



How to protect workers while thermal metal spraying

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A worker dies after applying thermal metal sprays

In 2003, a worker died in Oregon shortly after spending two days applying chromium- and nickel-based thermal sprays at a worksite in Washington State.

The victim developed progressive symptoms of fatigue, shortness of breath and cough. He was found dead by a family member in his home. His post-mortem examination revealed lung damage consistent with toxic exposure.

The victim had been applying the thermal metal sprays using portable equipment at a temporary worksite with inadequate ventilation. He was not wearing a suitable respirator and other personal protective equipment (PPE) when he did the work.

The employer was cited by Oregon-OSHA for the following violations:

- ◆ No exposure assessment was conducted;
- ◆ Wrong respirator provided, worn incorrectly, with a beard;
- ◆ Overexposures to nickel, chromium, carbon monoxide; and
- ◆ No engineering controls provided.

A worker died in 2003 after applying thermal metal sprays. Please read the information contained in this pamphlet – it could save a life!

What is thermal metal spraying?

The term “thermal metal spraying” refers to a process in which metals are melted and sprayed on a surface to form a coating. The metals may be melted using combustion (i.e., oxyfuel) or electrical processes (i.e., arc, plasma arc, or plasma induction). The sprayed metals can be pure metals or alloys in the form of powders, wires, or rods.

Other names for thermal metal spraying include flame spraying, metal spraying, plasma spraying, electric arc spraying, metallizing, and hardfacing.

Where is thermal metal spraying used?

Thermal metal spraying may be used to build up worn parts, apply a corrosion-resistant layer or to apply soldering or brazing filler metals. The process has found wide application in several industries, including:

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| ▪ Aerospace | ▪ Machine shops | ▪ Power plants |
| ▪ Agriculture | ▪ Marine | ▪ Pulp and paper |
| ▪ Automotive | ▪ Medical | ▪ Steel mills |
| ▪ Computers | ▪ Military | ▪ Textile |
| ▪ Electronics | ▪ Oil and gas
exploration and
refining | ▪ Transportation |

Why is thermal metal spraying hazardous?

The high temperatures, velocity, and projectile distance of the spraying process create a unique set of health and safety hazards for the operator and those nearby.

The use of portable thermal spray equipment for repair and maintenance work is particularly hazardous. These tasks are often performed at temporary worksites characterized by enclosed or confined spaces that do not have adequate ventilation or other means of controlling employee exposure.

The hazards posed to operators, helpers and others in the vicinity of thermal metal spraying operations include:

- **Metal fumes.** The potential for exposure to toxic metal fumes is common to all types of thermal metal spraying. Depending on the particular coating being applied, harmful levels of chromium, cobalt, nickel, lead, cadmium, and other metal fumes can be generated.
- **Gases.** The spray effluent may contain asphyxiating gases (argon, nitrogen, hydrogen, and helium), water/steam, carbon monoxide, carbon dioxide, nitrogen oxides, and potentially uncombusted fuel gases (acetylene, hydrogen, methane, propane, or propylene), depending on the specific process used. The high temperatures involved in thermal arc and plasma spraying processes can generate ozone. Carbon monoxide may also be a concern if the power generator is located inside a poorly ventilated workspace. Nickel carbonyl (a neurological and respiratory toxin that also causes cancer in laboratory animals) may be produced by the combination of fine nickel particles and carbon monoxide. Poisonous phosgene gas can be produced when chlorinated hydrocarbon vapors (from degreasing solvents) are exposed to ultraviolet radiation from these processes.

- **Dusts.** The fine metallic powders frequently used in thermal metal spraying are both an explosive and inhalation hazard.
- **Noise.** The noise generated by all thermal spraying techniques results in significant noise exposure, ranging from 88 decibels (dBA) to over 130 dBA.
- **Non-ionizing radiation.** These processes generate intense ultraviolet (UV) and infrared (IR) radiation that can damage the eyes and skin.
- **Other hazards** include electrical hazards (shock and electrocution from plasma equipment), burns (freeze burns from liquefied oxygen lines as well as thermal burns from handling hot metal), mechanical hazards, fire hazards, compressed gases, strong magnetic fields, and subaudible sound (infrasound).

How do I protect my workers and myself?

Owners and operators of thermal metal spraying equipment should contact their equipment manufacturer and spray material suppliers to ensure that the equipment is being used according to recommended operating parameters. These parameters may include work piece pre-heat, distance from metal spraying gun to work piece, and power supply settings.

Due to the numerous hazards associated with this process, it is not possible to describe all the control measures that apply to thermal metal spraying in this document. See the **Sources of information** section at the end of this document for additional resources.

In summary, the following control measures are recommended for thermal metal spraying:

Metal fumes, dusts, and gases:

- ✓ Where feasible, provide local exhaust ventilation to remove contaminants from the air. The system must be carefully designed to

ensure that it will adequately capture contaminants and must be cleaned and serviced periodically to ensure optimal ventilation efficiency. Electrostatic precipitation or wet collection of overspray may be used to scrub the exhausted air stream. Emissions limits imposed by environmental agencies may influence the choice of technology used to capture and contain contaminants. HEPA filters may be required if working with relatively toxic materials.

- ✓ Conduct air sampling to characterize workers' exposure to airborne contaminants. Thermal metal spraying can generate metal fumes, dusts, gases, and vapors at concentrations that exceed their respective Permissible Exposure Limits (PELs).
- ✓ Establish a respiratory protection program. This means medical screening of workers, proper selection and fitting of respirators, and worker training. Correct respirator storage and cleaning and an evaluation of the program are needed.
- ✓ Positive-pressure, air-supplied respirators are recommended when spraying toxic metals and should be provided to the operator and any helpers.
- ✓ Ensure that workers are not exposed to exhaust gases from the thermal metal sprayer's power generator. Power generators should be located and operated outside the building in a well ventilated area. This is essential to minimize the risk from carbon monoxide and also to avoid the creation of nickel carbonyl.

Noise:

- ✓ Establish a hearing conservation program that includes audiometric testing, noise monitoring, hearing protection devices, training, and recordkeeping.

Radiation:

- ✓ Protect workers from the effects of non-ionizing radiation by providing appropriate protection for their eyes and skin. Operators and helpers should be provided with

appropriate eye protection and tight woven protective clothing, including gloves and coveralls. Tinted welding curtains and screens will help prevent exposure of nearby workers.

Safety:

- ✓ Protect workers from the risk of electrocution by following the manufacturer's set-up and installation instructions for the equipment. Train all personnel using thermal metal spraying equipment to reduce the risk of electrical accidents.
- ✓ Keep work surfaces clean and dust free. A vacuum cleaner equipped with a HEPA filter will capture the smallest dust particles and help control dust deposits.
- ✓ To reduce fire hazards, remove combustibles from the work area and remove or isolate any ignition source not required for spraying.
- ✓ Ensure that compressed gases are handled and stored safely.

Promote good hygiene:

- ✓ Provide workers with work clothing, coveralls, and other PPE for use at work. Do not allow workers to take their work clothing home. Either launder clothing on-site or use a commercial laundry service.
- ✓ Do not allow workers to eat, drink, or use tobacco products in the work area. Workers should be provided with facilities where they can wash up and take breaks. Ensure that they wash their hands and any other exposed skin before their breaks.
- ✓ Provide showers and clothing change facilities.

Other WISHA requirements and rules may apply.

**Clean up and leave contaminated clothing at work!
Don't take dust that contains lead, cadmium, chromium, and other toxic metals home to your family!**

Sources of information

Books:

- “Handbook of Thermal Spray Technology”, Edited by J.R. Davis. September 2004. Thermal Spray Society and ASM International.
- “Recognition of Health Hazards in Industry: A Review of Materials Processes,” 2nd Edition by William A. Burgess. Chapter 14: Metal Thermal Spraying. January 1995. John Wiley & Sons.
- “Welding Health and Safety: A Field Guide for OEHs Professionals” by Michael K. Harris. Chapter 24: Thermal Spraying. September 2002. The American Industrial Hygiene Association.

On-line resources:

- American Welding Society Safety & Health Fact Sheets:
www.aws.org/technical/facts/index.html
- American Welding Society Fact Sheet No. 20: “Thermal Spraying Safety”:
www.aws.org/technical/facts/FACT-20.PDF
- California Air Resources Board Fact Sheet: “Thermal Spraying”:
www.arb.ca.gov/coatings/thermal/factsheets/factsheetthermalspry.pdf
- Haz-Map database entry for “Metal Thermal Spraying”: http://hazmap.nlm.nih.gov/cgi-bin/hazmap_generic?tbl=TblProcesses&id=67
- NIOSH Health Hazard Evaluation Report No. HETA-88-136-1945, “Miller Thermal Technologies, Inc., Appleton, Wisconsin”:
www.cdc.gov/niosh/hhe/reports/pdfs/1988-0136-1945.pdf
- OSHA Safety and Health Topics: “Welding, Cutting, and Brazing”:
www.osha.gov/SLTC/weldingcuttingbrazing/index.html

- Thermal Spray Society Safety Guidelines:
www.asminternational.org/MSTemplate.cfm?Section=Safety_Guidelines&Site=Thermal_Spray_Society&Template=/ContentManagement/ContentDisplay.cfm&ContentID=3821

L&I’s WISHA Services:

The Washington State Department of Labor & Industries (L&I) enforces Washington State’s workplace health and safety standards. L&I offers free assistance and information to both employers and employees upon request. L&I also investigates complaints from workers. Call 1-800-4BESAFE (1-800-423-7233). Visit L&I’s Safety web site at www.lni.wa.gov/Safety/.

Yellow Page Headings

- Industrial Hygiene Consultants
- Safety Equipment and Clothing (respirators, coveralls, etc.)

SHARP - Promoting Safer, Healthier Workplaces

This pamphlet was produced by the Safety & Health Assessment & Research for Prevention (SHARP) program - an independent research program within the Washington State Department of Labor & Industries. Our mission is to conduct research, monitoring, and demonstration projects that promote healthy work environments and the prevention of workplace injuries and illnesses.

If you have questions about this pamphlet, the SHARP program, or require assistance, please contact us at:

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