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# Type B Nickel Alloys

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Nickel-Molybdenum (Ni-Mo) alloys, commonly called B Type alloys, have excellent corrosion resistance in strong reducing acids like Hydrochloric acid, even outperforming popular Nickel-Chrome-Molybdenum (Ni-Cr-Mo) grades like C-276 when certain conditions are met. The purpose of this blog post is to discuss those certain conditions, which have caught more than one metallurgist by surprise.

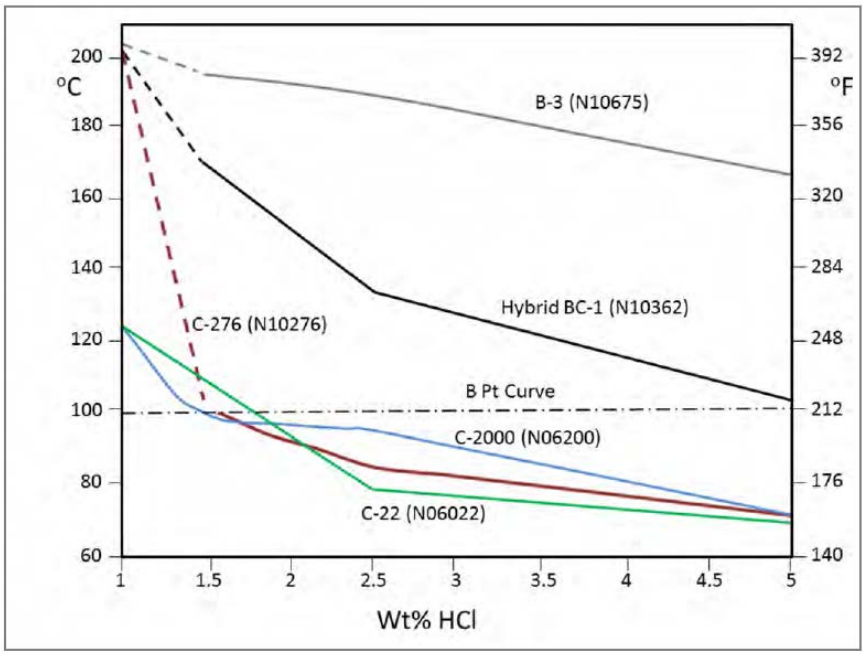


***Figure 3-21: Iso-corrosion, 0.5 mm/y (20mpy), lines for alloys in 1-5% HCl.***

As can be seen in the following table, the B Type alloys have a very high Molybdenum content. However they do not contain much Chromium. There are both advantages and disadvantages to this element mix. In pure reducing acids, a Chromium Oxide film cannot form or remain stable. So the Chrome in C Type alloys provides little benefit and can even be detrimental by diluting the Mo-rich protective surface layer. In contrast, in oxidizing conditions, a Chrome Oxide protective film is needed and the B Type alloys do not have enough Chromium to accomplish that. The key takeaway here is that the B Type alloys rely on the absence of oxidizers, rather than the formation of a protective $Cr_2O_3$ passive film for protection from oxidizing environments. This approach maximizes their performance in reducing environments but makes them more vulnerable if the environment becomes oxidizing.

| Nickel Alloy | UNS Number | Ni (wt%) | Cr (wt%) | Mo (wt%) |
|---|---|---|---|---|
| B-2 | N10665 | 64-66 | <1.5 | 28-30 |
| B-3 | N10675 | <65 | <1.5 | 28.5 |
| BC-1 | N10362 | 60-65 | ~15.5 | ~22 |
| C-22 | N06022 | ~56 | 22 | 13 |
| C-276 | N10276 | ~57 | 16 | 16 |
| C-2000 | N06200 | ~59 | 23 | 16 |

Even small concentrations of oxidizing species can shift the electrochemical potential of the solution, transforming a reducing environment into an oxidizing one. When this occurs, corrosion rates can increase rapidly to undesirable levels. Common oxidizers of concern for B-Type alloys include:

- Ferric ions ($Fe^{3+}$) (the most common)
- Cupric ions ($Cu^{2+}$)
- Dissolved oxygen
- Chlorine, hypochlorite or chlorate species
- Nitric acid or nitrates
- Peroxides

The problem is when these oxidizers show up but were not anticipated during design:

- Impurities in raw material inputs
- Air ingress during shutdowns, maintenance or venting
- Utility water containing oxidizers leaking across failed heat exchangers
- Introduction of iron corrosion product into the process (for example, failure of a piece of lined equipment)

Many of these scenarios are episodic and do not reflect routine operation. So, coupon testing, which is normally very reliable, can miss these excursion scenarios and provide a false sense of confidence that the B Type alloys will perform well in a given service.

Additionally, oxidizers can accumulate in recirculating or closed-loop systems, increasing in concentration over time. On-going corrosion releases more metals ions, which results in more oxidizing species, which results in faster corrosion.

The Type B Nickel alloys can be a great choice for clean reducing acid applications. But the process needs to be carefully considered for these potential game-changers that may not show up even in coupon testing or fluid sampling. If in doubt, it may be safer to consider a Type BC hybrid Nickel alloy, which has a higher Mo content similar to a B Type alloy but also has higher levels of Cr to allow the formation of a Chrome Oxide layer if oxidizing conditions do occur.

*References:*

*MS-3 Materials Selector Series for Hydrochloric Acid, Hydrogen Chloride and Chlorine Dioxide, 2nd ed., Materials Technology Institute, 2016.*

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