MECHANICAL, MATERIAL AND QUALITY REQUIREMENTS FOR CONSOLID-8® METRIC U-BOLTS

1. **Scope** – This standard covers the mechanical, material and quality requirements for Consolid8® cold drawn micro-alloy metric u-bolts used in automotive and related industries in sizes up to M36 inclusive. It is written in the format of the Society of Automotive Engineers (SAE) Product Standard J1199.

    1.1. The term U-Bolt as referred herein applies to a cylindrical rod, threaded on both ends and formed into a round, semi-round or square configuration. The cylindrical rod may be flattened in the bend and along the leg sections.

    1.2. The mechanical properties included in Table 1 were complied at an ambient temperature of approximately 20^{o} C (68^{o} F).

    1.3. This document covers the requirements of Consolid8® U-Bolts and follows the format of the Society of Automotive Engineers (SAE) J1199 Mechanical and Material Requirements for Metric Externally Threaded Fasteners.

2. References

2.1. Applicable Publications – The following publications form a part of this specification to the extent specified herein.

2.1.1 SAE Publications
SAE J1199- Mechanical and Material Requirements for Metric Externally Threaded Fasteners
SAE J121- Decarburization in Hardened and Tempered Unified Threaded Fasteners
SAE J429- Mechanical and Material Requirements for Externally Threaded Fasteners
SAE J1061- Surface Discontinuities on General Application Bolts, Screws, and Studs
SAE J1216- Test Methods for Metric Threaded Fasteners

2.1.2 ASTM Publications
ASTM A307- Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile
ASTM A354- Specification for Quenched and Tempered Alloy Steel Bolts, Studs and Other Externally Threaded Fasteners
ASTM A449- Specification for Quenched and Tempered Steel Bolts and Studs
ASTM F606M Standard Test Method for Metric Fasteners

2.1.3 ASME Publications
ASME B18.2.1
ASME B1.3M

2.1.4 ISO Publications
ISO 898-1 Mechanical Properties of Fasteners
ISO 965/1 ISO General Purpose Metric Screw Threads – Tolerances

2.1.5 ISS Publications
Steel Products Manual for Carbon Steel Wire and Rod
Steel Products Manual for Alloy, Carbon and High Strength Low Alloy Steels

3. References

3.1. Numbers designate property classes where increasing numbers generally represent increasing tensile strengths. The designation symbol consists of two parts:

a. The first numeral of a two-digit symbol or the first two numerals of a three-digit symbol approximates 1/100 of the minimum tensile strength in MPa.
b. The last numeral approximates 1/10 of the ratio expressed as a percentage between minimum yield stress and minimum tensile stress.

3.2. For specification purposes (on engineering drawings, purchase orders, etc.) all property class designations are used in combination with a single basic specification number as follows:

Consolid8® (C-8.8)
Consolid8® (C-9.8)
Consolid8® (C-10.9)

3.3. Property Classes – U-Bolts shall meet the mechanical properties shown in Table 1.

TABLE 1 – Mechanical Requirements for U-Bolts

	C-8.8	C-9.8	C-10.9
Tensile Min	830 MPa (120,400 psi)	900 MPa (130,500 psi)	1040 MPa (150,800 psi)
Yield Min	660 MPa (95,700 psi)	720 MPa (104,400 psi)	940 MPa (136,300 psi)
Elongation Min	12 % (15 – 20% typical)	10 % (15 – 20% typical)	9 % (12 – 15% typical)
Reduction of Area Min	32 % (35 – 45% typical)	30 % (35 – 45% typical)	30 % (35 – 42% typical)
Surface Hardness Min (HRC)	27 Average (24 – 30 typical)	27 Average (24 – 32 typical)	30 Average (27 – 34 typical)
SAE Equivalent	J1199 Class 8.8	J1199 Class 9.8	J1199 Class 10.9
ISO Equivalent	898-1 Class 8.8	898-1 Class 9.8	898-1 Class 10.9

3.3.1 Tests should be taken on full size specimens. When equipment of sufficient capacity for full size tests is not available, machine specimens may be tested. In all cases no more than 25% of the material diameter shall be removed in the preparation of the machined specimen. Reference ASTM F606M or SAE J1216.

3.3.2 Tensile strength shall take precedence to hardness. Minimum hardness requirement may be waved if minimum tensile is met.

3.3.3 U-Bolts must be free of burrs, which may be detrimental to satisfactory assembly, safe handling or function.

3.3.4 U-Bolts must be free of tool marks, which could result in stress risers that would adversely affect the function and/or performance of the U-Bolt.

4. Materials and Processes

4.1. Steel Characteristics – Consolid8® U-Bolts shall be made from cold drawn micro-alloy steel as shown in Table 2:

TABLE 2 – Chemical Composition

	C-8.8	C-9.8	C-10.9
C	.55 Max	.55 Max	.55 Max
Mn	.60 – 1.65	1.20 – 1.65	1.20 – 1.65
Si	.15 - .30	.15 - .30	.15 - .30
P	.04 Max	.04 Max	.04 Max
S	.05 Max	.05 Max	.05 Max
Cb, V, Al	Grain Refiner	Grain Refiner	Grain Refiner
SAE Grade (typical)	1045, 1541, 1552	.1541, 1552	1552

4.1.1 Consolid8® U-Bolts shall have a Pearlite and Ferrite microstructure.

4.1.2 Consolid8® U-Bolts shall have a Fine Grain size (5 minimum).

4.1.3 Hot rolled rods used to make Consolid8® U-Bolts shall meet the quality requirements of Medium High Carbon as defined by the Iron and Steel Society (ISS) Steel Products Manual for Carbon Steel Wire and Rod.

4.1.4 Hot rolled or cold finished bars used to make Consolid8® U-Bolts shall meet the quality requirements of Special Bar Quality as defined by the ISS Steel Products Manual for Alloy, Carbon and High Strength Low Alloy Steels.

4.2. Cold Drawing - Consolid8® U-Bolts are cold drawn to achieve mechanical properties and size control.

4.2.1 Consolid8® U-Bolts are cold drawn from hot rolled material to approximately the thread pitch diameter.

4.3. Stress Relieve – is a thermal treatment, which may be used at the option of the manufacturer to enhance the mechanical properties of cold drawn material.

4.3.1 The stress relief time, temperature and operation sequence is dependant upon the desired results.

4.3.2 Stress Relief is not normally required for Consolid8® U-Bolts.

4.4 Chamfer – a chamfer is a beveled end or under rolled threads at the end of the threaded section that facilitates easy assembly.

4.4.1 A standard rolled or cut chamfer is typically 1 – 2 threads in length. The chamfer angle is not critical except to facilitate easy assembly.

4.5 Threading practice – threads shall be rolled.

4.5.1 Threads may be rolled undersize to allow for coating thickness.

4.6 Marking – part identification markings and or taceablity markings required by the purchaser shall be rolled above the threaded section of the u-bolt.

4.7 Forming practice – u-bolts shall be cold formed into round, semi-round, square, flat-round, flat-semi-round, flat-square or other special bend configurations.

4.7.1 Warm forming may be required to produce some flatten design u-bolts. Warm forming is heating the material to below transformation temperatures during the bending or flattening operating.

4.7.2 It is recommended that the minimum bend radius in a u-bolt design exceed ½ the nominal diameter of the u-bolt. Smaller radii can be produced with special process controls.

4.8 Coating – u-bolts may be coated to enhance corrosion resistance. When corrosion resistance is desired, it is recommended to use a low hydrogen, low temperature cure, drip-drain coating process.

4.8.1 Cleaning – concentrated mineral acid cleaners, such as HCL, shall not be used during the manufacturing or coating.

4.8.2 Hydrogen - precautions must be taken to avoid coating process that release hydrogen gasses as a by-product. High strength materials are susceptible to hydrogen related problems such as hydrogen embrittlement and stress corrosion cracking.

4.8.3 Hydrogen Embrittlement Relief – if a plating process is used, u-bolts must be baked after coating.

4.8.4 Hydrogen Testing – ASTM F1624 may be used to determine the suitability of the coating process.

4.8.5 Part Integrity – handling systems, curing temperature, and other process characteristics must be evaluated to assure the dimensional integrity of the part.

4.8.6 Assembly – ease of assembly and torque-tension relationships must be considered when selecting a coating and or coating process. Customer requirements for coefficient of friction must be considered.

5. Mechanical and Physical Properties

5.1. Mechanical – u-bolts shall be tested in accordance with the mechanical testing requirements of the product as specified below and meet the mechanical requirements specified in Table 1. Tests should be taken on full size specimens. When equipment of sufficient capacity for full size tests is not available, machine specimens may be tests. In all cases no more than 25% of the material cross section shall be removed in the preparation of the machined specimen.

5.1.1 Tensile – standard test on all material. Determine the axial tensile strength. Tested per SAE J1216.

5.1.2 Yield – standard test on all material. Determine the load stress at an offset equal to 0.2% strain. Yield test is performed as an alternate to proof load. Tested per SAE J1216.

5.1.3 Elongation – standard test on all material. Determine the elongation in a 2-inch gage length. Tested per SAE J1216.

5.1.4 Reduction of Area – standard test on all material. Determine the reduction of the cross sectional area. Tested per SAE J1216.

5.1.5 Surface Hardness – standard test on all material. Surface hardness is performed as an alternate to core hardness. Tested per SAE J1216.

5.1.6 Wedge Tensile Test – conducted at the request of the purchaser. The threaded portion of the u-bolt leg may be tensile tested as a stud using the standard wedge tensile test described in SAE J1216.

5.1.7 Saddle Tensile Test – conducted at the request of the purchaser. The u-bolt shall be fitted with a saddle block, which fits snugly between the legs of the u-bolt and has sufficient mass to support the loads required to test the u-bolt. The minimum tensile strength of the u-bolt is specified in Appendix A.

5.2. Decarburization – the Consolid8® manufacturing process does not create decarburization. Therefore, u-bolts made by the Consolid8® manufacturing process are not normally checked for decarburization. When tested, Class C-8.8 and C-9.8 shall conform to decarburization class 1/2H and Class 10.9 shall conform to decarburization class 2/3H as specified in SAE J121.

5.3. Surface Discontinuities – u-bolts shall not have surface discontinuities exceeding the limits specified in SAE J1061.

5.3.1 When the engineering requirements of the application necessitate that surface discontinuities of u-bolts be more closely control, the purchaser may specify by referencing SAE J123.

6. Tolerance Standards

6.1 Many characteristics are called-out on u-bolt drawings without tolerances. Tolerance block or machining tolerance data may not be appropriate for the characteristic on the bases of fit, function or manufacturing cost. The tolerances listed below in Table 3 should ensure proper fit and function at an appropriate manufacturing cost.

TABLE 3 – Manufacturing Tolerance Standard

Characteristic	U-Bolt Design	Tolerance
Shank Diameter	All	Approximate Thread Pitch Diameter
Chamfer	All	As Rolled Typically 1 – 2 threads
Thread Pitch	All	ISO 965/1 6g
Thread Length	All	± 3mm
Leg Length	All	± 3mm
Span Between Legs at Threads	All	± 2mm
Span Between Legs at Bend	All	± 2mm
Bottom Radius	Semi-Round	0 – 150 mm ……± 6mm 151 – 230 mm……± 9 mm over 230 mm…… ± 13mm
Corner Radius	Square and Semi-Round	± 2mm
Flat Thickness	Flatten Designs	± 0.5 mm
Flat Width	Flatten Designs	Thickness governs width
Flat Length	Flatten Designs	± 3mm

APPENDIX A

DESIGN STRENGTH (SADDLE STRENGTH)
AND
TORQUE RECOMMENDATIONS

Standard fastener strength can be determined by multiplying the cross-sectional area of the thread (known as the stress area) by the tensile strength of the material. A u-bolt is different that a standard fastener because the small cross-sectional area