

Sales Engineering Technical Paper Series

Hexavalent vs. Trivalent Chromates: Why must we change, and what are the differences?

On February 28th, 2006 OSHA published a final standard addressing occupational exposure to hexavalent chromium (Federal Register # 71:10099–10385). The standard was published in agreement with a timetable set forth by the U.S. Court of Appeals, and covers exposure to hexavalent chromium (CR(VI) in general industry, construction and shipyards. This standard was deemed necessary by OSHA to reduce significant health risks posed by occupational exposure to hexavalent chromium.

The new standard significantly lowers the permissible exposure limit for hexavalent chromium from 52 to 5 micrograms per cubic meter of air. The standard also covers methods for controlling exposure when working with hexavalent chromes, including proper ventilation, respiratory protection, protective clothing, etc.

As stated above this standard will drastically restrict exposure limits to hexavalent chromium. This in turn has forced the plating industry to react in one of two ways. Option one, the industry could terminate the use of hexavalent chromes altogether, and change over to trivalent chromium. Although this option completely eliminates the use of hexavalent chrome, it does have its drawbacks, which we will discuss later in this document. Option two is for the plating companies to take protective measures to limit the exposure of their employees to hexavalent chromes, and continue to supply the same compound they have for years. This would require them to use both engineering methods and personal protective equipments to limit employee exposure to hexavalent chromes.

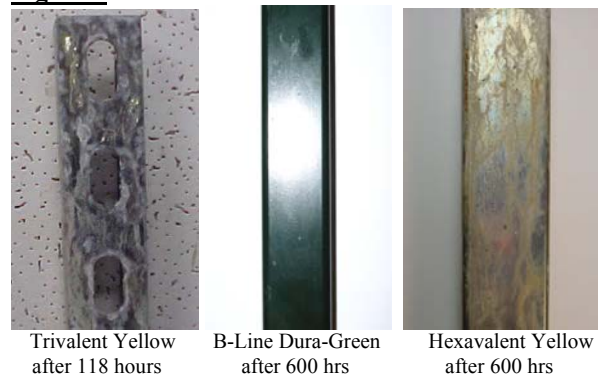
So what is the difference between trivalent and hexavalent chromium? Both trivalent and hexavalent chromium are conversion coatings added to the plating process to increase finish performance. Both are aqueous solutions, and are applied in the same manner. The only difference is the starting material Cr^3 vs. Cr^6 , and the performance properties of then new conversion coating.

Now that we've discussed the coating process, let's detail the performance difference between the two conversion coatings. Some of the major differences between the two chromium conversions are color variability, corrosion

resistance, self-healing, and paint adhesion. One other issue that must be addressed is how you tell the difference between the two finishes.

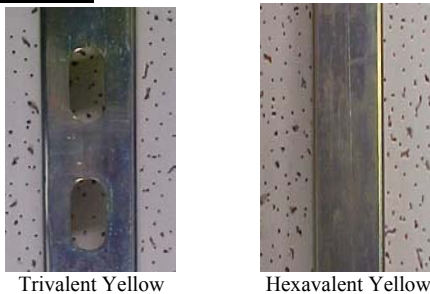
- **Color Variability** – In many cases customers are purchasing the yellow or gold version of zinc dichromate. This color change is created during the hexavalent chromate conversion process, which also greatly improves corrosion resistance. With the move to trivalent chrome the conversion process will no longer generate a color change, and color must be added by using a dye. The use of a dye makes it difficult to maintain a uniform color, and UV exposure can eventually cause the color to fade. This discrepancy in color can create problems when trying to match existing material, or when aesthetics are important. The corrosion properties are also sacrificed, as the die has no corrosion resistance properties. The product becomes no more than a clear zinc finish that has been dyed yellow.
- **Corrosion Resistance** – Under salt spray tests the trivalent chromate provides approximately 36 hours of protection. A topcoat can be added to increase corrosion resistance to similar levels achieved by hexavalent chromes (120+ hours). The amount of topcoat coverage directly affects the corrosion resistance of the product, and currently no industry standards exist that mandate topcoat thickness. This means the topcoat could vary, and so will the corrosion resistance. The topcoat also creates other barriers, such as increased cost, and the inability to paint. **Figure 2** compares the corrosion resistance of hexavalent vs. trivalent yellow.

Figure 2



- Self-Healing Properties** – The trivalent chromate alone has no self-healing properties. This can be improved with the addition of a topcoat, but still only provides about 33% of the self-healing protection of the hexavalent chromium. The topcoat also creates other barriers, such as increased cost, and the inability to paint.
- Identification** – There is no easy way to verify whether the products supplied are trivalent or hexavalent. Both are considered a yellow zinc finish, and are similar in color. The only true way to determine the finish is through chemical testing. **Figure 3** shows both options, and as you can see it is difficult to differentiate the two.

Figure 3



As you can see the differences between the two types of chromate conversions are significant. Although they may both look the same the corrosion properties, durability, and field flexibility varies a great deal. The biggest issue of all is how do you know what you have? Is it hexavalent, or is it trivalent? Do I need to wear protective equipment? How corrosion resistant is the coating? Unfortunately there is no good way to answer these questions in the field.

So now that we’ve covered the differences in the finishes, what are the viable alternatives available to the market? There are many material and finishes available that are easily identifiable, and well suited for various applications. These alternative material and finish options include painted, pre-galvanized, hot-dipped galvanized, stainless steel and aluminum. While each material is a viable alternative, some such as stainless steel, hot-dipped galvanized and aluminum may be cost prohibitive. The best alternative from both a cost and performance perspective would be a painted finish.

Cooper B-Line’s Dura-Green finish is an excellent alternative that offers excellent performance characteristics, and is extremely cost effective. **Table 1** shows the performance characteristics of green compared to other standard finishes. The Dura-Green finish

outperforms zinc chromate, pre-galvanized, and other industry green paints. **Figure 2** shows B-Line’s Dura-Green epoxy compared to the current hexavalent yellow zinc finish and the new trivalent yellow zinc. It is obvious in these pictures that Dura-Green is capable of not only maintaining the same corrosion requirements as the current hexavalent yellow, but greatly outperforms the new trivalent yellow.

Table 1

Finish Options	Dura-Green	Industry Green	Pre-Galv G90	Yellow Zinc Trivalent	Yellow Zinc Hexavalent(2)
Corrosion Resistance (Salt Spray ⁽¹⁾ hrs)	612 Hrs	36 Hrs	192 Hrs	36 Hrs	680 Hrs
Color Variability	Good	Good	Good	Poor	Good
Identifiable Finish	Good	Good	Good	Poor	Poor
No Hex Chromes Present ⁽²⁾	Good	Good	Good	Good	Poor
Paintable Surface ⁽³⁾	Good	Good	Poor	Good	Good
<div style="display: flex; justify-content: center; gap: 20px;"> Good Fair Poor </div>					

(1) All salt spray (fog) tests conducted in accordance with ASTM B117 and evaluated according to ASTM D1654 Table 1 & 2. Tests re performed and certified by an independent testing laboratory.

(2) OSHA regulates Hexavalent chrome exposure.

(3) Surface does not require cleaning prior to painting.

Although the industry has an alternative product to take the place of the hexavalent yellow, the performance capabilities are greatly reduced. Factors such as corrosion resistance & color cannot be maintained with the new trivalent yellow. There are also identification concerns, as the difference between the hexavalent and trivalent color cannot be seen with the naked eye. These factors will greatly reduce the long-term quality of the product, and may not meet your project’s aesthetic requirement. Cooper B-Line offers Dura-Green as a solution to your safety & corrosion requirements, while maintaining long-term quality standards demanded by our customers.