



NICKEL ALLOYS FOR COMPLETION EQUIPMENT & ACCESSORIES

Historically, high alloy downhole completion equipment has been manufactured from precipitation hardened “PH” nickel alloy bar stock. Starting with bar often results in significant material loss, additional machining time and costs, and limitations to part lengths compared to starting with a cold-worked nickel alloy tube.

Utilizing our job shop mill, CRA produces cold-worked, seamless, heavy-walled tubes for mechanical applications. CRA’s manufactured tubes are offered to semi-finished dimensions with an OD/ID concentricity maximum of 0.015”, allowing for a significant reduction in machining hours and cost. Providing reliable, quality products produced with accelerated deliveries creates opportunities to meet customers’ delivery requirements while reducing inventory risk. Though quicker delivery is our specialty, major cost reductions for our customers can also be realized with deliveries in the 20 - 30 week time frame when compared with PH nickel alloy bar stock.

Presented below are comparisons of the two most commonly used PH nickel alloys, 925 and 718, to alternative cold-worked nickel alloys 28Cr, 2535, G3, and 2550.

NOMINAL COMPOSITIONS

| TYPE | UNS | PREN | C | Cr | Ni | Fe | Mn | Mo | Co | Cu | Ti | Nb + Ta | Al |
|-------------|--------|---------|---------|-------------|-------------|---------|--------|-----------|-----|-----------|------------|------------|-----------|
| 28Cr | N08028 | 36 - 41 | ≤ 0.03 | 26 - 28 | 29.5 - 32.5 | BAL | ≤ 2.5 | 3 - 4 | - | 0.6 - 1.4 | - | - | - |
| 2535 | N08535 | 32 - 40 | ≤ 0.03 | 24 - 27 | 29 - 36.5* | BAL | ≤ 1 | 2.5 - 4 | * | ≤ 1.5 | - | - | - |
| G3 | N06985 | 41 - 50 | ≤ 0.015 | 21 - 23.5 | BAL | 18 - 21 | ≤ 1 | 6 - 8 | ≤ 5 | 1.5 - 2.5 | - | ≤ 0.5 | - |
| 2550 | N06255 | 43 - 56 | ≤ 0.03 | 23 - 26 | 47 - 52 | BAL | ≤ 1 | 6 - 9 | - | ≤ 1.2 | ≤ 0.69 | - | - |
| 925 | N09925 | 28 - 34 | ≤ 0.025 | 19.5 - 22.5 | 42 - 46 | ≥ 22 | ≤ 1 | 2.5 - 3.5 | - | 1.5 - 3.0 | 1.9 - 2.4 | 0.08 - 0.5 | 0.1 - 0.5 |
| 718 | N07718 | 26 - 32 | ≤ 0.045 | 17 - 21 | 50 - 55 | BAL | ≤ 0.35 | 2.8 - 3.3 | ≤ 1 | ≤ 0.23 | 0.8 - 1.15 | 4.87 - 5.2 | 0.4 - 0.6 |

*Ni+Co ≥ 29.5

STANDARD API STRENGTH CLASSIFICATIONS

| SPECIFICATION | TYPE | GRADE | YIELD STRENGTH MIN. (ksi) | TENSILE STRENGTH MIN. (ksi) | ELONGATION MIN. (%) |
|---------------|-------------|---------|---------------------------|-----------------------------|---------------------|
| 5CRA | 28Cr | 110/125 | 110/125 | 115/130 | 11/10 |
| 5CRA | 2535 | 110/125 | 110/125 | 115/130 | 11/10 |
| 5CRA | G3 | 110/125 | 110/125 | 115/130 | 11/10 |
| 5CRA | 2550 | 110/125 | 110/125 | 125/130 | 11/10 |
| 6ACRA | 925 | 110 | 110 | 140 | 18 |
| 6ACRA | 718 | 120 | 120 | 150 | 20 |

Higher yield strengths available upon request.



CORROSION RESISTANCE
NACE MR0175 Sour Service Limits

| TYPE | TEMP. (°F) | H2S PARTIAL PRESSURE MAX. (psi) |
|-------------|------------|---------------------------------|
| 28Cr | ≤ 270°F | No Limit |
| | ≤ 400°F | 150 |
| 2535 | ≤ 270°F | No Limit |
| | ≤ 400°F | 150 |
| G3 | ≤ 300°F | No Limit |
| | ≤ 400°F | 150 |
| 2550 | ≤ 300°F | No Limit |
| | ≤ 425°F | 300 |
| 925 | ≤ 275°F | No Limit |
| | ≤ 400°F | 500 |
| 718 | ≤ 275°F | No Limit |
| | ≤ 400°F | 500 |

These nickel alloys are all suitable for most sour service applications. Cold-worked alloys 2550 and G3, with their high Pitting Resistance Equivalent Number (PREN), are also suitable for injection wells and high chloride environments.

Where hydrogen embrittlement is a concern, the cold-worked nickel alloys are preferred. The need for higher strength bar products for equipment and accessories in sour service has been addressed by NACE MR0175/ISO 15156 and API6CRA through the addition of 718 bar grades 140 & 150. However, there have been several documented hydrogen embrittlement failures of 718 and other precipitation-hardened nickel alloys. No such failures have been reported with the cold-worked alloys, and laboratory studies have shown them to be essentially immune.

CRA 2535E & CRA 2550E

CRA 2535E (UNS N08535) and CRA 2550E (UNS N06255) are premium, electro-slag re-melted versions of alloys 2535 and 2550, respectively. The performance and consistency are enhanced through tightly controlled compositional limits and microstructural cleanliness. CRA 2550E has excellent hydrogen embrittlement resistance at all standard strength levels.

*While every effort has been made to ensure the accuracy of the above review, assessment, conclusions, and report, the appropriateness of their application and their interpretation remain the sole responsibility of the user.