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Metals Trivia:

- Former President Herbert Hoover was a metallurgist, and translated a Latin metallurgical text book into English. Leonid Brezhnev was also a metallurgist.
- If you bend a piece of pure tin between your fingers, it makes a sound like a cat mewing.
- Recycling 1 kg of aluminum saves up to 6 kg of bauxite, 4 kg of chemical products, and 14 kwh of electricity.
- Americans use about 80 billion aluminum cans per year.
- The raw materials in an iPhone are worth about 40 times more than the raw materials in a human body.

Have a Metals problem?
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DUPLEX STAINLESS STEELS

Duplex and super-duplex stainless steels comprise a special family of ferrous materials primarily used in aqueous corrosion environments, especially those containing chloride (seawater, for example). Micro-structurally, these alloys have approximately 50% ferrite and 50% austenite.

Compositionally, the materials contain over 20% chromium, molybdenum over 1.7%, and nitrogen over 0.10%, with lower levels of nickel than austenitic stainless steels. Corrosion resistance is achieved with a robust chromium oxide protective layer. Materials that have a PREn, or Pitting Resistance Equivalent Number, over 40 are classified as Super-duplex materials. (For more information about PREn, see the October, 2008 TekBulletin.)

Elements that control the PREn also have a significant effect on the relative composition balance (ferrite/austenite). Specifically, Cr, Fe, Mo, Si, and W are ferrite formers and promote a ferritic structure; while N, C, Ni, and Mn are austenite formers and help promote an austenitic structure. The ideal ferrite/austenite structure should be somewhat under 50% ferrite – this allows the proper strength levels and impact toughness to be achieved, but optimizes the alloy for heat treatment. The use of nitrogen is critical to achieving proper alloy balance in duplex alloys even though it is used in levels far below 1% wt. Argon Oxygen Decarburization (AOD) refining or nitrogen-bearing chromium are typically used to control nitrogen levels, with AOD being preferred.

Heat treatment of duplex alloys involves solution annealing at a temperature over 1040ºC / 1900ºF. Often, higher temperatures are used with a water quench from the higher temperature, or after furnace cooling toward 1040ºC / 1900ºF. Quenching rate is critical because duplex alloys form deleterious phases fairly rapidly across a wide temperature range from 980ºC / 1800ºF (e.g. sigma phase) to 370ºC / 700ºF (e.g. alpha prime). These phases negatively affect corrosion resistance, weldability and mechanical properties. Utilization of rapid transfer from the heat treating furnace to the water quench and fast cooling rates to below 370ºC / 700ºF are advised to avoid formation of sigma and alpha prime phases.

Welding of duplex alloys is accomplished using an over-alloyed weld electrode. This electrode typically has higher levels of nickel and molybdenum than the parent metal. All normal weld processes are used, with careful control of interpass temperatures to avoid formation of unwanted precipitate phases.

Application of the duplex family is limited to temperature ranges below the alpha prime formation zone – usually under 260ºC / 500ºF. Use of Grade 4A (2205) is allowed under ASME code up to 177ºC / 350ºF. Higher temperature applications usually favor austenitic (e.g. 316, 317) or superaustenitic (e.g. AL6XN or 254SMo) materials.

DUPLEX GRADES

ASTM LISTS THE FOLLOWING DUPLEX GRADES:

Grade	Type	UNS	ACI		Grade	Type	UNS	ACI
1A	25Cr-5Ni-Mo-Cu *	J93370	CD4MCu		3A	25Cr-5Ni-Mo-N	J93371	CD6MN
1B	25Cr-5Ni-Mo-Cu-N	J93372	CD4MCuN		4A	22Cr-5Ni-Mo-N	J92205	CD3MN
1C	25Cr-6Ni-Mo-Cu-N	J93373	CD3MCuN		5A	25Cr-7Ni-Mo-N	J93404	CE3MN
2A	24Cr-10Ni-Mo-N	J93345	CE8MN		6A	25Cr-7Ni-Mo-N	J93380	CD3MWCuN

* Current versions of CD4MCu may contain the intentional addition of nitrogen.