

HIGH STRENGTH, LOW ALLOY STEEL—SAE J410 JUN84

SAE Recommended Practice

Report of the Iron and Steel Technical Committee, approved January 1947, last revised October 1969, corrected June 1984. *COPIED FROM 1992 HANDBOOK*

NOTE: This document is being replaced by SAE J1392 for sheet and strip product and by SAE J1442 for plate, bar, and shape products. (June 1984)

Introduction—High strength, low alloy steel represents a specific group of steels in which enhanced mechanical properties and, in some cases, resistance to atmospheric corrosion are obtained by the addition of moderate amounts of one or more alloying elements other than carbon. Different types are available, some of which are carbon-manganese steels and others which contain further alloy additions, governed by special requirements for weldability, formability, toughness, strength, and economics. Descriptions of the different grades are given in the paragraph entitled General Information. These steels may be obtained in the form of sheet, strip, plates, structural shapes, bars, and bar size sections.

These steels are especially characterized by their mechanical properties, obtained in the as-rolled condition. They are not intended for quenching and tempering, and the purchaser should not subject them to such treatment without assuming responsibility for the ensuing mechanical properties. For certain applications these steels are sometimes annealed, normalized, or stress relieved with some influence on mechanical properties.

Where these steels are used for fabrication by welding, care must be exercised in selection of grade and in the details of the welding process. Certain grades may be welded without preheat or postheat.

Application—These steels, because of their high strength-to-weight ratio, abrasion resistance and, in the case of certain compositions, improved atmospheric corrosion resistance, are adapted particularly for use in mobile equipment and other structures where substantial weight savings are generally desirable. Typical applications are truck bodies, frames, structural members, scrapers, truck wheels, cranes, shovels, booms, chutes, and conveyors.

Mechanical Properties—The mechanical properties of these steels are shown in Table 1. For larger sizes than shown in the table, consultation with suppliers on availability and characteristics is suggested.

NOTE: Permissible use of yield point—Present steel industry practice is to express the yield of these materials as yield point rather than yield strength, and determination is by drop of beam, dividers, or other method, covered in ASTM A 370, Methods and Definitions for Mechanical Testing of Steel Products. Unless otherwise specified, this recommended practice is acceptable for material supplied in this report, and use of an extensometer is not required. The yield point shall meet the requirements shown for yield strength in Table 1A.

High strength, low alloy steel may be specified annealed or normalized, or otherwise specially prepared for special forming properties. In those cases mechanical properties should be agreed upon between supplier and purchaser.

Bend Test—Longitudinal bend test specimens shall stand being bent at room temperature through 180 deg without cracking on the outside

of the bent portion. The inside diameter of the bend shall have a relationship to the thickness of the specimen as prescribed in Table 1B.

The bend test requirements in Table 1B are for mill acceptance purposes and are made on prepared test specimens. They have no relationship to shop bending practices (see General Information) and are not to be

TABLE 1A—MINIMUM MECHANICAL PROPERTIES*

Grade	Form	Yield Strength, ^b psi min	Tensile Strength, psi min	Elongation, % min	
				2 in	8 in
942X	Plates, shapes, bars To 4 in incl	42 000	60 000	24	20
945A, C	Sheet and strip	45 000	60 000	22	—
	Plates, shapes, bars To 1/2 in incl	45 000	65 000	22	18
	1/2–1 1/2 in incl	42 000	62 000	24	19
	1–1 1/2–3 in incl	40 000	62 000	24	19
945X	Sheet and strip	45 000	60 000	25	—
	Plates, shapes, bars To 1–1/2 in incl	45 000	60 000	22	19
950A, B, C, D	Sheet and strip	50 000	70 000	22	—
	Plates, shapes, bars To 1/2 in incl	50 000	70 000	22	18
	1/2–1 1/2 in incl	45 000	67 000	24	19
	1–1 1/2–3 in incl	42 000	63 000	24	19
950X	Sheet and strip	50 000	65 000	22	—
	Plates, shapes, bars To 1–1/2 in incl	50 000	65 000	—	18
955X	Sheet and strip	55 000	70 000	20	—
	Plates, shapes, bars To 1–1/2 in incl	55 000	70 000	—	17
960X	Sheet and strip	60 000	75 000	18	—
	Plates, shapes, bars To 1–1/2 in incl	60 000	75 000	—	16
965X	Sheet and strip	65 000	80 000	16	—
	Plates, shapes, bars To 3/4 in incl	65 000	80 000	—	15
970X	Sheet and strip	70 000	85 000	14	—
	Plates, shapes, bars To 3/4 in incl	70 000	85 000	—	14
980X	Sheet and strip	80 000	95 000	12	—
	Plates to 3/8 in incl	80 000	95 000	—	10

* Mechanical properties to be determined in accordance with ASTM A 370.

^b Yield strength to be measured at 0.2% offset.

TABLE 1B—180 DEG BEND TEST REQUIREMENTS, RATIO OF BEND DIAMETER TO THICKNESS

Grade	Sheet and Strip	Plates, Shapes, Bars—Thickness of Material, in						
		To 3/8 incl	3/8–1/2 incl	1/2–3/4 incl	3/4–1 incl	1–1 1/2 incl	1 1/2–2 incl	2–4 incl
942X	—	1	1	1	1–1/2	2	2–1/2	3
945A	1	1	1	2	2	2	3	3
945C	1	1	1	2	2	2	3	3
945X	1	1	1	1	1–1/2	2	2–1/2	—
950A	1	1	1	2	2	2	3	3 ^a
950B	1	1	1	2	2	2	3	3 ^a
950C	1	1	1	2	2	2	3	3 ^a
950D	1	1	1	2	2	2	3	3 ^a
950X	d51	1	1	1	1–1/2	2–1/2	3	—
955X	1	1	1–1/2	1–1/2	2	3	3–1/2 ^b	—
960X	1–1/2	1–1/2	2	2	2–1/2	3	—	—
965X	2	2	2–1/2	3	—	—	—	—
970X	3	3	—	—	—	—	—	—
980X	3	3	—	—	—	—	—	—

^a Thickness 2–3 in inclusive.

^b Applicable to webs of structural shapes.

used as a basis for fabricating procedures.

Dimensional Tolerances—Standard manufacturing tolerances for dimensions as given in the AISI Steel Products Manual for High Strength-Low Alloy Steel shall apply.

Chemical Composition—Chemical composition of steel furnished to this specification shall conform to Table 2.

NOTE: Fully killed steel made to fine-grain practice may be specified by the use of suffix "K." EXAMPLE: 945AK. Each of these grades made to "K" practice may not be available from some suppliers, and this practice should only be specified when improved low temperature notch toughness is important.

The steels designated by the suffix "X" contain strengthening elements such as columbium, vanadium, or nitrogen, added singly or in combination. These steels are usually made semikilled; however, if killed steel is desired, it may be specified by use of the "K" suffix, as SAE 950XK.

Choice of, and limits for, additional elements, other than those specified in Table 2 necessary to attain required or desirable properties, shall be made known to the purchaser and not changed without his full knowledge and consent.

General Information—Recommended Bending Practice—The recommended fabricating practice for cold forming these steels is to avoid bends in any direction that are more severe than shown in Table 3.

Hot forming is recommended for bending thicknesses over 1/2 in. While the recommendations in Table 3 for inside radii for cold bending are minimum, it may be found necessary to increase the radii, depending on the strength level of the material and the application.

Description of Grades

Grade 942X—This is a columbium or vanadium treated carbon manganese high strength steel similar to 945X and 945C except for somewhat improved welding and forming properties.

Grade 945A—This is a high strength, low alloy steel with excellent welding characteristics, both arc and resistance, and the best formability, weldability, and low temperature notch toughness of the high strength steels. It is generally used in sheet, strip, and light plate thickness.

Grade 945C—This is a carbon-manganese high strength steel with satisfactory arc welding properties, if adequate precautions are observed. It is similar to grade 950C, except that lower carbon and manganese improve arc welding characteristics, formability, and low temperature notch toughness at some sacrifice in strength.

Grade 945X—This is a columbium or vanadium treated carbon-manganese high strength steel similar to 945C, except for somewhat improved welding and forming properties.

Grade 950A—This is a high strength, low alloy steel with good weldability, both arc and resistance, with good low temperature notch toughness, and good formability. It is generally used in sheet, strip, and light plate thickness.

Grade 950B—This is a high strength, low alloy steel with satisfactory arc welding properties and fairly good low temperature notch toughness and formability.

Grade 950C—This is a carbon-manganese high strength steel which can be arc welded with special precautions, unsuitable for resistance welding. The formability and toughness are fair.

Grade 950D—This is a high strength, low alloy steel with good weldability, both arc and resistance, and fairly good formability. Where low temperature properties are important, the effect of phosphorus in conjunction with other elements present should be considered.

Grade 950X—This is a columbium or vanadium treated carbon-manganese high strength steel similar to 950C, except for somewhat improved welding and forming properties.

Grade 955X, 960X, 965X, 970X, 980X—These are steels similar to 945X and 950X with higher strength obtained by increased amounts of strengthening elements, such as carbon or manganese or by the addition of nitrogen up to about 0.015%. This increased strength involves reduced formability and usually decreased weldability. Toughness will vary considerably with composition and mill practice.

TABLE 2—CHEMICAL COMPOSITION^{a,b} LADLE ANALYSIS, MAX, %

Grade	C	Mn	P
942X	0.21	1.35	0.04
945A	0.15	1.00	0.04
945C	0.23	1.40	0.04
945X	0.22	1.35	0.04
950A	0.15	1.30	0.04
950B	0.22	1.30	0.04
950C	0.25	1.60	0.04
950D	0.15	1.00	0.15
950X	0.23	1.35	0.04
955X	0.25	1.35	0.04
960X	0.26	1.45	0.04
965X	0.26	1.45	0.04
970X	0.26	1.65	0.04
980X	0.26	1.65	0.04

^a Sulfur, 0.05% max; silicon, 0.90% max.

^b It is generally believed that atmospheric corrosion resistance can be enhanced by the addition of moderate amounts of one or more alloying elements, other than carbon. If this characteristic is a requirement, the addition of such elements within the limits of this specification shall be negotiated.

TABLE 3—SUGGESTED MINIMUM INSIDE RADII FOR COLD BENDING—RATIO OF BEND RADIUS TO THICKNESS

Grade	Thickness of Material, in		
	To 0.180	0.180–0.250	0.250–0.500
942X	—	1	2
945A, C	1	2	2-1/2
945X	1	1	2
950A, B, C, D	1	2	3
950X	1-1/2	2-1/2	2-1/2
955X	2	3	3
960X	2-1/2	3-1/2	3-1/2
965X	3	4	4
970X	3-1/2	4-1/2	4-1/2
980X	3-1/2	4-1/2	4-1/2 ^a

^a Available to 0.375 in inclusive.

TABLE 4—GRADES IN APPROXIMATE ORDER OF INCREASING EXCELLENCE

Weldability	Formability	Toughness
980X	980X	980X
970X	970X	970X
965X	965X	965X
960X	960X	960X
955X, 950C, 942X	955X	955X
945C	950C	945C, 950C, 942X
950B, 950X	950D	945X, 950X
945X	950B, 950X, 942X	950D
950D	945C, 945X	950B
950A	950A	950A
945A	945A	945A