# Alloy 625 Grade 2: Key Differences, Manufacturing Process, and Applications

The ongoing exploration and development of deeper offshore reservoirs has necessitated the development of higher strength materials able to handle more elevated burst and collapse pressures, temperatures, and partial pressures of hydrogen sulfide. However, within the industry specifications, API 5CRA/ISO 13680 and NACE MR0175/ISO 15156, there has been little advancement of higher strength tubular products used for casing, tubing, coupling stock, and accessories. For sour service, API 5CRA/ISO 13680 currently limits these products to grades 110 & 125.

Alloy 625, also known as Inconel 625, is a superalloy renowned for its exceptional corrosion resistance and high strength in extreme environments. Its unique chemical composition, primarily composed of nickel, chromium, and molybdenum, makes it invaluable in industries such as oil & gas, marine, chemical processing, and aerospace.

**Alloy 625** is available in two grades: **Grade 1 and Grade 2**, with similar basic properties, but differing heat-treatment processes tailoring them for distinct applications. In this article, we'll delve into **Alloy 625 Grade 2**, how it differs from Grade 1, and its critical applications, focusing especially on **catalyst tubes for hydrogen dissociators** and other demanding industrial uses.

## Understanding Alloy 625 Grade 1 vs. Grade 2

**Alloy 625 Grade 1** is solution-annealed, providing excellent oxidation and corrosion resistance across a range of environments. It's widely used in applications requiring flexibility, strength, and corrosion resistance at elevated temperatures up to 1100F.

Conversely, **Alloy 625 Grade 2** undergoes a higher temperature solution anneal heat treatment which enhances creep and stress rupture resistance, making it suitable for high-pressure and high-stress applications where durability is critical. The key differences between the two grades are as follows:

1. **Heat Treatment**:
   - **Grade 1** is typically annealed around 1600F to 1800F (about 871°C to 982°C) to provide good ductility and corrosion resistance while maintaining higher strength than Grade 2.
   - **Grade 2** is heat-treated above 2000F (about 1093°C), which enhances creep and stress rupture resistance while retaining corrosion resistance.

2. **Mechanical Properties**:
   Per ASTM B444, ASME SB444, AMS 5581

| Condition | Tensile Strength | Yield Strength | Elongation |
|---|---|---|---|
| | minimum, ksi | minimum, ksi | minimum, % |
| **Grade 1** | 120 | 60 | 30 |
| **Grade 2** | 100 | 40 | 30 |

**These values may vary based on specific processing and treatment.*

3. **Applications**:
    - **Grade 1** is typically used in marine, oil & gas, aerospace, and chemical processing applications.
    - **Grade 2** is preferred in **hydrogen production** and **hydrogen dissociator catalyst tubes** where high-temperature performance and corrosion resistance are paramount.

## Key Applications of Alloy 625 Grade 2 Tubes

**Alloy 625 Grade 2 tubes** find their place in several industries, often where extreme temperatures, pressures, and corrosive environments are present. Some of the most important applications include:

1. **Catalyst Tubes for Hydrogen Dissociators**
   One of the key applications of **Alloy 625 Grade 2** is in **catalyst tubes** for **hydrogen dissociators**. Dissociators are used to crack or dissociate gases like methane, ammonia, or other hydrogen compounds to produce pure hydrogen or hydrogen-rich gas mixtures. This process requires materials that can withstand **extremely high temperatures**, **corrosive environments**, and **high-pressure conditions**—making Alloy 625 Grade 2 the perfect material for catalyst tubes in these systems.

   - **High-Temperature Resistance**: Dissociators operate at temperatures of **700°C to 1000°C**. Alloy 625 Grade 2 retains its strength and resists oxidation and scaling at these high temperatures, making it ideal for catalyst tubes.
   - **Corrosion Resistance**: The alloy's excellent resistance to **carburization**, **nitridation**, and **sulfidation** ensures durability in environments with hydrocarbons, ammonia, or hydrogen compounds.
   - **Hydrogen Embrittlement Resistance**: Alloy 625 Grade 2's high nickel content makes it highly resistant to hydrogen embrittlement, a common challenge in hydrogen-rich environments.

   These properties make **Alloy 625 Grade 2 tubes** the material of choice for **ammonia dissociators**, **methane reformers**, and other dissociation processes where reliability and performance at high temperatures are critical.

2. **Chemical Processing**
   In chemical processing plants, **Alloy 625 Grade 2 tubes** are used in systems exposed to aggressive chemicals like acids, chlorides, and seawater. The alloy's resistance to **localized corrosion** (such as pitting and crevice corrosion) makes it a reliable material for use in **heat exchangers**, **reactor tubes**, and **processing lines**.

3. **Nuclear Power**
   **Alloy 625 Grade 2** tubes are used in nuclear power applications, especially in **heat exchangers** and **steam generators**, where high temperatures and **radiation-induced embrittlement** pose challenges. Its ability to withstand extreme temperatures and its corrosion resistance make it a reliable choice in this industry.

4. **Gas Turbine Engines**
   In the power generation and aerospace industry, **Alloy 625 Grade 2** is used in high-temperature applications, such as **turbine engines** and **exhaust systems**, where both high temperature, strength, and excellent oxidation resistance are required.

## Manufacturing Process for Alloy 625 Grade 2 Tubes

The manufacturing process for **Alloy 625 Grade 2 tubes** involves several critical steps, including **melting and casting**, **forging or extrusion**, **piercing and tube forming**, **heat treatment**, and **surface finishing**. The heat treatment process in **Grade 2** is particularly important, as it makes the alloy more suitable for demanding high-temperature applications such as **catalyst tubes** in hydrogen dissociators. CRA utilizes a cold-pilger manufacturing process in the production of Alloy 625 grades 1 and 2. The main benefit of cold-pilgering is the resulting cold-worked strength, otherwise lost with annealing.

## Benefits of Alloy 625 Grade 2 Tubes

- **Superior Corrosion-Resistance**: Like Grade 1, Alloy 625 Grade 2 retains excellent corrosion resistance in oxidizing and reducing environments, including seawater, acidic environments, and high temperatures.
- **Longevity**: Alloy 625 Grade 2 tubes are designed for longevity in harsh environments, reducing downtime and replacement costs.
- **Hydrogen Embrittlement Resistance**: Alloy 625's nickel content ensures excellent resistance to **hydrogen embrittlement**, making it ideal for use in hydrogen production and dissociator applications.

## Conclusion

**Alloy 625 Grade 2** is a high-performance material widely used in industries that demand high temperature strength, corrosion resistance, and durability. Its ability to withstand **extreme temperatures**, resist **hydrogen embrittlement**, and perform reliably in corrosive environments makes it the preferred choice for applications such as **catalyst tubes in hydrogen dissociators**, power generation, and **chemical processing**. By combining these properties, Alloy 625 Grade 2 continues to play a critical role in advancing technologies in high-demand industries.

CRA's mill specializes in delivering manufacturing solutions for non-standard situations that demand quick turnaround times, customized sizes, specifications, lengths, and production runs. Whether it's for chemical processing, the Department of Defense, or the oil and gas sector, our distinctive approach to producing Alloy 625 pipe tailored to your precise requirements is aimed at supporting all industries with critical applications.