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Steering Ball Studs and Socket Assemblies

RATIONALE

The technical report covers general technology, products, or processes for Metric Ball Joints. Manufacturers should be consulted for specific design considerations with respect to application and usage.

STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE Materials, Processes and Parts Council and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

1. ***Scope***—This SAE Recommended Practice has been established for the purpose of providing design criteria and suggested dimensional proportions which may be used for ball studs and ball stud socket assemblies as used on steering systems or control mechanisms of passenger vehicles, trucks and off-road equipment.

The recommended practice does not cover all applications. It is intended to provide assistance in obtaining functional satisfaction and interchangeability.

The inclusion of dimensional data in this report is not intended to imply that all the products described are stock production sizes. Consumers are requested to consult with manufacturers concerning stock production parts.

2. References

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the lastest revision of SAE publications shall apply.

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

SAE J485—Holes in Bolt and Capscrew Shanks and Slots in Nuts for Cotter Pins

2.1.2 ANSI PUBLICATION—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI B1.3M

3. Definitions

3.1 Master Gage—A taper gage that serves as a standard or base, designed to specific dimensions within blueprint specifications.

3.2 Blueing—A nondrying light paste with a pigment or die (such as "Prussian Blue") that colors a contacting surface. Blueing must be distributed evenly with minimum thickness on the taper surface of the master gage.

3.3 Blueing in a Master Gage—Blueing as applied to a master gage and gage forced onto a taper by hand pressure with a slight twisting motion followed by a rocking motion of the stud in the gage. (The gage should not rock.) Gage is removed for visual check of contact surface of taper.

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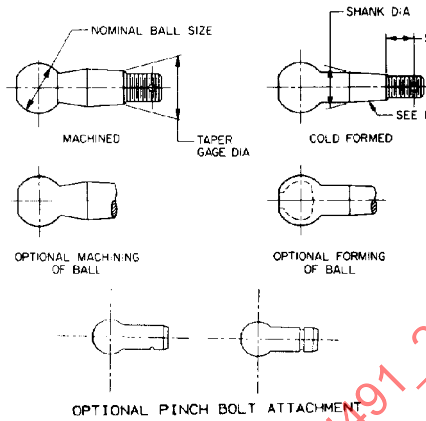

FIGURE 1—"FULL BALL" BALL STUDS

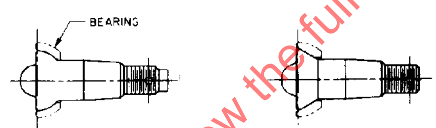

FIGURE 2—"HALF BALL" BALL STUDS FOR SEPARATE SPHERICAL BEARINGS

NOTE 1—Taper 1:8 on diameter unless other specified must show 60% minimum area of contact when blued in a master gage (See General Specifications).

NOTE 2—Cotter pin hole diameter should conform to SAE J485. The hole location is determined by the attachment eye and nut size. The hole should be located to provide a minimum of 50% engagement of the cotter pin with nut slot after allowing for draw-in at specified nut torque.

Cotter pin hole may be omitted and other than slotted nut used when application permits.

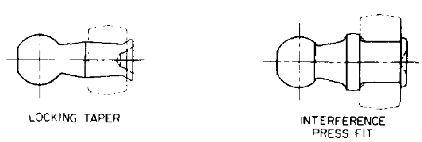

FIGURE 3—PERMANENTLY ATTACHED STUDS—RIVETED, WELDED, SPUN, OR STAKED

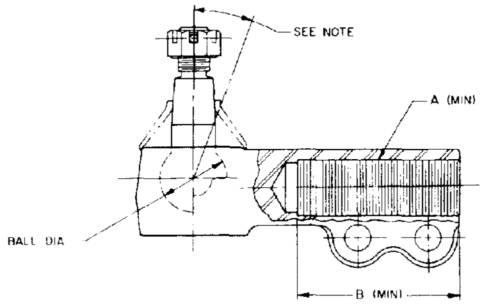

FIGURE 4—TYPICAL BALL STUD SOCKET ASSEMBLY WITH INTERNAL THREADED STEM

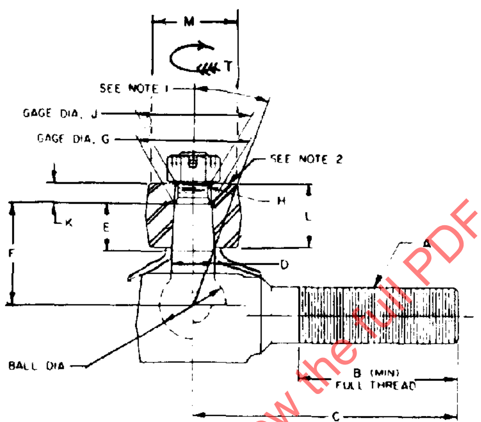

FIGURE 5—TYPICAL BALL STUD SOCKET ASSEMBLY WITH EXTERNAL THREADED STEM

NOTE 1—O - Angular travel determined as required for specific application.

NOTE 2—Nut surface on boss must be sufficiently square with tapered hole to prevent excessive stress on stud threaded end.

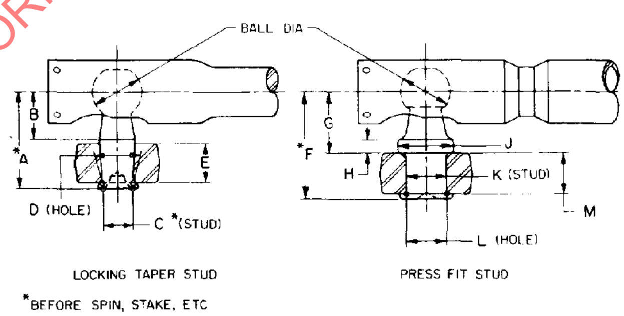

FIGURE 6—TYPICAL TUBULAR ("HORIZONTAL TYPE") SOCKET ASSEMBLY FOR RIVETED, SPUN, STAKED, WELDED, OR THREADED TAPER STUD ATTACHMENT. (FOR THREADED TAPER STUDS, USE TABLE 1 DIMENSIONS)

4. *Ball Studs*

4.1 Selection of Size—Tensile and compressive forces and functional load requirements of the steering link must be considered in selecting the proper ball stud size.

The proper ball stud size for a specific application can be reasonably well estimated by considering the stud as a cantilever beam supported at the junction with the mating boss, and loaded radially through the ball end by a force, or forces, the magnitude and direction of which have been previously determined. The type of loading, ball stud and bearing material, heat treatment, and load requirements will influence the size of unit chosen for a specific application.

Design requirements which cannot be satisfied by the tabulated dimensions may be adequately fulfilled by deviating wherever necessary provided due consideration is given to the functional stresses.

4.2 Materials—Plain carbon and alloy steels are widely used for all stud fabrication. The principal requirements for either type of steel are: case hardenability to provide a wear resistant surface, good machinability or formability, and adequate core toughness to avoid brittle fracture under impact loading. For plastic or rubber bearing socket constructions, case hardening may not be required. A quench and tempered alloy steel may be the preferred material. Some of the more popular standard materials used for ball studs lie in the same category as SAE 1019, 1541, 4615, 8115, 8620, and 8640 steels.

4.3 Processing—Processing of ball studs is usually dictated by the size, volume of production and equipment available. Ball studs used on passenger car and light truck steering systems are usually cold formed. Larger ball studs of relatively low production volume such as used on heavy duty trucks and off-road equipment are often fabricated as machined parts. Hot upset forging methods have also been used. The forming or machining is followed by total or selective hardening. Depending on the application and method of fabrication, it may be desirable to control the surface finish.

4.4 Attachment—The ball stud locking taper is usually used in conjunction with screw thread and nut attachment to allow for repair or replacement. The taper (usually 1:8) is designed to attach into mating parts made of steel; however, by proper design the ball studs can be adapted to mate with other materials for which different tapers may be desirable.

The nut selection should be determined by design requirements.

The specified nut torque or seating force may draw the stud locking taper into the mating arm significantly depending on several variables such as amount of taper, size of taper, material, heat treat and surface. When using a slotted nut, the nut is to be tightened to specification and then tightened further if necessary to align a slot with the cotter hole.

The amount of stud taper draw-in should be determined experimentally for each specific application.

The boss thickness and hole gage diameter at the nut face of the boss must be so related to the stud gage diameter as to provide sufficient unexposed threads to allow for draw-in at specified nut torque (reference Figure 5). To obtain the full stud cantilever strength, the face of the mounting boss should correspond nominally with the large end of the stud taper.

In addition to the screw thread and nut attachment method, locking pinch bolt type attachment may be used. permanent attachment means also may be used, such as riveting (upsetting), welding, spinning or staking. These methods may be used in conjunction with a locking taper or an interference press fit, in which case the stud is usually a straight shank end with a shoulder for locating purposes.

The permanently attached studs are used in conjunction with tubular ("horizontal type") sockets which can be assembled onto the stud (see Figure 6). The screw thread and nut tapered studs are usually preassembled into ball stud sockets, but can also be used with horizontal type sockets.

5. Sockets

5.1 Selection of Size—The socket size is generally dependent upon the ball stud size necessary for a specific application; however, the tensile and compressive forces and functional load requirements of the steering link must be considered in selecting the proper socket size.

5.2 Materials—Steering link sockets are often made of SAE 1030, 1038, 1040, and 1541 steels; however, a number of standard and special steels may be used to provide the desired mechanical properties for each application. Tubular ("horizontal type") sockets may also be made from seamless or welded tubing, frequently in SAE 1010, 1020 and 1025 steels.

5.3 Processing and Attachment—Steering link sockets are usually machined forgings with threaded stems for attaching to mating components. The stems may have external or internal threads. For internal threads, the socket may be forged with integral clamp ears that are machined to provide for locking the threads. Instead of clamp ears, lock nuts at the end of the internal threaded stem may also be used. Sockets may be forged into both ends of an integral link. In applications of sockets with threaded stems for attachment to tubular intermediaries or turnbuckles, a right-hand thread is usually paired with a left-hand thread to provide fast assembly and adjustment.

5.4 Socket Types & Dust Seals—In addition to sockets shown in Figure 4 and Figure 5, various other constructions are available. Selection depends on application. The sockets may have partial spherical surfaces under the dust seal area. Dust seals may be of the sliding type or boot seal type (which are attached to the socket). For limited angularity sockets, as may be used for some truck applications, the dust seal may be of dense resilient material to preload the socket against the attachment boss so as to restrict rocking motion of the steering links about the link center lines.

When the ball stud is drawn into the taper hole (as listed under Attachment for ball studs, above), the dust seal is preloaded to the proper amount to seal the socket against contamination. The socket and dust seal combination designed for the vehicle should not be modified in any way. The proper tools and extreme caution must be used when removing the socket for servicing attaching parts to prevent damaging the dust seal and ball stud threaded end.

5.5 Threads—Threads are Unified Class 2A of the size indicated in Table 1. Ends of threaded features should be chamfered approximately 0.02 in. below the minor diameter; the length of chamfer to be 1/2 to 1 1/2 threads.

Lead error and other dimensional limits should be controlled. A reference for control which may be used is: American National Standard ANSI B1.3M "Screw Thread Gaging Systems for Dimensional Acceptability."

In application of sockets with threaded stems, the length of engagement of stem threads with the attaching rod or sleeve depends on design and may vary, but should be approximately 2 1/2 times the thread diameter. Under extremes of adjustment, where the application permits, engagement may be as low as 1 1/2 times the thread diameter.

5.6 Lubrication—Lubrication fittings, if required, may be placed at any convenient location on the periphery or face of the socket provided the location does not create forging processing, assembly or functional complications.

5.7 Figures and Tables—The included Figures 4, 5, and 6 are intended to illustrate descriptions and table dimensions.

TABLE 1A—STEERING-BALL STUD SOCKET ASSEMBLY DIMENSIONS[1] (DIMENSIONS IN UNITED STATES CUSTOMARY UNITS) SEE FIGURE 5.

Nominal Ball Dia	Socket Thread		Socket Length C	Ball Stud					Attachment Arm				Stud Nut
	Size A	Length B		Shank Dia D	Taper Length E	Gage Dia Location F	G age Dia G	Thread Size H	Cage Dia J	Draw-in Clearance K[2]	Thickness L	Boss Dia M[3]	Tightening Torque T[4]
in	in	in	in	in	in	in	in	in	in	in	in	in	lb-ft0
5/8	1/2-20	1.74	2.62	0.469	0.41	1.06	0.418	3/8-24	0.402	0.128	0.50	1.25	15-30
3/4	9/16-18	1.94	2.94	0.547	0.45	1.20	0.490	7/16-20	0.473	0.136	0.56	1.38	30-45
7/8	11/16-18	2.06	3.12	0.625	0.52	1.36	0.560	1/2-20	0.543	0.136	0.62	1.50	35-55
1	11/16-18	2.21	3.38 0	0.703	0.72	1.62	0.613	9/16-18	0.590	0.184	0.88	1.75	55-80
1 1/8	7/8-18	2.75	3.88	0.781	0.84	1.88	0.675	5/8-18	0.652	0.184	1.00	1.88	80-110
1 1/4	1-16	3.19	4.25	0.875	0.94	2.03	0.758	5/8-18	0.731	0.216	1.12	2.00	80-110
1 1/2	1 1/8-12	3.75	4.88	1.031	1.12	2.44	0.890	3/4-16	0.863	0.216	1.31	2.25	100-140
1 3/4	1 1/4-12		5.75	1.250	1.28	2.81	1.074	7/8-14	1.043	0.248	1.50	2.75	120-170
2				1.350	1.50	3.22	1.166	1-12	1.131	0.280	1.75	3.00	140-220
2 1/4				1.510	1.78	3.72	1.285	1 1/8-12	1.250	0.280	2.00	3.25	180-270
2 1/2				1.700	2.06	4.34	1.441	1 1/4-12	1.406	0.280	2.25	3.50	230-320

1. These dimensions may be varied as required for specific applications. See General Specification.
2. Before tightening nut.
3. The boss diameter or "hoop size" was determined by using the recommended nut tightening torque to determine "hoop size" at recommended thickness "L" with the stress level below the yield strength of medium carbon steels forgings.
4. Ranges of tightening torque for 1:8 taper in medium carbon or alloy steel forgings. For other materials or tapers, these torque values must be adjusted. The torque values recommended are empirical values determined by combined experience of SAE Ball Stud and Tie Rod Socket Committee members.

TABLE 1B—STEERING-BALL STUD SOCKET ASSEMBLY DIMENSIONS (DIMENSIONS IN SI UNITS) SEE FIGURE 5.

Nominal Ball Dia[1]	Socket Thread		Socket Length C										
	Size A	Length B		Shank Dia D	Taper Length E	Gage Dia Location F	Gage Dia G	Thread Size H	Gage Dia J	Draw-in Clearance K[2]	Thickness L	Boss Dia M[3]	Tightening Torque T[4]
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	N.m
16	M12×1.25	45	65	12	10.4	26	10.62	M10×1.25	10.21	3.3	13	32	24–40
20	M14×1.5	50	75	14	11.4	30	12.45	M12×1.25	12.01	3.5	14	35	40–60
22	M16×1.5	50	80	16	13.2	34	14.22	M12×1.25	13.79	3.5	16	38	40–60
25	M16×1.5	55	85	18	18.3	41	15.57	M14×1.5	14.99	4.7	22	44	75–110
28	M24×1.5	70	100	20	21.3	48	17.15	M16×1.5	16.56	4.7	25	48	110–150
32	M24×1.5	80	110	22	23.9	50	19.25	M16×1.5	18.57	5.5	28	50	110–150
38	M30×1.5	95	125	26	28.5	62	22.61	M20×1.5	21.92	5.5	33	58	140–190
44	M30×1.5		150	32	32.5	72	27.28	M24×1.5	26.49	6.3	38	70	180–230
50				34	38.1	82	29.62	M24×1.5	28.73	7.1	44	76	160–230
58				38	45.2	95	32.64	M30×1.5	31.75	7.1	50	82	240–370
64				44	52.3	110	36.6	M30x1.5	35.71	7.1	57	88	240-370

1. These dimensions may be varied as required for specific applications. See General Specification.
2. Before tightening nut.
3. The boss diameter or "hoop size" was determined by using the recommended nut tightening torque to determine "hoop size" at recommended thickness "L" with the stress level below the yield strength of medium carbon steel forgings.
4. Ranges of tightening torque for one unit per eight units of length taper in medium carbon or alloy steel forgings. For other materials or tapers, these torque values must be adjusted. The torque values recommended are empirical values determined by combined experience of SAE Ball Stud and Tie Rod Socket Committee members.