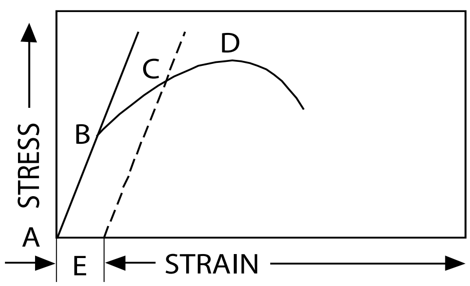
Mechanical and corrosion tests

The tests of materials and products can be divided in five categories: mechanical, physical, chemical, electrochemical, and non destructive tests.
The physical- and electrochemical tests are not discussed in this respect.

Mechanical tests
The aim of mechanical tests is to determine strength properties such as yield limit, tensile strength, elongation after rupture, constriction, hardness and impact value.

Tensile or Tension test
A tensile test, also known as tension test, is the fundamental type of mechanical test to determine how the material will react to forces being applied in tension.



A-B	The area of elastic deformation
B	Elastic limit
C	Yield point
D	Tensile strength
E	Permanent deformation at the yield point

For the tensile test the following characteristic values are important:

Elastic limit
The elastic limit is defined as the maximum limit before plastic deformation of the material take place.
The deformation is still entirely plastic. (entity Mpa or Nmm²)

Yield point
Load at which a solid material that is being stretched begins to flow it is usual to use the 0.2% offset- or the 1% yield strength. This is the tensile where permanent deformation appears. (entity Mpa or Nmm²)

Tensile strength
The pulling stress needed to break a material.
The tensile strength is defined as the maximum force divided by starting cross section from the test bar.
(entity Mpa or Nmm²)

Elongation
The total lengthening of a test bar concerning a certain length until fracture appears.
The elongation is expressed in %.

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Hardness testing
There are three types of tests used with accuracy by the metals industry; they are the Brinell hardness test, the Rockwell hardness test, and the Vickers hardness test. Since the definitions of metallurgic ultimate strength and hardness are rather similar, it can generally be assumed that a strong metal is also a hard metal. The way the three of these hardness tests measure a metal's hardness is to determine the metal's resistance to the penetration of a non-deformable ball or cone. The tests determine the depth which such a ball or cone will sink into the metal, under a given load, within a specific period of time. The followings are the most common hardness test methods used in today`s technology.

Hardness measurement according Brinell
Brinell hardness is determined by forcing a hard steel or carbide sphere of a specified diameter under a specified load into the surface of a material and measuring the diameter of the indentation left after the test.
The Brinell hardness number, or simply the Brinell number, is obtained by dividing the load used, in kilograms, by the actual surface area of the indentation, in square millimetres.
The result is a pressure measurement, but the units are rarely stated.

Brinell hardness is deveined as:

$$HB = \frac{\text{force}}{\text{surface indent}}$$

Hardness measurement according Rockwell
For many steel alloys, a 120 degrees diamond cone is used with up to a 150 kilogram load and the hardness is read on the "C" scale.
The Rockwell test uses two loads, one applied directly after the other. The first load, known as the "minor", load of 10 kilograms is applied to the specimen to help seat the indenter and remove the effects, in the test, of any surface irregularities. In essence, the minor load creates a uniformly shaped surface for the major load to be applied to.
The difference in the depth of the indentation between the minor and major loads provides the Rockwell hardness number.

Hardness measurement according Vickers
This testing is similar to Brinell in that a defined indenter is pressed into a material.
Once the indenting force is removed, the resulting indentation diagonals are measured.
Micro indentation Vickers is per ASTM E384 and Macro indentation Vickers is per ASTM E92.

$$HV = \frac{\text{force}}{\text{surface indent}}$$

Impact test
The notched test specimen is broken by the impact of a heavy pendulum or hammer, falling at a predetermined velocity through a fixed distance. The test measures the energy absorbed by the fractured specimen.

Charpy Impact Test
A test specimen is machined to a 10mm x 10mm (full size) cross-section, with either a "V" or "U" notch.
Sub-size specimens are used where the material thickness is restricted. Specimens can be tested down to cryogenic temperatures.

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Some Technological tests

Bend test
Bend testing is a procedure to determine the relative ductility of metal that is to be formed (usually sheet, strip, plate or wire) or to determine soundness and toughness of metal (after welding, etc.)
The specimen is usually bent over a specified diameter mandrel. The four general types of bends are: free bend, guided bend (ASTM E190), semi-guided bend (ASTM E290), and wrap around bend.

Flattening test
A tube sample 100mm - 150mm in length is flattened in two staps between parallel plates with the weld 90° from the direction of applied force until opposite walls of the tubing meet.
Applications for this test along with the flaring test include situations where round tubing is to be formed into other shapes.

Flaring test
This procedure tests the ability of a section of tube approximately 100mm in length to flare (with a tool having a 60° included angle) until the tube at the mouth of the flare has been expanded 15% of the inside diameter, without cracking or showing flaws.

Non destructive examination

Ultrasonic examination
Ultrasonic methods of NDT use beams of sound waves (vibrations) of short wavelength and high frequency, transmitted from a probe and detected by the same or other probes. Usually, pulsed beams of ultrasound are used and in the simplest instruments a single probe, hand held, is placed on the specimen surface.
Ultrasonic examinations are performed for the detection and sizing of internal defects, flaws or discontinuities in piping, castings, forgings, weldments or other components. Exact sizing techniques have been developed to detect and monitor progressive cracking in a variety of equipment.

Eddy-Current test
Eddy current testing is a rapid and accurate technique used to detect discontinuities in tubing, heat exchangers, condensers, wires, plates, etc. Eddy current testing is also performed for alloy separation and for the determination of treatment conditions. The location of repair welds, girth welds and seam welds may also be detected on ground machined surfaces.

Magnetic testing
The Magnetic Particle Inspection method of Non-Destructive testing is a method for locating surface and sub-surface discontinuities in ferromagnetic material.
Dry magnetic particle examinations and wet fluorescent magnetic particle examinations are performed on ferromagnetic materials to detect surface and slight subsurface discontinuities.

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Non destructive examination

Liquid (Dye) penetrant examination
This method employs a penetrating liquid, which is applied over the surface of the component and enters the discontinuity or crack.
Various types of liquid penetrant examination methods are utilized to detect open or surface cracks or defects in materials.
Red dye or fluorescent penetrants are utilized as well as various types of wet and dry developers.
Penetrants can contain a dye to make the indication visible under white light, or a fluorescent material that fluoresces under suitable ultra-violet light. Fluorescent penetrants are usually used when the maximum flaw sensitivity is required. Cracks as narrow as 150 nanometres can be detected

Radiographic examination
Conventional Radiography is a non-destructive examination method that uses X-ray and Gamma-ray for detecting internal imperfections, for measuring wall-thickness and for detection of corrosion. With radiographic examination the material is exposed to a homogenous ray from a radioactive isotope or an X-ray tube, while a negative film is positioned behind the material to be examined. After development of the film, thickness and density differences (i.e. material imperfections) will show as blackness differences.

Corrosion tests

Strauss test
This test is conducted to determine the susceptibility of austenitic stainless steel to intergranular attack associated with the precipitation of chromium-rich carbides. Once the specimen has been subjected to the solution (16% sulphuric acid) boil for most common 24hr, it is bent through 180° and over a diameter equal to the thickness of the specimen being bent. This test is based on a visual examination of the bent specimen.

Huey test
This procedure includes a boiling 65% solution of nitric acid test to evaluate the heat treatment or “sensitization” of material. It may also be used to check the effectiveness of stabilizing elements and of reductions in carbon content in reducing susceptibility to intergranular attack in chromium-nickel stainless steels.