OSHA Hexavalent Chromium Regulation

Daryl Crawmer
Thermal Spray Technologies Incorporated
Fall River, Wisconsin

There is a buzz among thermal sprayers and other industries about the newly adopted regulation concerning workplace exposure to hexavalent chromium or hex chrome, chrome 6, Cr+6, and other commonly used terms. OSHA has proposed, adopted, and instituted new limits on exposure, which effectively reduced the permissible exposure by a factor of ten.

Hexavalent chromium is a known carcinogen that can attack the respiratory system and in some forms attack the skin; when ingested, large doses are also a health concern. The primary concern for thermal sprayers is airborne particulate and fumes.

Studies show that Cr+6 can be produced by plasma-arc, flame (including HVOF), and electric-arc spray processes. Almost any chromium-bearing material can produce the hexavalent state when exposed to the high energy levels associated with thermal spray process. Chromium oxide, MCrAlY's, nickel-chrome, and other common materials produce hex chrome when sprayed.

Background

On February 28, 2006, OSHA regulation CFR 29 1910.1026 became law. This new regulation has been in the works since 1992 when the Oil, Chemical, and Atomic Workers International Union and Public Citizen's Health Research Group first petitioned OSHA to implement an emergency temporary standard to reduce worker exposure to 0.5? mg/m^3. At that time, the OSHA PEL (permissible exposure limit) for airborne hexavalent chromium was is 52 mg/m^3.

Leaving out the politics of what followed and getting straight to the point, in 2004 a proposed new standard for workplace exposure the chrome 6 was put forward for public comment. The proposal was to lower the PEL to 1 mg/m3 from the existing 52 mg/m^3. That proposal was to have entered into the federal register on January 18, 2006. Adoption of the regulation was delayed until February 28, 2006 and went into effect, on that date, without fanfare or the anticipated legal backlash from either side of the argument.

Action level and permissible exposure limit

When it was finally adopted, the limit was set at 5 mg/m^3. Another important number is the "action level" of 2.5 mg/m^3. Action levels in OSHA regulations trigger activities, which will be covered further down the page.

Understand, this regulation was written around and appears to have been targeted toward electroplating, chromate spraying, welding, and general construction. There is no specific mention of thermal spray. However, the first line of the regulation states: "This standard applies to occupational exposures to chromium (VI) in all forms and compounds in general industry, …" §1910.1026(a)(1) and "Chromium (VI) [hexavalent chromium or Cr(VI)] means chromium with a valence of positive six, in any form and in any compound." §1910.1026(b).

Key dates

Here are the key dates and discussion on how the new regulation affects thermal sprayers. On February 28, 2006, 29 CFR 1910.1026 was entered into the Federal Register. The effective date for the law was 90 days from that date, which was May 30. On May 30, the clock started ticking toward the November 27, 2006 deadline for compliance, i.e., 180 days after the effective date. May 31, 2010 is the deadline for installing engineering controls (4 yrs). "Except as permitted in paragraph (f)(1)(ii) and paragraph (f)(1)(iii) of this section, the employer shall use engineering and work practice controls to reduce and maintain employee exposure to chromium (VI) to or below the PEL…" Where engineering and administrative controls are not demonstrably feasible then respirator, clothing, and hygiene controls become necessary.

Exposure determination and medical surveillance

Following the May 30 date, an "exposure determination" had/has to be made to assess each employee's exposure to hexavalent chromium. If the 8-hour TWA (time weighted average) exceeds the action level, all employees exposed above the action level must undergo "medical surveillance." Medical surveillance involves a "medical and work history" and an examination by a physician. Employees must also be examined by a physician within 30 days after a physician's recommendation for additional testing, after an accidental release of Cr+6, or whenever the employee shows any signs or symptoms associated with exposure to Cr+6. HAZCOM (hazardous communication) is also triggered at the action level.

Exposure above the PEL

Above the 5 mg/m^3 PEL, considerable activity occurs. Respirators and controlled clothing are required for those individuals who are exposed above the PEL. Clothing cannot be taken home from the workplace, which requires either disposable or washable clothing that remains at the workplace.

Areas where the exposure exceeds the PEL are to be "demarcated from the rest of the workplace in a manner that adequately establishes and alerts employees of the boundaries of the regulated area." Access to these areas must be limited.

Continued air monitoring

When exposure is above the action level, but below the PEL, air monitoring must be conducted every six months until the exposure drops below 2.5 mg/m^3. If exposure is above the 5 mg/m^3 PEL, air monitoring must be conducted every three months.

Housekeeping and hygiene

Housekeeping and personal hygiene are also parts of this new regulation. Within the demarcated areas, "prohibited activities" include eating, drinking, smoking, chewing tobacco or gum, and the use of cosmetics. Housekeeping generally includes vacuuming, in lieu of sweeping, shoveling, and blowing down areas with air. There are also requirements for labeling and disposal of materials that are contaminated.

Parting comments

There are at least two peculiar requirements in this regulation.

Continued on page 25

OSHA Hexavalent Chromium Regulation,

continued from page 12

First is the "Prohibition of Rotation. The employer shall not rotate employees to different jobs to achieve compliance with the PEL." In other OSHA regulations, rotating employees is permissible, e.g. to reduce exposure to noise. Another is the implication that to avoid taking any remedial action, one must demonstrate under the worst case condition that the exposure is below the action level.

If the background levels in a facility (tested under worst-case conditions) are above the action level, then every employee in that facility must be tested and periodic air samples must be taken.

It is clear that even the act of changing dust collector filters would create an "uncontrolled release" or "emergency" as it is defined in 1910.1026(b). Controlling/confining exposure to hexavalent chromium during maintenance will be a challenge, since most dust collectors are not equipped with the means to contain dust when the filter cartridges are changed.

It may seem extreme to reduce the exposure limit by an order of magnitude, but it is not. Inconvenient, it is. Expensive, it is. Prudent, it is as well. Others can argue the validity of the numbers that produced this regulation. The regulation will almost certainly be challenged; that could take years. We have before us a new regulation, which attempts to make the workplace a bit safer for us all. It is, as the poker player says, the hand we have been dealt and we must play it.

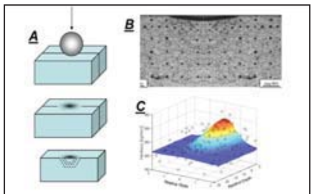
There is an opportunity here for the manufactures of booths, hoods, and dust collectors to provide better ways to mitigate the problem of exposure. There is also an opportunity for those in academia and industry to develop non-chrome-bearing materials for wear and corrosion. In response to pressures on the hard chrome plating industry, thermal spray has been pursuing hard chrome replacement coatings for decades. Many of those bear chrome themselves. The shoe may be on the other foot, so to speak. iTSSe

For more information: Daryl Crawmer is Director of Technology, Thermal Spray Technologies Incorporated, 124 Lazy Lake Dr., Fall River, WI 53932; tel: 608/825-2772; dcrawmer@tstcoatings.com; www.tstcoatings.com.

MEMBERS CORNER

From the TSS Mechanical Committee

Andrew Gouldstone
ASM Thermal Spray Society (TSS) Accepted Practices Committee on Mechanical Properties Chairman



Example of a multi-pronged strategy to explore fundamental properties of coatings. A. Split-specimen preparation allows observation of deformation field under macro-indent (B). C. Nano-indents can determine local changes in elasto-plastic behavior (e.g. from splat hardening, interfacial de-cohesion)

Despite major recent progess in thermal spray (TS) science, a near-century of non-prime reliant utility, simplified treatments, and haphazard descriptors (e.g. 'chaotic') of complex deposition phenomena have led to an internalization of TS research. That is to say, in the wider materials and engineering communities, TS is either a technology that "works just fine" or conversely is too difficult to study, with little inroads or philosophy for systematic investigation. One of the goals of TSS is to change this incorrect perception, with the specific tasks of 1) raising awareness and fundamental understanding of TS in the mainstream materials community, and 2) promotion of TS in other engineering interests.

How can mechanics play a role in this? For the most part, studies in TS mechanics have been controlled by well-known logistical limitations, namely (a) relatively thin coatings (< 1mm), (b) nonlinear, stress-dependent properties, and (c) anisotropic, defective microstructure. It is difficult to measure properties *per se*, so we do what we can, so to speak, by measuring hardness (a manufactured parameter) and modulus (different via indentation, or in-plane), or performing bending or pull-off tests. Conversely, we go straight to performance testing (wear, erosion, etc.). However, such efforts are often taken with the goal of comparing different coatings, or meeting a 'spec.' Progress has been made to relate properties to performance, but this has also been largely empirical. To address this, the following ideas are being discussed by the Mechanical Properties Committee.

1) We must continue to aggressively pursue a fundamental understanding of TS coatings for what they are – defective materials. For this, we should begin to move away from simplified descriptors of behavior. As an example, steps are being taken to quantify coating stress-strain behavior in terms of yield strength and strain hardening, but we should follow this up with new parameters describing physics that is prevalent in TS behavior. These parameters should describe not only as-sprayed conditions, but lifetime property evolution due to loading and/or environment. We need not start from the ground up in this. Collaboration with other communities, most notably civil engineers, etc., could provide insights in material models (i.e., concrete damaged elasticity) that may describe TS quite well. Importantly, it could provide access to experimental capabilities to test or develop models. Targeted interactions would not only raise the level of mechanical modeling of TS, but would also showcase to engineering researchers how far TS has come, and where the new interesting problems may be found.

2) Continuum-based models are important to develop. Most engineers who implement TS are mechanical engineers, and they simply cannot use a value of 'hardness' or a qualitative description of crack growth in any lifetime prediction scenario.

3) In attempts to raise our scientific credibility, we must be careful not to alienate everyone who uses TS coatings with a sudden U-turn in thinking. To educate our own, plans are being laid for 'how-to' sections in upcoming publications, and repeatability studies on common test methods.

Final thoughts - One of the limitations for TS in other mainstream communities is the lack of information, most notably in mechanical properties. We have our own methods (i.e., hardness testing, wear testing) to determine whether a change in feedstock or process is 'successful.' However, that benefits us within the community, and the results are not readily spreadable to other engineering disciplines. If we want to increase our membership and usage, we should provide tools, analyses, and descriptors that can be used by those we want to target. On the same note, we should continue to raise the basic abilities of our members to quantify their own coatings, for process comparison, and increased confidence.

For more information: Dr. Andrew Gouldstone, Center for Thermal Spray Research, SUNY at Stonybrook, Stony Brook, NY 11794; tel: 631/632-8480; andrew.gouldstone@stonybrook.edu; www.matscieng.sunysb.edu/ctsr.