

LEAF SPRINGS FOR MOTOR VEHICLE SUSPENSION—MADE TO CUSTOMARY U.S. UNITS

1. Scope

NOTE—For leaf springs made to metric units, see SAE J1123.

This SAE Standard is limited to concise specifications promoting an adequate understanding between spring maker and spring user on all practical requirements in the finished spring. The basic concepts for the spring design and for many of the details have been fully addressed in HS-J788, SAE Information Report, Manual on Design and Application of Leaf Springs, which is available from SAE Headquarters.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J419—Methods of Measuring Decarburization

SAE HS-J788—Manual on Design and Application of Leaf Springs

SAE J1123—Leaf Springs for Motor Vehicle Suspension—Made to Metric Units

3. Bar Sizes and Tolerances—Round edge flat spring steel has been adopted as the SAE standard.

The bars shall be of flat rolled steel having two flat surfaces and two rounded (convex) edges. They are subject to the tolerances shown in Table 1. These cross-section tolerances permit the two flat surfaces to be slightly concave. When that occurs, the radii of the arcs of the two concave surfaces shall be of approximately equal length.

The rounding of the convex edges shall be an arc with a radius of curvature that may vary from 65 to 85% of the thickness of the bar.

Bars shall be substantially straight and free from physical characteristics known as kinks or twists which render them unsatisfactory for spring manufacturing purposes.

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TABLE 1—CROSS-SECTION TOLERANCE, in

Nominal Width Over	Nominal Width To and Including	Tolerance in Width -0.00	For Thickness	Tolerance in Thickness ⁽¹⁾	Tolerance in Flatness ⁽²⁾	Max Difference ⁽³⁾ in Thickness
				(±)	(-)	
0.00	2.50	+0.030	0.375 or under	0.005	0.005	0.002
			Over 0.375 to 0.875, incl	0.006	0.006	0.002
2.50	4.00	+0.045	0.375 or under	0.006	0.006	0.003
			Over 0.375 to 0.875, incl	0.008	0.008	0.004
			Over 0.875 to 1.500, incl	0.012	0.012	0.006
4.00	5.00	+0.065	0.375 or under	0.007	0.007	0.004
			Over 0.375 to 0.875, incl	0.010	0.010	0.005
			Over 0.875 to 1.500, incl	0.016	0.016	0.008
5.00	6.00	+0.090	Over 0.375 to 0.875, incl	0.012	0.012	0.006
			Over 0.875 to 1.500, incl	0.020	0.020	0.010

1. Thickness measurements shall be taken at the edge of the bar where the flat surfaces intersect the rounded edge.
2. This tolerance represents the maximum amount by which the thickness at the center of the bar may be less than the thickness of the edges. Thickness at the center may never exceed the thickness at the edges.
3. Maximum difference in thickness between the two edges of each bar.

Distortions due to a bar being bent about either major axis of section shall be measured with the bar against a flat checking surface so as to make contact with this surface near both bar ends. Gaps between the bar and the checking surface shall not exceed 0.05 in/ft of bar length out of contact with the checking surface when this bar length is greater than 3 ft. Also, a gap between the bar and a straight edge, 3 ft long, applied along any portion of the surface or edge of the bar shall not exceed 0.15 in.

It is recommended that all leaf spring bars which have been cold straightened be identified by the steel mill so that the spring manufacturer can use them selectively.

Leaf spring bars are generally available in the following widths in inches: 1.75, 2.00, 2.25, 2.50, 3.00, 3.50, 4.00, 5.00, and 6.00.

Spring drawings shall specify steel of the following nominal thicknesses, in inches, to which all bars shall be rolled: 0.194, 0.204, 0.214, 0.225, 0.237, 0.249, 0.262, 0.276, 0.291, 0.307, 0.323, 0.341, 0.360, 0.380, 0.401, 0.423, 0.447, 0.473, 0.499, 0.527, 0.558, 0.590, 0.625, 0.662, 0.702, 0.744, 0.788, 0.836, 0.887, 0.941, 0.999, 1.061, 1.127, 1.197, 1.273, 1.354, and 1.440.

4. **Surface Decarburization**—Surface decarburization may reduce the fatigue durability of the springs; therefore, it is important that surface decarburization be at a minimum.

Hot-rolled steel bars as received from the mills have some decarb, at least of the minimum Type 3 (see SAE J419), where more than 50% of the base carbon content remains at the surface (i.e., some partial but not more than 50% loss of carbon).

If decarb is of Type 2, where 50% or less of the base carbon content remains at the surface (i.e., appreciable partial but not total loss of carbon), the decarb normally does not exceed a depth of 0.010 in for steels of thicknesses 0.194 to 0.499 in, nor a depth of 0.020 in for steels of thicknesses over 0.499 to 1.440 in.

With sections over 1.000 in thickness, some of the hot-rolled steel bars may have decarb of Type 1, in which virtually carbon-free ferrite (i.e., total loss of carbon) exists for a measurable distance below the surface.

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The depth of decarb varies from mill to mill, from rolling to rolling, and from bar to bar. The extent to which the depth and type of the decarb can be acceptable will be subject to agreement between the steel producer and the spring manufacturer.

The edges of the bars are somewhat higher in decarb than the flat surfaces; decarb on both the edges and the flat surfaces usually has greater depth with increased bar thickness.

After forging and nonatmospheric controlled heat treating, the spring leaves will have greater decarb. Scaling of the steel in this processing reduces the thickness of the leaf. While some of the surface decarb is removed with the scale, the final depth of decarb is usually greater than it was in the steel bars as received from the mills.

5. Definitions, Dimensions, and Tolerances

5.1 Leaf Spring—A spring of full elliptic, semi-elliptic, or quarter-elliptic shape with one or more leaves. The term multi-leaf has generally applied to springs of constant width and with stepped leaves, each of constant thickness except where leaf ends may be tapered in thickness. More recently, the term has been extended to include an assembly of stacked single leaves, each of which is characterized by tapering either in width or in thickness or by a combination of both. Examples of multi-leaf springs are shown in Figures 1 to 6; Figure 7 shows a single leaf spring.

The leaves of a multi-leaf spring are usually held together with a center bolt and prevented from lateral shifting by alignment clips. Prior to assembly, the leaves are formed (cambered) and heat treated by heating, quenching, and tempering to the required hardness. Quench dies or fixtures are used to maintain the required camber within tolerances.

5.2 Datum Line—Reference line used with many of the subsequently defined terms. In Figure 1 (where the springs are shown inverted as in a machine for load and rate checking), it is shown as the line X-X. On springs with eyes, the datum line passes through the centers of the eyes. On other springs it passes through the points where the load is applied near the ends of the spring. These points must be indicated on the drawing. When load and rate are checked, the spring ends shall be free to move in the direction of the datum line.

5.3 Seat Angle Base Line (see Figure 1)—Reference line drawn through the terminal points of the active spring length at each eye, taken along the tension surface of the main leaf. On springs without eyes the seat angle base line is coincident with the datum line.

5.4 Loaded Length—Distance between spring eye centers when the spring is deflected to the specified load position. On springs without eyes, it is the distance between the lines where load is applied under the specified conditions. Tolerance, ± 0.12 in.

5.5 Loaded Fixed End Length—Distance from the center of the fixed end eye to the projection on the datum line of the point where the centerline of the center bolt intersects the spring surface in contact with the spring seat. Tolerance, ± 0.06 in.

5.6 Straight Length—Distance between eye centers when the tension surface of the main leaf at the center bolt centerline is in the plane of the seat angle base line. The distance is measured parallel to the seat angle base line. Tolerance, ± 0.12 in.

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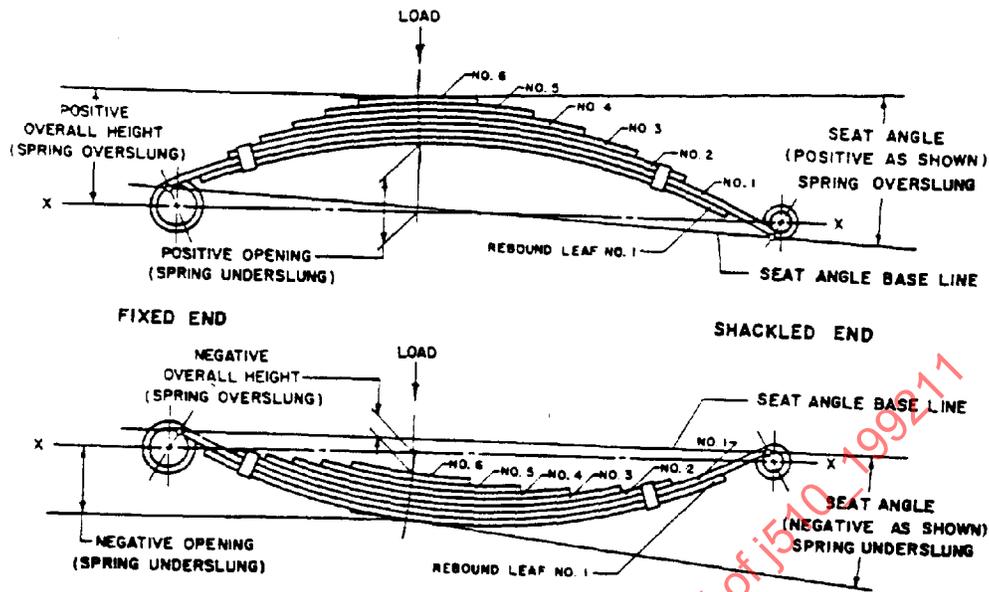
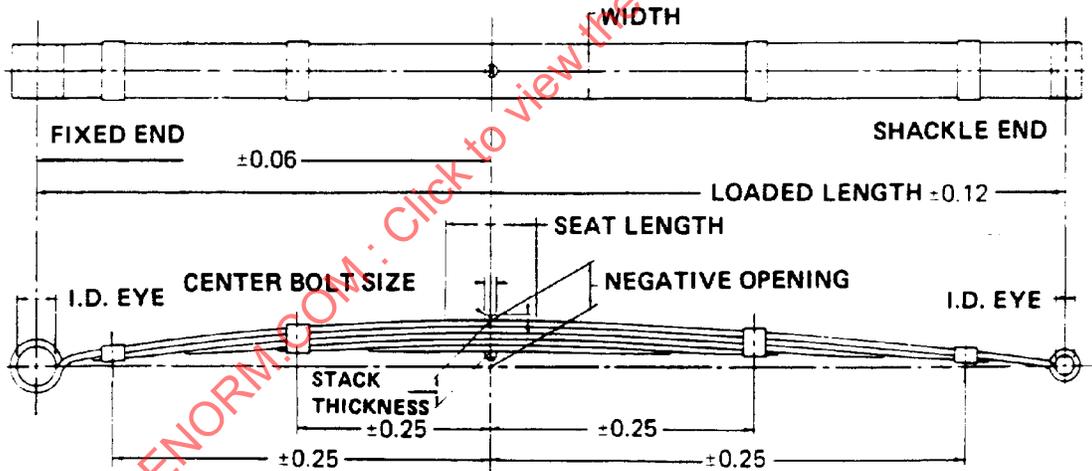


FIGURE 1—MEASUREMENT OF OPENING, OVERALL HEIGHT, AND SEAT ANGLE



SPRING SHOWN UNDER	± lb LOAD	MATERIAL
CLEARANCE in		HARDNESS RANGE
RATE	± lb/in	LEAVES
INTERLINERS BETWEEN	LEAVES	SHOT PEENED

FIGURE 2—MINIMUM SPECIFICATION REQUIREMENTS FOR UNDERSLUNG SPRINGS WITH NEGATIVE OPENING

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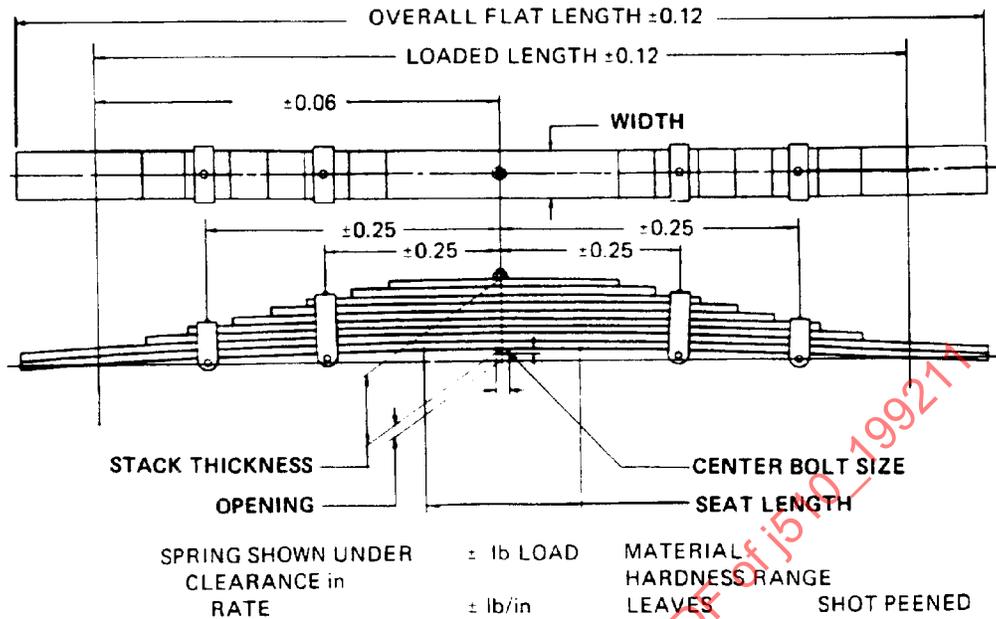


FIGURE 3—MINIMUM SPECIFICATION REQUIREMENTS FOR SPRINGS WITH PLAIN ENDS

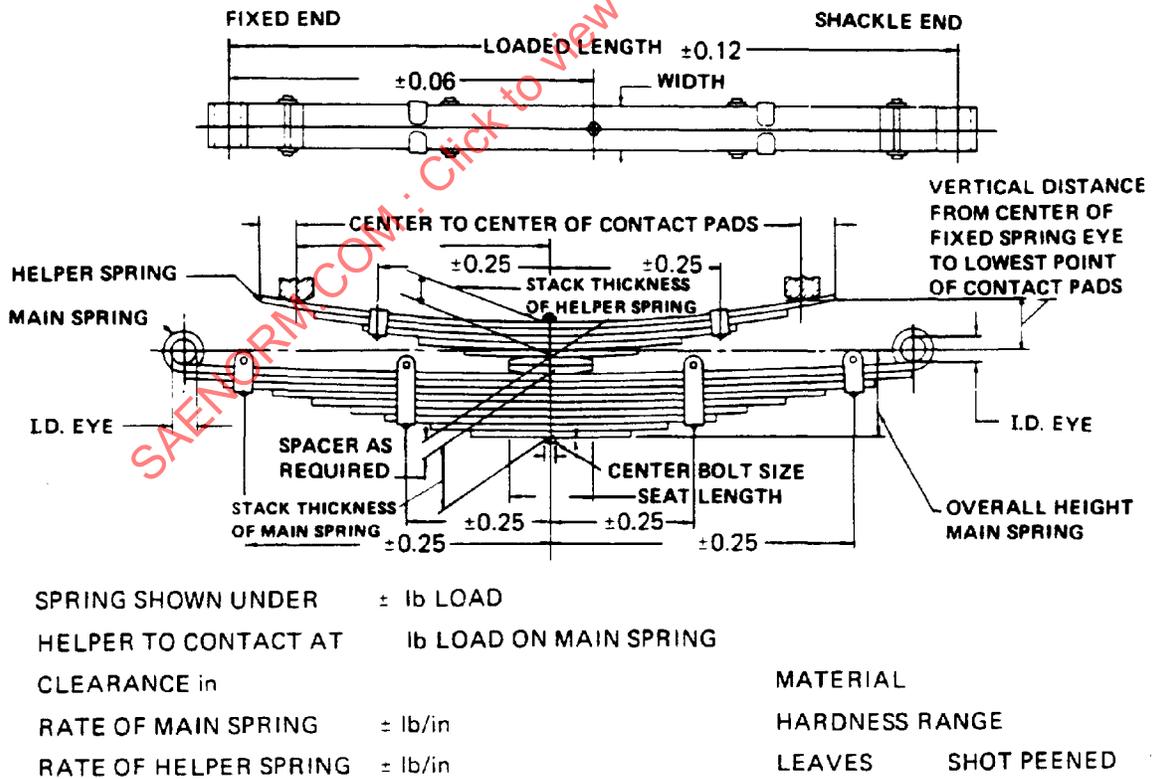


FIGURE 4—MINIMUM SPECIFICATION REQUIREMENTS FOR OVERSLUNG COMMERCIAL VEHICLE SPRINGS

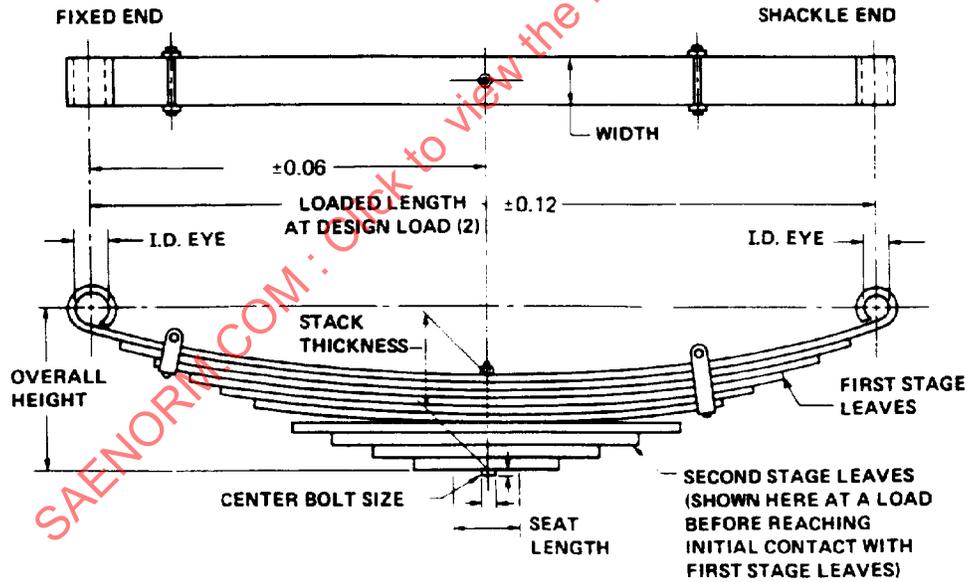
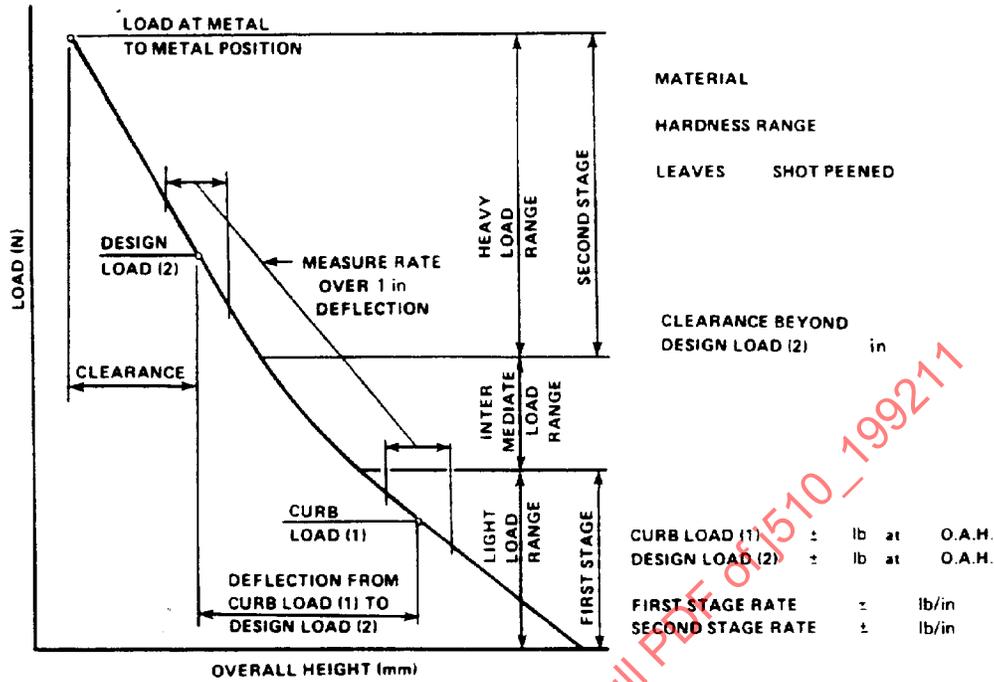


FIGURE 5—MINIMUM SPECIFICATION REQUIREMENTS FOR VARIABLE RATE OR PROGRESSIVE RATE SPRINGS (OVERSLUNG TYPE SHOWN)

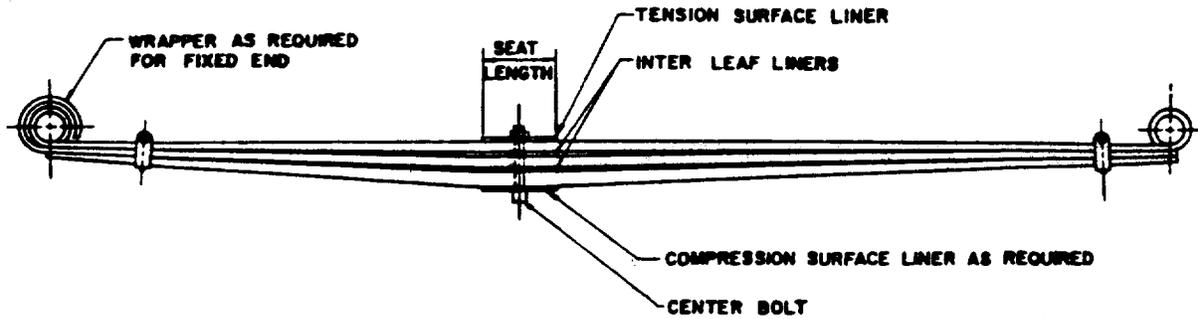


FIGURE 6—STACKED SINGLE LEAF SPRINGS

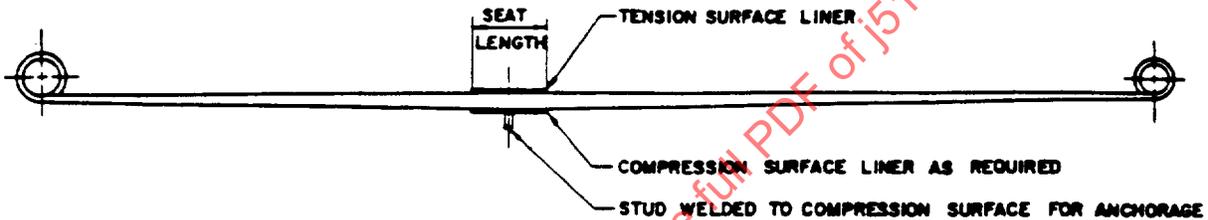


FIGURE 7—SINGLE LEAF SPRINGS

- 5.7 **Seat Length**—Length of spring that is in actual engagement with the spring seat when installed on a vehicle at design height. It is always greater than the inactive length.
- 5.8 **Inactive Length**—Length of spring rendered inactive by the action of the U-bolts or clamping bolts.
- 5.9 **Seat Angle (see Figure 1)**—Angle between the tangent to the center of the spring seat and the seat angle base line. When the spring is viewed with the fixed end of the spring to the left, as shown, and the load is applied to the shortest leaf from above, the seat angle may be specified as either positive (counterclockwise) or negative (clockwise), depending upon the angular direction in which the tangent to the center of the spring seat is disposed from the seat angle base line.

Consequently, with the spring in normal vehicle position so that the load is applied from below as shown in Figures 2, 4, 5, 6, 7, and again with the fixed end of the spring to the left of the drawing, the seat angle is defined as positive when that tangent is disposed clockwise; and as negative when the tangent is disposed counterclockwise.

- 5.10 **Finished Width**—Width to which the spring leaves are ground or milled to give the edges a flat bearing surface. If the spring ends have a finished width, the required length of the finished edge must also be indicated. The usual tolerances for finished widths are as indicated in Table 2.

TABLE 2—TOLERANCES FOR FINISHED WIDTHS

Leaf Width Over	Leaf Width To and Including	Tolerance from Nominal Width +0.000
0.00	2.00	-0.010
2.00	2.50	-0.015
2.50		-0.020

5.11 Assembled Spring Width—Where more than one leaf constitutes a spring assembly, the overall width tolerance of the assembly within the spring seat length shall be as follows in Table 3:

TABLE 3—WIDTH TOLERANCE OF THE ASSEMBLY

Leaf Width Over	Leaf Width To and Including	Tolerance -0.000
0.00	2.50	+0.100
2.50	4.00	+0.120
4.00	5.00	+0.145
5.00	6.00	+0.175

5.12 Stack Thickness—Aggregate of the nominal thicknesses of all leaves of the spring including any liners and spacer plates which are part of the spring at the seat.

5.13 Leaf Ends—The leaf ends used most generally are: square as sheared; trimmed to a shape; taper rolled; and taper rolled, trimmed or forged to a shape, or both.

5.14 Surface Finish—Condition of the surface of the spring leaves after the steel has been heat treated and prior to coating.

5.14.1 "AS HEAT-TREATED" FINISH—The surface of the spring leaves is in the condition as taken from the heat treating furnace where generally the leaves have a finish of oxide coating.

5.14.2 "SHOT-PEENED" FINISH—The tension surface of the spring leaves has been exposed to the shot peening operation where the oxide coating and scale are removed and a matte luster finish is produced.

5.14.3 GROUND OR POLISHED LEAF ENDS—The bearing areas of leaves are ground or polished to produce a smooth surface for reduced friction. The distance or length to be ground or polished should be specified.

5.15 Protective Coating—Material added to surface of spring leaves or exposed areas of assembled springs. For additional information, see HS-J788.

5.16 Leaf Numbers (see Figure 1)—Leaves are designated by numbers, starting with the main leaf which is No. 1. The adjoining leaf is No. 2 and so on. If rebound leaves are used, the rebound leaf adjoining the main leaf is rebound leaf No. 1, the next one rebound leaf No. 2, and so on. (Rebound leaves are assembled adjacent to the side opposite the load bearing leaves.) Helper springs are considered as separate units.

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5.16.1 **OPENING AND OVERALL HEIGHT (SEE FIGURE 1)**—Distance from the datum line to the point where the center bolt centerline intersects the surface of the spring that is in contact with the spring seat.

If the surface in contact with the seat is on the main leaf or a rebound leaf (as on underslung springs), this distance is called opening.

If the surface in contact with the seat is on the shortest leaf (as on overslung springs), this distance is called overall height.

Opening and overall height may be positive or negative (see Figure 1). They are specified dimensions not subject to a tolerance. See 5.18 on Load.

5.17 **Clearance**—Difference in opening or overall height between the design load position and the extreme position (of maximum stress) to which the spring can be deflected on the vehicle.

5.18 **Load**—The force exerted by the spring at the specified opening or overall height. The total tolerance on load at the specified overall height or opening is usually expressed as a load range (lb) which is equivalent to a deflection (in) at the nominal rate (lb/in). This deflection may be as small as 0.25 in for a passenger car spring and as large as 0.50 in for a heavy truck spring.

5.19 **Rate**—The change of load per unit of spring deflection (lb/in). For leaf springs it is determined as half of the difference between the loads measured 1 in above and 1 in below the specified load position, unless otherwise specified Figure 5. The tolerance is usually held within $\pm 5\%$ on low rate springs and within $\pm 7\%$ on high rate springs.

5.20 **Load and Rate Checking**—Load and rate are the terms usually employed to describe the basic characteristics of a leaf spring and, as specified on the spring drawing, refer to quantities measured on the spring without center clamp and without shackles. They are, therefore, not the same as those of the installed spring.

When the load is measured, the spring ends are free to move in the direction of the datum line; the ends are usually mounted on carriages with rollers.

The spring shall be supported on its ends, and the load shall be applied to the shortest leaf from above. It shall be transmitted from the testing machine head through a standard SAE loading block, shown in Figure 8. The loading block shall be centered over the center bolt with the legs of the V resting on the spring. It is understood that the load specified on the spring drawing does not include either the weight of the spring or the weight of the loading block.

Just before the spring is checked for load or rate, it shall undergo a preloading operation. During the initial preloading by the spring maker, the spring shall be deflected at least to the position defined under 5.17 on Clearance. During any subsequent preloading, the spring shall be deflected only to and not beyond this clearance position in order to remove any temporary recovery from the set incurred during the initial preloading. After the spring has been preloaded, it shall be released to the free position before the load is applied for load and rate checking. For additional information on preloading, see HS-J788.

Load and rate shall be measured in terms of the forces exerted by the spring during compression of the spring (compression loads) and not during release of the spring (release loads). The compression load in any position shall be read only after the spring has been thoroughly rapped in that position with a plastic or soft metal hammer.

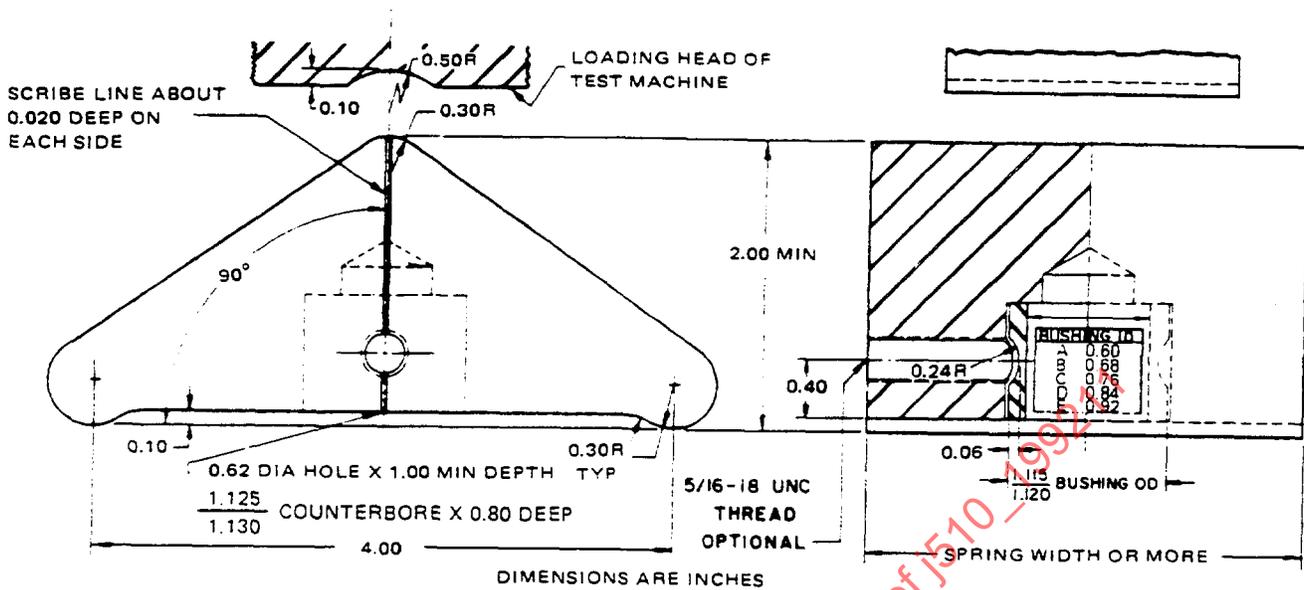


FIGURE 8—SPRING LOADING BLOCK

5.21 Specification Requirements—Minimum specification requirements are given in Figures 2 to 5.

5.22 Spring Eyes and Bushings—For some types of currently used spring eyes, spring ends, bushings, and shackle constructions, see HS-J788.

For eyes with specified inside diameter, the size and roundness of the eye should be checked by means of a round plug gage from which two opposite segments of 60 degrees have been removed. The gage shall have a taper on diameter per unit of length of 0.002-1 (see Figure 9). The gage shall be inserted into the eye three times from each side at angular positions differing by about 60 degrees. The eye is acceptable only if the gage reading on the side of the eye from which the gage is inserted is within the specified diametral limits at each of the six checks.

Also, the eye should be checked with a round plug, GO/NO GO gage, to determine if the eye is cone shaped or tapered. The GO diameter must pass completely through the eye and the NO GO diameter must not enter the eye from either side.

Total tolerance—For 1 in or less diameter—0.010 in; for larger than 1 in diameter—1% of nominal diameter (example: 0.015 in for 1.50 in ID eye); where bushing retention is critical, the 1% tolerance may be reduced to 0.75%.

For a bushing where the ID may have been affected by pressing into the spring eye, it should be checked with a round plug gage. Total tolerance—0.005 in unless otherwise specified.

Eyes of the main leaf in the assembled spring, measured in the unloaded condition, shall be parallel to the surface at the spring seat, and square with a tangent to either edge of the main leaf at the spring seat, within ± 1 degree.

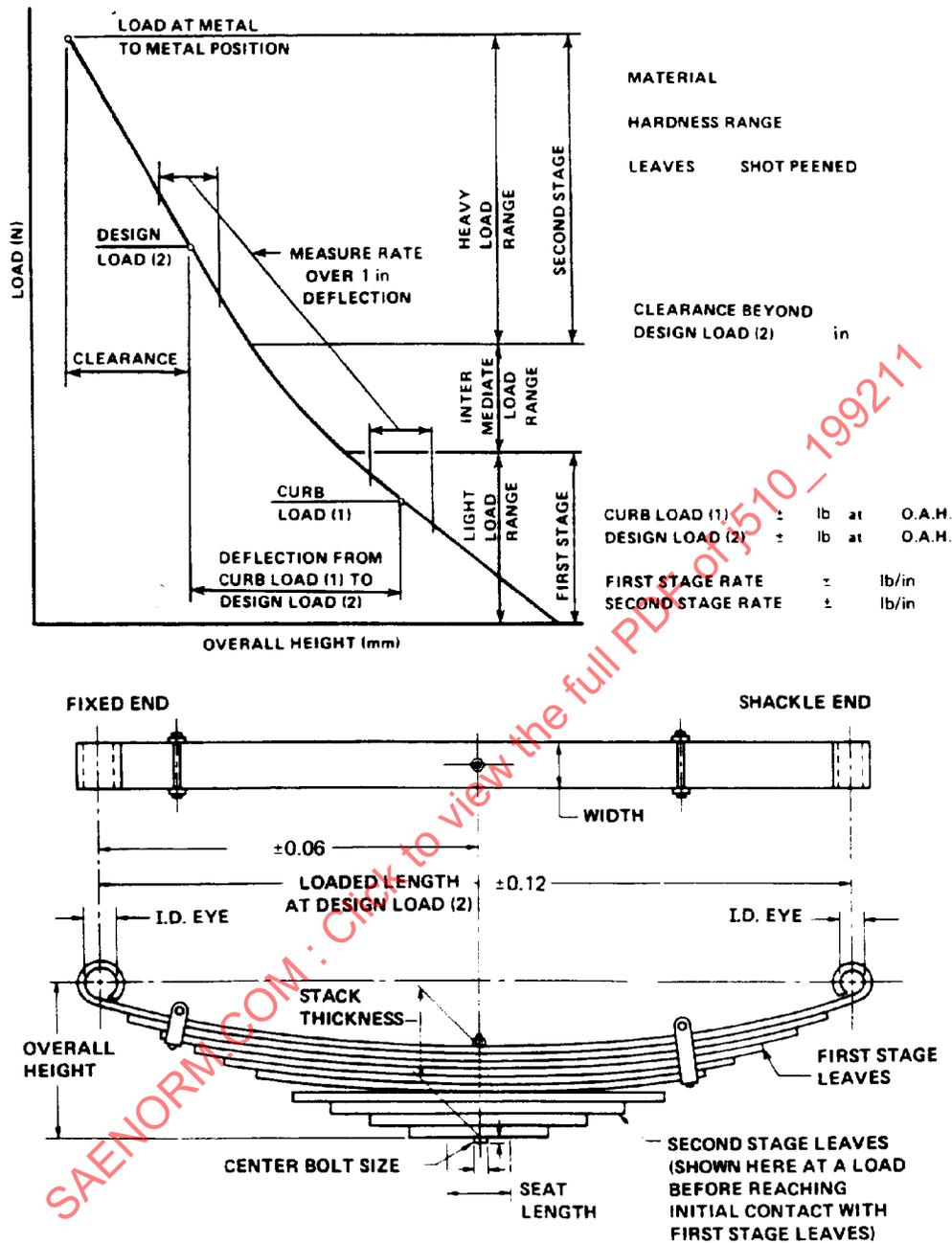


FIGURE 9—GAGE-LEAF SPRING EYE PLUG

5.23 Alignment Clips—Most surface vehicle leaf springs are fitted with clips of some form which serve primarily to prevent sideways spread and vertical separation of the leaves.

Clips employed for passenger car springs show a great variety in design, but commercial vehicle springs are generally equipped with either bolt-type or clinch-type clips. (See HS-J788.) Dimensions must be chosen to suit the individual service requirement.