Materials of Construction

The material of construction is dependent on the tensile strength, ductility, corrosion resistance, and sustainability of the solvents amongst other characteristics.

Ductility is the ability of the material to be deformed in response to stress applied. The ductility for this tool has been described as “LOW”,” MEDIUM” and “HIGH”. The “LOW” terminology is an indication of a material of construction that has a low ductility according to its characteristics. This is most common in materials that have a high carbon content. The “HIGH” terminology is an indication of high material ductility. A similar methodology was used for a “MEDIUM” ranking.

Corrosion resistance is the ability of a material of construction to prevent deterioration of the material through a chemical/electrochemical reaction. A similar terminology was used to determine the corrosion resistance of the materials. “LOW” is an indication of a material that has poor corrosion resistance. “MEDIUM” is an indication of a much more corrosion-resistant material. “HIGH” is an indication of the material of construction with the lowest corrosion rate.

Stress Capability is the measure of the materials state when introduced to applied external forces. The stress capability of the material is relative to the tensile strength. The “LOW”, “MEDIUM” and “HIGH” ranking was based on the tensile strength of the material.

Material of construction	**CARBON STEEL**
Tensile strength	540 MPa
Ductility	Medium
Corrosion resistance	Medium
Sustainability to solvents	Low sustainability to solvents - Cannot be used in applications with chlorinated solvents. Least corrosion resistant to concentrated sulphuric acid and caustic alkali environments.
Stress capability	Medium to tolerable stress capability
Typical industry used in	Engineering and chemical applications
Other material characteristics	Cheaper alternative to stainless steel. Most suitable for applications with organic solvents. Carbon steel has a lower corrosion resistance in aggressive environments and hence is corroded uniformly.

Material of construction	**Stainless steel 304/304L**
Tensile strength	505 MPa
Ductility	High
Corrosion resistance	Medium. Intergranular corrosion, also known as weld decay and stress corrosion cracking, are operational problems associated with the use of stainless steel.
Sustainability to solvents	Tolerable sustainability to solvents except in conditions with a high chloride environment.
Stress capability	Low tolerability to stress capability
Typical industry used in	Saucepans, Cutlery and flatware, Architectural paneling, Sanitaryware and troughs, Tubing, Brewery, dairy, food and pharmaceutical production equipment, Spring, nuts, bolts and screws
Other material characteristics	Alternative to 316/316L stainless steel however 304/304L has a higher corrosion susceptibility. Stainless steel 304 is an austenitic grade of steel and 304 L is the low carbon version of stainless steel 304. Pitting and crevice corrosion can occur in environments containing chlorides. Stress corrosion cracking can occur at temperatures over 60°C. Stainless steel 304 has a good resistance towards oxidation for intermittent to continuous service. In instances where corrosion resistance, in water with temperatures within the ranges of 425-860°C, is required, the use of stainless steel 304L is preferred as it has a high resistance towards carbide precipitation. It is inexpensive and is best suited for applications that require low temperature performance. It is also resistant to scaling that may be caused from alkali solution, organic acids and inorganic acids. Although 304/304L is most commonly used in industrial applications the short coming of this grade is its low mechanical strength.

Material of construction	**Stainless steel 316/316L**
Tensile strength	579 MPa
Ductility	Medium
Corrosion resistance	High
Sustainability to solvents	High sustainability to solvents and can be suitable for high corrosive environments.
Stress capability	High tolerability to stress capability
Typical industry used in	Exhaust manifolds, furnace parts, heat exchangers, valve and pumps, chemical processing equipment, tanks, evaporators, pulp, paper and textile processing equipment and for any parts exposed to marine environments.
Other material characteristics	Stainless steel grade 316 is a more reliable variation of 304 with the addition of molybdenum and a higher nickel content. This results in an increased corrosion resistance in aggressive environments. The molybdenum makes the steel more resistant to pitting and crevice corrosion in chloride-contaminated media, sea water and acetic acid vapors. The lower rate of general corrosion in mildly corrosive environments gives the steel good atmospheric corrosion resistance in polluted marine atmospheres. At higher temperatures 316 has a higher strength and better creep resistance. This grade of stainless steel has good mechanical properties and fabricability. Stainless steel 316 is used in tanks and storage vessels for corrosive liquids, as well as being widely applied in process equipment in the chemical, food, paper, pharmaceutical, petroleum and mining industries

Material of construction	**Stainless steel Alloy 20**
Tensile strength	621 MPa
Ductility	Low
Corrosion resistance	Higher than stainless steel
Sustainability to solvents	Higher than stainless steel and has a good resistance to acids and acidic chlorides
Stress capability	High tolerability to stress capability
Typical industry used in	Automotive applications, chemical processing and power generating equipment, Aqueous environment
Other material characteristics	Super austenitic, high-nickel stainless steels containing between 29-30% nickel and 20% chromium, have a good resistance towards acids and chlorides. Duplex and super-duplex stainless steels contain high percentages of chromium. They are called duplex because their structure is a mixture of austenitic and ferritic phases. They have a better corrosion resistance than austenitic stainless steel and have a reduced susceptibility to stress corrosion cracking. The super-duplex steels were developed for use in aggressive offshore applications. The principal applications for these steels are for chemical-processing and power-generating equipment involving corrosion service in aqueous or liquid-vapor environments at temperatures normally below 315°C. These alloys are also used for special services at temperatures up to 650°C.

Material of construction	**Plastics** **(PVC, Low Density Polyethylene, Propylene, PTFE, GRP)**
Tensile strength	15-85 MPa
Ductility	Low
Corrosion resistance	High Corrosion resistance
Sustainability to solvents	High sustainability to solvents
Stress capability	Low tolerability to stress capability
Typical industry used in	Chemical Plant construction, Food processing and biochemical plants.
Other Material Characteristics:	
PVC	PVC is the most common thermoplastic material in the chemical industry. It is resistant to most inorganic acids with the exception of salt solutions, concentrated sulphuric and nitric acid. They are unsuitable when exposed to organic solvents as they are prone to swelling. The maximum operating temperature for PVC is 60 °C. The main grade of PVC that is used is CPVC. It has a greater high-temperature resistance. CPVC also has an excellent chemical resistance, it is also capable to transport hot fluids. It has been successful in the chemical processing piping systems, pulp and paper processing piping systems, food processing pipe systems and water and sewage treatment piping systems.
Low Density Polyethylene	Low- density polyethylene is inexpensive, tough and flexible. Its low softening points which makes it not suitable for temperatures larger than 60 °C. The solvent resistance to polyolefins are similar to that of PVC.
Polytetrafluoroethylene (PTFE)	PTFE is commonly referred to as Teflon and Fluon, it is resistant to all chemicals with the exceptions of molten alkalis and fluorine and can be used for temperatures up to 250 °C. PTFE is used for gaskets, on valve stems and as coatings which acts as non-stick coating to surfaces such as filter pads. It is also used as vessel linings.
Glass Fiber Reinforced Plastics	Polyester resins, reinforced with glass fiber are the most common thermosetting plastics used in a chemical plant. They are relatively strong and have a resistance to a wide range of chemicals such as dilute

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	mineral acids, inorganic salts and solvents. They are less to alkalis. Reinforced glass fibers are wound on in the form of a continuous filament which results in a high strength material that can be used to make pressure vessels.

Material of construction	**Concrete**
Tensile strength	2-5 MPa
Ductility	Low
Corrosion resistance	High corrosion resistance due to high resistivity
Sustainability to solvents	High
Stress capability	Low
Typical industry used in	Construction, petrochemical, electrical. Concrete has many vast applications. It is typically used in a wide range of industries as storage tanks, raw water reactors and versatile equipment handling.
Other material characteristics	Concrete has a good corrosion resistance. It can have a limited pressure range and has the additional risk of corrosion of reinforcement beams/structures and Spalding. It can degrade in soft water.

Material of construction	**Monel**
Tensile strength	517-620 MPa
Ductility	High can withstand temperatures from 700-900 o C
Corrosion resistance	High corrosion resistance (higher than stainless steel)
Sustainability to solvents	High
Stress capability	High
Typical industry used in	Marine engineering, chemical and hydrocarbon processing equipment, valves, pumps, shafts, fasteners and heat exchangers
Other material characteristics	Monel the classic nickel- alloy (ratio of 2:1). It is commonly used in chemical plants and is more expensive than stainless steel. Monel has good corrosion resistance in dilute mineral acids. It can potentially used in equipment handling of alkalis, organic acids, salts and sea water.

Material of construction	**Lead**
Tensile strength	18 MPa
Ductility	Low, considered as not ductile due to its crystal structure
Corrosion resistance	High corrosion resistance (capable of withstanding long term corrosion)
Sustainability to solvents	High
Stress capability	Low
Typical industry used in	Batteries, manufacturing of ships, radiation protection, health sector, metallurgy, chemical industry, aviation, construction.
Other material characteristics	Lead forms alloys with many metals. Alloys formed with tin, copper, arsenic, antimony, bismuth, cadmium, and sodium are all of industrial importance