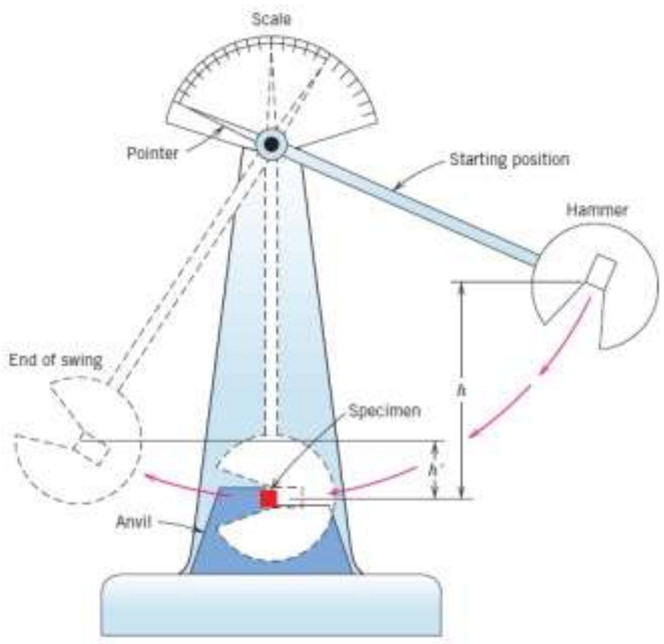
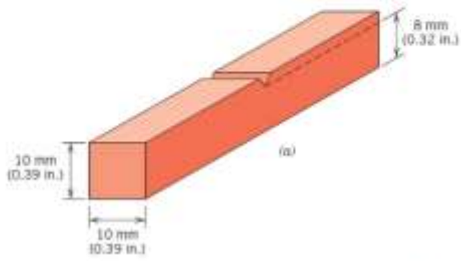
IMPACT TEST

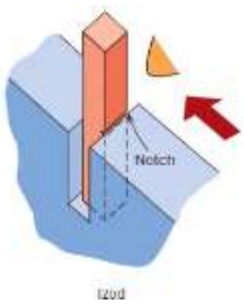
Introduction

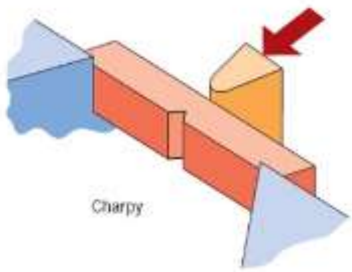
Notched-bar impact test of metals provides information on failure mode under high velocity loading conditions leading sudden fracture where a sharp stress raiser (notch) is present. The energy absorbed at fracture is generally related to the area under the stress-strain curve which is termed as toughness in some references. Brittle materials have a small area under the stress-strain curve (due to its limited toughness) and as a result, little energy is absorbed during impact failure. As plastic deformation capability of the materials (ductility) increases, the area under the curve also increases and absorbed energy and respectively toughness increase. Similar characteristics can be seen on the fracture surfaces of broken specimens. The fracture surfaces for low energy impact failures, indicating brittle behavior, are relatively smooth and have crystalline appearance in the metals. On the contrary, those for high energy fractures have regions of shear where the fracture surface is inclined about 45° to the tensile stress, and have rougher and more highly deformed appearance, called fibrous fracture.





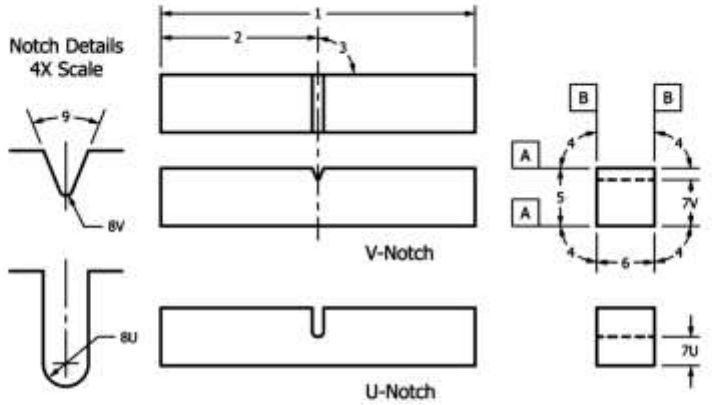
Two standardized tests, the Charpy and Izod, were designed and are still used to measure the impact energy, sometimes also termed *notch toughness*. The Charpy V-notch (CVN) technique is most commonly used in the United States. For both Charpy and Izod, the specimen is in the shape of a bar of square cross section, into which a V-notch is machined. The apparatus for making V-notch impact tests is illustrated schematically in the Figure.





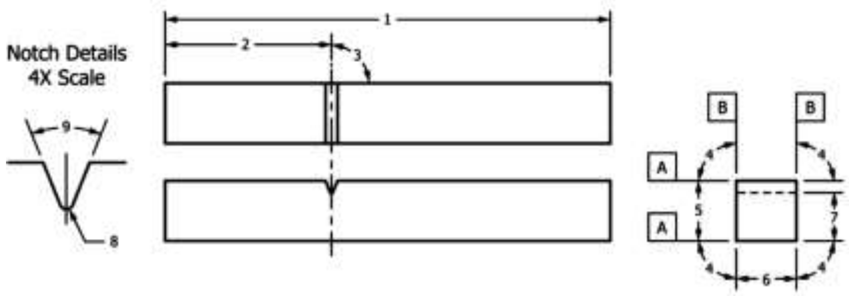
Specimen Preparation

The load is applied as an impact blow from a weighted pendulum hammer that is released from a cocked position at a fixed height *h*. The specimen is positioned at the base as shown. Upon release, a knife edge mounted on the pendulum strikes and fractures the specimen at the notch, which acts as a point of stress concentration for this high-velocity impact blow. The pendulum continues its swing, rising to a maximum height *h'* which is lower than *h*. The energy absorption, computed from the difference between *h* and *h'* is a measure of the impact energy. The primary difference between the Charpy and Izod techniques lies in the manner of specimen support, as illustrated in Figure. Furthermore, these are termed impact tests in light of the manner of load application. Variables including specimen size and shape as well as notch configuration and depth influence the test results.



ID Number	Description	Dimension	Tolerance
1	Length of specimen	55 mm	+0/-2.5 mm
2	Centering of notch		±1 mm
3	Notch length to edge	90°	±2°
4	Adjacent sides angle	90°	±0.17°
5	Width	10 mm	±0.075 mm
6	Thickness	10 mm	±0.075 mm
7V	Ligament length, Type V	8 mm	±0.025 mm
7U	Ligament length, Type U	5 mm	±0.075 mm
8V	Radius of notch, Type V	0.25 mm	±0.025 mm
8U	Radius of notch, Type U	1 mm	±0.025 mm
9	Angle of notch	45°	±1°
A	Surface finish requirements	2 μm (Ra)	≤
B	Surface finish requirements	4 μm (Ra)	≤

FIG. 1 Charpy (Simple-Beam) Impact Test Specimens, V-Notch and U-Notch



ID Number	Description	Dimension	Tolerance
1	Length of specimen	75 mm	+0/-2.5 mm
2	Notch to top	28 mm	
3	Notch length to edge	90°	±2°
4	Adjacent sides angle	90°	±0.17°
5	Width	10 mm	±0.025 mm
6	Thickness	10 mm	±0.025 mm
7	Ligament length	8 mm	±0.025 mm
8	Radius of notch	0.25 mm	±0.025 mm
9	Angle of notch	45°	±1°
A	Surface finish requirement	2 μm (Ra)	≤
B	Surface finish requirement	4 μm (Ra)	≤

FIG. 2 Izod (Cantilever-Beam) Impact Test Specimen

The absorbed energy shall be taken as the difference between the energy in the striking member at the instant of impact with the specimen and the energy remaining after breaking the specimen. This value is determined by the machine's scale reading which has been corrected for windage and friction losses. The energy absorbed at fracture *E* can be obtained by simply calculating the difference in potential energy of the pendulum before and after the test such as,

$$E = m.g.(h-h')$$

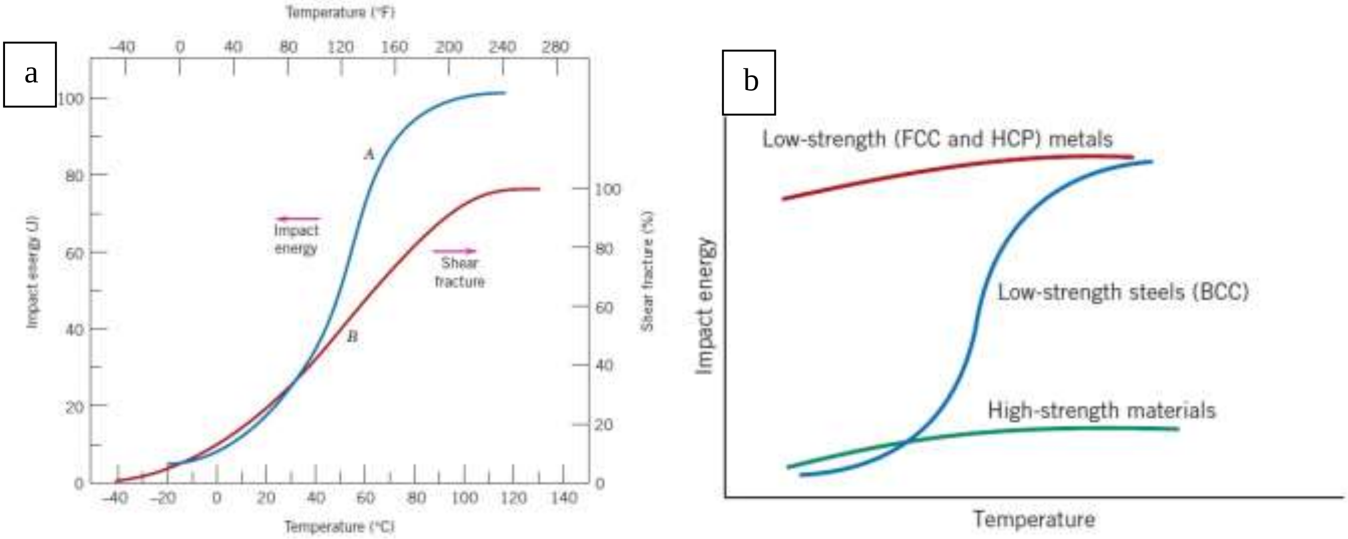


FIG. 3 (a) Temperature dependence of V-notch impact energy (curve A) and percent shear fracture (curve B). (b) Schematic curves for the three general types of impact energy-versus-temperature behavior.

References

- ASTM E23-16b Standard Test Methods for Notched Bar Impact Testing of Metallic Materials, ASTM International, West Conshohocken, PA, 2016
- Materials Science and Engineering, Eight Edition, William D. Callister and David G. Rethwisch

Tasks

Temperature (°C)	*Impact Energy (J)*
50	76
40	76
30	71
20	58
10	38
0	23
−10	14
−20	9
−30	5
−40	1.5

1- Following is tabulated data that were gathered from a series of Charpy impact tests on a commercial low-carbon steel alloy.
(a) Plot the data as impact energy versus temperature.
(b) Determine a ductile-to-brittle transition temperature as that temperature corresponding to the average of the maximum and minimum impact energies.

2- Determine the absorbed energy by the specimen if the starting height is 800 mm, end of swing height is 100 mm and mass of the hammer is 8 kg.