

STEEL

Prof. Katya Brunelli

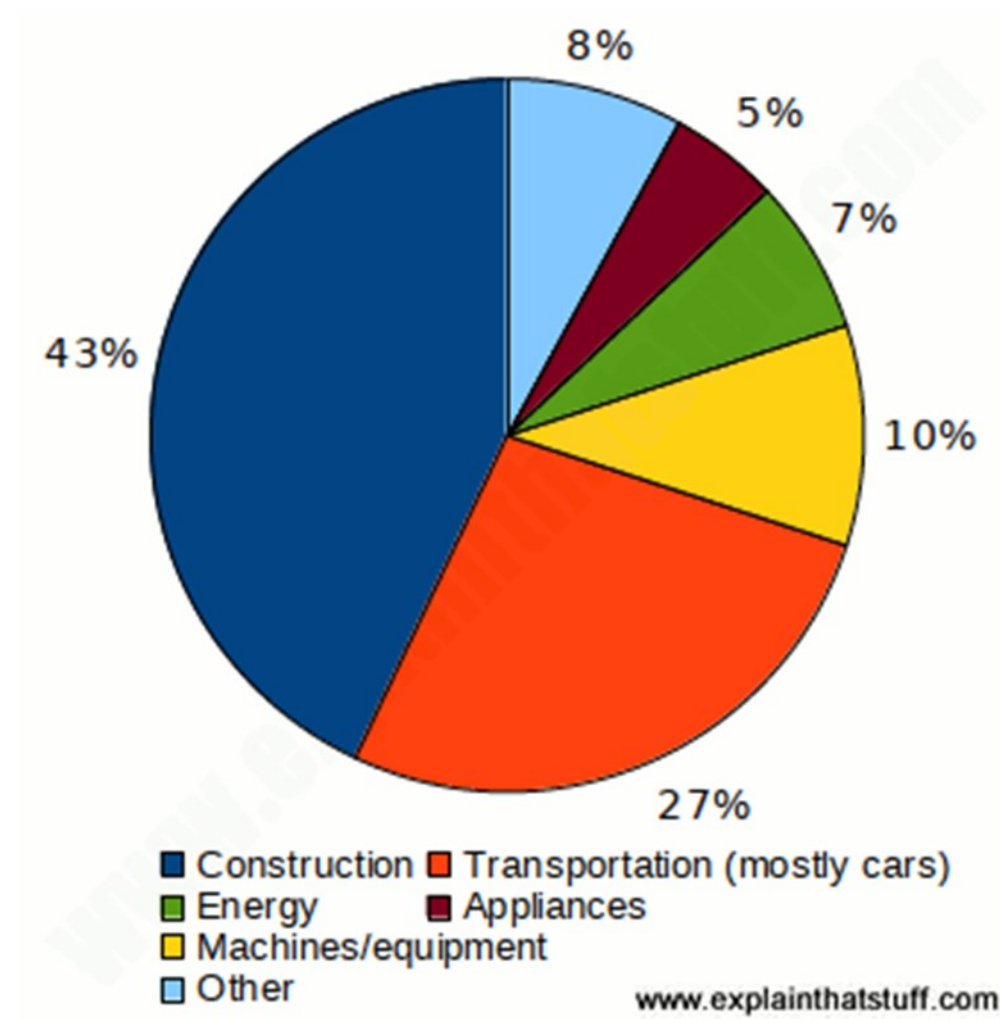


1. Definition and classification of grades of steel:
European standard EN 10020
- 2. Classification of steels based on uses**
3. Production and Recycling of steel
4. Steel scrap

Classification of steels based on uses

- STEELS FOR GENERAL STRUCTURAL PURPOSES
- “SPECIAL CONSTRUCTION” STEELS
- STAINLESS STEELS
- Tool steels
- Steel for particular uses

Major consumers of steel include the construction industry, the automobile and shipbuilding industries, producers of food cans, and manufacturers of electrical appliances.



STEELS FOR GENERAL STRUCTURAL PURPOSES

- Construction steels are the most commonly used alloys due to their low cost and good mechanical characteristics.
- About 80% of the world's steel production.
- They are designed to withstand static or dynamic stresses without breaking or deforming. They must be weldable.
- They are used to construct residential and commercial buildings, warehouses, aircraft hangers, hospital and school buildings, metro stations, stadiums, bridges, etc.
- A particular chemical composition is NOT required for these steels, even if the reference standards provide for certain compositional forks for each type and the presence of certain elements in some cases and certain limits.
- Steels designated based on their use and their mechanical properties.
- They are NOT subjected to heat treatments.

They belong to Category 1 of designation of steels.

STEELS FOR GENERAL STRUCTURAL PURPOSES

Steel	C % max	Mn % max	Si % max	P % max	S % max	N % max
S 185	-	-	-	-	-	-
S 235 JR	0,170	1,400	-	0,045	0,045	0,009
S 235 JR G1	0,170	1,400	-	0,045	0,045	0,007
S 235 JR G2	0,170	1,400	-	0,045	0,045	0,009
S 235 JO	0,170	1,400	-	0,040	0,040	0,009
S 235 J2 G3	0,170	1,400	-	0,035	0,035	-
S 235 J2 G4	0,170	1,400	-	0,035	0,035	-
S 275 JR	0,210	1,500	-	0,045	0,045	0,009
S 275 JO	0,180	1,500	-	0,040	0,040	0,009
S 275 J2 G3	0,180	1,500	-	0,035	0,035	-
S 275 J2 G4	0,180	1,500	-	0,035	0,045	-
S 355 JR	0,240	1,600	0,55	0,045	0,045	0,009
S 355 JO	0,200	1,600	0,55	0,040	0,040	0,009
S 355 J2 G3	0,200	1,600	0,55	0,035	0,035	-
S 355 J2 G4	0,200	1,600	0,55	0,035	0,035	-
S 355 K2 G3	0,200	1,600	0,55	0,035	0,035	-
S 355 K2 G4	0,200	1,600	0,55	0,035	0,035	-
E 295	-	-	-	0,045	0,045	0,009
E 335	-	-	-	0,045	0,045	0,009
E 360	-	-	-	0,045	0,045	0,009

STEELS FOR GENERAL STRUCTURAL PURPOSES

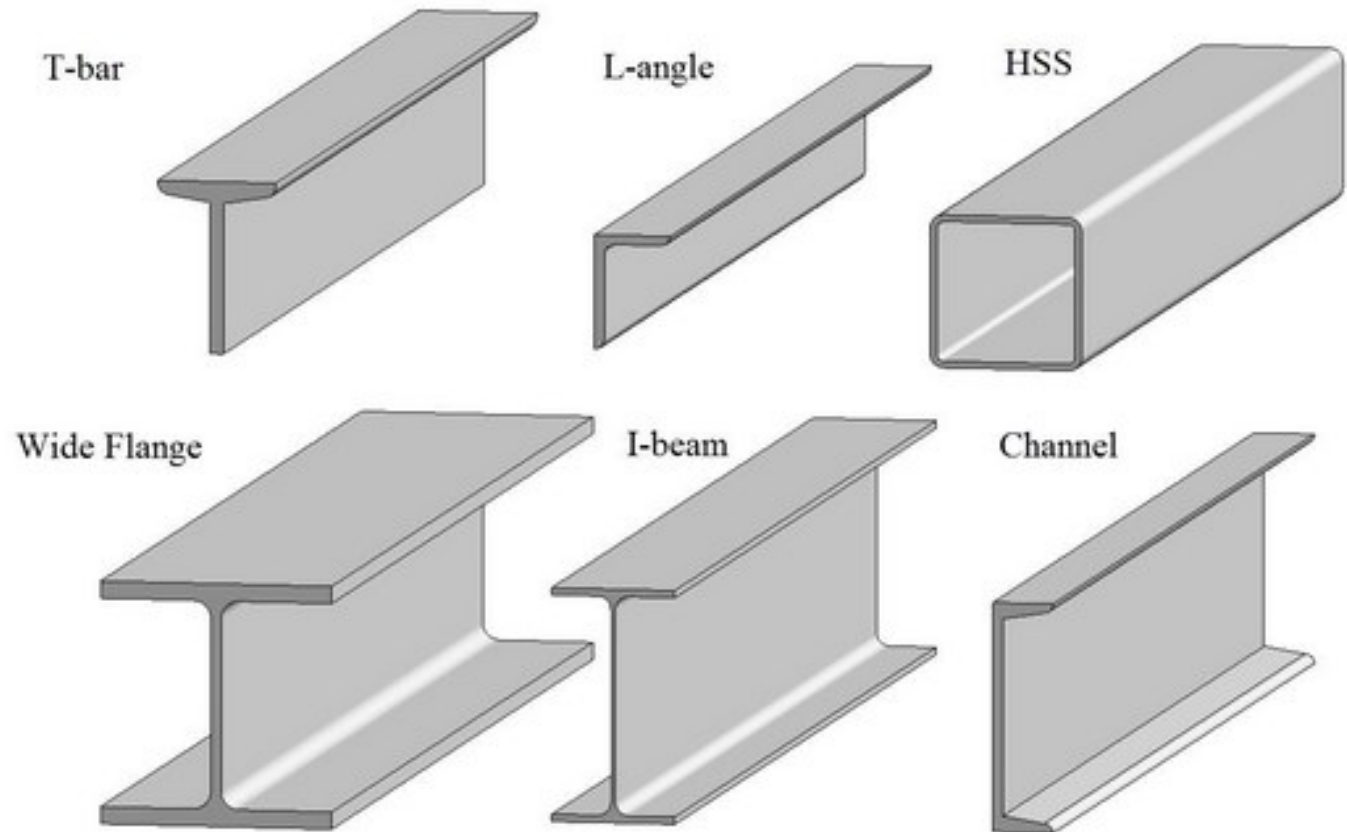
steel	yield strength N/mm ² min	impact property	
		C°	J
S 185	185	-	-
S 235 JR	235	20	27
S 235 JR G1	235	20	27
S 235 JR G2	235	20	27
S 235 JO	235	0	27
S 235 J2 G3	235	-20	27
S 235 J2 G4	235	-20	27
S 275 JR	275	20	27
S 275 JO	275	0	27
S 275 J2 G3	275	-20	27
S 275 J2 G4	275	-20	27
S 355 JR	355	20	27
S 355 JO	355	0	27
S 355 J2 G3	355	-20	27
S 355 J2 G4	355	-20	27
S 355 K2 G3	355	-20	40
S 355 K2 G4	355	-20	40
E 295	295	-	-
E 335	335	-	-
E 360	360	-	-

STEELS FOR GENERAL STRUCTURAL PURPOSES

GENERAL STRUCTURAL STEELS BASED ON TENSILE STRENGTH	
S235JR	Construction, industry, box profile, bar making and hot rolled industry profiles
S235JRG1	Construction, industry, box profile, bar making and hot rolled industry profiles
S235JRG2	Construction, industry, box profile, bar making and hot rolled industry profiles
S235J2G3	Construction, flat plane materials, materials for which brightness is desired, welded-seamless pipes
S275JR	Construction and industry, high resistant hot rolled industry profiles
S275J0	Construction and industry, high resistant hot rolled industry profiles
S355J0	Industry and construction, practices for which high resistance is desired
E295	Loads subject to compressive stress, lever arm, mold and press bases
E335	Machinery elements, gearwheels, etc. for which high resistance is desired
E360	Rivet, special bolt, wedge and machinery elements for which resistance is desired

STEELS FOR GENERAL STRUCTURAL PURPOSES

Structural steel is a category of steel used for making construction materials in a variety of shapes. Many structural steel shapes take the form of an elongated beam having a profile of a specific cross section.



STEELS FOR GENERAL STRUCTURAL PURPOSES

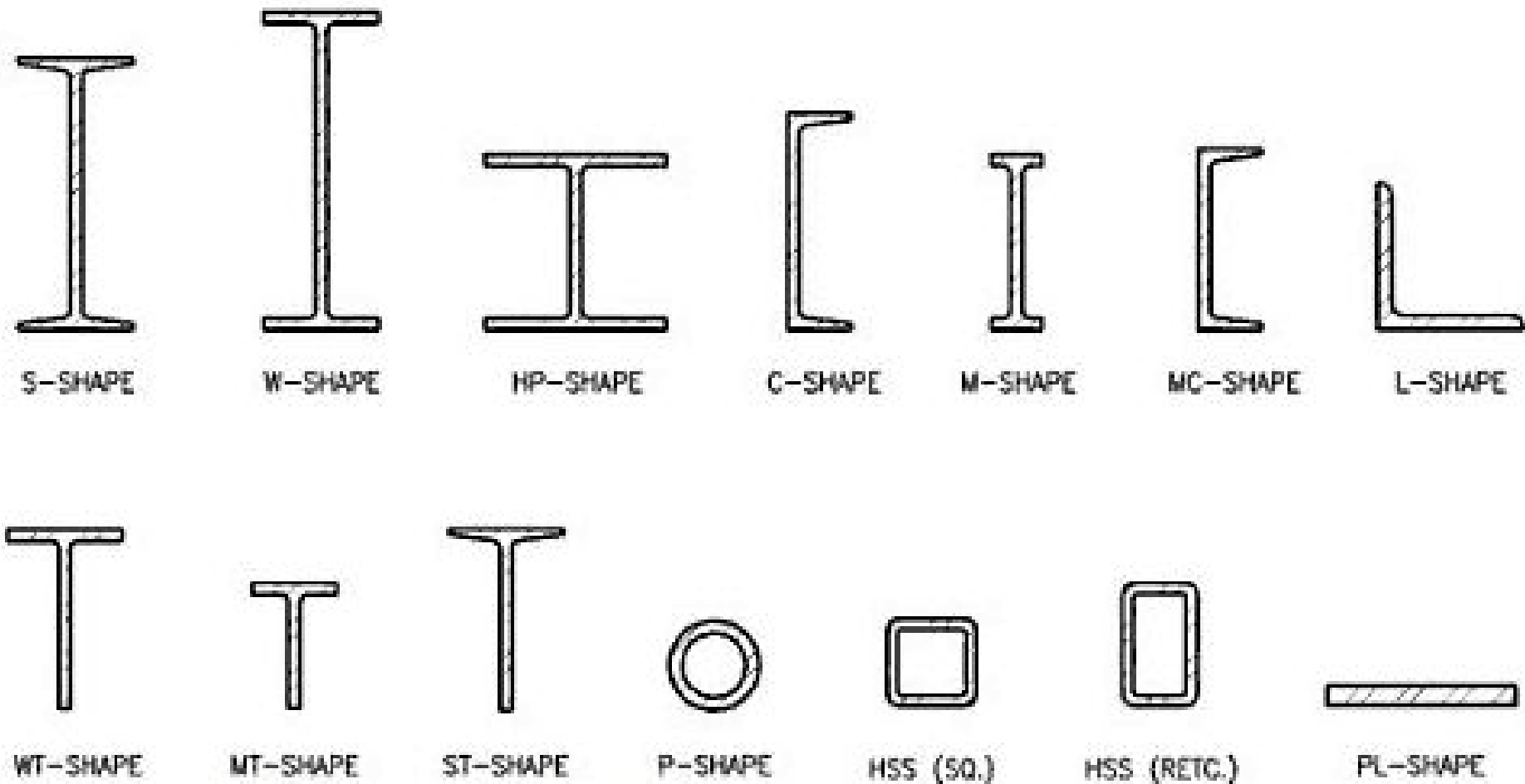


Figure 2: The Various Types of Structural Steel Shapes

STEELS FOR GENERAL STRUCTURAL PURPOSES



STEELS FOR GENERAL STRUCTURAL PURPOSES

Galvanizing

Galvanization or galvanizing is the process of applying a protective zinc coating to steel, to prevent corrosion.

The most common method is hot-dip galvanizing, in which the parts are submerged in a bath of molten hot zinc.



“SPECIAL CONSTRUCTION” STEELS

“Special construction” steels :

they must withstand static and dynamic stresses of considerable magnitude in service.

A particular chemical composition is required for these steels.

They are always subjected to heat treatments.

They are:

- Steels for hardening and tempering
- Self-hardening steels
- Case hardening steels
- Nitriding steels
- Spring steels
- Bearing steels
- Steel for ropes

They belong to category 2 of designation of steels: group 1 and 2

“SPECIAL CONSTRUCTION” STEELS

Steels for hardening and tempering:

They are the most important and used of special structural and engineering applications:

Not alloy:

- C 20 – C 60

Alloy:

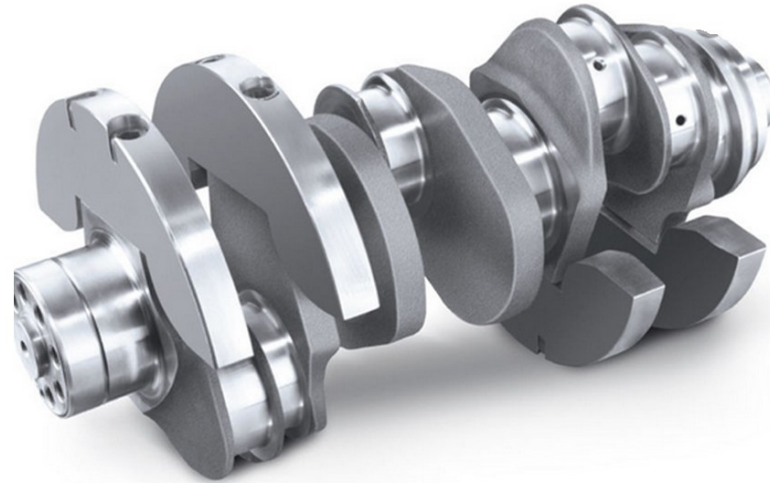
- with Cr: 41 Cr 4
- with Cr-Mo: 42 CrMo 4
- with Cr-Ni: 35 NiCr 9
- with Cr-Ni-Mo: 38 NiCrMo 4, 30 NiCrMo 12

“SPECIAL CONSTRUCTION” STEELS

Steels for hardening and tempering:

They are used to produce:

- power Transmission Shafts,
- crankshafts,
- axles,
- rail axles,
- camshafts,
- transfer shafts,
- connecting rods,
- hooks,
- discs,
- bolts,
- pistons, etc.



“SPECIAL CONSTRUCTION” STEELS

Steels for hardening and tempering

Steel grade	CHEMICAL ELEMENTS (% on mass)							
	C		Si		Mn		P	S
	Min.	Max.	Min.	Max.	Min.	Max.	Max.	Max.
C22	0.17	0.24	–	0.40	0.40	0.70	0.035	0.035
C35	0.32	0.39	–	0.40	0.50	0.80	0.035	0.035
C45	0.42	0.50	–	0.40	0.50	0.80	0.035	0.035
C60	0.57	0.65	–	0.40	0.60	0.90	0.035	0.035
38Mn6	0.34	0.42	0.15	0.35	1.40	1.65	0.035	0.035

For all the a.m. steelgrades: $\text{Cr} \leq 0.40\%$; $\text{Mo} \leq 0.10\%$; $\text{Ni} \leq 0.40\%$; $\text{Cr} + \text{Mo} + \text{Ni} \leq 0.63\%$.

"SPECIAL CONSTRUCTION" STEELS

Steels for hardening and tempering

Steel grade	CHEMICAL Elements % (*)					Mechanical properties			
	C	Mn	Cr	Ni	Mo	R N/mm ²	R _{m,2} min N/mm ²	A min %	KV min J
C 25	0,25	0,60	—	—	—	625	360	19	45
C 30	0,30	0,65	—	—	—	700	400	17	40
C 35	0,35	0,70	—	—	—	700	430	16	35
C 40	0,40	0,70	—	—	—	750	460	15	30
C 45	0,46	0,70	—	—	—	800	490	14	25
C 50	0,51	0,75	—	—	—	830	520	13	—
C 55	0,56	0,75	—	—	—	865	550	12	—
C 60	0,60	0,75	—	—	—	905	580	11	—
41 Cr 4	0,40	0,70	1,00	—	—	1150	800	11	30
51 CrV 4	0,51	0,90	1,00	—	—	1200	900	9	30
25 CrMo 4	0,25	0,75	1,00	—	0,20	1000	700	12	45
34 CrMo 4	0,35	0,75	1,00	—	0,20	1100	800	11	35
42 CrMo 4	0,42	0,75	1,00	—	0,20	1200	900	10	30
50 CrMo 4	0,50	0,65	1,00	—	0,20	1200	900	9	30
30 CrNiMo 8	0,31	0,45	2,00	2,00	0,40	1350	1050	9	30
34 CrNiMo 6	0,34	0,65	1,50	1,50	0,20	1300	1000	9	35
36 CrNiMo 4	0,36	0,65	1,00	1,00	0,20	1200	900	10	35
36 NiCrMo 16	0,35	0,45	1,80	3,80	0,30	1350	1050	9	30

Si = 0,40%; S e P ≤ 0,035%; (**) Il tenore di Vanadio è V = 0,10 ÷ 0,25%.

STAINLESS STEELS

STAINLESS STEELS

- ~39,1 million of ton/year in the world
- Steels resistant to corrosion (atmosphere and other environments)
- Contain more than 12% Cr dissolved in a solid solution.
- Corrosion resistant due to a Cr_2O_3 protective layer.

According to the structure:

Austenitic (Cr-Ni): best corrosion resistance, **paramagnetic**

X 5 CrNi 18 10 (AISI 304); X 5 CrNiMo 18 10 (AISI 316)

Martensitic (Cr): best mechanical properties, magnetic

X 20 Cr 13 (AISI 410); X 30 Cr 13 (AISI 420); X 70 CrMo 17 (AISI 440)

Ferritic (Cr); intermediate properties, magnetic

X 8 Cr 17 (AISI 430)

They belong to category 2 of designation of steels: group 3

STAINLESS STEELS

Applications:

Aircrafts and Aerospace: Stainless steel is resistant to corrosion and able to withstand even the harshest environmental conditions. This makes it ideal for aircrafts, as they operate in various temperatures, elevations, and precipitation. The material is also highly durable, an important quality when operating in the air.

High-Pressure Energy Systems: The durable nature of stainless steel is also able to withstand high pressures and temperatures, making it ideal for energy production. This includes land-based power plants as well as more remote military applications.

Medical Equipment: A familiar use, medical equipment needs to be in top condition and able to be sanitized easily. Stainless steel provides this level of cleanliness for tools and other medical appliances.

STAINLESS STEELS

Applications:

Oil And Gas Sourcing: Similar to its use in energy plants, stainless steel is also used in the harvest of natural gas and oil. These alloys are appropriate materials for these applications because they are able to stand up to the high pressure and heat under the earth's surface.

Food Processing: Using stainless steel for food production is a healthy protection for consumers, as it provides clean, corrosion-free tools and surfaces with which food is made and packaged. Much like in the medical industry, it is able to be sanitized very easily.

STAINLESS STEELS

		Chemistry of selected elements (percent by weight, maximum or range shown)						Mechanical properties (min values after annealing)				
		Carbon	Manganese	Chromium	Nickel	Molybdenum	Other	Yield Strength		Tensile Strength		Elongation
Family	Grade	C	Mn	Cr	Ni	Mo		MPa	ksi	MPa	ksi	(%)
Austenitic	201	0.15	5.5 to 7.5	16.0 to 18.0	3.5 to 5.5		0.25 N	260	35	515	75	40
Austenitic	304	0.07	2.0	17.5 to 19.5	8 to 10.5		0.1 N	205	30	515	75	40
Austenitic	316	0.08	2.0	16.0 to 18.0	10 to 14	2.0 to 3.0	0.1 N	205	30	515	75	40
Ferritic	409	0.08	1.0	10.5 to 11.7	0.5		Ti: [0.08+8x(C+N)] to 0.75	170	25	380	55	20
Ferritic	430	0.12	1.0	16.0 to 18.0	0.75			205	30	450	65	22
Ferritic	439	0.03	1.0	17.5 to 18.5	0.5		Ti: 0.1 to 0.6; Nb: min [0.30+(3×C)]	205	30	415	60	22
Chemistry and Typical Mechanical Properties of Selected Stainless Steel Alloys (data from ASTM Specification A240/A240M)												

STAINLESS STEELS

		Common Steel Applications
Stainless Steel Alloy	Classification	Typical Applications
430	Ferritic	Used for moderately corrosive applications involving vegetables, fruits, and dry foods. Ideal for table surfaces, equipment trim, and places with little welding or forming.
420	Martensitic	Very durable; excellent corrosion resistance. Used for knife blades, spatulas, and other utensils.
316	Austenitic	Superior durability; ideal for food processing equipment and components. Can withstand corrosive foods and frequent cleaning and sanitizing.
304	Austenitic	Excellent corrosion resistance; often used for items requiring welding and forming, such as vats, bowls, and piping.
303	Austenitic	Less weldable but more machinable than 304. Good corrosion resistance; widely used in trim and other applications not intended for direct contact with food.
1.4539	Austenitic	Suitable for hot or cold corrosive foods that sit for long periods, such as brines and other salty liquids.
1.4462	Duplex	Stronger than 1.4539; ideal for same applications.
6% Molybdenum	Austenitic	Well suited for corrosive foods and high temperatures such as steam heating and hot work areas.

STAINLESS STEELS



Pots and pans



Tanks



Surgical components



sinks



Washing machine drums



Chemical plants

Tools Steels

Tools Steels

They are steels that find application in the tooling field and they must be characterized by high hardness and non-deformability.

They can be divided into 3 classes.

- Tool steels for cold working
- Tool steels for hot working
- High speed steels



Tool steels belong to category 2 of designation of steels: group 3

High speed steels belong to category 2 of designation of steels: group 4

Tools Steels

Classification and description of tool steels.

AISI classification	Division into groups by AISI standards	Important group characteristic	Principal alloying elements	Examples of applications
High speed steels	Group M, Mo-rich	High hardness for high speed cutting of materials, red hardness.	C, Mo, W, V, Cr	Cutting tools of all sorts.
	Group T, W-rich		C, W, V, Cr, Co	
Cold-work steels	Group A, air hardening	Deep hardening in air (up to 100 mm)	C, Mn, Cr, Mo	Punches, forming-, coining dies.
	Group D, high-C high-Cr	High wear resistance at normal temp.	C, Cr, (Mo)	Long run dies for blanking.
	Group O, oil hardening	High wear resistance at normal temp.	Varies	Dies for punches and blanking
Hot-work steels	Group H, Cr-hot-work steels	Deep hardening, high toughness	C, Cr, W, (V)	Dies for extrusion of Al and Mg.
	Group H, W-hot-work steels	Improved thermal stability relative to the Cr-	C, W, V, Cr, Co	Extrusion dies for brass, Ni alloys and steel.
	Group H, Mo-hot-work steels	Hot-work steels, properties similar to HSSs.	C, Mo, W, V, Cr, Co	
Shock-resisting steels	Group S	High shock loading resistance	Mn, Si, Cr, W, Mo	Chisels, hammers, punches.
Mold steels	Group P	Low softening resistance at elevated temp.	Cr, Ni	Molds, critical-finish molds.
Spec.-purpose steels	Group L	Low alloyed steels. Group W- exhibits im-	Cr, V, Ni, Mo	Various
Water-hardened steels	Group W	proved toughness relative to group L steels.	C	Woodworking-, coining tools.