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MLU-CQJ/sss

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A factual comment on the question about hexavalent chromium in stainless steel

Hexavalent Chromium in Stainless Steel?

A frequently occurring question seems to be whether or not there is ”hexavalent chromium” in the stainless steel. According to the definition, stainless steel contains chromium, however, is this chromium present as the dreaded hexavalent chromium?

Metals and Salts

In the real world, metals may be present in two different forms:

1. Solid metals in which the number of electrons in the “shells” equals the number of positively charged protons in the nucleus. Thereby, the charge of the atom becomes 0. We say that the level of oxidation and/or the valence is 0.
2. Salts, in which the metal is present in some sort of ”oxidized state”, i.e. the metal has given away one or more electrons, so that the total number of negative electrons in the shells is *lower* than the number of positive protons. This is called an ”ion”, and the net charge is *positive* due to the loss of electrons. Dependent on the number of lost electrons, the oxidation state /valence is from +1 and upwards. For most metals, oxidation states above +3 is rare.

Thus, all the alloying metals of stainless steel are present as free, uncharged atoms (**1.**), while the salts (**2.**) can only be made through corrosion. As an example, common “rust” consists of iron salts, mostly Fe^{II} and Fe^{III}, in which each iron atom has lost two or three electrons, respectively, from the original 26. By the way, trivalent iron oxides and hydroxides (e.g. Fe_2O_3) is commonly known as red rust.

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Hexavalent Chromium in Stainless Steel?

Hexavalent chromium, Cr^{VI}, is an oxidized state in which the chromium atom has donated no less than six electrons from the original 24. In practice, Cr^{VI} is never present in the solid steel, but can only be made through a very strong oxidation process. Thus, Cr^{VI} cannot be made through normal corrosion reactions, but requires ”artificial help” through a very strong electron acceptor. This is confirmed by the fact that Cr^{VI}-salts are thermodynamically unstable under ”normal conditions forhold” and easily *accepts* electrons, whereby Cr^{VI} is reduced to the more stable Cr^{III} . Thus, hexavalent Cr^{VI} may be viewed upon as a thermodynamically unstable “extreme” of chromium.

Is There Any Hexavalent Chromium in the Steel?

The short answer is NO. All grades of stainless steel contain at least 10.5 % chromium, however, all this chromium is present as *metallic chromium* (oxidation state 0), and not as ions or salts. As such, *no* type of stainless steel contains any hexavalent chromium.

Can Hexavalent Chromium be Formed During Manufacturing?

Should the stainless steel be exposed to a very strong energy source, it is theoretically possible for a part of the chromium to be oxidized to Cr^{VI}. Low-temperature processes, such as cutting, sawing, bending, polishing etc., do not imply such a risk, however, welding does. Welding stainless steel is by far the most energy-consuming manufacturing process, and, In theory, this implies a risk of oxidizing the chromium all the way to +6, i.e. *hexavalent* chromium.

As all stainless steel contains chromium, it is not possible to avoid the potential problems by switching to another type of steel. Fortunately, the problem is not big, especially if we follow the recommendations by the local health authorities. In Denmark, such requirements are issued by “Arbejdstilsynet”:
https://at.dk/nyheder/2018/11/is-in-beskyttet-mod-chrom-6/.
Pay special attention to the need of proper ventilation and personal protection.

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