Transit Damage and Hot Rolled Steel

Hot Rolled Steel

Much of the world’s production of steel is used in the hot rolled or as-rolled condition. Hot rolled steel is one of the basic raw materials of industry and is transported great distances throughout the world. Usually there is no surface treatment (such as blasting, painting, or galvanizing) until it reaches its end user. Thus it is transported and stored unprotected. Inevitably incidents occur along the way and insurance claims are lodged, alleging that damage has been done. Sometimes there is no known incident, but the condition of the steel is pointed to as evidence that something must have happened.

When claims are made, adjusters and insurers need to determine some combination of the following:

• cause of damage
• timing of damage
• extent of damage

This article explains ways in which a technical investigation provides answers to these questions.

Mill Scale

When steel emerges from a hot rolling mill, it is not a pretty material. At the high temperature at which rolling takes place, oxidation occurs rapidly, and hot rolled steel is covered with a thick, dark gray material, known to the steel industry as mill scale and to a geologist as magnetite. It is one of the forms in which iron is found in nature (Fig. 1), and it has the formula Fe₃O₄. As the name implies, it is magnetic and is the lode-stone of old, by which mariners found their way. As stated previously, most steel going under the title hot rolled steel has no additional treatment and the mill scale is left on, although occasionally some is surface treated after rolling, say by pickling in acid or grit blasting, and then left in that condition.

Mill scale is said by some to confer a degree of corrosion resistance. However, it is brittle and at some time will begin to flake off, thus exposing the steel, whereupon corrosion will begin. Other references say that mill scale increases the corrosion by virtue of potential differences between it and the exposed steel. Which of these effects predominates is largely irrelevant to the gist of this article.

Rusting

As mill scale is lost, rusting begins (Fig. 2a). The initial rust is a hydrated ferric oxide, with a formula approximating FeOH₂. As the rust ages, the oxygen content increases, approaching the formula Fe₂O₃. During this process, the light orange-brown color of fresh rust darkens to a reddish, dark brown (Fig. 2b-c). The geological name for Fe₂O₃ is hematite, and this is the most usual form in which iron is found in nature.

![Fig. 1](Red hills of hematite in Northwest Australia. Rust is iron (steel) reverting to nature. Photograph by David Dare Parker reproduced courtesy of Australian Geographic.)

![Fig. 2](a) A magnetite coating on hot rolled sheet, with fresh rust breaking through; (b) Hot rolled surface, about 60% covered with fresh rust; (c) Hot rolled steel, with all the original magnetite lost. Rust is beginning to darken where arrowed, to form hematite.)
When steel that has been exposed for weeks to months is closely examined, it is common to see all these varieties of iron oxide. There will be mill scale, and at the edges of this scale where the steel has been freshly exposed, there will be fresh rust, alongside which older, darker rust will be apparent. The variation is even more complicated since at any location there will be variations in oxygen content and water content with depth. However this article is about the immediately visible rust.

When exposed rolls are viewed from a distance, the above localized variations merge to produce an even patina. (There is a range of steels designed to never be painted, with the intent that they be used in applications where the eventual dark patina will appear as a natural effect, perhaps merging with the environment. Sometimes this works, depending on the skill of the architect.) With longer exposure the patina changes in color for the reasons given above. Examples are shown in Fig. 3a-b. When looking at these photographs, it should be taken into account that the coils were exposed in a tropical country six degrees from the equator, with a year-round average temperature of 27 °C and 70% average humidity. For poses of comparison, an exposed test sheet is shown in Fig. 3c.

**Insurance of Hot Rolled Steel**

Given that rusting begins when the steel is rolled and is a natural, inevitable process in which the iron is simply reverting to nature, it is curious that this material should be insured by policies that sometimes include the words *rust*, *oxidation* and *discoloration*. The difficulty presented by the presence of these words is highlighted further when a study of product standards for hot rolled steel reveal the absence of these same words. In fact, to a metallurgist, it is odd that there should be any claims at all for the rusting of hot rolled steel.

The inappropriate wording of such policies is further highlighted by the fact that hot rolled steel is never wrapped for protection and is commonly stored outdoors. Clearly, from the background given above, every shipment of hot rolled steel coil and plate is rusted to some extent. The questions are “How much?” and “Is the rusting logically claimable under an insurance policy?” In my organization, we are often asked to provide qualitative data and opinions to enable an adjuster to interpret the policy.

**Storage**

For an article devoted to damage during transit, there might seem to be undue emphasis on deterioration that occurs during land storage. On many claims for which we have been consulted, the sea voyage occupied only a small proportion of the insurance interval. The reason for this is the wide range of time intervals covered by marine policies. These can cover the voyage itself or might extend for long intervals on either side, during which the coils are simply sitting outdoors, sometimes in abysmal conditions (Fig. 4).