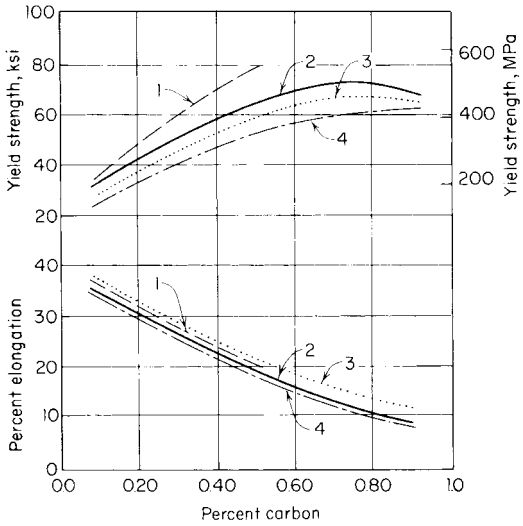


Fig. 6.3.11 Yield strength and elongation versus carbon content for cast carbon steels. (1) Water quenched and tempered at 1,200°F; (2) normalized; (3) normalized and tempered at 1,200°F; (4) annealed.

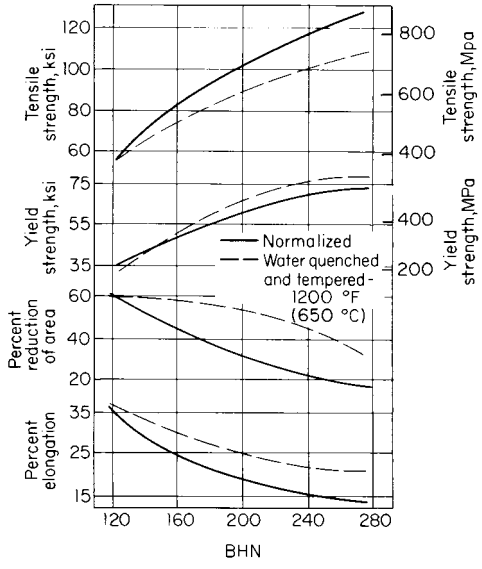


Fig. 6.3.12 Tensile properties of carbon steel as a function of hardness.

For equal tool life, the skin of a steel casting should be machined at approximately one-half the cutting speed recommended for the base metal. The machinability of various carbon and low-alloy cast steels is given in Table 6.3.15.

Welding steel castings presents the same problems as welding wrought steels. It is interesting to note that cast low-alloy steels show greater resistance to underbead cracking than their wrought counterparts.

Purchase Specifications for Steel Castings Many steel castings are purchased according to mechanical property specifications, although more frequent use of specifications which indicate the use of steel castings may be more helpful. Note that it is now possible to order steel castings as cast equivalents of the SAE/AISI chemical composition

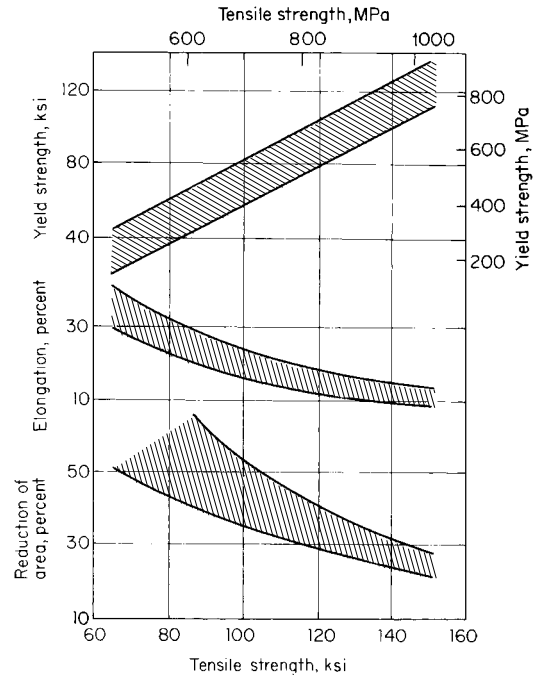


Fig. 6.3.13 Properties of normalized and tempered low-alloy cast steels.

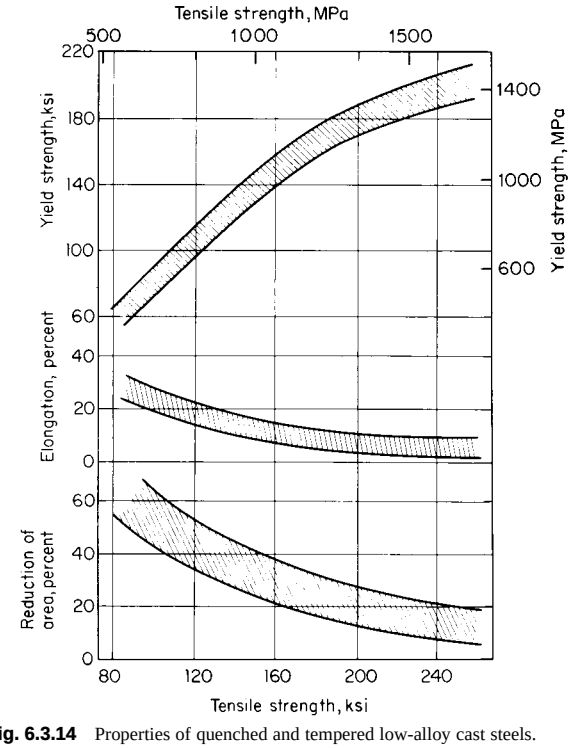


Fig. 6.3.14 Properties of quenched and tempered low-alloy cast steels.

Table 6.3.15 Machinability Index for Cast Steels

Steel	BHN	Conventional		Metcut*	
		Carbide	HSS	HSS	Carbide
B1112 Free machining steel (wrought)	179	. . .	100		
1020 Annealed	122	10	90	160	400
1020 Normalized	134	6	75	135	230
1040 Double normalized	185	11	70	130	400
1040 Normalized and annealed	175	10	75	135	380
1040 Normalized	190	6	65	120	325
1040 Normalized and oil-quenched	225	6	45	80	310
1330 Normalized	187	2	40	75	140
1330 Normalized and tempered	160	3	65	120	230
4130 Annealed	175	4	55	95	260
4130 Normalized and spheroidized	175	3	50	90	200
4340 Normalized and annealed	200	3	35	60	210
4340 Normalized and spheroidized	210	6	55	95	290
4340 Quenched and tempered	300	2	25	45	200
4340 Quenched and tempered	400	½	20	35	180
8430 Normalized and tempered at 1,200°F (660°C)	200	3	50	90	200
8430 Normalized and tempered at 1,275°F (702°C)	180	4	60	110	240
8630 Normalized	240	2	40	75	180
8630 Annealed	175	5	65	120	290

* The Metcut speed index number is the actual cutting speed (surface ft/min) which will give 1 h tool life in turning.

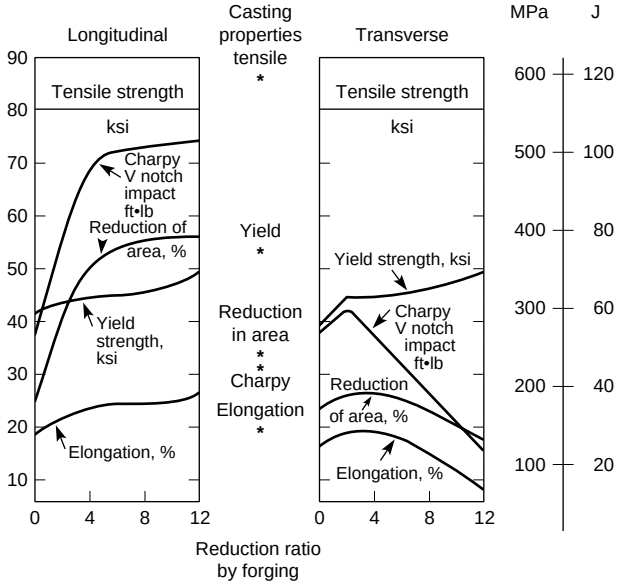


Fig. 6.3.15 Influence of forging reduction on anisotropy for a 0.35 percent carbon wrought steel. Properties for a cast of 0.35 percent carbon steel are shown with an asterisk for comparison purposes. *(Steel Founders Society of America Handbook, 5th ed.)*

ranges using ASTM A915. It is preferable to order steel castings to conform with national standards such as ASTM. ASTM standards are prepared by purchasers and suppliers and are well understood by steel foundries. The property levels specified in ASTM specifications A27 and A148 are shown in Table 6.3.16. Table 6.3.17 lists current applicable ASTM steel castings standards.

Steel Melting Practice Steel for steel castings is produced commercially by processes similar to those used for wrought steel production, but electric arc and electric induction melting furnaces predominate. Some steel foundries also use secondary refining processes such as **argon oxygen decarburization** (AOD) and/or **vacuum oxygen degassing** (VOD). Wire injection is also used selectively depending on service and process requirements for the steel casting. In addition to the materials

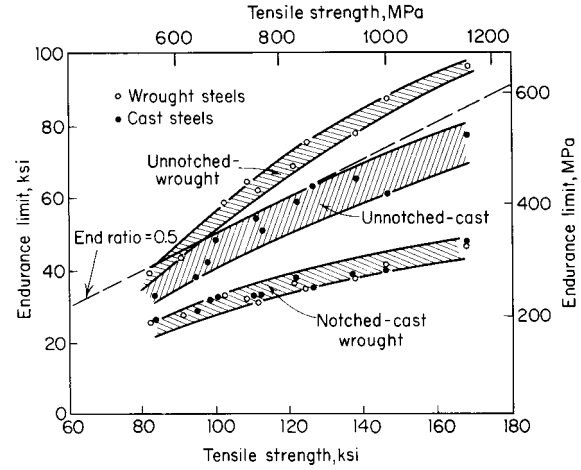


Fig. 6.3.16 Variations of endurance limit with tensile strength for comparable carbon and low-alloy cast and wrought steels.

listed in the ASTM standards, the steel casting industry will produce compositions tailored especially for particular service applications, and even in small quantity.

Allowances for Steel Castings

Dimensional allowances that must be applied in the production of castings are due to the fact that different metals contract at different rates during solidification and cooling. The shape of the part has a major influence on the as-cast dimensions of the casting. Some of the principal allowances are discussed briefly here.

Shrinkage allowances for steel castings vary from 9⁄32 to 1⁄16 in/ft (0.03 to 0.005 cm/cm). The amount most often used is ¼ in/ft (0.021 cm/cm), but if it is applied indiscriminately, it can lead to problems in steel casting dimensions. The best policy is to discuss shrinkage allowances with the foundry that makes the castings before patterns are made.

Minimum Section Thickness The fluidity of steel when compared to other metals is low. In order that all sections may be completely filled, a minimum value of section thickness must be adopted that is a function of the largest dimension of the casting. These values are suggested for design use:

Table 6.3.16 ASTM Requirements for Steel Castings in A27 and A148

Grade	Tensile strength, min, ksi (MPa)	Yield point min, ksi (MPa)	Elongation, min, %	Reduction of area, min, %
		ASTM A27		
U-60-30	60 (415)	30 (205)	22	30
60-30	60 (415)	30 (205)	24	35
65-35	65 (450)	35 (240)	24	35
70-36	70 (485)	36 (250)	22	30
70-40	70 (485)	40 (275)	22	30
		ASTM A148		
80-40	80 (550)	40 (275)	18	30
80-50	80 (550)	50 (345)	22	35
90-60	90 (620)	60 (415)	20	40
105-85	105 (725)	85 (585)	17	35
115-95	115 (795)	95 (655)	14	30
130-115	130 (895)	115 (795)	11	25
135-125	135 (930)	125 (860)	9	22
150-135	150 (1,035)	135 (930)	7	18
160-145	160 (1,105)	145 (1,000)	6	12
165-150	165 (1,140)	150 (1,035)	5	20
165-150L	165 (1,140)	150 (1,035)	5	20
210-180	210 (1,450)	180 (1,240)	4	15
210-180L	210 (1,450)	180 (1,240)	4	15
260-210	260 (1,795)	210 (1,450)	3	6
260-210L	260 (1,795)	210 (1,450)	3	6

SOURCE: Abstracted from ASTM data, by permission.

Min section thickness		Max length of section	
in	mm	in	cm
¼	6	12	30
½	13	50	125

Casting finish allowances (unmachined) are based on the longest dimension of the casting, but the casting weight may also influence these allowances. Other factors which affect allowances include pattern materials and the method of pattern construction. Average values of allowance as a function of pattern type are shown in Table 6.3.18; other sources of similar data are ''Steel Castings Handbook,'' Supplement 3, ''Tolerances,'' SFSA, and ISO 8062 (Castings—System of Dimensional Tolerances and Machining Allowances). It is strongly recommended that designers discuss allowance requirements with the foundry to avoid unnecessary costs.

Machining finish allowances added to the casting dimensions for machining purposes will depend entirely on the casting design. Definite values are not established for all designs, but Table 6.3.19 presents a brief guide to machining allowances on gears, wheels, and circular, flat castings.

Use of Steel Castings

All industries use steel castings. They are used as wheels, sideframes, bolsters, and couplings in the railroad industry; rock crushers in the mining and cement industries; components in construction vehicles; suspension parts and fifth wheels for trucks; valves; pumps; armor. High-alloy steel castings are used in highly corrosive environments in the chemical, petrochemical, and paper industries. Generally, steel castings are applied widely when strength, fatigue, and impact properties

Table 6.3.17 A Summary of ASTM Specifications for Steel and Alloy Castings

A 27	Steel Castings, Carbon, for General Application
A 128	Steel Castings, Austenitic Manganese
A 148	Steel Castings, High Strength, for Structural Purposes
A 216	Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
A 217	Steel Castings, Martensitic Stainless and Alloy, for Pressure-Containing Parts, Suitable for High-Temperature Service
A 297	Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat-Resistant, for General Application
A 351	Steel Castings, Austenitic, Austenitic-Ferritic (Duplex), for Pressure-Containing Parts
A 352	Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service
A 356	Steel Castings, Carbon, Low-Alloy, and Stainless Steel, Heavy-Walled for Steam Turbines
A 389	Steel Castings, Alloy, Specially Heat-Treated, for Pressure-Containing Parts, Suitable for High-Temperature Service
A 426	Centrifugally Cast Ferritic Alloy Steel Pipe for High-Temperature Service
A 447	Steel Castings, Chromium-Nickel-Iron Alloy (25-12 Class), for High-Temperature Service
A 451	Centrifugally Cast Austenitic Steel Pipe for High-Temperature Service
A 487	Steel Castings, Suitable for Pressure Service
A 494	Castings, Nickel and Nickel Alloy
A 560	Castings, Chromium-Nickel Alloy
A 660	Centrifugally Cast Carbon Steel Pipe for High-Temperature Service
A 703	Steel Castings, General Requirements, for Pressure-Containing Parts
A 732	Castings, Investment, Carbon and Low-Alloy Steel for General Application, and Cobalt Alloy for High Strength at Elevated Temperatures
A 743	Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion-Resistant, for General Application
A 744	Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion-Resistant, for Severe Service
A 747	Steel Castings, Stainless, Precipitation Hardening
A 757	Steel Castings, Ferritic and Martensitic, for Pressure-Containing and Other Applications, for Low-Temperature Service
A 781	Castings, Steel and Alloy, Common Requirements, for General Industrial Use
A 890	Castings, Iron-Chromium-Nickel-Molybdenum, Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application
A 915	Steel Castings, Carbon and Alloy, Chemical Requirements Similar to Standard Wrought Grades

SOURCE: Abstracted from ASTM data, by permission.