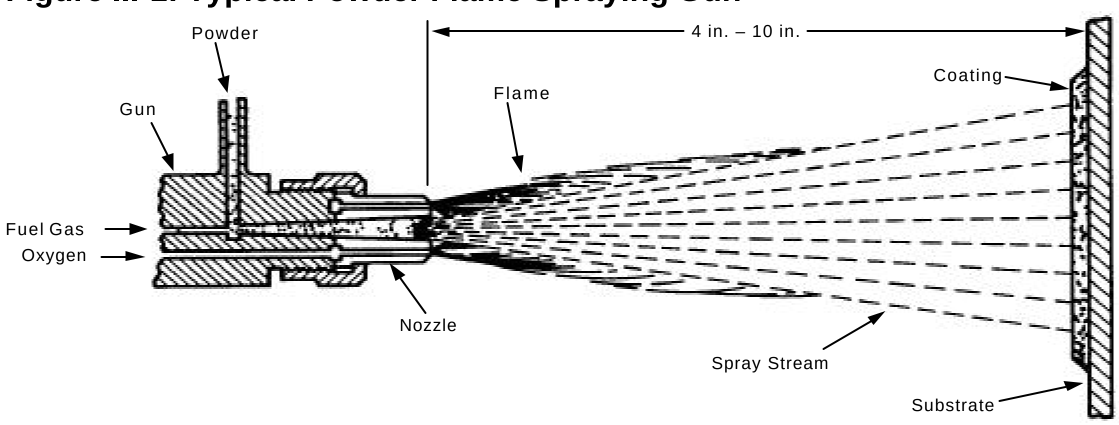
Process	**Material Form**	**Energy Source**
Flame Spraying	Powder, Wire, Rod	Oxyacetylene Flame
Twin-Wire Electric Arc Spraying	Wire	Electric Arc
Plasma Arc Spraying	Powder	Plasma Gun
HVOF	Powder	Oxygen, Hydrogen, & Fuel (e.g. methane)
Detonation Gun	Powder	Spark Ignition of Explosive Gas Gun

1. Flame Spraying

Flame spraying can be accomplished using materials in either a powder form or a wire/rod form. The flame can be produced using acetylene, propane, or another flammable gas. Flame-sprayed coatings may not be suitable for high-quality applications that require a very low level of oxides and porosity.

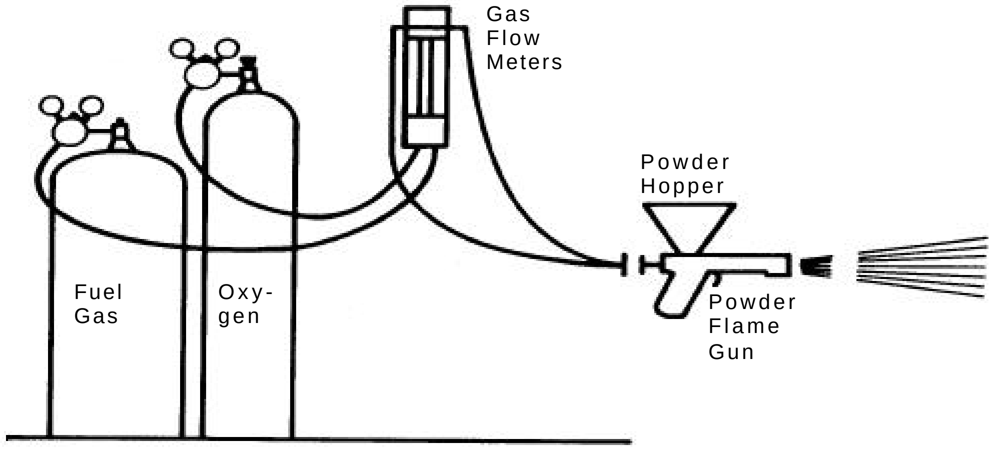
For powder flame spraying, the powder is stored in a hopper and is propelled through the gun by compressed gas (see Figures III-1 and III-2). The molten drops are propelled to the part surface by a high-velocity stream of air that surrounds the flame or via a diverted stream of the fuel gases. Powder flame spraying can achieve particle velocities of 130 ft/s (40 m/s) (Halldearn, 2001) and temperatures of 5,400°F (3,000°C) (Sulzer Metco, 2003). The deposition rate for powder flame spraying can reach up to 22 lbs/hr (10 kg/hr) of applied material (Halldearn, 2001). This is a relatively inexpensive process that is suitable for portable applications.

Figure III-1: Typical Powder Flame Spraying Gun



(AWS, 1985)

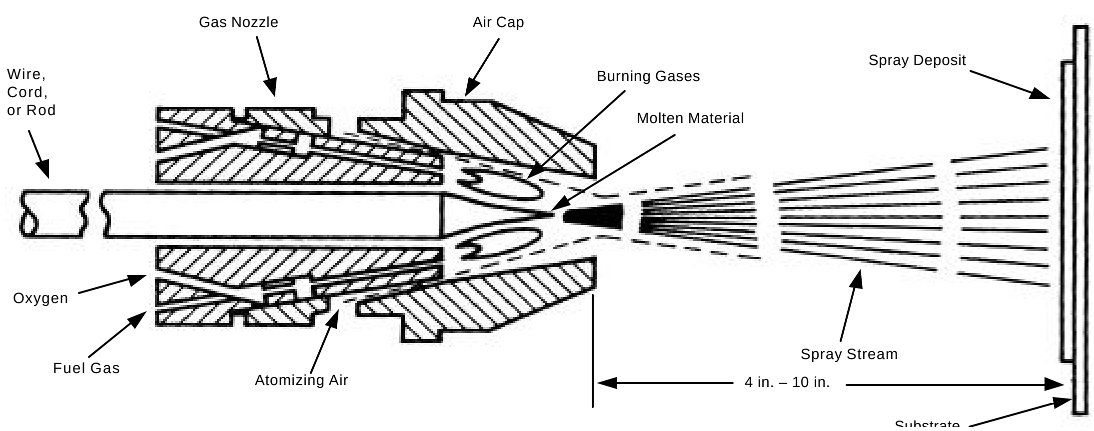
Figure III-2: Typical Powder Flame Spraying Equipment



(AWS, 1985)

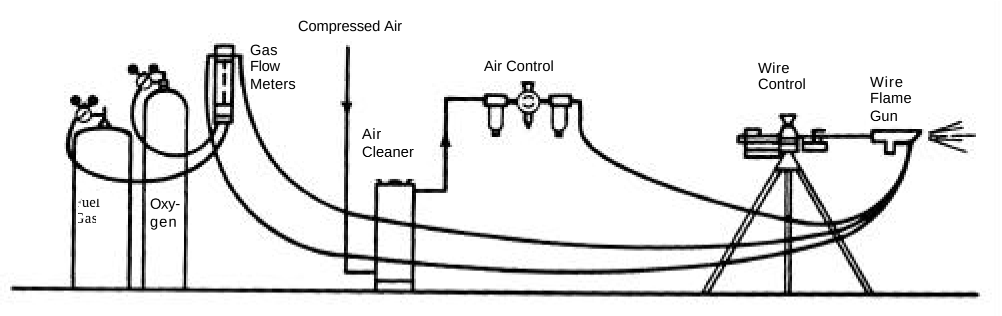
For wire flame spraying, a mechanized system feeds the wire through the gun into the oxygen-fuel flame where it is melted (see Figures III-3 and III-4). The molten drops are propelled to the part surface by a high-velocity stream of air that surrounds the flame. Particle spray velocities can be as high as 1,150 ft/sec (350 m/sec) (ATEM, 2001) and flame temperatures can reach 5,400°F (3000°C) (Sulzer Metco, 2003). The deposition rate for wire flame spraying can be as high as 130 lbs/hr (60 kg/hr) (Halldearn, 2001). This is a relatively inexpensive process that is suitable for portable applications.

Figure III-3: Typical Wire Flame Spraying Gun



(AWS, 1985)

Figure III-4: Typical Wire Flame Spraying Equipment

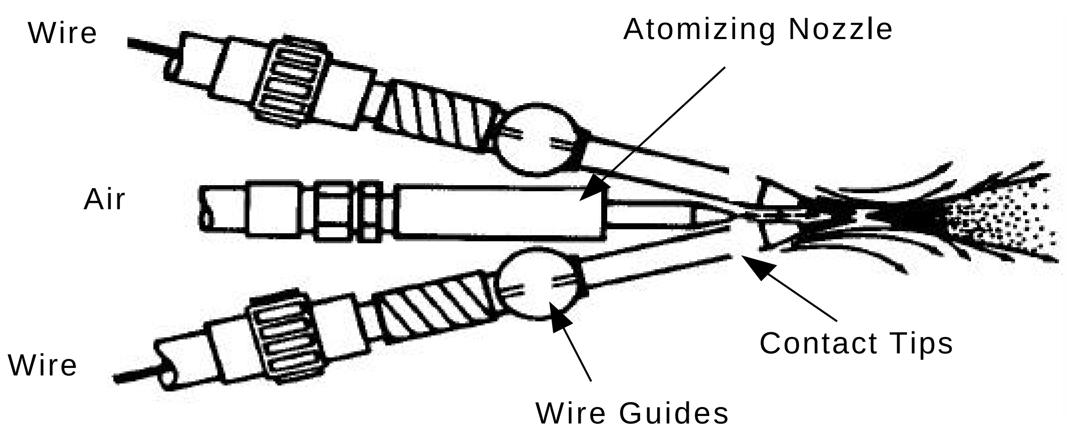


(AWS, 1985)

2. Twin-Wire Electric Arc Spraying

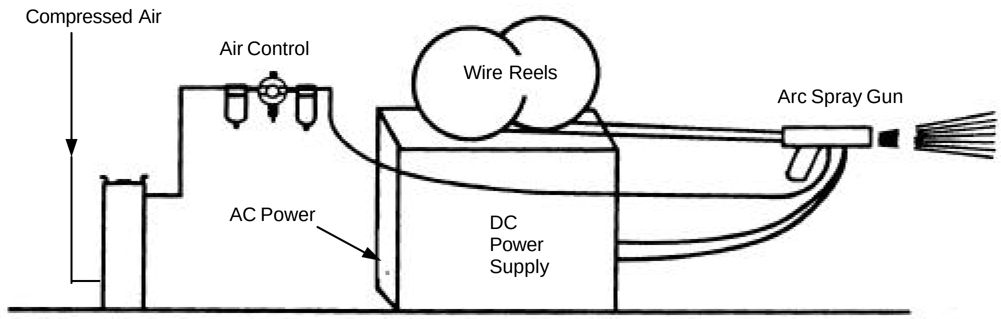
Two oppositely-charged wires are fed through a gun and brought together where they form an electric arc that melts the wires (see Figures III-5 and III-6). A high-velocity air stream (up to 100 m/s) propels the molten drops to the part surface where they form a dense coating that can be superior to flame-sprayed coatings (Halldearn, 2001). This process can generate temperatures up to 10,000°F (5,538°C) (Flame Spray, 2003). Electric arc equipment is considered to have the highest productivity rate among thermal spraying processes and it can deposit up to 132 lbs/hr (60 kg/hr) (Halldearn, 2001) with particle velocities as high as 250 m/sec (820 ft/sec) (Zowarka, 1998). This is a relatively inexpensive process and it doesn't require the use of a fuel gas. It is also suitable for portable applications.

Figure III-5: Typical Twin-Wire Electric Arc Spray Gun



(AWS, 1985)

Figure III-6: Typical Twin-Wire Electric Arc Spray Equipment

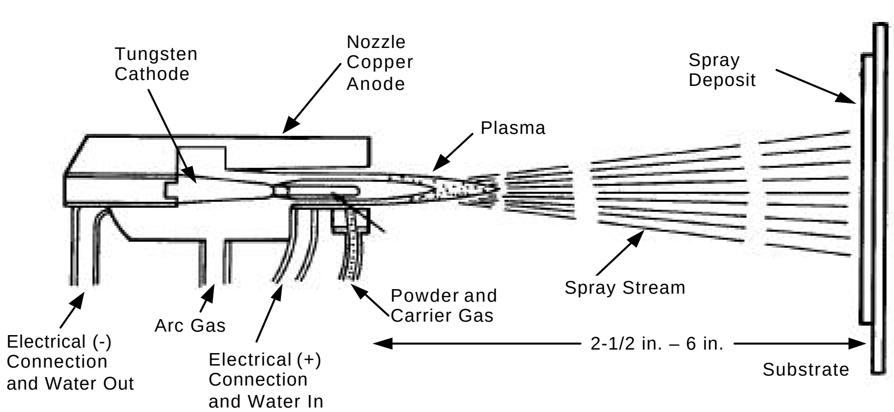


(AWS, 1985)

3. Plasma Arc Spraying

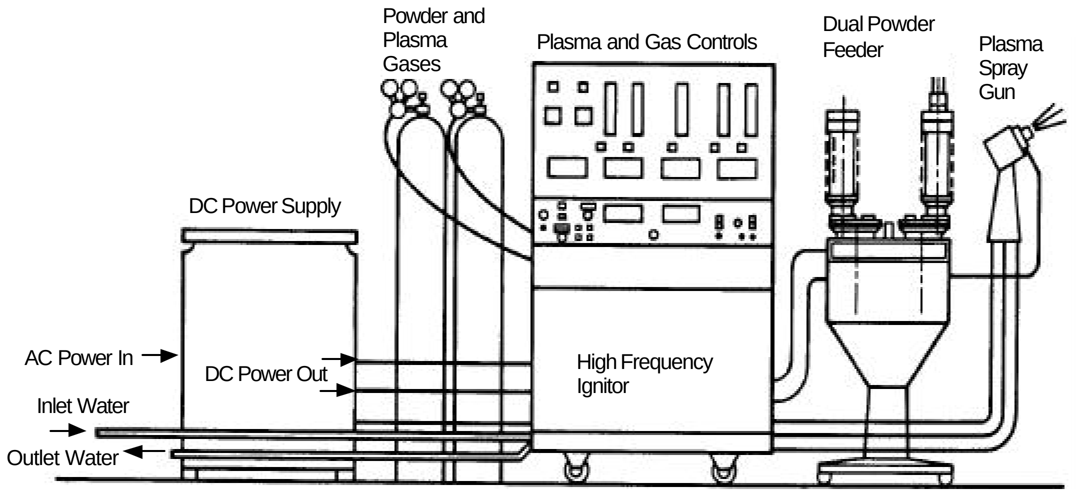
A plasma jet is generated by feeding a gas (e.g., hydrogen, nitrogen, argon, helium) through an electric arc which ionizes the gas (see Figures III-7 and III-8). The plasma process can generate particle velocities greater than 500 m/s, which forms a dense coating (AWS, 1985). Higher impact velocities result in higher bond strengths. Plasma spraying can generate the highest temperatures of all thermal spraying processes, reaching as high as 28,800°F (16,000°C) (Sulzer Metco, 2003). Therefore, plasma spraying can be used for ceramics and other materials that cannot be melted in other thermal spraying processes. The deposition rate for plasma spraying can reach 10 lbs/hr (5 kg/hr) (Halldearn, 2001). This is a relatively expensive process, as compared to flame spraying and twin-wire electric arc spraying.

Figure III-7: Typical Plasma Spray Gun



(AWS, 1985)

Figure III-8: Typical Plasma Flame Spraying Equipment



(AWS, 1985)

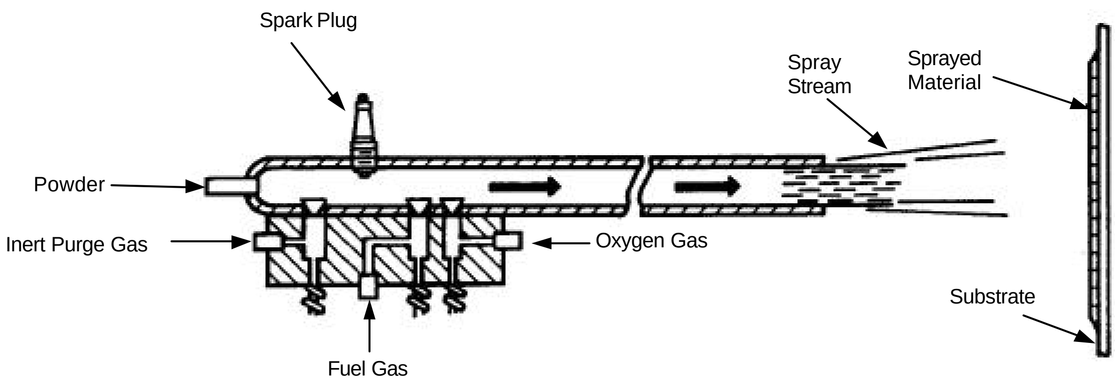
4. High Velocity Oxygen Fuel (HVOF)

HVOF uses a unique nozzle design and extremely high velocity gas to propel molten drops to a part surface. Gas temperatures are as high as 5,400°F (3,000°C) (Sulzer Metco, 2003). Particle velocities can reach 1000 m/s (Halldearn, 2001). The HVOF process can create extremely dense coatings that have high bond strengths and low stresses. The deposition rate for HVOF can be as high as 10 lbs/hr (5 kg/hr) (Halldearn, 2001). This is a relatively expensive process, as compared to flame spraying and twin-wire electric arc spraying.

5. Detonation Gun

The detonation gun has a long barrel, into which powder and fuel gas are injected. The fuel gas is ignited by a spark plug within the barrel and the resulting explosion melts the powder and propels the molten drops to the part surface (see Figure III-9). After each detonation, the barrel is purged with nitrogen gas. Repeated detonations build up a hard, dense coating surface. Detonation guns can achieve particle velocities of 2,500 ft/s (760 m/s) and temperatures of 6,000°F (3,315°C) (AWS, 1985).

Figure III-9: Typical Detonation Gun



(AWS, 1985)

6. Other Related Processes

Plasma Transferred Arc (PTA) surfacing is a welding process in which the powder is introduced into a combined arc/plasma stream to form a molten pool on the work-piece. The arc between work-piece and gun also results from surface melting of the base material, and a dilution of 5–15% in the deposit is typical. Coating thickness ranges from 1–6 mm, and deposit rate is up to 12 kg/h. Some thermal spraying materials can be used for both PTA and flame spraying processes.

III.C. THERMAL SPRAYING APPLICATIONS

Thermal spraying has a wide variety of applications in numerous industries, including the following:

- Repair or build-up of worn or damaged surfaces
- Wear Resistance
- Corrosion Resistance
- Undercoat for paint
- Temperature Resistance/Insulation
- Electrical Conductance

1. Benefits

The benefits of thermal spraying have led to a continual expansion of applications and technologies. For corrosion prevention, the cost of thermal spraying may initially be higher than traditional painting, but thermally sprayed coatings can last much longer. Therefore, the life cycle cost for thermal spraying may actually be lower than the cost of painting. In addition, thermal spraying does not require time for curing and it can eliminate or reduce emissions of volatile organic compounds. For damaged or worn surfaces, the cost of using a thermally sprayed coating to repair the surface can be much less than the cost of replacing the part. In some cases, inexpensive metals can be used to form a part that can be coated by thermal spraying to produce a high-quality surface. If thermal spraying is used as a replacement for hard chromium electroplating, it can reduce the emissions of hexavalent chromium.

2. Industrial Applications

Table III-2: lists some of the industrial applications for thermal spraying and the types of materials that are used to form a coating.

Table III-2: Thermal Spraying Industrial Applications

Industry	Apply Coatings To:	Coating Materials	Benefit
Aerospace	Jet engine components	Chromium carbide cermet, tungsten carbide/cobalt	Heat control, wear resistance, and build up of damaged surfaces
	Jet engine fan blades	Tungsten Carbide, Copper/Nickel/Indium Alloy, Chromium Carbide	Improve durability and prevent surface fatigue wear
	Jet engine gas path seals	Abradable materials (Al, Co, Cu, Ni), alumina, alumina-titania, nickel-aluminum cermet, nickel-chromium-chromium carbide	Wear resistance for rotating blade tips
	Aircraft landing gear	Tungsten carbide, chromium carbide	Sliding wear resistance, replacement for hard chrome electroplating
	Jet engine turbine components	Tungsten carbide-cobalt	Fretting wear resistance
	Airfoils, combustors, blades, vanes	Cobalt-chromium-nickel	Build up damaged surfaces and prevent oxidation
Aerospace	Composite aircraft panels	Aluminum	Protect against lightning strikes and dissipate electricity
	Jet engine combustors and nozzle guide vanes	Zirconia-yttria	Thermal barrier coating
	Helicopter pulleys	High carbon steel	Rebuild surface

Table III-2: Thermal Spraying Industrial Applications			
Industry	**Apply Coatings To:**	**Coating Materials**	**Benefit**
Agriculture	Crop harvesting machinery (knives, blades, flails, bars)	Tungsten carbide-cobalt	Wear resistance
Automotive	Plastic components in automobile ignitions	Aluminum, stainless steel, zinc	Electromagnetic Interference (EMI) shielding
	Engine valve lifters (made of aluminum rather than steel)	Iron-carbon- silicon-manganese	Reduce engine weight
	Aluminum brake discs	Ceramic	Reduce brakes weight
	Integrated circuit brackets in automotive computers	Aluminum oxide/ Magnesium oxide	Prevent electrical shorting
Chemical Manufacturing	Storage vessel	Stainless steel	Corrosion resistance
Computers/ Electronics	Apply metal coatings to non-conductive substrates	Aluminum, copper, silver, zinc	Create electrical circuits
	Paper or polymeric capacitors	Tin/Zinc	Enable electrical connection
	Electronic component housings	Aluminum, copper, zinc	EMI shielding
	Electronic components	Aluminum oxide, magnesium oxide	Wear resistance and insulation
Medical	Replacement hips	Titanium, synthetic bone	Promote fixation in body
Marine	Marine structures	Copper-nickel, aluminum bronze	Corrosion resistance
	Ship hulls, decks, rudders, lifeboats, etc.	Zinc	Corrosion resistance
	Piers, pilings, ferry berths	Zinc	Corrosion resistance
Military	Landing gear on military aircraft	Cobalt, tungsten carbide; aluminum	Resurfacing, replacement for hard chromium electroplating
	High temperature steam valves on Navy ships	Zirconia- titanium oxide-yttria	Resurfacing
	Helicopter flight decks on Navy ships	Aluminum	Non-skid coating

Table III-2: Thermal Spraying Industrial Applications			
Industry	**Apply Coatings To:**	**Coating Materials**	**Benefit**
Oil/Gas exploration and refining	Drill bit cones and other drilling components	Tungsten carbide-cobalt, chromium oxide	Prevent corrosion and provide wear resistance
	Offshore platforms	Aluminum, zinc	Corrosion resistance
	Pipelines	Zinc	Corrosion resistance
Power plants	Transmission towers, water tanks, etc.	Aluminum, zinc	Corrosion resistance
	Combustion components (e.g., boiler tubes, hydroelectric turbine parts)	Yttria-Zirconia, stainless steel	Prevent oxidation damage and provide corrosion protection
	Turbine combustion chambers	Zirconia coating	Thermal barrier coating
Pulp and paper	Drive rollers	Tungsten carbide	Provide a long-lasting surface that is rough enough to move paper without tearing paper
	Yankee dryers that dry tissue paper at paper mills	Stainless steel, molybdenum-nickel-chromium-boron-silicon (MoNiCrBSi)	Resurfacing and wear resistance
	Central impression cylinders at printing presses	Nickel superalloy	Resurfacing
	Anilox rolls that transport ink in flexographic printing machines	Chromium oxide ceramic	Resurfacing and wear resistance
	Gloss calendar rolls	Tungsten carbide-nickel-chromium, tungsten carbide-cobalt	Wear resistance
Pump/Motors	Pump sleeves, shafts, etc.	Stainless steel	Corrosion resistance and wear resistance

Table III-2: Thermal Spraying Industrial Applications			
Industry	**Apply Coatings To:**	**Coating Materials**	**Benefit**
Steel Mills	Hearth rolls that transport steel sheets through annealing furnaces	Ceramic	Repair surface, provide wear resistance, and prevent thermal shock
	Repair sink rolls that transport steel sheet through the galvanizing pot.	Tungsten, carbon, cobalt, chromium, nickel, aluminum, yttrium, oxide	Repair surface
	Process rolls in a steel mill		Resurfacing and corrosion resistance
Textile	Thread guides, rollers, etc.	Ceramic, chromium oxide, alumina-titania	Protect against abrasive fibers
Transportation	Bridges and concrete columns	Aluminum, zinc	Corrosion resistance
	Railroad cars	Zinc	Corrosion resistance, prevent contamination of transported fluid
	Bicycle rims	Aluminum oxide ceramics, carbide-based ceramic metals	Wear resistance

III.D. THERMAL SPRAYING ANCILLARY EQUIPMENT

1. Spray Booths

For many sources, thermal spraying is conducted in spray booths, equipped with filters or water curtains which capture most of the solid overspray that is not deposited on the part. Traditionally, the spray booths for thermal spraying were equipped with water curtains, but the use of high-efficiency dry filters has increased with increasing concerns about toxic emissions. Smaller facilities may use local exhaust to draw fumes away from the operator, but these units may not be equipped with filters that control particulate emissions. Other facilities may not use any type of control equipment or local exhaust.

2. Control Devices

Thermal spraying generates airborne metal dusts that can result in toxic air emissions, as well as explosion hazards. Aluminum dust is considered to be particularly hazardous, because it can generate explosive hydrogen gas in the presence of water. Ventilation and dust collection systems must be designed with explosion vents and other safety devices to ensure safe operation. In some cases, it is necessary to install a cyclone or other device to knock out the larger hot metal particles before they contact the dry filter media.

Older facilities have traditionally used water curtain booths to control emissions from thermal spraying processes. Water curtain booths can have a relatively low control efficiency (70% - 90%). Some of the larger air districts have required facilities to install HEPA filters for newly installed or modified thermal spraying operations. HEPA filters can achieve greater than 99.9% control efficiency (SDAPCD, 1998), but they can cost significantly more than a water curtain booth.

III.E. THERMAL SPRAYING MATERIALS

Thermal spraying materials can be divided into two main categories: powders and wires. Some manufacturers sell hundreds of different products with a wide variety of chemical compositions and physical properties, specifically formulated for different spraying processes and application methods. Many manufacturers in the aerospace and defense industries have specifications which govern the types of thermal spraying materials that can be applied to the surfaces of their products. Suppliers of thermal spraying materials often refer to these specifications when marketing their products. Specifications for thermal spraying materials are also maintained by trade organizations and the military, as provided below:

- American Welding Society AWS C2.25 "Specification for Solid and Composite Wires and Ceramic Rods for Thermal Spraying" (June 2002)
- Military Specification MIL-R-171731C "Rods and Powders, Welding, Surfacing" (16 January 1981)
- Military Specification MIL-STD-1687A "Thermal Spray Processes for Naval Ship Machinery Applications" (11 February 1987)

Based on information reported in ARB's 2003 survey of material suppliers, more than 50 different powders and more than 10 different wires containing chromium or nickel were sold in California in 2002.

III.F. THERMAL SPRAYING AS AN ALTERNATIVE TO HARD CHROMIUM ELECTROPLATING

Thermal spraying can be an alternative to hard chromium electroplating. Hard chromium electroplating is a process in which a layer of chromium metal is deposited directly on metal substrates such as engine parts, industrial machinery, and tools to provide protection against corrosion and wear. The electrical charge during the chromium plating process causes the hexavalent chromium to be emitted from the bath as a mist or aerosol.

In California, airborne emissions from chromium electroplating processes are regulated by a statewide ATCM, which requires the use of control technologies, depending on the type of facility. Other regulations that apply to hard chromium electroplating are South Coast Air Quality Management District (SCAQMD) Rule 1469 ("Hexavalent Chromium Emissions from Chrome Plating and Chromic Acid Anodizing Operations") and the federal National Emission Standards for Chromium Emissions from Hard and Decorative Chromium Electroplating and Chromium Anodizing Tanks (40 CFR Subpart N).

Worker exposures for hexavalent chromium are subject to the permissible exposure level (PEL) of 100 micrograms/cubic meter, as established by the Occupational Safety and Health Administration (OSHA) (CCR, 2002). In response to court action, OSHA is working on a revision of the current PEL, with a court-ordered deadline of October 4, 2004, for the proposed rule and a deadline of January 18, 2006, for the final rule (OSHR, 2003). Preliminary information indicates that the revised PEL could be in the range of 0.5 to 5.0 micrograms/cubic meter, a significant reduction from the current level. If the PEL is reduced significantly, it will become more challenging to provide the necessary worker protection while conducting hard chromium electroplating.

In an effort to reduce toxic emissions and reduce regulatory burdens, many electroplating facilities are investigating alternatives to the hard chromium electroplating process. For example, the Hard Chrome Alternatives Team (HCAT) includes representatives from the military and the aerospace industry in the United States and Canada. HCAT is investigating the use of HVOF thermal spraying as a replacement for hard chromium electroplating for a variety of applications. The HCAT research program has determined that HVOF coatings can provide superior performance and can be applied more quickly than electroplated coatings for certain applications (HCAT, 2003). In conjunction with the HCAT program, Hill Air Force Base has begun to use the HVOF process to apply tungsten carbide-cobalt coatings. According to officials at Hill Air Force Base, the hard chromium electroplating process required five days, while the HVOF process only required one day and less rework, due to the precision of the robotic HVOF system (Berk, 2002). A Northwestern University study estimated that HVOF coatings have the capability of replacing up to 80% of all hard chromium coatings at Department of Defense (DOD) maintenance activities (Sartwell, 1998).

Some advantages of thermal spraying as an alternative to hard chromium electroplating are provided below:

> **<u>Cost</u>** – Thermal spraying often costs less than electroplating. The capital cost of establishing a thermal spraying facility is usually much less than the cost for a hard chromium electroplating facility with similar production throughput. In addition, the labor costs for thermal spraying can be much lower than the cost for electroplating, because the thermal spraying deposition process takes less time. Material costs for thermal spraying may be higher than for electroplating, but the savings in labor and operating costs can offset the increased material costs, resulting in a net savings for thermal spraying.

> **<u>Facility Size</u>** – The floor space for a thermal spraying facility can be significantly less than the space required for a plating facility.

> **<u>Coating Properties</u>** – Some HVOF coatings have higher hardness ratings and superior wear resistance, when compared to coatings applied by hard chromium electroplating. Improved wear resistance means an increase in the usable life of a coating, which can result in fewer overhauls and lower costs.

> **<u>Fatigue</u>** – Hard chromium electroplating can reduce the fatigue strength of a part, but some studies have indicated that HVOF causes little or no reduction in fatigue strength (Sartwell, 1998).

> **<u>Flexibility</u>** – A thermal spraying facility can be used to apply a wide variety of coatings to various substrates, while hard chromium electroplating only applies chromium. Thermal spraying coating materials can be formulated to provide very specific properties, depending on the chemical composition and physical form of the material being sprayed.

> **<u>Waste Disposal</u>** – Thermal spraying generates a much smaller quantity of hazardous waste than hard chromium electroplating. Wastes from thermal spraying may include dry powder overspray, wastewater from water curtains, and contaminated filters from dust collectors. Electroplating can generate large quantities of wastewater that require treatment and/or disposal, as well as contaminated filters from filtration devices.

While thermal spraying has several advantages, it does not perform as well as hard chromium electroplating in certain applications. For each proposed application, it is often necessary to conduct an extensive evaluation to compare thermal spraying to electroplating. Therefore, thermal spraying is not considered to be a complete drop-in replacement for all hard chromium electroplating applications. Listed below are some of the disadvantages of thermal spraying that may limit its suitability as a replacement technology:

Geometry – Thermal spraying is most suitable for relatively simple geometries and is usually limited to line-of-sight applications. Some inner diameters can be adequately coated by adding extensions to thermal spraying guns, but electroplating may be more appropriate for parts that have complex geometries because the plating solution can flow into and around the part.

Coating Properties – Thermal spraying coatings may provide less corrosion protection than hard chromium on aluminum alloys (Sartwell, 1998).

Noise – Thermal spraying is much louder than electroplating with noise levels from 90 decibels to more than 130 decibels (similar to the noise level of a jet engine) (USACE, 1999). Hearing protection can be an issue for thermal spraying operators, as well as other workers within a facility. In some cases, it may be necessary to conduct spraying in a separate room or booth, to reduce the noise levels. Some facilities use robotically-controlled equipment that allows the operator to be outside of the booth while spraying is being conducted.

Surface Finishing – After plating or thermal spraying, it may be necessary to grind the coating to obtain the desired surface finish. For a chromium surface, a standard carbide wheel can be used for the grinding, but some thermally sprayed coatings (e.g., tungsten carbide-cobalt) may require the use of a diamond wheel, which is much more expensive (Legg, 2000).

Conversion Cost – Chromium electroplating may present environmental issues, but it is a well-known process that has a long history of use. For thermal spraying, it may be necessary to devote significant resources to research and testing to verify that thermal spraying will be a suitable replacement for electroplating.

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IV. EMISSIONS FROM THERMAL SPRAYING OPERATIONS

IV.A. OVERVIEW

This chapter presents estimates of hexavalent chromium and nickel emissions from thermal spraying activities in California. Emission estimates are based on ARB survey results, data provided by local air districts, and emission factors that were developed from stack tests, scientific studies, and industry information.

IV.B. MATERIAL SALES DATA - ARB SURVEY

Data on material sales were obtained by ARB from companies that manufacture thermal spraying materials (ARB, 2004). In May 2003, ARB staff conducted a survey of companies that supply thermal spraying materials to California facilities. The survey collected data on sales quantities, chemical constituents, industrial applications, and applicable thermal spraying processes for materials sold in California during calendar year 2002. The survey only gathered data for thermal spraying materials that contain hexavalent chromium, nickel, and other specified chemicals of concern. A copy of the survey package is contained in Appendix B. The survey was distributed to 42 companies identified by the ARB as potential manufacturers of thermal spraying materials. The survey had a high response rate of 90%, with 15 companies reporting sales and 23 companies stating that they did not have any California sales of the targeted materials. Four companies did not respond to the survey, but it is expected that these companies represent a very small percentage of the market, based on discussions with an industry working group. Table IV-1 contains a summary of key survey results. A report of the manufacturer survey results can be obtained on ARB's website (http://www.arb.ca.gov/coatings/thermal/thermal.htm).

Table IV-1: Thermal Spraying Materials Survey – Key Results	
Number of manufacturers that were surveyed	42
Number of manufacturers that responded	38
Number of manufacturers that reported 2002 sales in California	15
Reported sales of materials that contained chemicals of concern*	103 tons
Reported quantity of chemicals of concern in thermal spraying materials	64 tons
# of companies that reported products with chromium or chromium compounds	14
Reported sales of materials that contained chromium or chromium compounds	72 tons
Reported quantity of chromium in thermal spraying materials	18 tons
# of companies that reported products with nickel or nickel compounds	14
Reported sales of materials that contained nickel or nickel compounds	63 tons
Reported quantity of nickel in thermal spraying materials	34 tons

* Chemicals of concern include Toxic Air Contaminants and Copper, which may present an acute health risk.

ARB treats a company's reported sales data as confidential information. To maintain confidentiality, but still allow the publishing of survey results, the ARB implemented the historical practice of concealing all sales data values that did not represent at least three companies, otherwise known as the "Three Company Rule." The term "Protected Data" (or PD) is used to reflect that compliance with the "Three Company Rule" could not be satisfied and the data were concealed. Table IV-2 provides sales totals based on the material form (powder or wire) and the type of process.

Table IV-2: Thermal Spraying Materials Survey – Sales Summary

Material/Process Description*		CA Sales in 2002 (Lbs)	CA Sales in 2002 (Tons)
Powder:	Flame Spray	9,967	5.0
	Flame Spray/Other	PD	PD
	Flame Spray/Plasma Spray	PD	PD
	HVOF	10,827	5.4
	HVOF/Flame Spray/Plasma Spray	PD	PD
	HVOF/Plasma Spray	20,654	10.3
	Plasma Spray	17,382	8.7
	Plasma Spray/Other	PD	PD
	Powder Subtotal =	**103,980**	**52.0**
Wire:	Single-Wire Flame Spray	PD	PD
	Twin-Wire Electric Arc	PD	PD
	Wire Subtotal =	**102,249**	**51.1**
	GRAND TOTAL =	**206,230**	**103.1**

* If a product was designated for more than one process, all process descriptions are listed.
"PD": Protected data (fewer than three companies reported sales).

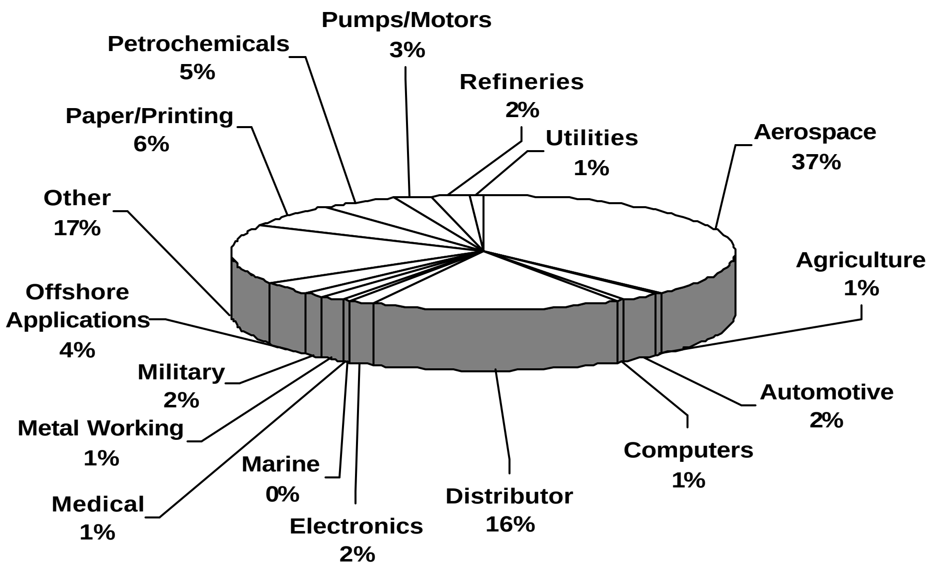
Table IV-3 lists the chemicals of concern and the associated sales quantities for each chemical. The table also contains the reported weight percentages of these chemicals in thermal spraying materials, including the sales-weighted averages (SWAs.)

Table IV-3: Thermal Spraying Materials Survey –Chemicals of Concern

Chemical Name	CAS	Form	Weight Percent			Quantity of Chemical Sold (lbs)
			Min.	Max.	SWA	
Antimony	7440-36-0	Wire	7.5	7.5	7.5	66
Chromium	7440-47-3	Powder	0.1	70.3	30.7	17,163
Chromium	7440-47-3	Wire	8.0	27.0	20.1	11,376
$Chromium^{3+}$ (trivalent)	16065-83-1	Wire	13.0	13.0	13.0	2,991
Chromium Oxide (Cr_2O_3)	1308-38-9	Powder	91.0	99.3	99.1	7,551
Cobalt	7440-48-4	Powder	0.3	66.4	30.2	13,080
Cobalt	7440-48-4	Wire	1.0	1.0	1.0	4
Copper	7440-50-8	Powder	0.1	99.0	35.1	1,777
Copper	7440-50-8	Wire	3.5	99.0	81.3	5,099
Lead	7439-92-1	Wire	0.1	0.3	0.2	2
Manganese	7439-96-5	Powder	0.3	2.0	0.9	56
Manganese	7439-96-5	Wire	0.5	8.5	1.8	673
Nickel	7440-02-0	Powder	0.3	99.8	54.1	36,736
Nickel	7440-02-0	Wire	0.3	99.0	53.1	30,580
					TOTAL (lbs) =	**127,153**
					TOTAL (tons) =	**63.6**

Figure IV-1 illustrates the thermal spraying material sales breakdown by industry, based on total sales in California during 2002.

Figure IV-1: Thermal Spraying Materials Survey – Industrial Breakdown



IV.C. THERMAL SPRAYING FACILITY DATA – ARB SURVEY

Data on material usage and operating conditions for thermal spraying facilities were obtained from businesses that perform thermal spraying. In January 2004, the ARB staff conducted a survey of thermal spraying facilities in California. The data collected included information on thermal spraying processes, pollution control devices, material usage, and operating parameters. Data from this survey and information from districts were combined to compile a list of active thermal spraying facilities in California. Table IV-4 contains a listing of thermal spraying facilities and the associated air districts.

Table IV-4: Number of Thermal Spraying Facilities in California			
Air District	**Total Facilities**	**%**	**Permitted Facilities**
Bay Area AQMD	9	18%	3
Feather River AQMD	1	2%	0
North Coast Unified AQMD	1	2%	0
South Coast AQMD	26	51%	16
San Diego County APCD	8	16%	8
San Joaquin Valley APCD	4	8%	0
Ventura County APCD	2	4%	1
Totals =	**51**		**28**

Table IV-5 contains permit and control device information for facilities that reported the use of chromium or nickel. Many districts have not required permits for thermal spraying facilities, due to the relatively low emission quantities and the lack of specific regulations for these types of facilities.

Table IV-5: Thermal Spraying Facility Data		
	Facilities that Use Chromium	**Facilities that Use Nickel**
Total Number	30	35
Have Air Permits	15	17
Unpermitted	15	18
Best Control Device*		
HEPA Filter	15	17
Dry Filter	9	10
Water Curtain	2	3
Uncontrolled	4	5

* Many facilities have multiple booths and different booths may have different control devices. This table reflects the best control device (i.e., the highest control efficiency) at each facility.

IV.D. CHROMIUM FUMES FROM THERMAL SPRAYING

Hexavalent chromium and hexavalent chromium compounds are classified as toxic air contaminants, but hexavalent chromium compounds are not generally present in thermal spraying materials as a raw ingredient. The types of chromium that are listed as ingredients include:

- Chromium CAS # 7440-47-3
- Chromium +3 (trivalent) CAS # 16065-83-1
- Chromium Oxide CAS # 1308-38-9

Even though hexavalent chromium compounds are not originally present in thermal spraying materials, numerous stack tests have measured emissions of hexavalent chromium from thermal spraying facilities. This indicates that a conversion occurs during the thermal spraying process to change chromium from an elemental or trivalent state to a hexavalent state. A supplier of thermal spraying materials has found that hexavalent chromium may be produced when materials are exposed to the high temperatures that are involved in many thermal spraying processes (Praxair, 2002). In addition, a thermal spraying industry report states that vaporized metallic chromium can cause a small fraction of the chromium to oxidize and form chromates that contain a hexavalent form of chromium (Smith, 1994). This conversion to hexavalent chromium was measured during Sawatari's study of a plasma metal spraying process with chromium metal (Sawatari, 1986). Results indicated that the fumes contained 30% hexavalent chromium compounds and 70% trivalent chromium compounds. A 1990 study by Serita found that plasma spraying with chromium powder produced fumes that contained 26.4% hexavalent chromium (Serita, 1990). The California Occupational Safety and Health Administration (Cal/OSHA) measured 33% hexavalent chromium in plasma spraying fumes and the National Institute for Occupational Safety and Health (NIOSH) measured 11% hexavalent chromium in twin-wire electric arc spraying fumes (Gold, 2000; NIOSH, 1989).

As these studies demonstrate, the formation of hexavalent chromium during thermal spraying has been documented for a variety of sources, but the quantities that are emitted can vary widely, depending on the type of process and the type of control device. Some stack tests have found that more than 90% of the total chromium being measured consists of hexavalent chromium, while other tests have found less than 5%. The most conservative approach for estimating statewide emissions would be to assume maximum conversion to hexavalent chromium and complete consumption of all materials sold in California during 2002. However, ARB staff has developed emission factors for thermal spraying, based on data that were compiled from a variety of sources for a range of control devices (see Table IV-6.) Appendix C contains a detailed explanation of the methods that were used to develop emission factors and estimate hexavalent chromium emissions on an annual and average hourly basis.

IV.E. HEXAVALENT CHROMIUM EMISSION ESTIMATES FROM THERMAL SPRAYING

The general approach for estimating hexavalent chromium emissions involves multiplying emission factors by material usage rates. Emission factors were obtained from a variety of sources, based on the type of process, the form of material being used (i.e., powder or wire), and the type of control device. In some cases, emission factors were taken directly from stack test results, while other factors were derived from a combination of stack test results, research data, and control efficiency information. Table IV-6 summarizes the emission factors that were used and Appendix C describes how these factors were derived.

Table IV-6: Emission Factor Summary – Hexavalent Chromium				
Process	Emission Factors (lbs Cr^{+6}/lb Cr sprayed)			
	0% Ctl. Eff. (Uncontrolled)	90% Ctl. Eff. [1] (e.g. Water Curtain)	99% Ctl. Eff. (e.g. Dry Filter)	99.97% Ctl. Eff. (e.g., HEPA Filter)
Single-Wire Flame Spray[2]	4.68E-03	4.68E-04	4.68E-05	1.40E-06
Twin-Wire Electric Arc Spray[2]	6.96E-03	6.96E-04	6.96E-05	2.09E-06
Flame Spray[3]	6.20E-03	1.17E-03	6.20E-05	1.86E-06
HVOF[3]	6.20E-03	1.17E-03	6.20E-05	1.86E-06
Plasma Spray[4]	1.18E-02	6.73E-03	2.61E-03	2.86E-06
Other Thermal Spraying[5]	7.17E-03	2.05E-03	5.70E-04	2.01E-06

1. Listed below the control efficiencies are examples of control devices that may meet the control efficiency.
2. Emission factors based on American Welding Society study (AWS, 1979.)
3. Emission factors based on SDAPCD stack test data for flame spraying.
4. Emission factors based on stack test results compiled by CATEF, SCAQMD, and SDAPCD.
5. For "Other Thermal Spraying" processes, we used an average of the emission factors for the listed thermal spraying processes.

ARB staff estimated annual emissions using two approaches: (1) potential to emit, based on manufacturer sales data, and (2) actual emissions, based on usage data as reported by individual facilities. When calculating the potential to emit, we used material sales data from ARB's 2003 Thermal Spraying Material Survey. When calculating actual emissions, we used material throughput data from thermal spraying businesses, that were obtained from ARB's 2004 Thermal Spraying Facility Survey.

Table IV-7 summarizes the California sales in 2002 for thermal spraying products that contain chromium and the associated quantity of chromium contained in those products. Table IV-7 also contains the associated processes and annual potential to emit values. To calculate potential emissions, we multiplied the applicable emission factor times the quantity of chromium sold. As shown in Table IV-7, 18 tons of chromium were potentially used at thermal spraying facilities and the potential to emit is 66 pounds for hexavalent chromium statewide in 2002.

To calculate actual emissions, we multiplied the applicable emission factor times the quantity of chromium usage reported by individual facilities. Actual emissions were estimated to be 9.4 pounds, based on usage data, process descriptions, and control device information as provided by facilities. It is expected that our estimates of actual emissions and the potential to emit represent lower and upper boundaries for statewide emissions. Therefore, we estimate that annual hexavalent chromium emissions from thermal spraying are in the range of 9.4 to 66 pounds. The difference between estimates of maximum potential emissions and actual emissions may be due to the following factors: 1) materials sold in one year may be used over multiple years; 2) some materials sold to California distributors may be redistributed out of State; and 3) some businesses that conduct thermal spraying may not have been captured by the ARB facility survey.

For this thermal spraying ATCM, we estimated the potential range of emission reductions based on data from the ARB 2004 Thermal Spraying Facility Survey, the 2003 ARB Thermal Spraying Materials Survey, and the proposed ATCM control efficiency requirements. Implementation of this thermal spraying ATCM is expected to reduce hexavalent chromium emissions significantly. For a facility with no existing control devices, the proposed ATCM would require at least a 99% reduction in emissions. For the largest facility in the State, the proposed ATCM would require that the control device efficiency be increased from a minimum of 81% to at least 99.97%. Overall, the proposed ATCM is expected to reduce hexavalent chromium emissions by nearly 80 percent (7 to 50 lbs/yr.)

Table IV-7: Thermal Spraying Sales & Potential to Emit Summary - Hexavalent Chromium

Process	Material	Sales of Products Containing Chromium (lbs) [1]	Qty. of Chromium in Products (lbs Cr)	Potential to Emit (lbs Cr^{+6}/yr) [2]
Flame Spray	Powder	6,788	713.4	0.6
Flame Spray/Other	Powder	PD	2,415.0	2.8
Flame Spray/Plasma Spray	Powder	PD	736.5	1.7
HVOF	Powder	7,731	3,279.0	2.8
HVOF/Flame Spray/Plasma Spray	Powder	PD	2,860.7	5.3
HVOF/Plasma Spray	Powder	10,918	5,307.9	12.4
Plasma Spray	Powder	14,780	6,962.3	26.5
Plasma Spray/Other	Powder	PD	22.8	0.1
Powder Subtotal =		**63,612**	**22,298**	**52.1**
Single-Wire Flame Spray	Wire	PD	1,330.1	0.9
Twin-Wire Electric Arc	Wire	PD	13,036.6	12.6
Wire Subtotal =		**79,708**	**14,367**	**13.4**
GRAND TOTAL =		**143,320**	**36,664**	**65.6**

1. "PD": Protected data (fewer than three companies reported sales).
2. Based on survey data, it was assumed that 13% of products are used at uncontrolled facilities and 87% of products are used at controlled facilities (i.e., those equipped with a dry filter control device.)

In addition to estimating annual emissions, we also determined the average hourly emissions, which were estimated to be **9.8E-05** grams Cr^{+6}/second. Average hourly emissions (in units of grams/second) are used for estimating cancer risks.

Maximum hourly emissions are used to calculate impacts from short-term acute exposures. Reference Exposure Levels (RELs) for short-term acute exposures have not yet been established for hexavalent chromium. Therefore, we did not calculate maximum hourly emissions for hexavalent chromium.

IV.F. NICKEL EMISSIONS ESTIMATES FROM THERMAL SPRAYING

The general approach for estimating nickel emissions involves multiplying emission factors by material usage rates. Emission factors were obtained from a variety of sources, based on the type of process and control device. In some cases, emission factors were taken directly from stack test results, while other factors were derived from a combination of stack test results and data on control efficiencies. Table IV-8 summarizes the emission factors that were used and Appendix D describes how these factors were derived.

Table IV-8: Emission Factor Summary – Nickel

Process	Emission Factors (lbs Ni/lb Ni sprayed)			
	0% Ctl. Eff. (Uncontrolled)	90% Ctl. Eff. [1] (e.g. Water Curtain)	99% Ctl. Eff. (e.g. Dry Filter)	99.97% Ctl. Eff. (e.g., HEPA Filter)
Twin-Wire Electric Arc Spray[2]	6.0E-03	6.0E-04	6.0E-05	1.8E-06
Flame Spray[3]	1.10E-01	4.64E-02	1.10E-03	3.30E-05
HVOF[3]	1.10E-01	4.64E-02	1.10E-03	3.30E-05
Plasma Spray[4]	1.5E-01	3.67E-02	1.5E-03	1.72E-05
Other Thermal Spraying[5]	9.4E-02	3.25E-02	9.4E-04	2.13E-05

1. Listed below the control efficiencies are examples of control devices that may meet the control efficiency.
2. Uncontrolled emission factor based on Wisconsin stack test data.
3. Emission factors based on SDAPCD stack test data for flame spraying.
4. Emission factors based on SCAQMD and SDAPCD stack test data.
5. For “Other Thermal Spraying” processes, we used an average of the emission factors for the listed thermal spraying processes.

Table IV-9 summarizes the California sales in 2002 for thermal spraying products that contain nickel and the associated quantity of nickel contained in those products. Table IV-9 also contains the associated processes and annual potential to emit values. As shown in Table IV-9, 34 tons of nickel were potentially used at thermal spraying facilities and the potential to emit is 740 pounds for nickel statewide in 2002.

Actual emissions were estimated to be 105 pounds, based on usage data, process descriptions, and control device information as provided by individual facilities. It is expected that our estimates of actual emissions and the potential to emit represent lower and upper boundaries for statewide emissions. Therefore, we estimate that annual nickel emissions from thermal spraying are in the range of 105 – 740 pounds. The difference between estimates of maximum potential emissions and actual emissions may be due to the following factors: 1) materials sold in one year may be used over multiple years; 2) some materials sold to California distributors may be redistributed out of State; and 3) some businesses that conduct thermal spraying may not have been captured by the ARB facility survey.

For this thermal spraying ATCM, we estimated the potential range of emission reductions based on data from the ARB 2004 Thermal Spraying Facility Survey, the ARB 2003 Thermal Spraying Materials Survey, and the proposed ATCM control efficiency requirements. Implementation of this thermal spraying ATCM is expected to reduce nickel emissions by 51 percent (54 to 377 lbs/yr).

In addition to estimating annual emissions, we also determined the average hourly emissions (which were estimated to be **9.6E-04** grams Ni/sec) and the maximum hourly emissions (as shown in Table IV-10). Average hourly emissions (in units of grams/second) are used for estimating cancer risks. Maximum hourly emissions are used to calculate impacts from short-term acute exposures.

Table IV-9: Thermal Spraying Sales & Potential to Emit Summary - Nickel

Process	Material	Sales of Products Containing NIckel (lbs)[1]	Qty. of Nickel in Products (lbs Ni)	Potential to Emit (lbs Ni/yr)[2]
Flame Spray	Powder	9,917	7,021.1	114.8
Flame Spray/Other	Powder	PD	8,429.3	162.8
Flame Spray/Plasma Spray	Powder	PD	9,567.7	184.8
HVOF	Powder	5,776	1,361.3	22.3
HVOF/Flame Spray/Plasma Spray	Powder	PD	828.0	15.2
HVOF/Plasma Spray	Powder	11,473	6,408.4	123.8
Plasma Spray	Powder	9,435	3,056.7	68.1
Plasma Spray/Other	Powder	PD	63.6	1.4
Powder Subtotal =		**67,911**	**36,736**	**693.1**
Single-Wire Flame Spray	Wire	PD	1,259.4	20.6
Twin-Wire Electric Arc	Wire	PD	29,320.2	26.1
Wire Subtotal =		**57,640**	**30,580**	**46.7**
GRAND TOTAL =		**125,550**	**67,316**	**739.9**

1. "PD": Protected data (fewer than three companies reported sales).
2. Based on survey data, it was assumed that 14% of products are used at uncontrolled facilities and 86% of products are used at controlled facilities (i.e., those equipped with a dry filter control device.)

The maximum hourly emissions depend on the hourly spray rate for a given facility. To estimate maximum hourly emissions, we used a range of spray rates (low, medium, and high) to cover a variety of scenarios. For most thermal spraying processes, the hourly spray rates for nickel were 0.5, 5, and 15 lbs/hr (or 0.063, 0.63, and 1.89 g/s). Twin-Wire Electric Arc spraying can achieve a substantially higher spray rate than flame spraying, according to information from manufacturers and technical literature. Therefore, the "high" estimated spray rate for electric arc spraying was 25 lbs/hr (or 3.15 g/s) instead of 15 lbs/hr (1.89 g/s).

Maximum hourly emission rates were estimated for uncontrolled facilities and for facilities equipped with a control device that achieves 99% control efficiency. The maximum hourly values were calculated for low, medium, and high nickel spray rates. Table IV-10 contains the high-end values that were calculated for low, medium, and high spray rates. For the purposes of risk assessment, these data are presented in units of "grams/second", rather than units of "lbs/hr".

Table IV-10: Maximum Hourly Emissions – Nickel			
	Estimated Emissions (grams Ni/sec)		
	Low Spray Rate	**Medium Spray Rate**	**High Spray Rate**
Uncontrolled	9.45E-03	9.45E-02	2.83E-01
Controlled (dry filter)	9.45E-05	9.45E-04	2.83E-03

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V. HEALTH ASSESSMENT FOR THE PROPOSED AIRBORNE TOXIC CONTROL MEASURE

This chapter presents an overview of the health risk assessment process that forms the health basis for this ATCM, the potential health impacts from exposure to hexavalent chromium and nickel from thermal spraying, as well as information on control devices that can reduce risk levels. This chapter also addresses the benefits of the proposed ATCM in terms of statewide emissions and potential health impacts. Appendix F contains a more detailed explanation of the health risk assessment methods.

V.A. OVERVIEW

A health risk assessment (HRA) is an evaluation or report that a risk assessor develops to describe the potential a person or population may have of developing adverse health effects from exposure to a facility's emissions. Some health effects that are evaluated include cancer, developmental effects, and respiratory illness. We evaluated the cancer and non-cancer health impacts and found that the potential cancer health impacts were more significant than non-cancer impacts. Therefore, the following sections focus on the cancer risk assessment. Section V.E. contains a discussion of non-cancer health impacts.

Exposure to toxic air contaminants (TAC) can occur through pathways that include inhalation, skin exposure, and the ingestion of soil, water, crops, fish, meat, milk, and eggs. According to the Office of Environmental Health Hazard Assessment (OEHHA), hexavalent chromium and nickel are only treated as carcinogenic by the inhalation route (OEHHA, 2003.) Therefore, we only evaluated the cancer risk impacts of hexavalent chromium and nickel via the breathing or inhalation pathway. Appendix F contains a detailed explanation of the health risk assessment calculations.

Generally, to develop a HRA, the risk assessor would consider information developed under the following four steps:

Step 1 - Hazard Identification	The risk assessor determines if a hazard exists, and if so, identifies the pollutant(s) and the type of effect, such as cancer or respiratory effects.
Step 2 - Dose-Response Assessment	The risk assessor characterizes the relationship between a person's exposure to a pollutant and the occurrence of an adverse health effect.
Step 3 - Exposure Assessment	The risk assessor estimates the extent of public exposure by looking at who is likely to be exposed, how exposure will occur, and the magnitude of exposure (e.g., the airborne concentration of a pollutant.)
Step 4 - Risk Characterization	The risk assessor combines airborne pollutant concentrations with cancer potency factors (for cancer risk) and reference exposure levels (for non-cancer effects) to quantify the potential cancer risk and non-cancer health impacts.

The methods used in this risk assessment are consistent with the Tier 1 analysis presented in the OEHHA Air Toxics "Hot Spots" Program Risk Assessment Guidelines, the Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments (OEHHA, 2003).

Table V-1 summarizes the key parameters that were used when conducting the air dispersion modeling and the health risk assessment.

Table V-1: Key Parameters for Air Dispersion Modeling and Health Risk Assessment	
Air Dispersion Model:	U.S. EPA, Industrial Source Complex Short Term (ISCST3), Version 02035
Source Type:	Volume and Point
Dispersion Setting:	Urban
Receptor Height:	1.2 meters
Stack Information (Point Sources):	
Stack Diameters	0.55, 0.81, and 0.88 meters
Stack Heights	5.5, 10.7, and 13.7 meters
Stack Temperatures	300, 294, and 293 degrees Kelvin
Stack Exhaust Velocities	24, 19, and 13 meters/second
Volume Source Information:	
Release Height	1.8 meters
Lateral Dimension	9.9 meters
Vertical Dimension	2.3 meters
Meteorological Data:	Los Angeles area – Vernon, West LA San Francisco Bay area – San Francisco Airport San Diego area – Barrio Logan, Miramar Naval Air Station, Lindbergh Airport
Receptor's Hypothetical Exposure Time:	70 yrs, 350 days/year
Adult Daily Breathing Rates:	393 liters/kg body weight-day (high-end) 302 liters/kg body weight-day (80th percentile) 271 liters/kg body weight-day (mean)
Adult Body Weight:	70 kg
Cancer Inhalation Potency Factors:	Hexavalent Chromium – 510 $(mg/kg\text{-}day)^{-1}$ Nickel – 0.91 $(mg/kg\text{-}day)^{-1}$
Non-Cancer Acute Reference Exposure Levels (RELs) – Inhalation:	Hexavalent Chromium – not established Nickel – 6.0 ug/m^3
Non-Cancer Chronic RELs - Inhalation:	Hexavalent Chromium – 0.20 ug/m^3 Nickel – 0.05 ug/m^3
Non-Cancer Chronic RELs - Oral:	Hexavalent Chromium – 0.02 mg/kg-day Nickel – 0.05 mg/kg-day

V.B. FACTORS THAT AFFECT THE OUTCOME OF A HEALTH RISK ASSESSMENT

The results of a health risk assessment include an evaluation of potential adverse health impacts from exposure to TACs. Factors that affect the potential health impacts include:

- product usage rates and quantities;
- the concentration of TAC (e.g., chromium or nickel) in the products being used at a facility;
- the toxicity of a pollutant;
- the facility operating schedule;
- the physical dimensions of the facility; and
- local meteorology.

The combination of these factors will ultimately determine the potential health impact. Due to the variability of these factors, the potential health impacts can also vary. For example, if only the chromium content was to increase, and all other factors were held constant, the resulting potential health impacts would also increase. In addition, hexavalent chromium is a very toxic chemical, so the potential health impacts can be quite significant even if the level of exposure is relatively low.

V.C. MULTI-PATHWAY HEALTH RISK ASSESSMENT

In evaluating the potential health effects of a pollutant, it is important to identify the different routes by which an individual could be exposed to the pollutant. The appropriate pathways to include in a HRA are dependent on the specific toxic air pollutant that a person (receptor) is exposed to, and can include inhalation, dermal exposure, and the ingestion of soil, water, crops, fish, meat, milk, and eggs. However, hexavalent chromium and nickel are only considered to be carcinogenic via inhalation exposure (OEHHA, 2003.) In addition, our analysis indicates that the inhalation pathway and the potential impacts on the respiratory endpoint would present the most significant non-cancer chronic health impacts. Therefore, this health risk assessment focused upon the impacts of exposure to hexavalent chromium and nickel via the inhalation pathway.

V.D. HEALTH RISK ASSESSMENT PROCESS

The following sections describe details of the health risk assessment process and the resulting health risk estimates.

<u>Step 1 - Hazard Identification</u>

Thermal spraying can generate emissions of TACs, such as hexavalent chromium, nickel, and cobalt. Hexavalent chromium and nickel have been formally identified by the Board as TACs without threshold exposure levels below which adverse health effects are not anticipated.

Both hexavalent chromium and nickel are classified as carcinogens. Exposure to hexavalent chromium may cause lung and nasal cancers, respiratory irritation, severe nasal and skin ulcerations and lesions, perforation in the nasal septum, liver and kidney failure and birth defects. Exposure to nickel may cause lung and nasal cancers, allergic sensitization, asthma, and other respiratory ailments.

Step 2 - Dose-Response Assessment

OEHHA develops dose-response factors to characterize the relationship between a person's exposure to a pollutant and the occurrence of an adverse health effect. A cancer potency factor is used when estimating potential cancer risks and reference exposure levels (RELs) are used to assess potential non-cancer health impacts (OEHHA, 1999; OEHHA, 2002; OEHHA, 2003). Cancer potency factors are the upper bound probability of developing cancer, assuming continuous lifetime exposure to a substance at a dose of one milligram per kilogram of body weight. Hexavalent chromium is a very potent carcinogen in comparison to other common carcinogens, as shown in Table V-2.

Table V-2: Inhalation Cancer Potency Factors for Common Carcinogens
(in descending order)

Compound	Cancer Potency Factor $(mg/kg\text{-}day)^{-1}$
Dioxin (2,3,7,8-Tetrachlorodibenzo-p-Dioxin)	1.3 E+5
Hexavalent Chromium	**5.1 E+2**
Cadmium	1.5 E+1
Arsenic (inorganic)	1.2 E+1
Diesel Exhaust	1.1 E+0
Nickel	**9.1 E-1**
1,3-Butadiene	6.0 E-1
Ethylene Oxide	3.1 E-1
Vinyl Chloride	2.7 E-1
Ethylene Dibromide	2.5 E-1
Carbon Tetrachloride	1.5 E-1
Benzene	1.0 E-1
Ethylene Dichloride	7.2 E-2
Lead	4.2 E-2
Formaldehyde	2.1 E-2
Perchloroethylene	2.1 E-2
Chloroform	1.9 E-2
Acetaldehyde	1.0 E-2
Trichloroethylene	7.0 E-3
Methylene Chloride	3.5 E-3

(OEHHA, 2003)

A REL is used as an indicator of potential non-cancer adverse health effects, and a REL is defined as a concentration level at or below which no adverse health effects are anticipated. RELs are designed to protect the most sensitive persons in the population by including safety factors in their development, and can be created for both acute and chronic exposures. An acute exposure is defined as one or a series of short-term exposures generally lasting less than 24 hours. Chronic exposure is defined as long-term exposure usually lasting from one year to a lifetime.

Non-cancer acute RELs have been established for nickel, but not for hexavalent chromium. Table V-3 contains non-cancer RELs and toxicological endpoints for hexavalent chromium and nickel.

Table V-3: Health Effects Values Used in Health Risk Assessment

	Hexavalent Chromium	**Nickel**
Non-Cancer Reference Exposure Levels		
Acute – Inhalation (ug/m^3)	N/A	6.0
Chronic – Inhalation (ug/m^3)	0.20	0.05
Chronic – Oral (mg/kg-day)	0.02	0.05
Toxicological Endpoints		
Acute – Inhalation	N/A	Immune System and Respiratory System
Chronic – Inhalation	Respiratory system	Hematopoietic System and Respiratory System
Chronic - Oral	Hematologic	Alimentary

(OEHHA, 2003)

Step 3 - Exposure Assessment

Hexavalent chromium and nickel are only considered to be carcinogenic when exposure occurs by the inhalation route (OEHHA, 2003.) Therefore, we evaluated the cancer risk impacts of hexavalent chromium and nickel via the breathing or inhalation pathway only.

For thermal spraying activities, the persons that are most likely to be exposed include off-site workers located near the facility or nearby residents. On-site workers could be impacted by the emissions; however, they are not included in this HRA because Cal/OSHA has jurisdiction over on-site workers.

The magnitude of exposure was assessed through the following process. ARB staff conducted air dispersion modeling to provide downwind airborne concentrations of hexavalent chromium and nickel in the air. The downwind concentration is a function of the quantity of emissions, release parameters at the source, and appropriate meteorological conditions. Results of the modeling are detailed in Appendix E.

Air dispersion modeling was conducted using the U.S. EPA, Industrial Source Complex Short Term (Version 02035) air dispersion model (ISCST3 model). The ISCST3 model estimates concentrations at specific locations around each facility, directly caused by each facility's emissions. When conducting the modeling, ARB staff used operating data from four actual thermal spraying facilities whose annual emissions of hexavalent chromium ranged from 0.0001 to 0.02 pounds per year. We also used meteorological data from three areas (Bay Area, Los Angeles, and San Diego) when conducting modeling for each of these facilities The modeling analyzed airborne concentrations for potential receptor distances that ranged from 30 – 5,000 meters (or 100 –16,400 feet) away from the thermal spraying facilities.

Step 4 - Risk Characterization

This section presents the results of the health risk assessment for thermal spraying facilities that use materials containing chromium and/or nickel. The analyses included the cancer and non-cancer health impacts for potential receptors located at distances from 30 – 5,000 meters (or 100 – 16,400 feet) away from the thermal spraying facilities. When evaluating potential health risks for individual facilities, we used actual emissions data, based on each facility's reported material usage. Emissions were quantified using the methods discussed in Chapter IV and Appendices C and D.

Figures V-1 and V-2 illustrate the cancer risk levels for set emission levels of hexavalent chromium at different receptor distances. The shaded areas indicate cancer risks that are less than or equal to 10 in a million, based on the 95th percentile daily breathing rate.

Figure V-1: Hexavalent Chromium - Estimated Risk Range vs. Receptor Distance for Thermal Spraying Point Sources

Emissions (lbs Cr^{+6}/yr)								
0.004	A	A	A	A	A	A	A	A
0.01	A	A	A	A	A	A	A	A
0.05	B	B	B	A	A	A	A	A
0.1	B	B	B	A	A	A	A	A
0.5	C	C	C	B	A	A	A	A
	40	**50**	**100**	**200**	**500**	**1000**	**2000**	**5000**
	Receptor Distance (meters)							

KEY: A: ≤ 10 in a million
B: >10 and ≤ 100 in a million
C: >100 in a million

Figure V-2: Hexavalent Chromium – Estimated Risk Range vs. Receptor Distance for Thermal Spraying Volume Sources

Emissions (lbs Cr^{+6}/yr)									
0.004	A	A	A	A	A	A	A	A	A
0.01	B	B	B	A	A	A	A	A	A
0.05	B	B	B	B	A	A	A	A	A
0.1	C	C	C	B	A	A	A	A	A
0.5	C	C	C	C	B	A	A	A	A
	30	**40**	**50**	**100**	**200**	**500**	**1000**	**2000**	**5000**
	Receptor Distance (meters)								

KEY A: ≤ 10 in a million
B: >10 and ≤ 100 in a million
C: >100 in a million

The results illustrated in Figures V-1 and V-2 show that a very low level of hexavalent chromium emissions can lead to cancer risks that exceed 10 in a million at nearby receptors.

Figures V-3 and V-4 illustrate the cancer risk levels for set emission levels of nickel at different receptor distances. Figures V-3 and V-4 are based on nickel emission levels that are much higher than the hexavalent chromium emission levels shown in Figures V-1 and V-2. Even though the nickel emissions are higher than the emissions of hexavalent chromium, the health risks from nickel are much lower than the risks caused by hexavalent chromium because nickel is less toxic. For example, 0.01 pounds of hexavalent chromium could trigger a potential cancer risk of 10 in a million, while it would take 5 pounds of nickel to trigger a 10 in a million cancer risk.

Figure V-3: Nickel – Estimated Risk Range vs. Receptor Distance for Thermal Spraying Point Sources

Emissions (lbs Ni/yr)								
2	A	A	A	A	A	A	A	A
5	A	A	A	A	A	A	A	A
10	A	A	A	A	A	A	A	A
50	B	B	B	A	A	A	A	A
100	B	B	B	B	A	A	A	A
	40	**50**	**100**	**200**	**500**	**1000**	**2000**	**5000**
	Receptor Distance (meters)							

KEY A: ≤ 10 in a million
B: >10 and ≤ 100 in a million

Figure V-4: Nickel - Estimated Risk Range vs. Receptor Distance for Thermal Spraying Volume Sources

Emissions (lbs Ni/yr)									
2	A	A	A	A	A	A	A	A	A
5	B	B	B	A	A	A	A	A	A
10	B	B	B	A	A	A	A	A	A
50	C	C	C	B	A	A	A	A	A
100	C	C	C	B	B	A	A	A	A
	30	**40**	**50**	**100**	**200**	**500**	**1000**	**2000**	**5000**
	Receptor Distance (meters)								

KEY
A: ≤ 10 in a million
B: >10 and ≤ 100 in a million
C: >100 in a million

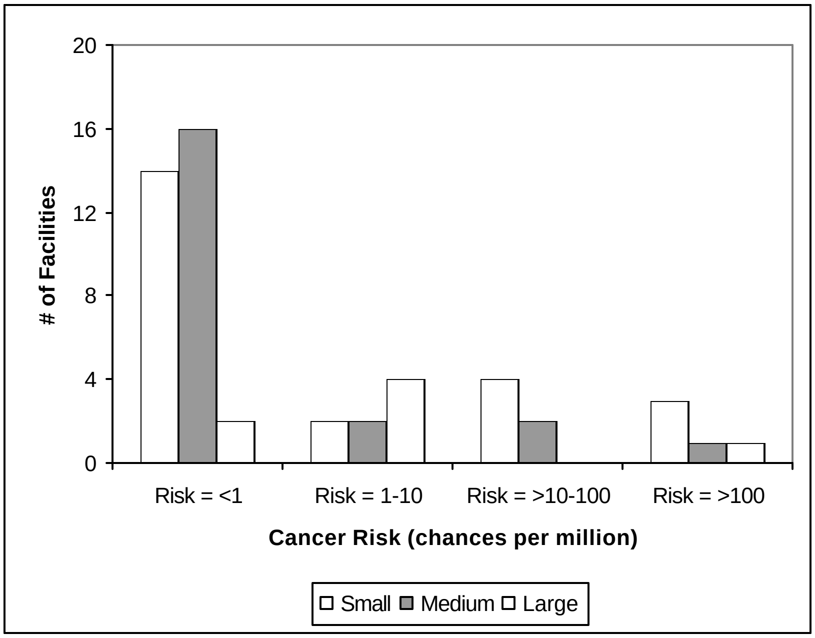
Table V-4 summarizes the maximum estimated cancer risks from hexavalent chromium emitted by small, medium, and large thermal spraying facilities. This table shows all thermal spraying facilities, including those that do not use materials containing chromium. Small facilities are those that reported an annual usage of 500 pounds or less of thermal spraying materials. Medium facilities reported an annual material usage of 500 to 5,000 pounds. Large facilities reported usage of more than 5,000 lbs/yr of thermal spraying materials.

Table V-4: Distribution of Maximum Cancer Risks from Thermal Spraying Hexavalent Chromium Emissions

Maximum Cancer Risk	**Number of Facilities**		
	Small (500 lbs/yr or less)	**Medium** (500 – 5,000 lbs/yr)	**Large** (>5,000 lbs/yr)
Risk = <1	14	16	2
Risk = 1-10	2	2	4
Risk = >10-100	4	2	0
Risk = >100	3	1	1
Totals:	**23**	**21**	**7**

Figure V-5 illustrates the distribution of maximum estimated cancer risks from thermal spraying hexavalent chromium emissions, based on facility size (i.e. the quantity of thermal spraying materials used annually.) This figure includes facilities that do not use materials containing chromium. The potential cancer risk ranges from less than one per million up to approximately 300 per million for most facilities, with one facility having a potential cancer risk of 2,800 per million. ARB is working with the SCAQMD to address the impacts from the facility with a potential cancer risk of 2,800 per million as soon as possible and prior to the adoption and implementation of the proposed ATCM. The SCAQMD has notified this facility that it is subject to the AB 2588 program requirements and must perform a health risk assessment. The facility will be conducting a source test to quantify their emissions for use in the health risk assessment.

Figure V-5: Maximum Estimated Cancer Risk from Hexavalent Chromium Based on Facility Size



Small - 500 lbs/yr or less; Medium - > 500 - 5000 lbs/yr; Large - > 5000 lbs/yr

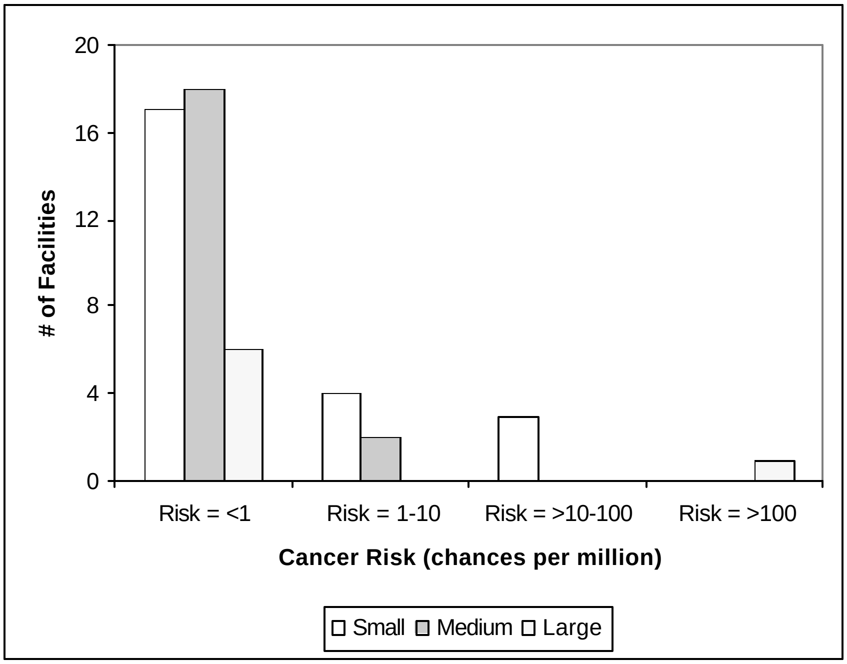
Table V-5 summarizes the maximum estimated cancer risks from nickel emitted by thermal spraying facilities. This table shows all thermal spraying facilities, including those that do not use materials containing nickel.

Table V-5: Distribution of Maximum Cancer Risks from Thermal Spraying Nickel Emissions

Maximum Cancer Risk	**Number of Facilities**		
	Small (500 lbs/yr or less)	**Medium** (500 – 5,000 lbs/yr)	**Large** (>5,000 lbs/yr)
Risk = <1	17	18	6
Risk = 1-10	4	2	0
Risk = >10-100	3	0	0
Risk = >100	0	0	1
Totals:	**24**	**20**	**7**

Figure V-6 illustrates the distribution of maximum estimated cancer risks from thermal spraying nickel emissions, based on facility size (i.e. the quantity of thermal spraying materials used annually). This figure shows all thermal spraying facilities, including those that do not use materials containing nickel.

Figure V-6: Maximum Estimated Cancer Risk from Nickel Based on Facility Size



Small - 500 lbs/yr or less; Medium - > 500 - 5000 lbs/yr; Large - > 5000 lbs/yr

V.E. NON-CANCER RISK ASSESSMENT

For the purposes of this risk assessment, we performed a multi-pathway risk assessment for non-cancer health impacts. The assessment included potential impacts from long-term (chronic) exposures and short-term (acute) exposures. Potential chronic and acute health impacts are expressed in terms of a hazard quotient (for a single substance) or a hazard index (for multiple substance.) Typically, a hazard quotient or hazard index that is greater than 1.0 is considered to be unacceptable.

Our chronic risk analysis was based on the assumption that both hexavalent chromium and nickel could be emitted simultaneously. The analysis indicated that long-term exposure to hexavalent chromium and nickel emissions from a small number of high-use thermal spraying facilities could result in a chronic hazard index greater than one. For long-term chronic health impacts, all but a few of the thermal spraying facilities in the State are expected to have hazard indices less than 1.0. The highest estimated hazard index for a specific thermal spraying facility was approximately two.

We also determined the minimum emission rates that would likely result in a potential chronic hazard index that does not exceed 1.0 for hexavalent chromium and nickel combined. For hexavalent chromium, the emission rates that would likely result in a chronic hazard quotient of up to 1.0 are much higher than the emission rates that would trigger the need for additional controls to protect against cancer risk. Therefore, the controls that would be required to protect against cancer impacts would keep emission rates well below the level that could result in chronic health impacts from either hexavalent chromium or nickel.

If nickel was the only pollutant being emitted, the emission rates that would likely result in a chronic hazard quotient of up to 1.0 are higher than the emission rates that would trigger the need for additional controls to protect against cancer risk. Therefore, the controls that would be required to protect against cancer impacts would keep emission rates below the level that could result in chronic health impacts.

The primary non-cancer health impacts from thermal spraying are potential acute impacts from short-term exposure to nickel. Our analysis indicated that hourly nickel emissions from thermal spraying facilities could result in a hazard quotient that is greater than 1.0. The peak hourly nickel emission rates that would likely result in a potential acute hazard quotient of up to 1.0 are lower than the annual average hourly emission levels that would likely result in a potential cancer risk of up to 10 in a million or chronic hazard quotient of 1.0. Therefore, it is possible to have a potential acute hazard quotient that is greater than 1.0, even though the potential cancer risk from nickel is less than 10 in a million. For that reason, the proposed ATCM would include an hourly emission limit for nickel to protect against acute health risks. This hourly limit is designed to ensure that the acute hazard quotient does not exceed 1.0. Hexavalent chromium does not have an established acute reference exposure level. Therefore, our evaluation for acute impacts only included nickel.

V.F. RISK REDUCTION TECHNIQUES

The health risks associated with thermal spraying are directly related to the emissions of hexavalent chromium and nickel. Therefore, limiting emissions of these pollutants will result in reduced health risks. A very high degree of emission reductions can be achieved by using add-on air pollution control equipment. Section III.D. describes some of the common control devices that are in use at thermal spraying facilities. Each facility would need to evaluate their particular operation to determine which type of control equipment would be most suitable. Our risk assessment indicates that all facilities that exceed defined thresholds must use some type of control device to protect public health. For a small facility that uses very small quantities of chromium-containing materials, a water curtain or high-efficiency dry filter may limit emissions to levels that result in very low risk. For a larger facility that uses chromium-containing materials on a regular basis, it may be necessary to install a HEPA filter system.

The risk assessment (as illustrated in Figures V-1 and V-2) shows that there are two situations which result in cancer risks of 10 in a million or less:

1. Limiting hexavalent chromium emissions to 0.01 lbs Cr^{+6}/yr (for point sources) and 0.004 lbs Cr^{+6}/yr (for volume sources); or
2. Locating thermal spraying facilities at least 1,640 feet (or 500 meters) from sensitive receptors and limiting hexavalent chromium emissions to 0.5 lb/yr.

Limiting emissions could be difficult for facilities that are not equipped with air pollution controls. For example, emissions of 0.01 lbs Cr^{+6}/yr could be generated at an uncontrolled facility by using approximately 5 lbs/yr of flame spraying powder (containing 30.7% by weight chromium).

Another alternative for emission reduction is a limitation on the quantity of chromium-containing materials used at a facility. If a facility keeps their usage low enough to remain below the threshold levels that would trigger a health risk, it may be possible to protect public health without having to install new controls or upgrade to HEPA filters. In some cases, it may be possible to use non-chromium thermal spraying materials as a replacement for chromium-containing products. However, existing aviation and military specifications may limit the amount of product replacement that can be achieved in the near term.

Cold spraying is another potential alternative for reducing the emissions of hexavalent chromium. In cold spraying, powder particles at or near room temperature are sprayed onto surfaces at velocities of 500 to 1500 meters/second, using a supersonic gas jet (Sandia, 2000). The high velocity causes the particles to flatten and bond with the substrate surface. Since the process occurs at room temperature, oxidation is minimized, which may prevent the formation of chromium oxides that contain the hexavalent form of chromium. Additional research is needed to quantify hexavalent chromium emissions from cold spraying. This technology is currently in the early stages of development, but it may be a suitable alternative for some industrial applications in the future.

V.G. STATEWIDE EMISSION AND RISK REDUCTION BENEFITS OF THE AIRBORNE TOXIC CONTROL MEASURE

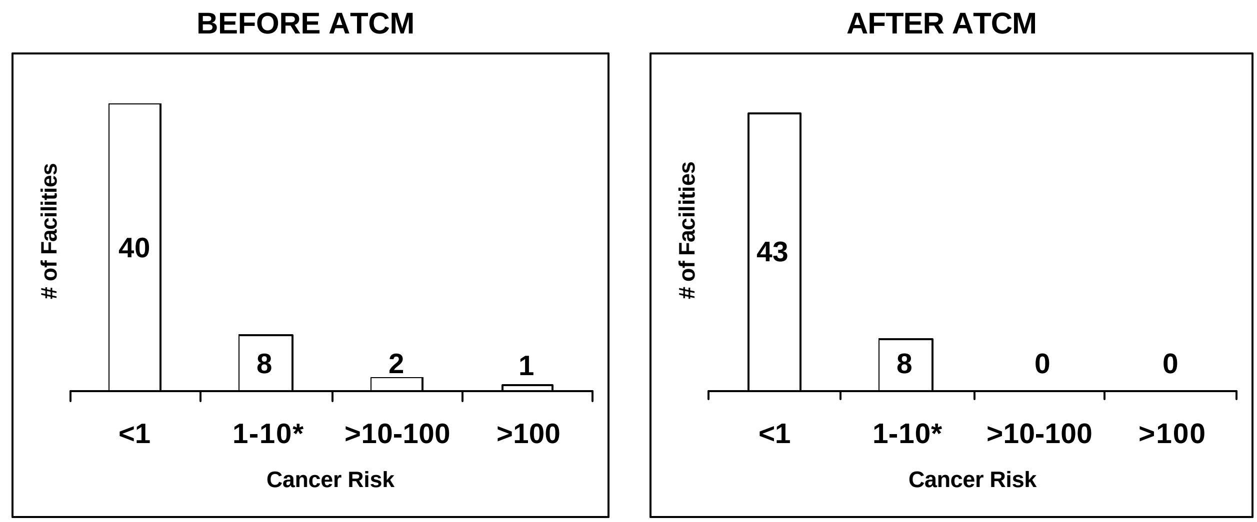
Estimated statewide emissions from thermal spraying range from 9.4 to 66 lbs/yr for hexavalent chromium and 105 to 740 lbs/yr for nickel. For a facility with no existing control devices, the proposed ATCM would require at least a 99% reduction in emissions. For the largest facility in the State, the proposed ATCM would require that the control device efficiency be increased from a minimum of 81% to at least 99.97%. Overall, the proposed ATCM is expected to reduce hexavalent chromium emissions by nearly 80 percent (7 to 50 lbs/yr) and nickel emissions by 51 percent (54 to 377 lbs/yr) from thermal spraying facilities.

The health risk assessment indicates that using small quantities of thermal spraying materials can cause near-source potential cancer risks that exceed 10 in a million. Hence, the proposed ATCM would eliminate a significant near-source cancer risk from facilities that currently use chromium- or nickel-containing thermal spraying materials and are not equipped with the best available control technology.

Figure V-7 illustrates the distribution of estimated cancer risks, before and after implementation of the ATCM. This chart represents the potential cancer risks at the nearest sensitive receptor. However, the proposed ATCM is designed to ensure that potential cancer risks remain below 10 in a million, regardless of where a receptor may be located.

Figure V-7 includes all 51 thermal spraying facilities in California, including the fourteen facilities that don't use chromium or nickel. For 40 of the 51 facilities, our analysis indicated that hexavalent chromium and nickel emissions would likely result in potential cancer risks of less than 1 per million, prior to implementation of the ATCM. The proposed ATCM will require the three facilities that exceed 10 in a million to install control devices or eliminate their thermal spraying operations that use chromium. After implementation of the ATCM, 43 of the 51 facilities are expected to have potential cancer risks of less than 1 per million and the remaining facilities are expected to have potential cancer risks that do not exceed 3 per million.

Figure V-7: Estimated Cancer Risk from Hexavalent Chromium and Nickel, Before and After ATCM Implementation



* The maximum cancer risk in the "1-10" range is 3 in a million.

In addition to the risk reduction benefits for potential receptors, we expect a reduction in overall ambient levels of hexavalent chromium and nickel. By reducing ambient levels of hexavalent chromium and nickel, overall statewide risk reduction benefits will be achieved.

V.H. WORKPLACE EXPOSURE

Hexavalent chromium and nickel are human carcinogens. As such, the California Department of Industrial Relations, Division of Occupational Safety and Health Administration (Cal/OSHA) regulates these compounds in the workplace environment. To protect worker safety, Cal/OSHA has established permissible exposure limits (PEL) for these compounds. The PEL is the maximum, eight-hour, time-weighted average concentration for occupational exposure and is 0.01 mg/m^3 for hexavalent chromium and 0.1 mg/m^3 for nickel (CCR, 2002.) Since the proposed ATCM will require ventilation systems for certain uncontrolled facilities, worker exposure to hexavalent chromium and nickel from the use of these products will be reduced.

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VI. PROPOSED AIRBORNE TOXIC CONTROL MEASURE AND ALTERNATIVES

In this chapter, staff provides a “plain English” discussion of key requirements of the proposed ATCM to Reduce Emissions of Hexavalent Chromium and Nickel from Thermal Spraying. This chapter begins with a general summary of the proposed ATCM, and then discusses and explains each major requirement.

VI.A. SUMMARY OF THE PROPOSED AIRBORNE TOXIC CONTROL MEASURE

The text of the proposed ATCM can be found in Appendix A to this staff report. The proposed ATCM only applies to thermal spraying operations in California that use products containing chromium, chromium compounds, nickel, or nickel compounds. The regulation will reduce hexavalent chromium and nickel emissions from thermal spraying operations at stationary sources, but it does not prohibit the use of thermal spraying materials containing chromium, chromium compounds, nickel or nickel compounds. Reducing emissions of hexavalent chromium and nickel is accomplished by requiring air pollution control systems.

For existing thermal spraying operations, defined as those in existence before January 1, 2005, the level of control efficiency required by the proposed ATCM varies, depending on the type of thermal spraying operation (point or volume source) and the thermal spraying operation’s total emissions of hexavalent chromium and nickel from thermal spraying activities. Control efficiency requirements increase in stringency as the emissions quantity increases.

Modified thermal spraying operations (those modified on or after January 1, 2005) must install a HEPA filter or equivalent control device. New thermal spraying operations (those not in existence until on or after January 1, 2005) must install a HEPA filter or equivalent control device. In addition, new thermal spraying operations cannot operate in, or within 500 feet of, the boundary of a residential or mixed use zone. New thermal spraying operations must also undergo a site-specific analysis to ensure adequate protection of public health.

The proposed ATCM establishes requirements for new and modified thermal spraying operations that are more stringent than the requirements for existing thermal spraying operations. January 1, 2005, is the cutoff date in the proposed ATCM for distinguishing between existing operations, and new and modified operations. For example, a thermal spraying operation is considered “new” if it begins initial operations on or after January 1, 2005. A thermal spraying operation is considered “modified” if it undergoes a physical modification on or after January 1, 2005, that requires an application for an authority to construct and/or a permit to operate. We are proposing this cutoff date for two reasons. First, we want to minimize the potential for existing thermal spraying operations to modify their operations prior to the ATCM’s effective date in order to avoid the more stringent requirements for modified operations. Secondly, we want to minimize the potential that companies considering construction of a new thermal spraying operation will begin initial operations before the ATCM's effective date in order to avoid the more stringent requirements that apply to new operations. The January 1, 2005, cutoff date will also provide such companies adequate notice of the ATCM requirements before they undertake the expense of construction.

In addition, we would like to clarify that the proposed ATCM does not impose retroactive requirements on thermal spraying operations. California law is quite clear that the proposed ATCM cannot become legally effective until it is adopted by the ARB and is approved by the Office of Administrative Law (OAL). Since it is very unlikely that both the ARB and OAL will approve the ATCM before January 1, 2005, this date should be viewed as the demarcation line between existing thermal spraying operations, and new and modified thermal spraying operations, that will apply once the ATCM becomes legally effective (and is enforced by the local air districts as provided in Health and Safety Code section 39666(d)). Until then, thermal spraying operations are not required to comply with any requirement specified in the ATCM, unless a local district independently imposes the same or similar requirement pursuant to its own local rules or permitting authority.

For example, section (c)(3)(A)1. of the ATCM requires that upon initial startup a new thermal spraying operation must install a HEPA filter or equivalent control device. However, a new thermal spraying operation could begin operations in January 2005 without a HEPA filter if the ATCM had not yet been approved by OAL (assuming that the local district did not independently impose such a requirement). And the thermal spraying operation could continue operating without a HEPA filter (again assuming that the local district did not independently require it) until such time as the ATCM is approved by OAL and the local district begins enforcing this requirement under section 39666(d). When this happens, the thermal spraying operation must have a HEPA filter (or equivalent control device) in place and operating as specified in the ATCM.

Following is a more detailed discussion of the provisions of the proposed ATCM.

1. Applicability

The proposed ATCM applies to thermal spraying operations at stationary sources that use materials containing chromium, chromium compounds, nickel, or nickel compounds. The proposed ATCM does not apply to portable thermal spraying operations (i.e., temporary offsite field applications that do not remain in one place for more than 30 consecutive days.)

2. Exemption

There is one exemption allowed in the proposed ATCM. The exemption is for thermal spraying operations with low emissions. An existing thermal spraying operation that is a point source is not subject to the control efficiency requirements if it meets all of the following criteria: annual hexavalent chromium emissions are less than 0.004 pound; annual nickel emissions are less than 2.1

pounds; and maximum hourly nickel emissions do not exceed 0.1 pound. There are also no additional requirements for enclosure or ventilation. However, the owner or operator of the thermal spraying operation must still comply with the permitting, monitoring, and recordkeeping requirements of the proposed ATCM. The owner or operator of the thermal spraying operation must also provide the permitting agency an annual report quantifying their emissions of hexavalent chromium and nickel.

An existing thermal spraying operation that is a volume source is not subject to the control efficiency requirements, if it meets all of the following criteria: annual hexavalent chromium emissions are less than 0.001 pound; annual nickel emissions are less than 0.3 pound; and maximum hourly nickel emissions do not exceed 0.01 pound. There are also no additional requirements for enclosure or ventilation. However, the owner or operator of the thermal spraying operation must still comply with the permitting, monitoring, and recordkeeping requirements of the proposed ATCM. The owner or operator of the thermal spraying operation must also provide the permitting agency an annual report quantifying their emissions of hexavalent chromium and nickel.

The criteria for exempt thermal spraying operations is designed to ensure that the potential health risks are kept at low levels. The criteria are designed to ensure that potential cancer risks do not exceed 10 in a million, as well as ensuring that the chronic hazard index and acute hazard quotient do not exceed one.

3. Definitions

The definitions listed in subsection (b) of the proposed ATCM were taken from prior ARB rulemakings, local air districts' regulatory language, and thermal spraying industry documents. Please refer to subsection (b) of the proposed ATCM for a list of definitions.

4. Standards

Effective January 1, 2006, all existing thermal spraying operations must control emissions of hexavalent chromium and nickel as described in the proposed ATCM. For existing thermal spraying operations, the amount of hexavalent chromium and nickel emitted will determine what level of control is required under the proposed ATCM.

To determine if a thermal spraying operation's emissions of hexavalent chromium and nickel trigger control requirements under the proposed ATCM, it is necessary to first determine the type of source. A thermal spraying operation can be either a point source or a volume source. If the thermal spraying operation's emissions come through a stack, chimney, or vent, it is considered a point source and must comply with the control efficiency requirements for point sources. If the thermal spraying operation's emissions are released inside a building prior to being released to the outside, are released through a horizontal stack (e.g., the side of a building), or are released directly to the outside, it is considered a volume source and must comply with the control efficiency requirements for volume sources. Remotely located thermal spraying operations may qualify for a 90 percent control efficiency requirement.

5. Hourly Emissions Limits for Nickel

The proposed ATCM limits the maximum hourly emissions of nickel to 0.1 pound for point sources and 0.01 pound for volume sources. Emissions are determined using the methodology in Appendix 1 of the proposed ATCM, or may be based on the results of an emissions source test approved by the permitting agency. The hourly nickel emissions limit is designed to protect against acute health impacts and ensure that the potential acute hazard quotient does not exceed one.

6. Control Efficiency Requirements

a) Existing Thermal Spraying Operations: The proposed ATCM establishes control efficiency requirements for existing thermal spraying operations. Three tiers of requirements, increasing in stringency from Tier 1 to Tier 3, are established for point and volume sources, based on the annual emissions of hexavalent chromium and nickel from all thermal spraying operations. These control efficiency requirements are designed to ensure that the maximum potential cancer risk is less than 10 in a million. For thermal spraying operations with a permit, annual emissions are calculated based on their potential to emit as specified in the permit and the emission calculation methods in Appendix 1 of the proposed ATCM. Permitted thermal spraying operations may also base their emissions on the results of an emissions source test that is approved by the permitting agency. For thermal spraying operations without a permit, emissions can be determined by using the emission calculation methods described in Appendix 1 of the proposed ATCM or may be based on the results of an emissions source test approved by the permitting agency. This emissions information would then be used to establish permit limits for the thermal spraying operation.

After a thermal spraying operation calculates its emissions, the control efficiency requirement can be determined. The control efficiency requirements for point sources and volume sources are shown in Tables VI-1 and VI-2, respectively. These tables appear as Tables 1 and 2 in subsection (c)(1) of the proposed ATCM. It is possible that the emissions from the thermal spraying operation may be used to establish that no additional air pollution control system requirements are necessary (i.e., if the point or volume source has emissions that are less than the minimum emissions specified in the tables).

Table VI-1: Point Sources -
Control Efficiency Requirements for Existing Thermal Spraying Operations

Tier	Annual Hexavalent Chromium Emissions from Thermal Spraying	Annual Nickel Emissions from Thermal Spraying	Minimum Control Efficiency Requirements
1	≥ 0.004 lbs/yr and ≤ 0.04 lbs/yr	≥ 2.1 lbs/yr and ≤ 20.8 lbs/yr	90% by weight (e.g., a water curtain)
2	> 0.04 lbs/yr and ≤ 0.4 lbs/yr	> 20.8 lbs/yr and ≤ 208 lbs/yr	99.999% @ 0.5 microns (e.g., a high-efficiency dry filter)
3	> 0.4 lbs/yr	> 208 lbs/yr	99.97% @ 0.3 microns (e.g., a HEPA filter)

Table VI-2: Volume Sources -
Control Efficiency Requirements for Existing Thermal Spraying Operations

Tier	Annual Hexavalent Chromium Emissions from Thermal Spraying	Annual Nickel Emissions from Thermal Spraying	Minimum Control Efficiency Requirements
1	≥ 0.001 lbs/yr and ≤ 0.01 lbs/yr	≥ 0.3 lbs/yr and ≤ 3.1 lbs/yr	99% by weight (e.g., a dry filter)
2	> 0.01 lbs/yr and ≤ 0.1 lbs/yr	> 3.1 lbs/yr and ≤ 31 lbs/yr	99.999% @ 0.5 microns (e.g., a high-efficiency dry filter)
3	> 0.1 lbs/yr	> 31 lbs/yr	99.97% @ 0.3 microns (e.g., a HEPA filter)

Please note that the emissions from all thermal spraying activities at a thermal spraying operation must be considered when determining the total emissions for the thermal spraying operation, and the most stringent Tier applies. For example, if a thermal spraying operation emits 3 lbs/yr of nickel (Tier 1) and 0.5 lbs/yr of hexavalent chromium (Tier 3), the thermal spraying operation would have to comply with the more stringent Tier 3 requirements. The tiers are designed to ensure that potential cancer risks do not exceed 10 in a million at the point of maximum impact which provides public health protection for all potential receptors, regardless of location.

All existing thermal spraying operations subject to Tier 1, Tier 2, or Tier 3 control efficiency requirements are also subject to the enclosure and ventilation requirements of the proposed ATCM (see subsection (c)(1)(B) and (c)(1)(C) of the proposed ATCM). All existing thermal spraying operations must meet the requirements for control device, enclosure, and ventilation systems by January 1, 2006, and new or modified thermal spraying operations must meet these same requirements upon initial startup.

b) Remotely Located Existing Thermal Spraying Operations: Some existing thermal spraying operations may be able to comply with the proposed ATCM without installing additional controls, if they are remotely located and have low emissions. An existing thermal spraying operation may qualify for a less stringent 90 percent control efficiency requirement if it is located at least 1,640 feet (or 500 meters) from the nearest sensitive receptor and emits no more than 0.5 pound per year of hexavalent chromium. Qualifying for this standard is contingent upon the thermal spraying operation's submission of a permit application and annual reports of hexavalent chromium and nickel emissions. In addition, before the standard is approved, a site-specific analysis of public health impacts must be conducted by the permitting agency. The permitting agency will verify annually that the thermal spraying operation continues to meet the requirements for this standard.

c) Modified Thermal Spraying Operations: Thermal spraying operations that will emit hexavalent chromium or nickel and who modify operations on or after January 1, 2005, must install a HEPA filter (or equivalent control device).

d) New Thermal Spraying Operations: Thermal spraying operations that will emit hexavalent chromium or nickel and who begin operations on or after January 1, 2005, can not operate in, or within 500 feet of, the boundary of a residential or mixed use zone. In addition, new thermal spraying operations must install a HEPA filter (or equivalent control device) and are required to undergo a site-specific analysis to ensure adequate protection of public health.

7. Enclosures and Ventilation

Those thermal spraying operations required to comply with Tier 1, Tier 2, or Tier 3 requirements for control efficiency are also required to meet the proposed ATCM standards for enclosures and ventilation. The requirements for enclosures and ventilation are the same for new, modified, and existing thermal spraying operations. Existing thermal spraying operations must meet enclosure and ventilation requirements by January 1, 2006, and new or modified thermal spraying operations must meet enclosure and ventilation requirements upon initial startup.

All enclosures must have an exhaust and be ventilated with continuous air flowing at either a minimum velocity of 100 feet per minute or the minimum velocity as defined for metal spraying facilities in "Industrial Ventilation, A Manual of Recommended Practice." Any openings other than make-up air vents must be covered, and a minimum of three air exchanges must occur after thermal spraying ceases and before the enclosure is opened. Material collected by the control system must be discharged into a completely sealed closed container or enclosed system.

8. Test Requirements and Test Methods

a) Testing of Enclosure and Ventilation Systems: Thermal spraying operations must conduct testing to ensure compliance with enclosure and ventilation standards for all new and modified thermal spraying operations and all existing thermal spraying operations that are subject to Tier 1, Tier 2, or Tier 3 requirements in the proposed ATCM. The air velocity (or "inward face velocity") must be measured at least every 30 days with a velocity measuring device approved by the permitting agency. Appendix 2 of the proposed ATCM describes these velocity measuring devices and defines the areas where measurements are to be made. Thermal spraying operations must also conduct a visual leak inspection test, as described in Appendix 3 of the proposed ATCM, at least every 90 days.

For existing thermal spraying operations, testing of the enclosure or ventilation system must take place no later than 60 days after the date the permitting agency enforces the proposed ATCM. For new or modified thermal spraying operations, testing of the enclosure or ventilation system must be conducted no later than 60 days after initial startup. The owner or operator must inform the permitting agency at least 30 days prior to conducting testing on enclosure and ventilation systems.

b) Verifying Control Efficiency: All new and modified and all existing thermal spraying operations subject to Tier 2 or Tier 3 control efficiency requirements must use control devices with the control efficiency verified by the manufacturer. There are four test methods listed in subsection (d)(2)(A) through (d)(2)(D) of the proposed ATCM, which are acceptable for use by the manufacturer. Existing thermal spraying operations subject to Tier 1 control efficiency requirements do not need manufacturer verification of control efficiency.

c) Source Testing to Determine Emissions of Hexavalent Chromium and Nickel: Source testing is not required by the proposed ATCM, however, permitting agencies may require that a source test be performed. The owner/operator of the thermal spraying operation may choose to have a source test conducted if they do not wish to use the emissions calculation methods described in Appendix 1 of the proposed ATCM. All source tests must be conducted by an independent tester, and the test protocol must be approved by the permitting agency. A source test conducted prior to January 1, 2006, may be used with permission of the permitting agency. Test methods to determine emissions of hexavalent chromium and nickel are in subsection (d)(3)(B)1. and subsection (d)(3)(B)2. of the proposed ATCM, respectively. In addition to the test methods set forth in the proposed ATCM, the permitting agency may approve alternative test methods. The owner or operator must use an independent tester to conduct the source test and a pre-test protocol must be submitted to the permitting agency at least 60 days prior to the source test. The requirements for the pre-test protocol are in subsection (d)(3)(C) of the proposed ATCM.

9. Monitoring, Inspection, Maintenance and Recordkeeping Requirements

a) Dry Particulate Filter Systems (e.g. HEPA Filter and Dry Filter Cartridge): While conducting thermal spraying, a pressure differential gauge must continually monitor pressure drop across the control device, and this pressure drop must be recorded once per work shift.

If at any time the pressure drop on a dry particulate filter system is outside of the acceptable limits, the owner or operator must immediately shut down the thermal spraying operation and take corrective action to get the pressure drop within the specified limit(s). The requirements for pressure drop gauges and their operation are in subsection (e)(2) of the proposed ATCM.

The control device, filter media, and ductwork from the work area to the control device needs to be visually inspected to ensure there are no leaks, and the filter replaced per the manufacturer's recommendations or the permitting agency's requirements. Appendix 3 of the proposed ATCM provides a checklist for conducting and recording visual inspections. The inward face velocity at each opening must be measured and recorded, as defined in Appendix 2 of the proposed ATCM, at least once every 30 days.

b) Conventional Water Curtain: While conducting thermal spraying, a flow meter must continuously monitor the flow rate of the water. Water curtain booths must provide a continuous sheet of water down the rear wall of the booth, without any gaps or dry spots, and the water curtain must be visually inspected to ensure there are no gaps. The water flow rate and results of the visual inspection of the water curtain must be recorded once per week.

At least once every 90 days, a visual inspection of the ductwork, from the booth to the exhaust stack, must be conducted and the results recorded. A Leak Check Visual Inspection Checklist, found in Appendix 3 of the proposed ATCM, includes the minimum requirements for conducting a leak check. Additional requirements specified by the manufacturer, if any, must be added to this checklist. The inward face velocity at each opening must be measured and recorded, as defined in Appendix 2 of the proposed ATCM, at least once every 30 days.

c) Pumpless Water Curtain*:* While conducting thermal spraying, monitoring of booth performance according to manufacturer's recommendations must be conducted. Water curtain booths must provide a continuous sheet of water down the rear wall of the booth, without any gaps or dry spots, and the water curtain must be visually inspected to ensure there are no gaps. Results of the monitoring and visual inspection of the water curtain must be recorded once per week.

At least once every 90 days, a visual inspection of the ductwork, from the booth to the exhaust stack, must be conducted and the results recorded. A Leak Check Visual Inspection Checklist, found in Appendix 3 of the proposed ATCM, includes the minimum requirements for conducting a leak check. Additional requirements specified by the manufacturer, if any, must be added to this checklist. The inward face velocity at each opening must be measured and recorded, as defined in Appendix 2 of the proposed ATCM, at least once every 30 days.

d) Recordkeeping: In addition to keeping records specific to the type of air pollution control system used by the thermal spraying operation such as the visual inspections, filter changes, flow rate, and inward face velocity described above, the owner/operator must keep records on all maintenance performed and any repairs made. A monthly record, with annual usage to date, must also be kept for thermal spraying materials used that contain chromium, chromium compounds, nickel, or nickel compounds. Source test records and records detailing malfunctions or failure of equipment, and the action taken to correct the malfunction or failure must be maintained. All records must be kept at the thermal spraying operation and readily accessible for review for a period of at least five years. The requirement to retain records for five years is consistent with existing permitting agency practices.

10. Reporting Requirements

a) Initial Reporting for All Existing Thermal Spraying Operations: The owners or operators of all thermal spraying operations in existence before January 1, 2005, whether or not the thermal spraying operation has a permit and regardless of their location, must submit an emission inventory for hexavalent chromium and nickel to the permitting agency no later than October 1, 2005. The emission inventory is necessary to determine the applicable control efficiency requirement.

b) Modification of Thermal Spraying Operation: Existing thermal spraying operations that were not initially using hexavalent chromium,

chromium compounds, nickel, or nickel compounds but begin using these materials on or after January 1, 2005, shall notify the permitting agency at least 45 days prior to use of these materials.

c) Remotely Located and Low Emitting Existing Thermal Spraying Operations: Those thermal spraying operations that have been determined by the permitting agency to be subject to the standard for remotely located thermal spraying operations under subsection (c)(1)(E) or are exempt from the air pollution control system requirements of the ATCM under subsection (c)(1)(F) must provide the permitting agency with an annual report quantifying their emissions of hexavalent chromium and nickel. This report is necessary to verify that these thermal spraying operations still qualify for the less stringent standard or the exemption.

d) Reports of Malfunction: The operator or owner of a thermal spraying operation that experiences an equipment breakdown, malfunction or failure must report these incidences to the permitting agency as required. This requirement is consistent with existing permitting agency practices.

e) Source Tests: The owner or operator of the thermal spraying operation must notify the permitting agency at least 60 days before a source test to measure emissions of hexavalent chromium or nickel is performed, and must provide the permitting agency the results of the test no more than 60 days after the test is conducted. The permitting agency may allow changes to the due dates and content of reports at its discretion, as long as the same information is provided and the changes will not reduce the overall frequency of reporting.

11. Severability

This provision ensures that if any part of the proposed ATCM is found to be invalid, the remaining parts of the proposed ATCM will still be in effect.

VI.B. BASIS FOR THE PROPOSED AIRBORNE TOXIC CONTROL MEASURE

The proposed ATCM is based on our evaluation of BACT for reducing hexavalent chromium and nickel emissions from thermal spraying operations, in consideration of health risk and cost. In evaluating BACT, we analyzed information from ARB's 2003 thermal spraying material manufacturer survey and ARB's 2004 thermal spraying facility survey. Based on this information and discussions with air districts, industry and control equipment manufacturers, we determined that suitable control devices are readily available and widely used. Further, the application of BACT, as proposed by staff, will result in potential cancer risk levels being reduced to less than three in a million for the nearest sensitive receptor. In addition, the application of BACT will ensure that the chronic hazard index and acute hazard quotient do not exceed one.

VI.C. ALTERNATIVES TO THE PROPOSED AIRBORNE TOXIC CONTROL MEASURE

California Government Code section 11346.2 requires the ARB to consider and evaluate reasonable alternatives to the proposed ATCM and to provide reasons for rejecting these alternatives. This section discusses the alternatives evaluated and provides the reasons they were not chosen. Staff considered the following alternatives to the proposed ATCM: no action and require HEPA filters (the most effective control system) for all thermal spraying operations using chromium, chromium compounds, nickel or nickel compounds.

We evaluated each of the alternatives and determined that the alternatives did not meet the objective of HSC section 39666 to reduce emissions to the lowest level achievable through the application of BACT, or a more effective control method, in consideration of cost, health risk, and environmental impacts.

1. No Action

The “no action” alternative would not address the public health risk posed by hexavalent chromium and nickel emissions from thermal spraying operations. Since hexavalent chromium is a potent human carcinogen, and short-term exposure to nickel emissions can result in acute health effects, this alternative would not be protective of public health.

2. Require All Thermal Spraying Operations to Install HEPA Filters

Another alternative to the proposed ATCM would require that all chromium or nickel containing thermal spraying materials be applied inside an enclosed booth that is equipped with a HEPA filter (or equivalent control device).

It is not uncommon for large thermal spraying operations to have a booth and control device, but smaller thermal spraying operations (e.g., machine shops) do not generally have booths in which to conduct their thermal spraying operations. Requiring the installation of booths and control devices at thermal spraying operations with very low emissions and low risk would impose a significant cost burden on these operations.

In addition to capital costs, these businesses would incur ongoing labor, maintenance, utility and repair costs. Operators would also be required to check and record pressure drop across the filter, perform or schedule filter replacement and booth maintenance, and quantify the thermal spraying materials usage inside the spray booth.

State law requires control measures for TACs to be based on BACT, or a more effective control method, in consideration of cost and health risk. While this alternative would be slightly more effective in reducing health risk, the cost to industry would be nearly three times the cost of the proposed ATCM. The proposed ATCM will be health protective because it will reduce the potential cancer risk from thermal spraying to less than three potential cancer cases per million for the nearest sensitive receptor. It will also ensure that the chronic hazard index and acute hazard quotient do not exceed one. Therefore, we decided not to choose this alternative.

VII. ECONOMIC IMPACTS OF PROPOSED AIRBORNE TOXIC CONTROL MEASURE

In this chapter, ARB staff presents the estimated costs and economic impacts associated with implementation of the proposed airborne toxic control measure (ATCM) for thermal spraying operations. The expected initial capital costs and annual recurring costs for potential compliance options are discussed. The costs and associated economic impacts are given for private companies and governmental agencies.

VII.A. SUMMARY OF THE ECONOMIC IMPACTS

Overall, the proposed ATCM is not expected to have a significant adverse impact on the profitability of operators of thermal spraying facilities in California. Profitability impacts were estimated by calculating the decline in the return on owner's equity (ROE). A decline in ROE of 10 percent or more indicates a significant adverse impact. The proposed ATCM is expected to result in an ROE decline of less than five percent for most businesses impacted, which is not considered to be a significant impact on the profitability of affected businesses. One thermal spraying facility may experience a significant adverse economic impact, as discussed below in Section VII.B. The primary customers of thermal spraying facilities are other businesses in the aerospace, petrochemical, paper/printing and electronics industries. These businesses sell their products or services to consumers. Thermal spraying customers may absorb any increased costs in thermal spraying or pass some or all of the cost increase on to the consumers. We expect any increased cost to consumers to be negligible because of the small impact on the affected facilities as shown by the decline in ROE.

Overall, we expect the proposed ATCM to have no significant impact on employment; business creation, elimination or expansion; or business competitiveness in California. We also expect no significant adverse fiscal impacts on any local or State agencies.

Of the 37 facilities affected by the proposed ATCM, only six would be required to expend significant capital to meet the requirements of the proposed ATCM. Some of these operators may have difficulty securing the required capital to finance the control device upgrades required by the proposed ATCM. Four of these facilities may stop using chromium and nickel in their thermal spraying operations or cease their thermal spraying operations altogether, because it is a minor part of their overall gross revenue and less than an hour per day is spent on thermal spraying. If this occurs, four employees could be affected adversely, but these businesses are expected to retain these employees to perform other duties.

We expect the two remaining facilities to install new control devices. One of these facilities may incur a significant adverse cost impact. This facility is a large dedicated thermal spraying operation that poses the greatest public health risk. This facility has a gross annual revenue of about $10 million. The annual cost of compliance with the proposed ATCM would be about 0.6 to 1.7 percent of their gross annual revenue depending on the number of spray booths they choose to upgrade.

We estimate the total cost of the proposed ATCM to affected businesses to range from approximately $672,000 to $1,195,000 in initial capital and permitting costs and $55,000 to $94,000 in annual recurring costs. This corresponds to a total annualized cost of $150,000 to $257,000 over the useful life of the control equipment. This cost represents the capital cost of equipment, annualized over its useful life, plus the permitting and annual recurring costs in 2004 dollars. The annual cost for facilities that would not be required to install additional controls ranges from $600 to $850 per facility. The annual cost for facilities that would be required to install additional controls ranges from about $5,000 to $55,000 per facility.

One public agency, the Eastern Municipal Water District in Riverside County, would be minimally impacted. The public agency would need to conduct monitoring, recordkeeping, and reporting. The annual cost to the public agency is estimated to be $600.

VII.B. ECONOMIC IMPACT ANALYSIS AS REQUIRED BY THE ADMINISTRATIVE PROCEDURE ACT

1. Legal Requirements

Section 11346.3 of the Government Code requires State agencies to assess the potential for adverse economic impacts on California business enterprises and individuals when proposing to adopt or amend any administrative regulation. The assessment shall include a consideration of the impact of the proposed regulation on California's jobs, business expansion, elimination or creation, and the ability of California businesses to compete with businesses in other states.

In addition, State agencies are required to estimate the cost or savings to any State or local agency and school district in accordance with instructions adopted by the Department of Finance. The estimate shall include any non-discretionary cost or savings to local agencies and the cost or savings in federal funding to the State.

Health and Safety Code section 57005 requires the ARB to perform an economic impact analysis of submitted alternatives to a proposed regulation before adopting any major regulation. The proposed ATCM is not considered to be a “major regulation”, because the estimated cost to California business enterprises does not exceed 10 million dollars in any single year.

2. Affected Businesses

Any business operating a thermal spraying device that uses materials containing chromium, chromium compounds, nickel, or nickel compounds would be affected by the proposed ATCM. Also potentially affected are businesses that are customers of thermal spraying facilities, such as the aerospace and electronics industries. The focus of this analysis, however, will be on thermal spraying facilities because these businesses would be directly affected by the proposed ATCM.

The affected businesses fall under a number of Standard Industrial Classification (SIC) and North American Industry Classification System (NAICS) codes. A list of these codes is provided in Table VII-1.

Table VII-1: List of Industries with Affected Facilities

SIC Code	NAICS Code	Description
2851	32551	Paints and Allied Products
3471	332813	Plating and Polishing
3479	333812	Metal Coating and Allied Services *
3599	333999	Industrial Machinery And Equipment, NEC *
3679	334419	Electronic Components, NEC
3721	336411	Aircraft Manufacturing
4581	488119	Airports, Flying Fields, and Services
7349	56179	Building Maintenance Services, NEC
7694	335312	Armature Rewinding Shops Repair *
7699	81131	Repair Services, NEC *

* A total of six facilities in these categories are expected to need control device upgrades to comply with the proposed ATCM. The cost to install and operate controls may result in a significant economic impact for these facilities.

3. Potential Impacts on Profitability for Affected Businesses

The approach used in evaluating the potential economic impact of the proposed ATCM on California businesses is as follows:

- All affected facilities are identified from responses to the ARB's 2004 Thermal Spraying Facility Survey (ARB, 2004c.) Standard Industrial Classification (SIC) codes associated with these businesses are listed in Table VII-1 above.

- Dun and Bradstreet 2002-2003 financial data and net profit data are identified for typical businesses in each affected industry (Dun, 2003).

- The annual cost of compliance is estimated for the businesses that are affected by the proposed ATCM.

- The annual cost of compliance for each business is adjusted for both federal and state taxes.

- These adjusted business costs are subtracted from net profit data (Dun and Bradstreet) and the results are used to recalculate the ROE.

- The resulting ROE is then compared with the ROE before the subtraction of the adjusted fees to determine the impact on the profitability of the businesses. A reduction of more than 10 percent in profitability is considered to indicate a potential for significant adverse economic impacts. This threshold is consistent with the thresholds used by the U.S. EPA and the ARB in previous regulations.

California businesses are affected by the proposed ATCM to the extent that the implementation of the regulation reduces their profitability. Using ROE to measure profitability, we estimate the decline in ROE for most affected businesses would be less than five percent based on 2002-3 financial data. This does not represent a noticeable decline in the profitability of most affected businesses. However, for the six businesses that would be required to install HEPA filters, dry filters, or water curtains the estimated decline in profitability ranges from 16 to 68 percent. Four of these businesses are expected to cease thermal spraying instead of installing control devices because it provides a small fraction of their revenue.

One of the two remaining businesses required to install control devices could incur a significant adverse cost impact. This business could experience a decline in profitability of 68 percent if they installed one HEPA system for three spray booths to comply with the ATCM. Based on information provided by the facility, we believe that one HEPA system for three spray booths would be sufficient to accommodate the quantities of chromium- and nickel-based materials being used at the facility. However, if the business chose to install three HEPA systems for nine spray booths, the estimated decline in profitability is 202 percent. This business poses the greatest health risk of all the thermal spraying facilities in California. The other remaining business which does small amounts of thermal spraying, indicated it would pass the cost of controls on to its customers to minimize the cost impacts. However, the overall cost impact on its customers is not expected to be significant.

The remaining 31 businesses are required to obtain or modify permits, conduct monitoring, and maintain records. The decline in profitability for these businesses ranged from 0.1 to 4.6 percent. This magnitude of change in profitability is not considered to be significant.

4. Assumptions for Business Profitability Analysis

The business profitability ROE calculations were based on the following assumptions.

- All affected businesses are subject to federal and State tax rates of 35 percent and 9.3 percent, respectively.

- Affected businesses absorb the costs of the proposed ATCM instead of increasing the prices of their products or lowering their costs of doing business through cost-cutting measures.

5. Potential Economic Impacts for Individual Thermal Spraying Facilities

We have identified 37 thermal spraying facilities in California that use materials containing chromium or nickel. Thirty-four are businesses, two are federal government facilities, and one is a local government facility. The two federal facilities are the U.S. Naval Aviation Depot and the 32nd Street Naval Station, both in the San Diego area. The local government facility is the Eastern Municipal Water District in Riverside County. Twenty-six of the 34 affected businesses are small businesses (<100 employees). Twenty-four facilities already meet the best available control technology (BACT) requirements, and would only need to obtain or modify their permit, report their emissions, and meet monitoring and recordkeeping requirements. We estimate the cost of obtaining an air permit to be $2,232, and the annual permit fees to be $246. This represents the upper range of costs that could be incurred by the permitting process, as most districts have permit application and annual fees that are less than the figures used in this analysis. We estimate the cost to keep records as specified in the proposed ATCM to be $600 per year. This includes the cost of labor to track emissions and to submit this information to the districts. Annualized costs for these facilities range from $600 per year for facilities which would only need to keep records, to $1,362 per year for facilities that would need to obtain a new permit, keep records and pay annual permit fees. The initial permit costs are annualized over five years.

We estimate that nine facilities may qualify for the standard for remotely located thermal spraying operations. Seven of these facilities are expected to meet the 90 percent control efficiency standard with their existing control devices. These facilities may need to obtain a new permit or modify their existing permit in addition to keeping records and reporting emissions annually. The cost for these facilities ranges from $600 annually for facilities that would only need to start keeping records and report emissions, to an annualized cost of $1,362, which would cover recordkeeping, reporting and permitting costs. Two facilities may need to install a control device such as a water curtain. The annual cost for these facilities is estimated to be $5,000 per facility.

For the six facilities needing to install new control devices, the cost is estimated to be $629,200 to $1,152,800 for initial capital costs (including installation) and $33,600 to $72,000 in annual recurring costs. This equates to an annualized cost of $118,000 to $226,900 in 2004 dollars over the life of the equipment. The estimated costs for individual facilities installing new control devices range from $28,600 for initial capital costs and $1,200 in annual recurring costs for a facility with low material usage installing a water curtain system, up to $787,700 for initial capital costs and $58,200 in annual recurring costs for a larger facility installing three HEPA systems to control emissions from nine spray booths.

6. Assumptions for Facility Cost Estimates

The facility cost estimates are based on the following assumptions. First, we assumed that facilities that need to meet the 99.999 percent control efficiency requirement will install a dry cartridge filter system. We also assumed that facilities that need to meet the 99.97 percent control efficiency requirement will install a dry cartridge filter system with a HEPA filter unit. We assumed that the two uncontrolled facilities that may qualify for the 90 percent standard for remotely located thermal spraying operations would install a water curtain.

We also assumed that installation would not require any special modification to the facility, which could significantly increase the installation costs. We assumed that three filters will fit in a 55-gallon drum for disposal purposes (Jettan, 2004; Donaldson 2004), and that the hopper discharge collection drum containing particles released from the filter system's self-cleaning cycle is disposed when the filters are changed. The cost of labor to operate the filter systems was assumed to be negligible. A sales tax of 8.25% was added to the cost of the filter systems (BOE, 2004).

We annualized non-recurring fixed costs using the Capital Recovery Method. Using this method, we multiplied the non-recurring fixed costs by the Capital Recovery Factor (CRF) to convert these costs into equal annual payments over a project horizon at a discount rate. The Capital Recovery Method for annualizing fixed costs is recommended by Cal/EPA (Cal/EPA, 1996), and is consistent with the methodology used in previous cost analyses for ARB regulations (ARB, 2000a; ARB, 2000b).

The CRF is calculated as follows:

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

where,

CRF	=	*Capital Recovery Factor*
i	=	*discount interest rate (assumed to be 5%)*
n	=	*project horizon or useful life of equipment*

All costs of the control devices were annualized over 10 years, except the cost of the blower, which was annualized over five years. These values are based on a conservative estimate of the expected lifetime of the equipment. The permit application or renewal fees were annualized over five years. The total annualized cost was obtained by adding the annual recurring costs to the annualized fixed costs derived by the Capital Recovery Method.

The annual recurring cost estimates assuming all six facilities subject to control requirements elect to install new control devices, were based on discussions with control equipment manufacturers, hazardous waste disposal companies, and published prices for filters and electricity. Recurring costs include replacement filters, disposal of filters and hopper discharge collection drums, electrical usage, annual permit fees, monitoring, recordkeeping and reporting costs (Donaldson, 2004; Jettan, 2004; Gottes, 2004; BLS, 2004). More details of these costs can be found in Appendix G.

7. Potential Impact on Manufacturers of Thermal Spraying Materials and Suppliers

We do not expect manufacturers of thermal spraying materials to incur any costs, because the proposed ATCM does not regulate material formulations. However, it is possible that some thermal spraying facilities will choose to discontinue their use of materials that contain chromium and nickel, rather than install control devices. It is not expected that this potential decline in material usage will have a significant economic impact, because our research indicates that only facilities with very low usage levels are considering the elimination of chromium and nickel-based materials.

8. Potential Impact on Consumers

The potential impact of the proposed ATCM on consumers depends upon the extent to which affected businesses are able to pass on the increased cost to consumers in terms of higher prices for their goods and services. Given the small impact of the proposed ATCM on the profitability of most affected thermal spraying businesses, we do not expect a noticeable change in the prices of goods and services provided by these businesses. We anticipate the impact, if any, on consumers to be negligible.

9. Potential Impact on Employment

Of the 37 affected businesses, 35 provided employee data and they reported a total of 120 employees that perform thermal spraying. These 35 businesses also reported a total job base of 14,222 employees. We expect the proposed ATCM to have a minimal impact on most of the employees that do thermal spraying. Approximately one-third of the affected employees spend less than one hour per day performing thermal spraying and most affected employees spend less than four hours per day on thermal spraying tasks. Nonetheless, the ATCM may impose hardship on six businesses if they elect to continue thermal spraying operations. These six businesses have 13 employees who do thermal spraying. Of the six businesses, we expect four to cease using materials containing chromium or nickel or cease their thermal spraying operations completely. For these four businesses, thermal spraying provides a minor portion (<5 percent) of their overall gross revenue and less than one hour per day is spent on thermal spraying. If these four businesses decide to cease their thermal spraying operations, the workload for four employees is likely to be affected, but the employees are not expected to lose their jobs.

10. Potential Impact on Business Creation, Elimination or Expansion

The proposed ATCM would have no noticeable impact on the status of California businesses. The compliance costs of the proposed ATCM are expected to be minor for most thermal spraying operators as demonstrated above by small impacts on the profitability of most affected businesses. Only one business that is required to install HEPA filters is likely to be affected adversely. The other businesses subject to control requirements are expected to pass the cost on to their customers or cease the operations of their thermal spraying units and shift the resources to other parts of their business.

11. Potential Impact on Business Competitiveness

The proposed ATCM is not expected to have a significant impact on the ability of California businesses to compete with businesses from another state. Most thermal spraying businesses are independent operations (e.g., machine shops, job shops) who compete for local business within their region and rarely seek business from outside the State. In addition, many thermal spraying operations are conducted as internal support services for manufacturing or repair businesses and they don't compete with external thermal spraying businesses from outside the State. As indicated above, one business that is a large dedicated thermal spraying operation could be affected adversely by the proposed ATCM.

12. Costs to Public Agencies

Health and Safety Code (HSC) section 39666 requires that, after the adoption of the proposed ATCM by the Board, the air districts must implement and enforce the ATCM or adopt an equally effective or more stringent regulation. Because the air districts will have primary responsibility for implementing and enforcing the proposed ATCM, we evaluated the potential cost to the air districts. We also evaluated the potential cost to local and State agencies. This section provides the conclusions we reached and the basis for those conclusions.

We expect one local public agency that performs thermal spraying using materials that contain chromium or nickel to be minimally impacted. The annual cost to this agency, the Eastern Municipal Water District in Riverside County, is estimated to be $600. These costs are not State-mandated costs that are required to be reimbursed under State law, because the proposed ATCM applies generally to all thermal spraying facilities that use chromium or nickel in the State and does not impose unique requirements on local agencies.

The thermal spraying facilities affected by the proposed ATCM are located in six air districts, as shown in Table VII-2. Most of the facilities are located in the South Coast Air Quality Management District (AQMD), San Diego County Air Pollution Control District (APCD), and the Bay Area AQMD.

Table VII-2: Location of Thermal Spraying Facilities in California		
Location	**Affected Facility**	**Percent**
Bay Area AQMD	6	16
Feather River AQMD	1	3
South Coast AQMD	18	49
San Diego APCD	7	20
San Joaquin Valley APCD	3	8
Ventura County APCD	2	5
Total	**37**	**100**

The costs to districts from the proposed ATCM would be incurred through permitting, inspections, annual inventory reviews, and coordinating stack testing, if necessary. Districts that do not currently permit thermal spraying facilities would incur costs, which the districts can recover through fees charged to the facilities. The total increased cost for six districts is expected to be approximately $60,200. This is based on an estimated cost of approximately $2,232 per facility to process applications for new and modified permits for 25 facilities. In addition, we estimated that it would cost approximately $246 per facility to conduct annual inspections and permit reviews for 18 facilities that currently do not have permits. The costs to the districts can be recovered under the fee provisions authorized by HSC sections 42311 and 40510. Therefore, the proposed ATCM imposes no costs on the districts that are required to be reimbursed pursuant to Section 6 of Article XIIIB of the California Constitution and Part 7 (commencing with section 17500), division 4, title 2 of the Government Code.

The proposed ATCM for thermal spraying facilities will not affect any State agency or program other than the ARB. Although the districts will have primary responsibility for enforcing the proposed ATCM, the ARB may, at the request of a district, provide technical expertise, legal support, or other enforcement support, as needed, to assist in the enforcement of the proposed ATCM. We do not expect requests for assistance on a regular basis. All costs incurred from this rulemaking action would be minimal and absorbable within the existing ARB budget.

13. Total Cost of the Proposed Airborne Toxic Control Measure

Based on information provided in the ARB’s 2004 Thermal Spraying Facilities Survey and discussions with thermal spraying facilities and filter manufacturers, we estimated the total cost of the proposed ATCM. The total cost ranges from $672,000 to $1,195,000 in initial capital and permitting costs and $55,000 to $94,000 in annual recurring costs. This corresponds to a total annualized cost of $150,000 to $257,000 over the life of the regulation.

The cost ranges represent minimum and maximum costs associated with the one facility that would need to upgrade from water curtains to a HEPA filter. Based on information provided by the facility, we believe that one HEPA system for three spray booths would be sufficient to accommodate the quantities of chromium- and nickel-based materials being used at the facility and comply with the proposed ATCM. This situation is reflected in the lower end of the cost ranges provided above. If the business chose to install three HEPA systems for nine spray booths, to provide maximum operational flexibility, the costs would be greater, as represented by the upper end of the cost ranges provided above. However, the expenditure for upgrading nine spray booths would be a business decision that is not mandated by the proposed ATCM.

These cost estimates include the cost of purchasing and installing control equipment, as well as the cost of replacing the filters regularly. We also accounted for the operating costs for electricity, disposal, permitting, reporting and recordkeeping (see Appendix G).

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VIII. ENVIRONMENTAL IMPACTS OF PROPOSED AIRBORNE TOXIC CONTROL MEASURE

The intent of the proposed ATCM is to protect public health by reducing public exposure to emissions of hexavalent chromium and nickel. An additional consideration is the impact that the proposed ATCM may have on the environment. This chapter describes the potential impacts that the proposed ATCM may have on air quality, wastewater treatment, and hazardous waste disposal. Based upon available information, the ARB staff has determined that no significant adverse environmental impacts should occur as a result of adopting the proposed ATCM.

VIII.A. LEGAL REQUIREMENTS APPLICABLE TO THE ENVIRONMENTAL IMPACT ANALYSIS

The California Environmental Quality Act (CEQA) and ARB policy require an analysis to determine the potential environmental impacts of proposed regulations. ARB's program for adopting regulations has been certified by the Secretary of Resources, pursuant to Public Resources Code section 21080.5. Consequently, the CEQA environmental analysis requirements may be included in the Initial Statement of Reasons (ISOR) for this rulemaking. In the ISOR, the ARB must include a functionally equivalent document, rather than adhering to the format described in CEQA of an Initial Study, a Negative Declaration, and an Environmental Impact Report. In addition, staff will respond in the Final Statement of Reasons for the proposed ATCM to all significant environmental issues raised by the public during the 45-day public review period or at the Board hearing.

Public Resources Code section 21159 requires that the environmental impact analysis conducted by ARB include the following:

- An analysis of reasonably foreseeable environmental impacts of the methods of compliance;
- An analysis of reasonably foreseeable feasible mitigation measures; and
- An analysis of reasonably foreseeable alternative means of compliance with the proposed ATCM.

Compliance with the proposed ATCM is expected to directly affect air quality and potentially affect other environmental media as well. Our analysis of the reasonably foreseeable environmental impacts of the methods of compliance is presented below.

VIII.B. ANALYSIS OF REASONABLY FORESEEABLE ENVIRONMENTAL IMPACTS OF THE METHODS OF COMPLIANCE

1. Potential Air Quality Impacts

The proposed ATCM is expected to have a positive impact on air quality. The regulation will improve air quality by reducing emissions of hexavalent chromium and nickel throughout California, including urban areas and those areas that are non-attainment for the State and federal ambient air quality standards for PM_{10} and $PM_{2.5}$.

As previously discussed, hexavalent chromium and nickel are found in the particulate emissions from thermal spraying operations. Thus, thermal spraying should be performed inside a booth equipped with a ventilation system sufficient to draw the air from the booth through a control device that captures particulates. Most thermal spraying facilities exhaust the work area and booth air to the outside.

For the proposed thermal spraying ATCM, we estimated the potential emission reductions based on data from the ARB 2004 Thermal Spraying Facility Survey, the ARB 2003 Thermal Spraying Materials Survey, and the proposed ATCM control efficiency requirements. Implementation of this thermal spraying ATCM is expected to achieve significant emission reductions. For a facility with no existing control devices, the proposed ATCM would require at least a 99% reduction in emissions. For the largest facility in the State, the proposed ATCM would require that the control device efficiency be increased from a minimum of 81% to at least 99.97%. Overall, the proposed ATCM is expected to reduce hexavalent chromium emissions by approximately 80 percent (7 to 50 lbs/yr) and nickel emissions by approximately 50 percent (54 to 377 lbs/yr) from thermal spraying operations. These reductions will occur in six air districts, with the greatest benefits occurring in the SCAQMD and BAAQMD.

The proposed ATCM establishes emission standards that reflect the use of BACT and are designed to ensure that the potential cancer risk from hexavalent chromium and nickel does not exceed 10 in a million and the chronic hazard index does not exceed one. In addition, the proposed ATCM includes hourly emission limits for nickel that have been established to make sure that the acute hazard quotient does not exceed one.

The California Department of Industrial Relations, Division of Occupational Safety and Health Administration (Cal/OSHA) regulates the concentration of many TACs in the workplace environment. To protect worker safety, Cal/OSHA has established a permissible exposure limit (PEL) for many TACs. The PEL is the maximum, eight-hour, time-weighted average concentration for occupational exposure and is 0.1 mg/m^3 for hexavalent chromium, and 1 mg/m^3 for nickel (CCR, 2002). The proposed ATCM will require ventilation systems that will reduce worker exposure and will result in a reduction in hexavalent chromium and nickel emissions. Therefore, a decrease in workplace exposure and ambient air exposure from TAC emissions is expected.

2. Potential Wastewater Impacts

The Water Resources Control Board regulates wastewater in California. In California, it is illegal to dispose of wastewater containing hazardous substances in the sewer system. Discharge of wastewater from thermal spraying facilities to a sanitary sewer can result in metals such as hexavalent chromium and nickel accumulating in sewage treatment sludge, preventing its beneficial use. Some contaminants "pass through" and are discharged to lakes, rivers, bays, and oceans.

Although the practice is illegal, facility operators may introduce hazardous substances to the sewer system by washing down areas containing overspray and allowing that water to enter the sewer system. The requirement in the proposed ATCM to capture a greater percentage of these hazardous substances from thermal spraying operations should reduce the amount of these metals deposited into sewer systems and storm drains.

Most thermal spraying coating waste is a result of over spray and is collected primarily on the spray booth exhaust filter or in floor sweepings. However, thermal spraying facilities may also generate coating-contaminated masking supplies. These dry coating related wastes are potentially hazardous if they contain hexavalent chromium or nickel. If these wastes are landfilled, metals may leach out of the waste into the groundwater. While the proposed ATCM has no direct impact on waste disposal, it is anticipated that adoption and enforcement of the proposed ATCM will result in increased awareness of proper disposal methods by owners and operators of thermal spraying facilities, resulting in less hazardous wastes being landfilled.

3. Potential Hazardous Waste Impacts

Hazardous waste is regulated in California by federal and State laws. In California, all hazardous waste must be disposed of at a facility that is registered with the Department of Toxic Substances Control (DTSC). Under these programs, thermal spraying wastes would be classified as hazardous waste if they contain substances listed as toxic, such as hexavalent chromium and nickel.

Because TACs would otherwise be released into the air, this ATCM will benefit the environment by capturing a greater portion of these metallic particles. However, the particles collected by the control device must be removed periodically to maintain the effectiveness of the control device.

Thermal spraying facilities that have filter-type control systems also generate exhaust filters that may contain hexavalent chromium or nickel. Booth exhaust filters are typically changed once per year, but may be changed more or less often depending on the amount of thermal spraying being done. The waste filters may need to be tested for toxicity characteristics. The "*Toxicity Characteristic*

Leaching Procedure" (TCLP) is used to determine if the filters contain toxic metals. Hexavalent chromium and nickel are among the compounds for which testing is required. Filters containing these metals are typically disposed of as hazardous waste. While it is anticipated that there will be an increase in the amount of spray booth filters disposed of as hazardous waste, it is not expected to be a significant increase. This is due to the fact that most thermal spraying facilities already have control devices and are currently disposing of dry filters. The proposed ATCM would only require up to four facilities to install new dry filter systems, which would result in a new hazardous wastestream for these facilities. Of these four facilities, three facilities are expected to cease their thermal spraying operations that use chromium and nickel-containing materials, which would mean that no additional filters would need to be disposed at these facilities. The fourth facility currently operates water curtain booths that generate hazardous waste in the form of sludge. It is not expected that the quantity of filters being disposed will be substantially greater than the quantity of sludge currently being disposed.

Some thermal spraying facilities generate hazardous waste in the form of metal sludge from water curtain booths. The proposed ATCM is expected to result in a small decrease in the quantity of metal sludge disposed as hazardous waste, as some water curtain booths are upgraded to more efficient dry filter systems.

4. Reasonably Foreseeable Mitigation Measures

CEQA requires an agency to identify and adopt feasible mitigation measures that would minimize any significant adverse environmental impacts described in the environmental analysis. The ARB staff has concluded that no significant adverse environmental impacts should occur from adoption of and compliance with the proposed ATCM. Therefore, no mitigation measures would be necessary.

5. Reasonably Foreseeable Alternative Means of Compliance With the Proposed Airborne Toxic Control Measure

Alternatives to the Proposed ATCM are discussed in Chapter VI of this ISOR. The ARB staff has concluded that the proposed ATCM provides the most effective and least burdensome approach to reducing the public's exposure to hexavalent chromium and nickel emitted from thermal spraying operations.

VIII.C. COMMUNITY HEALTH AND ENVIRONMENTAL JUSTICE

Environmental Justice is defined as the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies. The ARB is committed to integrating environmental justice into all of our activities. On December 13, 2001, the Board approved "Policies and Actions for Environmental Justice," which formally established a framework for incorporating Environmental Justice into the ARB's programs, consistent with the directive of California state law. These policies apply to all communities in California. However, environmental justice issues have been raised specifically in the context of low-income areas and ethnically diverse communities.

The Environmental Justice Policies are intended to promote the fair treatment of all Californians and cover the full spectrum of the ARB's activities. Underlying these Policies is a recognition that the agency needs to engage community members in a meaningful way as it carries out its activities. People should have the best possible information about the air they breathe and what is being done to reduce unhealthful air pollution in their communities. The ARB recognizes its obligation to work closely with all communities, environmental and public health organizations, industry, business owners, other agencies, and all other interested parties to successfully implement these Policies.

During the ATCM development process, the ARB staff proactively identified and contacted representatives from thermal spraying materials manufacturers and thermal spraying operations, environmental organizations, and other parties interested in thermal spraying. These individuals participated by providing data, reviewing draft regulations, and attending public meetings in which staff directly addressed their concerns.

The proposed ATCM is consistent with our environmental justice policy to reduce health risks from toxic air pollutants in all communities, including those with low-income and ethnically diverse populations, regardless of location. Potential risks from thermal spraying can affect both urban and rural communities. Therefore, reducing emissions of toxic air pollutants from thermal spraying operations will provide air quality benefits to urban and rural communities in the State, including low-income areas and ethnically diverse communities.

To address environmental justice and general concerns about the public's exposure to hexavalent chromium emissions, the proposed ATCM establishes criteria for the operation of new thermal spraying facilities that use materials containing chromium or nickel. New facilities would be required to install HEPA filters (or equivalent). In addition, a new thermal spraying facility cannot operate unless it is located outside of a residential or mixed use zone and is located at least 500 feet from the border of a residential or mixed use zone. Also, new thermal spraying facilities would be required to undergo a site-specific analysis to ensure adequate protection of public health. These criteria will help ensure that new thermal spraying operations are not operated in environmental justice communities with residential areas. These operational limitations only apply to new thermal spraying operations that use materials containing chromium or nickel. We believe these criteria are necessary for new thermal spraying facilities because hexavalent chromium is a potent carcinogen, and short-term exposure to nickel can cause acute health impacts. While we believe these precautions are necessary for thermal spraying sources of hexavalent chromium and nickel, due to extreme toxicity and acute health effects, similar requirements may not be appropriate for sources of other TACs. Each TAC should be evaluated on a case by case basis to ensure public health protection.

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