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Red Lead Oxide Staining

An Environmental Phenomenon

How changing atmospheric pollutants can discolor lead-tin-alloy-coated stainless steel roofing.

Terne Coated Stainless Steel (TCS) was manufactured by Follansbee Steel from about 1968 to 1997.[1] It consists of Type 304 stainless steel sheet with an eighty percent lead/twenty percent tin alloy coating on both sides. The thickness of the coating was approximately twenty-five microns. TCS had many advantages over traditional terne metal (lead/tin alloy on steel sheet) for roofing and cladding.

It was very durable (with an expected service life of one hundred years or more), maintenance free, and generally weathered to a pleasing dark, dull grey color, or patina.

For most of the twentieth century, there were enough pollutants in the atmosphere (mainly sulphur dioxides stemming from the burning of fossil fuels) for high-lead alloy metals (e.g., TCS and lead coated copper) to react with the pollutants to form a dark grey, lead sulphate patina (chemically, likely $PbSO_4$). In the absence of these pollutants, a rusty, reddish-brown colored staining can form on the surface of TCS (photo to right). Lead in the lead-tin coating of the TCS oxidizes to form red lead oxide—chemically, PbO or, likely more frequently, Pb_3O_4. PbO is reddish-yellow in color. Pb_3O_4 is orange-red in color.[2]

In the past, red oxide staining on TCS, or lead-coated copper for that matter, was primarily limited to rural and marine environments—so-called "pristine environments" with little pollution. With stricter environmental regulations in the later part of the twentieth century, there are fewer sulphates in the atmosphere and the problem of red oxide staining of lead-bearing metals is becoming more widespread. The formation of Pb_3O_4—red lead—is favored in cleaner, less polluted air.

Red oxide staining on TCS roofing and cladding can be widespread or more localized due to the presence of "microclimates." Oxidation is a complex, natural process that occurs at the micro level. Thus, the microclimate can be an elevation or roof slope, or even particular pans on a given elevation. Very small differences in moisture level, slope, exposure to the sun, drying time, concentrations of pollutants, dwell times (how long pollutants and other contaminants stay on the surface of the metal), heat, pH levels, and working of the metal during installation can impact the surface chemistry of the TCS enough to support, or not support, the formation of red lead oxide. One key microclimate factor acting on buildings can be concentrated water flows over the surface of the TCS (photo on next page). All other things being equal, lower-sloped surfaces and

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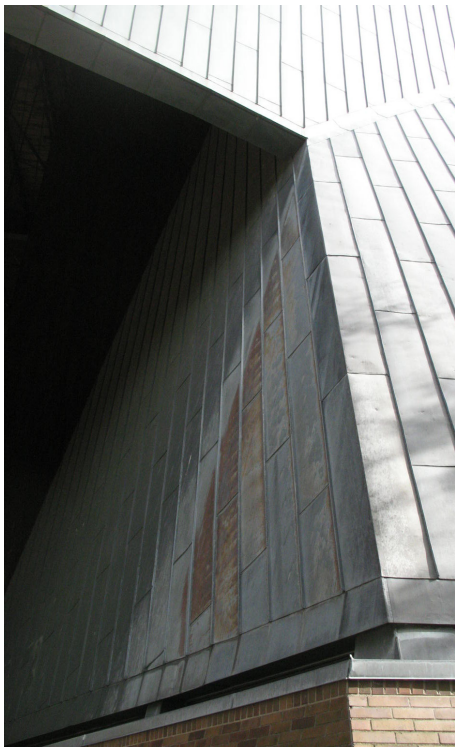
Red Lead Oxide Staining (CONTINUED)

surfaces frequently washed by water will have lower concentrations of atmospheric pollutants on their surfaces and will therefore be more susceptible to red oxide staining.

Fortunately, the consensus seems to be that red oxide staining is a surface phenomenon—a natural patina with no significant accelerated or detrimental corrosion of the stainless steel substrate taking place. In other words, the staining is primarily an aesthetic issue rather than a performance issue in most cases. The exception would be "microclimates" where water washing is the primary feature. Water washing over a surface is, by its nature, an erosive process, however slight and slow. Coating loss will occur. It is, however, unlikely to impact the integrity/watertightness of the TCS panels as the stainless steel base metal is, itself, very resistant to atmospheric corrosion and erosion.

Removal of red oxide staining is difficult and expensive. Moreover, if the underlying factors contributing to the staining are not addressed (also difficult), the staining will recur. In most instances, therefore, allowing the staining to remain and permitting the TCS panels to patina naturally is recommended.



Red oxide staining from concentrated water flows over the surface of TCS wall cladding.

[1] TCS was replaced by TCS II (a zinc-tin-alloy-coated stainless steel) in c.1997. (TCS II was called "Viromet" from 1997 to 1998.) Follansbee Steel went out of business c.2012.

[2] There are many different lead oxides. Their characteristics and color vary depending on the number of oxygen atoms the lead is attached to, the valence state of the lead, and their crystal structure.

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