SAE Aerospace
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AEROSPACE STANDARD

SAE AS4536 | REV. B

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Superseding AS4536A

Safety Cable Kit Procurement Specification and Requirement for Use

RATIONALE

AS4536B has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE:

1.1 Purpose:

This procurement specification covers aerospace quality safety cable kits consisting of safety cables and ferrules made from the same corrosion and heat resistant steels and a nickel base alloy of the type identified under the Unified Numbering system as follows:

a. UNS S30400 - Corrosion resistant steel (AMS 5697)
b. UNS S32100 - Corrosion and heat resistant steel (AMS 5689)
c. UNS N06600 - Nickel base alloy (AMS 5687)

The requirements for installation practices are also specified.

1.2 Field of Application:

For use in aerospace systems for securing fasteners and other utility parts which may have the potential of coming loose during operation.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 5687	Alloy Wire, Corrosion and Heat Resistant, 74Ni - 15.5Cr - 8.0Fe, Annealed
AMS 5689	Steel Wire, Corrosion and Heat Resistant, 18Cr - 10.5Ni - 0.40Ti, Solution Heat Treated
AMS 5697	Steel Wire, Corrosion Resistant, 19Cr - 9.5Ni, Solution Heat Treated
AS3509	Cable, Safety, Kit - Nickel Alloy, UNS N06600
AS3510	Cable, Safety, Kit - Corrosion and Heat Resistant Steel, UNS S32100
AS3511	Cable, Safety, Kit - Corrosion Resistant Steel, UNS S30400

2.1.2 Military Publications: Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

There are no referenced publications specified herein.

2.1.3 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM E 4	Standard Practices for Load Verification of Testing Machines
ASTM E 8	Standard Test Methods for Tension Testing of Metallic Materials
ASTM D 3951	Packaging, Commercial

2.2 Definitions:

STRAND: A group of wires helically wound around a core wire in a left-hand direction or a right-hand direction.

CABLE: A group of strands helically twisted together in a right-hand direction without a core.

DEFECTIVE: A defective part is a unit of product which contains one or more defects.

DIAMETER: The diameter of wire strand and cable is the diameter of the circumscribing circle, or across diametrically opposite wires.

FERRULE/END FITTING: Metal sleeve used for crimping onto the cable to maintain tension in the cable.

LAY: The helical form taken by the wires in the strand and by the strands in the cable is characterized as the lay (or twist) of the wires in a strand, or strands in a cable, respectively. In a right-hand lay, the wires of the strand are the same direction as the thread on a right-hand screw, and a left-hand lay the strands or wires lay in the opposite direction.

LENGTH OF LAY (or pitch): The distance parallel to the axis of the strand, in which a wire makes one complete turn about the axis.

PING: Ping is an audible sound given off as a result of an individual wire breaking in the wire strand.

2.2 (Continued):

PRODUCTION INSPECTION LOT: Shall be all finished parts of the same part number, made from a single heat of alloy, heat treated at the same time to the same specified condition, produced as one continuous run, and submitted for vendor's inspection at the same time.

PULL-OFF LOAD: The force required to pull the cable out of either the ferrule or cable end fitting.

SAFETY CABLE: An inseparable assembly consisting of a length of cable and an end fitting affixed to one end of the cable.

SAFETY CABLE ASSEMBLY: An assembly consisting of a ferrule affixed to the safety cable.

TERMINATION POINT: The point at which the cable end fitting or ferrule attach to the cable.

WIRE: Each individual cylindrical element is designated as a wire.

3. TECHNICAL REQUIREMENTS:

3.1 Material:

Unless otherwise specified on the part drawing, the material for the cable, end fitting, and ferrule shall be as in Table 1 for the specified procurement specification dash number.

3.2 Design:

Finished safety cable shall conform to AS3509, AS3510, or AS3511.

3.3 Construction:

3.3.1 Wire Properties: Tensile strength of wire and wire sizes shall be such that the cable will be capable of meeting the requirements of this specification.

3.3.1.1 Preforming of Wires: The individual wires comprising a strand shall be shaped into the exact helical position they will have in the finished strand or cable, so that if the strand or cable is cut, the measured diameter of the cable at the unfused cut ends shall not increase by more than 0.006 in (0.15 mm).

3.3.1.2 Splicing and Joining: There shall be no wire splices in the finished strand or cable.

3.3.2 Type of Construction:

3.3.2.1 0.020 in (0.51 mm) diameter Safety Cable shall be 1 X 7 construction.

Strand 1 X 7: The 0.020 in (0.51 mm) nominal diameter cable shall be a strand of wires having 1 X 7 construction, consisting of a layer of six wires laid around a center core wire in a left-hand, or right hand direction. The length of lay shall be not more than 0.25 in (6.35 mm) nor less than 0.20 in (0.51 mm).

3.3.2.2 0.032 in (0.81 mm) diameter Safety Cable shall be 3 X 7 construction.

Cable 3 X 7: The 0.032 in (0.81 mm) nominal diameter cable shall consist of three strands of seven wires each, laid together without a core. Each strand shall consist of a layer of six wires laid around a center core wire in a left-hand direction. The three strands shall be laid together in a right-hand direction. The length of the lay of the six outer wires in each strand shall not exceed 70% of the lay of the finished cable. The length of lay of the finished cable shall be not more than 0.25 in (6.35 mm) nor less than 0.18 in (4.57 mm).

3.3.2.3 0.040 in (1.02 mm) diameter Safety Cable shall be 7 X 7 construction.

3.3.2.3.1 Cable 7 X 7: The 0.040 in (1.02 mm) nominal diameter cable shall consist of 6 outer strands of 7 wires each laid around a core of seven wires. The 6 outer strands shall consist of 6 wires laid around a center wire in a left-hand direction. The core strand shall consist of 6 wires laid around a center wire in a right-hand direction. The 6 outer strands shall be laid around a core in a right-hand direction. The length of lay of the outside 6 wires in each of the 6 outside strands, and the outside 6 wires of the core strand shall not exceed 60% of the length of lay of the finished cable. The length of lay of the finished cable shall be not more than 0.37 in (9.40 mm) nor less than 0.24 in (6.10 mm).

3.3.3 Safety Cable:

3.3.3.1 The 0.020 in (0.51 mm) nominal diameter safety cable comprises the following:

a. One strand of wires, 1 X 7 construction as in 3.3.2.1.
b. Fitting end, as specified on part drawing, crimped onto strand at one end.
c. Free end of strand is fused by brazing or welding.
d. Ferrule, as specified on part drawing, to be crimped onto the free end of the strand at installation.

3.3.3.2 The 0.032 in (0.81 mm) nominal diameter safety cable comprises the following:

a. Three strands of wires, 3 X 7 construction as in 3.3.2.2.
b. Fitting end, as specified on part drawing, crimped onto cable at one end.
c. Free end of cable is fused by brazing or welding.
d. Ferrule, as specified on part drawing, to be crimped onto the free end of the cable at installation.

3.3.3.3 The 0.040 in (1.02 mm) nominal diameter safety cable comprises the following:

a. Seven strands of wire, 7 X 7 construction as in 3.3.2.3.1.
b. Fitting end, as specified on part drawing, crimped onto cable at one end.
c. Free end of cable is fused by brazing or welding.
d. Ferrule, as specified on part drawing, to be crimped onto the free end of the cable at installation.

3.3.3.4 The length of the safety cable shall be as specified on the part drawing.

3.4 Performance:

3.4.1 Breaking Strength: Strength of 0.020 in (0.51 mm) nominal diameter cable as in 3.3.2.1, of 0.032 in (0.81 mm) nominal diameter cable as in 3.3.2.2, and of 0.040 in (1.02 mm) nominal diameter cable as in 3.3.2.3 shall be not less than the minimum breaking strength specified in Table 2, for the applicable material, and determined in accordance with ASTM E 8.

3.4.2 Stretch Limits: When tested in accordance with 3.4.2.1, the stretch limit in the cable shall be as follows:

a. The 0.020 in (0.51 mm) nominal diameter cable as in 3.3.2.1 shall not exceed 1% when it is loaded to 60% of the minimum breaking strength as specified in Table 2.

b. The 0.032 in (0.81 mm) nominal diameter cable as in 3.3.2.2 shall not exceed 1.5% when it is loaded to 60% of the minimum breaking strength as specified in Table 2.

c. The 0.040 in (1.02 mm) nominal diameter cable as in 3.3.2.3 shall not exceed 1.5% when it is loaded to 60% of the minimum breaking strength as specified in Table 2.

3.4.2.1 Stretch Test: For each size and material, one specimen from each sample of wire strand or cable, taken from the production inspection lot, shall be tested to determine the percent stretch. The length of the wire strand or cable specimen to be tested shall not be less than 24 in (609.60 mm). The amount of stretch shall be determined on a tension testing machine in accordance with ASTM E 8. The specimen shall be loaded to 1% of the minimum breaking strength specified in Table 2 to straighten the wire strand or cable. While the specimen is under tension, a gage length not less than 10 in (254.00 mm) shall be marked on the specimen between the end fittings of the testing machine. The specimen shall then be loaded to 60% of the minimum breaking strength and measured for elongation under load. From this data, the percent stretch can be read directly or calculated using Equation 1:

$$\% \text{ Stretch} = (100)\ (\text{elongation under load})/(\text{original length}) \qquad \text{(Eq. 1)}$$

3.4.3 Test Load: Each wire strand or cable shall carry 80% of its respective minimum breaking load, as specified in Table 2, without any failures. The test loading shall be made using the same specimen used in the stretch test. Load the specimen to 1% of the breaking strength, then increase the loading to 80% of the minimum breaking strength of the wire strand or cable and applied for 5 seconds. At the end of the test, the specimen shall be removed and the entire specimen be completely unwound and each individual wire inspected. A suitable electronic device capable of detecting the breaking of individual wires during testing may be used instead of unwinding the wires from the specimen. The failure of any wire shall be cause for rejection.

3.4.3.1 Use of Electronic Device for First Wire Break Test: The load shall be increased to 80% on the test specimen. If no ping is heard, the specimen has passed the test. If one or more pings are heard, the specimen will be unraveled and the broken wires shall confirm failure of the specimen. If no broken wires are found, the specimen has passed the test.

3.4.4 Pull-Off Test: The crimped fitting end on the safety cable shall withstand a pull-off load not less than that specified in Table 3, determined in accordance with ASTM E 8.

3.5 Installation:

3.5.1 Maximum Span: The maximum span of safety cable between two termination points shall be 6 in (152.4 mm) unless otherwise specified.

3.5.2 Installation Defects: Any cable defect (nick, fray, kink, or any other mutilation of the safety cable) found prior to, during, or subsequent to installation, at or between termination points, is not acceptable.

3.5.3 Installation Holes: In all cases the safety cable must be installed through the holes intended for this application of the parts being secured.

3.5.4 Safety Cable/Ferrule Reuse: Safety cable and ferrule shall be new upon each application. Reuse is not acceptable.

3.5.5 Installation: Various examples of safety cable installation are shown in Figures 1 to 3. All possible combinations are not shown. Unless otherwise specified in the application engineering drawing, safety cable shall be installed in two or three bolt patterns with two bolt patterns being the preferred method when safety cable is applied to an even number of fasteners. Although every possible combination is not shown, any combination must adhere to the basic rules outlined in this specification.

3.5.5.1 Hose and Electrical Requirements: Hose and electrical coupling nuts shall have safety cable installed in the same manner as tube coupling nuts.

3.5.6 Crimp Requirements (Pull-Off Load): Safety cable shall be installed with the Safety Cable Manufacturers recommended tool, or equivalent. The tool shall have a repeatable mechanism which applies tension to the cable, crimps the ferrule, and cuts the cable to the requirements of 3.5.7.4. The safety cable assembly must be capable of meeting the minimum crimp requirements in Table 3.

3.5.7 Detailed Installation:

3.5.7.1 Hole Alignment: Undertorquing or overtorquing to obtain proper alignment of the holes is not permitted.

3.5.7.2 Adjacent Units: It is recommended that safety cable be installed in such a manner that any tendency for a fastener to loosen will be counteracted by an additional tension on the cable. The recommended practice for installation is to avoid sharp turns; in excess of 90°, as the cable is threaded through the fasteners. This will produce installed safety cable with either positive or neutral pull.

3.5.7.3 Cable Flex Limits: After installing, the maximum cable flex limits between termination points shall be no greater than that specified in Figure 4 and Table 7.

3.5.7.4 Excess Cable: After installing safety cable, excess cable from crimped ferrule shall be cut off. The maximum allowable length of cable extending beyond the ferrule shall be .031 in (0.79 mm).

3.5.7.5 Total flex for twisted cable may not exceed the limits of Table 7 when light finger pressure (approximately 2 lb) is applied at mid-span.

3.6 Quality:

Kits of safety cables, individual safety cables, and individual ferrules as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials, and from imperfections detrimental to usage of the parts. The cut end of the safety cable shall not contain frayed strands of wire.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The manufacturer of parts shall supply all samples for manufacturer's test and shall be responsible for performing all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the parts conform to the requirements of this specification.

4.2 Responsibility for Compliance:

The manufacturer's system for parts production shall be based on preventing product defects, rather than detecting the defects at final inspection and then requiring corrective action to be invoked. An effective manufacturing in-process control system shall be established, subject to the approval of the purchaser, and used during the production of parts.

4.3 Production Acceptance Tests:

The purpose of production acceptance tests is to check, as simply as possible, using a method which is inexpensive and representative of the part usage, with the uncertainty inherent in random sampling, that the parts comprising a production inspection lot satisfy the requirements of this specification.

4.3.1 Tests to determine conformance to all technical requirements of this specification are classified as acceptance tests and shall be performed on each production inspection lot. A summary of acceptance tests is specified in Table 4.

4.4 Acceptance Tests Sampling:

4.4.1 Material: One sample of wire, from which safety cable kit was made, from each heat of alloy.

4.4.2 Nondestructive Tests - Visual and Dimensional: A simple random sample shall be selected from each production inspection lot in accordance with Table 5.

4.4.3 Destructive Tests: A simple random sample shall be selected from each production inspection lot; the size of the sample shall be as specified in Table 6, except the sample for the stretch test as in 3.4.2.1 and the test load as in 3.4.3 shall be a specimen as specified in 3.4.2.1.

4.4.4 Acceptance Quality: Of simple random samples tested, acceptance quality shall be based on zero defectives.

4.5 Reports:

The vendor of safety cable kits, individual safety cables, and individual ferrules shall furnish with each shipment a report stating that the chemical composition of the kits, or individual safety cables and ferrules. conforms to the applicable material specification, showing the results of performance tests, and stating that the kits, or individual safety cables and ferrules conform to the other technical requirements. This report shall include the purchase order number, AS4536, lot number, contractor or other direct supplier of material, part number, nominal size, and quantity.

4.6 Rejected Lots:

If a production inspection lot is rejected, the vendor of the parts shall perform corrective action to screen out or rework the defective parts, and resubmit for acceptance tests inspection as in Table 4. Resubmitted lots shall be clearly identified as reinspected lots.

5. PREPARATION FOR DELIVERY:

5.1 Packaging and Identification:

5.1.1 Kits, individual safety cables, and ferrules having different part numbers shall be packed in separate containers.

5.1.2 Each container of parts shall be marked to show not less than the following information:

KIT, SAFETY CABLE, OR SAFETY CABLE, OR FERRULES NICKEL ALLOY (or CRES, as applicable)
AS4536
PART NUMBER
LOT NUMBER
PURCHASE ORDER NUMBER
QUANTITY
MANUFACTURER'S IDENTIFICATION

5.1.3 Safety cable kits, or safety cable, or ferrules shall be suitably protected from abrasion and chafing during handling, transportation, and storage.

5.1.4 Containers of kits, or safety cable, or ferrules which are to be delivered to the US Government shall be packaged in accordance with ASTM D 3951.

6. ACKNOWLEDGEMENT:

A vendor shall mention this specification in all quotations and when acknowledging purchase orders.

7. REJECTIONS:

Parts not conforming to this specification, or to modifications authorized by purchaser, shall be subject to rejection.

8. NOTES:

None

8.1 Patents:

When the cable of a safety cable is passed through holes in two or more fasteners or other utility parts and a ferrule or end fitting is affixed to the free end of the cable, the assembly is a safety cable system (apparatus) which may be covered by U.S. Patent 5,116,178 to GE Aircraft Engines of General Electric Company (Cage Code 07482) (see Figures 1 and 2). Corresponding patent applications have been filed in various foreign countries. Currently, the following providers of safety cable kits are licensed under the U.S. Patent:

a. Bergen Cable Technologies (Lodi, NJ) (Cage Code 70958)
b. Daniels Manufacturing Corp.(Orlando, FL) (Cage Code 11851)

Additional licenses to prospective kit providers and users of the safety cable system who do not obtain kits through GE's licenses are available from GE Aircraft Engines (Cincinnati, OH).

8.2 Key Words:

Kit, safety cable, procurement specification, system, safety cable

TABLE 1 - Material

Procurement Specification Designation	Cable, End Fitting, and Ferrule	Material
AS4536	AMS 5687	Nickel base alloy
AS4536	AMS 5689	Corrosion and heat resistant steel
AS4536	AMS 5697	Corrosion resistant steel

TABLE 2 - Construction and Physical Property of Cables

Material	Nom Cable Dia in (mm)	Tolerance on Dia Plus Only in (mm)	Construction	Breaking Strength Min lbf (N)
AMS 5687	0.020 (0.51)	0.006 (0.15)	1 X 7	60 (266.9)
AMS 5689	0.020 (0.51)	0.006 (0.15)	1 X 7	60 (266.9)
AMS 5697	0.020 (0.51)	0.006 (0.15)	1 X 7	60 (266.9)
AMS 5687	0.032 (0.81)	0.006 (0.15)	3 X 7	100 (444.8)
AMS 5689	0.032 (0.81)	0.006 (0.15)	3 X 7	100 (444.8)
AMS 5697	0.032 (0.81)	0.006 (0.15)	3 X 7	100 (444.8)
AMS 5687	0.040 (1.02)	0.006 (0.15)	7 X 7	180 (800.6)
AMS 5689	0.040 (1.02)	0.006 (0.15)	7 X 7	180 (800.6)
AMS 5697	0.040 (1.02)	0.006 (0.15)	7 X 7	180 (800.6)

TABLE 3 - Safety Cable Minimum Crimp Requirements (Pull-Off Load)

Nominal Cable Diameter in (mm)	Safety Cable Construction	Minimum Pull-Off Load lbf (N)
.020 (0.51)	1 X 7	30 (133.4)
.032 (0.81)	3 X 7	70 (311.4)
.040 (1.02)	7 X 7	110 (489.3)

TABLE 4 - Summary of Acceptance Tests

TABLE 4A - Nondestructive Tests

Characteristic	Req. Para.	Sample Size	Test Method
Design & Dimensions	3.2	Table 6	Conventional measuring methods
Construction	3.3	Table 6	Visual
Quality	3.6	Table 6	Visual

TABLE 4B - Destructive Tests

Characteristic	Para.	Size	Test Method
Material Composition	3.1	4.4.1	Per material specification
Breaking Strength	3.4.1	Table 7	ASTM E 8
Stretch Limits	3.4.2	3.4.2.1	ASTM E 8
Test Load	3.4.3	3.4.2.1	ASTM E 8
Pull-Off Test	3.4.4	Table 7	ASTM E 8

TABLE 5 - Sampling Data

Nondestructive Tests Visual and Dimensional Production Inspection Lot Size	Nondestructive Tests Visual and Dimensional Sample Size
2 to 15	2
16 to 50	3
51 to 150	5
151 to 500	8
501 to 3200	13
3201 to 35 000	20
35 001 to 500 000	32
500 001 and over	50