



Why Are Metal Standards and Why Are They Important?

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Metallurgy101

A metal is a solid material that is typically hard, opaque, shiny, and features good electrical and thermal conductivity. Industrial metals are generally *malleable* — which means they are capable of being hammered or bent into different shapes without breaking or cracking; *fusible* — capable of being liquefied by heat; and *ductile* — able to be drawn out into a thin wire. Ninety-one out of the 118 elements on the periodic table are classified as metals.

The **ferrous group** of metals is composed mainly of iron. When carbon, a non-metal is added to iron, the result is a common alloy known as steel. Steel alloys may also have small amounts of other metals or elements added such as manganese, nickel, chromium, silicon, titanium, tungsten etc., to give it the required properties.

Non-ferrous metals are those that do not contain any iron. Commonly used non-ferrous metals include aluminum, copper, silver, and gold.

Pure Metals

Individual pure metals possess specific electrical conductivity, strength, hardness, and heat and corrosion resistance properties. Commercial metal alloys, formed through chemical interactions based on their constituent metals and the production method, combine the beneficial properties of individual pure metals into a single compound that is more useful for a particular application.

The development of steel, for example, required finding the optimal combination of carbon and iron in order to produce a metal that is stronger, lighter, and more workable than pure iron. Over the years, stronger steels have been developed by adjusting the steel's chemical composition and carefully controlling the heating and cooling of the steelmaking process. Advanced computer-controlled process technology of the 21st century gives metal producers the ability to make such precise adjustments to composition and production values that thousands of alloys are now in regular production, and new compositions/components are developed regularly.



Component Metals

Discerning engineers give great consideration to selecting the best and most appropriate material for component construction. As a central aspect to component design and vital to creating products that perform their function safely and effectively, a thorough understanding of the key chemical, mechanical, and metallurgic properties of metal and metal alloys, and how those properties change in response to processing and environmental exposure, is required. Factors that influence material selection include:

- chemical properties,
- mechanical properties,
- cost, availability,
- compatibility with other system components,
- life expectancy, reliability, and
- appearance

When sourcing metals, it is of critical importance to have a uniform and consistent means of assuring metal properties meet the desired performance characteristics — from production lot to production lot, one service center to the next. Therein lies the benefit of metal standards.



Characteristics of Metal Standards

Several widely recognized organizations set standards that specify the material, chemical, mechanical, and metallurgical properties of metal materials. These standards are widely used by refineries, metallurgical laboratories, and manufacturers and provide a means of assuring a consistent grade of metal or alloy from a producer and a uniform methodology for quality and integrity testing.

A clear definition of material properties is essential to all users throughout the supply chain. Metal producers use standards to develop the correct formulations, process parameters, and determine dimensional and tolerance requirements for their production. Engineers use them to select the best-suited metal for a project, both in terms of its manufacturability and its end use.

A few of the many characteristics defined in a metal standard include:

- compressive and tensile strength,
- ductility,
- hardness,
- toughness,
- fatigue strength, and
- corrosion resistance

These characteristics can vary widely between different types of metals and alloys. Even within one category, they can vary by the grade of material.

Manufacturers use the properties outlined in standards to assess the suitability of the material for use in one or more metalworking, fabrication, or machining processes that will be applied during a component's manufacture.

Some processes may require the metal to withstand high compressive forces, while others, such as in the case of wire forming, require a material with high tensile strength that can be easily stretched. Manufacturers must also base material selection on end-use customer requirements. Many industries, such as aerospace and automotive, specify that a particular standard grade metal be used in the construction of a component, and manufacturers rely on the ability to easily procure materials that are in compliance with those requirements. The clear-cut and comprehensive definition of a metal grade also removes the risk of errors in production due to lack of complete specifications.

Metal Standards and Testing Standards

Metal standards also reference the testing standards that must be applied for the inspection, analysis, and evaluation of the metal's composition and performance properties for quality assurance. Standards are frequently used by mills and metallurgical laboratories to determine the specific mechanical properties of a production lot and evaluate its conformance to the material specification. The test standards define the material condition at the time of testing, sampling frequency, specimen location and orientation, reporting requirements, and other test parameters. In many cases, more than one test standard must be applied to verify conformance.

Material testing

Material testing requirements are comprehensive and typically include chemical analysis as well as metallurgic inspection and evaluation of the metal's grain size and structure.

Mechanical property testing employs various means of measuring the ductility, strength, hardness properties, and fracture toughness, and may also include measurement of characteristics related to torsion, shear, bending, and fatigue, with additional measurements of creep behavior in cases of elevated temperature materials. A salt spray test is also widely used for the evaluation of corrosion resistance.

Conformance to a standard is assured by means of certification reports. A certified **mill test** report, also referred to as **mill certification** or **metallurgical test report** is a quality assurance document used in the metals industry that certifies a material's chemical and physical properties. It also confirms that a product made of metal complies with a set of specific standards. This document is generated by the raw material manufacturer and provides companies at all levels of the supply chain with certification that the material received matches the requirements of the standards set forth in their order. It provides full traceability of the material from its initial inception to its inclusion in a finished part.

Standard test methods can also be used for other purposes, such as incoming material acceptance testing by the purchaser or evaluation of components after service exposure.

Metal standards make a significant contribution to the development and production of industrial and consumer items, equipment, and machines, and are vital for the free trade of metal products throughout the supply chain. In addition to establishing a comprehensive set of criteria for product performance to ensure the product is fit for its purpose, they also ensure that processors, fabricators, and distributors receive products that have comparable composition and key performance attributes.

Standards Compliance

In the current market, where competition is fierce and resources are scarce, complying with standards can improve the quality and consistency of the product. The ability to purchase materials with defined properties and a recognized level of quality reduces the risk of incompatibility or failure, and ensures that products perform as intended. Businesses can be assured that metals and components supplied by different companies will be mutually compatible. Using standards also helps businesses demonstrate to regulators and customers that their products and services meet defined safety, quality, and environmental standards. Improved ability to meet legislative and regulatory requirements enables companies to develop competitive manufacturing capabilities and expand their market reach by ensuring conformity with various industry, military, aerospace, and automotive standards.



ASTM International and Metal Standards

ASTM International is a globally recognized leader in the development and delivery of international voluntary consensus standards. Formerly known as the American Society for Testing and Materials, it is the standards development partner of the metals producing industry, and has been since its inception over a century ago. There are literally thousands of ASTM standards that cover both ferrous and nonferrous metals, including steel, copper, aluminum, and many others, including high performance alloys. Standards can be general, such as ASTM A108 - 13 *Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished*, or very specific, such as ASTM A888 - 13a *Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications*.

Technical Committees are made up of volunteers that represent manufacturers, consumers, government, and academia. They develop and maintain the standards, which are grouped by designation according to related activities.

The following categories of standards are related to the metals industry.

A. Analytical Chemistry Standards

ASTM's analytical chemistry standards cover the chemical analysis of various metals, alloys, and ores. They also describe and specify certain instruments and equipment that must be used for chemical analysis.

B. Cast Iron Standards

ASTM's ferroalloy and casting standards are instrumental in classifying, evaluating, and specifying the material, chemical, mechanical, and metallurgical properties of iron alloys and their castings.

C. Copper Standards

ASTM's copper standards classify, evaluate, and specify the material, chemical, mechanical, and metallurgical properties of copper materials, including bronze and their alloys with other metals.

D. Corrosion Standards and Wear Standards

ASTM's corrosion and wear standards provide the appropriate procedures for executing corrosion, wear, and abrasion tests on specified metallic materials and alloys. These tests evaluate the behavior, susceptibility, and extent of resistance of certain materials to many types of corrosion, cracking, cavitation, erosion, friction, pitting, and hydrogen embrittlement.

E. Fastener Standards

ASTM's fastener standards are used for specifying, testing, and evaluating the material, dimensional, mechanical, and metallurgical properties of the various forms of hardware fasteners used to mechanically join or affix other hardware objects together. They come in many forms, including rivets, nuts, bolts, studs, screws, washers, eyebolts, nails, and threaded fasteners. .

F. Fatigue Standards and Fracture Standards

ASTM's fatigue and fracture standards provide the appropriate procedures for carrying out fatigue, fracture, and other related tests on specified materials. These tests are conducted to examine and evaluate the behavior, susceptibility, and extent of resistance of certain materials to tension, tear, fatigue, strain, and cracks, as well as other stress factors.

G. Metallic Coating Standards

ASTM's metallic coating standards apply to the physical, chemical, mechanical, and metallurgical properties of metallic powders intended for use as coating material. These standards help to identify characteristics such as density, particle size, compressibility, rupture strength, and surface finish, among others.

H. Nonferrous Metal Standards and Nonferrous Alloy Standards

ASTM's nonferrous metals and alloys standards are instrumental in specifying, testing, and evaluating nonferrous metals and alloys (excluding copper) and light metals and alloys and refractory metals. ASTM nonferrous metals and alloys standards provide the proper procedures for carrying out tests and other evaluation procedures to assess and identify compositions, properties, dimensions, classification, nomenclature, analysis, and quality assurance.

I. Steel Standards

ASTM's steel standards address the material, chemical, mechanical and metallurgical properties of the different types of steels, including carbon, structural, stainless, ferritic, austenitic, and alloy types.

Several other standards bodies either incorporate or refer to ASTM standards into their specifications, or are involved in the process of developing and coordinating technical standards that affect organizations involved in the metals industry.

Military Specifications and Metal Standards

Military specifications, which evolved from the need to ensure proper performance, maintainability, reparability, and logistical practicality of military equipment, are another set of standards. It is vital that the appropriate specifications be identified and strictly adhered to for each individual military project. Military specifications have very strict criteria, and the ability to reliably produce or source certified military grade metal provides expanded business opportunities beyond the commercial and industrial markets.

ISO Standards for Metals

ISO, the International Organization for Standardization, is the world's largest developer of voluntary international standards that are developed through global consensus and help to break down barriers to international trade. They have also published hundreds of standards revolving around the composition and testing of metals and metal products.

Metal standards provide a universal technical communication that promotes mutual understanding between the producer, purchaser, and user. Unambiguous test methods ensure product consistency and uniformity, which helps businesses to establish and meet quality objectives. Standards are essential for achieving interoperability and ensuring that products meet certain functional requirements and performance characteristics. The ability to demonstrate compliance with widely recognized standards is an effective means of differentiating yourself in a highly competitive marketplace. The ability to manufacture products that are compatible with those manufactured by others also increases the potential for new sales.

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