Manufacturing Process of

ASTM A516 Grade 70 Pressure Vessel Steel Plate

ASTM A516 Grade 70 is a normalized fine-grained carbon-manganese-silicon steel plate specifically designed for pressure vessels and other critical applications where notch toughness is required. Its manufacturing is a tightly controlled process to ensure high purity, homogeneity, and mechanical properties.

The typical process involves the following key stages:

1. Ironmaking (Blast Furnace or Alternative):

The process begins with the reduction of iron ore into molten pig iron in a blast furnace. The primary raw materials are iron ore, coke (as a fuel and reducing agent), and limestone (as a flux). Alternatively, pig iron can be produced via Direct Reduced Iron (DRI) processes.

The output is molten pig iron, which has a high carbon content (around 4-5%) and contains impurities like silicon, manganese, sulfur, and phosphorus.

2. Steelmaking (Basic Oxygen Furnace or Electric Arc Furnace):

The molten pig iron is transferred to a steelmaking vessel.

Basic Oxygen Furnace (BOF): The predominant method. Molten pig iron is charged into the BOF along with scrap steel. A high-purity oxygen lance is lowered into the vessel, blowing oxygen onto the metal. This oxidizes and removes excess carbon and impurities. Alloys are added to achieve the initial chemical composition.

Electric Arc Furnace (EAF): Commonly used for recycling scrap steel. A charged basket of scrap steel is melted using powerful electric arcs generated by graphite electrodes. Alloying elements are added to achieve the desired chemistry.

The key goal of this stage is to precisely control the levels of carbon, manganese, phosphorus, and sulfur.

3. Secondary Refining (Ladle Metallurgy Furnace - LMF):

This is a critical stage for achieving the high quality required for A516 Gr. 70. The molten steel from the BOF or EAF is poured into a ladle and transferred to a Ladle Metallurgy Furnace.

In the LMF, the steel undergoes further refinement:

Homogenization: The chemistry is fine-tuned by adding precise amounts of alloys (e.g., Ferro-manganese, Silicon).

De-sulfurization: The sulfur content is drastically reduced to very low levels (typically <0.015% for A516) using a basic slag and stirring with argon gas, which improves toughness.

De-gassing: To reduce hydrogen content (preventing hydrogen-induced cracking) and oxygen content (reducing oxides/inclusions), the ladle may be placed in a vacuum chamber (Vacuum Degassing).

Temperature Control: The steel is heated to the precise temperature required for casting.

4. Continuous Casting:

The refined molten steel is poured from the ladle into a tundish and then into a water-cooled copper mold of a continuous casting machine.

The steel solidifies at the mold's surface and is continuously withdrawn as a solid strand, which is then cut into long slabs of predetermined dimensions. This process ensures a uniform and sound internal structure.

5. Reheating and Hot Rolling:

The continuous cast slabs are reheated to a high temperature (around 1200-1250°C / 2192-2282°F) in a furnace to achieve a uniform temperature for rolling.

The hot slab is then passed through a series of rolling mills (roughing and finishing stands) where it is progressively reduced in thickness to the specified plate dimensions.

Hot rolling breaks down the cast structure, refines the grain, and improves mechanical properties.

6. Heat Treatment: Normalizing

This is a mandatory requirement for ASTM A516 Grade 70 ("Grade 70" implies normalized condition). The hot-rolled plate is reheated to a temperature above its upper critical temperature (typically between 890-950°C / 1634-1742°F), held for a sufficient time to form a uniform austenitic structure, and then allowed to cool in still air.

Purpose of Normalizing: To refine the grain size resulting from hot rolling, achieve a uniform and fine-grained microstructure (primarily ferrite and pearlite), and obtain the specified mechanical properties (strength, toughness, and ductility).

7. Testing, Inspection, and Certification:

Mechanical Testing: Samples are taken from each heat-treated plate (or from a test coupon representing the plate) and tested for Tensile Strength, Yield Strength, Elongation, and Impact Toughness (Charpy V-Notch tests) at specified temperatures to ensure they meet ASTM A516/A516M standards.

Non-Destructive Testing (NDT): Plates are typically subjected to ultrasonic testing to check for internal discontinuities.

Certification: The manufacturer provides a Mill Test Certificate (MTC) that documents the heat number, chemical composition, mechanical test results, and heat treatment status, certifying the plate's compliance with the ASTM A516 Gr. 70 specification.

8. Final Processing and Shipping:

The plates may be shot blasted, primed, or otherwise prepared for shipment as per customer requirements.

They are then marked with heat number, grade, size, and other identifying information before being shipped.

This controlled multi-step process ensures that A516 Grade 70 steel possesses the excellent weldability, formability, and most importantly, the reliable notch toughness required for the safe construction of pressure vessels.