



# AEROSPACE STANDARD

**AS81914™**

|            |         |
|------------|---------|
| Issued     | 2011-01 |
| Reaffirmed | 2020-11 |

Tubing, Plastic, Flexible, Convolute, Conduit,  
General Specification for

## RATIONALE

AS81914 has been reaffirmed to comply with the SAE five-year review policy.

## 1. SCOPE

The tubing described in this document is for use in electrical interconnect systems for the protection and routing of wire bundle installations.

### 1.1 Purpose

This specification establishes requirements for plastic convolute tubing that provides mechanical protection and support for electric wire bundles. The continuous operating temperatures range from -55 °C (-67 °F) to 260 °C (500 °F) (See 6.1).

## 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, supercedes applicable laws and regulations unless a specific exemption has been obtained.

#### 2.1.1 SAE Publications

Application for copies should be addressed to SAE International, 400 Commonwealth Drive, Warrendle, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

|           |                                                                                                               |
|-----------|---------------------------------------------------------------------------------------------------------------|
| AS81914/1 | Tubing, Plastic, Flexible, Convolute, Helical, Polytetrafluoroethylene (PTFE), Standard Convolution.          |
| AS81914/2 | Tubing, Plastic, Extra Flexible, Convolute, Helical, Polytetrafluoroethylene (PTFE), Close Convolution.       |
| AS81914/3 | Tubing, Plastic, Flexible, Convolute, Helical, Fluorinated Ethylene Propylene (FEP), Standard Convolution.    |
| AS81914/4 | Tubing, Plastic, Extra Flexible, Convolute, Helical, Fluorinated Ethylene Propylene (FEP), Close Convolution. |

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|             |                                                                                                                                 |
|-------------|---------------------------------------------------------------------------------------------------------------------------------|
| AS81914/5   | Tubing, Plastic, Flexible, Convolute, Helical, Ethylene-Tetrafluoroethylene (ETFE), Close Convolution.                          |
| AS81914/6   | Tubing, Plastic, Flexible, Convolute, Helical, Ethylene-Tetrafluoroethylene (ETFE), Standard Convolution.                       |
| AS81914/7   | Tubing, Plastic, Flexible, Convolute with Integral Braid.                                                                       |
| AS81914/8   | Tubing, Plastic, Flexible, Convolute, Annular Polyvinylidene Fluoride (PVDF), Thermally Stabilized, Standard Convolution.       |
| AS81914/9   | Tubing, Plastic, Flexible, Convolute, Helical, Perfluoroalkoxy (PFA), Standard Convolution.                                     |
| AS81914/10  | Tubing, Plastic, Extra Flexible, Convolute, Helical Perfluoroalkoxy (PFA), Close Convolution.                                   |
| AS81914/11  | Tubing, Plastic, Lightweight, Zero Halogen, Extra Flexible, Convolute, Helical, Polyetheretherketone (PEEK), Close Convolution. |
| AS9100      | Quality Management System - Aerospace Requirements.                                                                             |
| AMS2700     | Requirements for Passivation of Corrosion Resistant Steel.                                                                      |
| AMS-QQ-P-35 | Passivation Treatments for Corrosion Resistant Steel.                                                                           |

#### 2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, [www.astm.org](http://www.astm.org).

|             |                                                                          |
|-------------|--------------------------------------------------------------------------|
| ASTM A 313  | Wire Stainless Steel Spring                                              |
| ASTM D 632  | Sodium Chloride, Specification for                                       |
| ASTM D 638  | Test for Tensile Properties of Plastics.                                 |
| ASTM D 792  | Tests for Specific Gravity and Density of Plastics by Displacement.      |
| ASTM D 876  | Testing Nonrigid Vinyl Chloride Polymer Tubing.                          |
| ASTM D 1924 | Determining Resistance of Synthetic Polymeric Materials to Fungi.        |
| ASTM D 1974 | Fiberboard Boxes, Methods of Closing, Sealing and Reinforcing            |
| ASTM D 5168 | Containers, Fabrication and Closure of Triple Wall Corrugated Fiberboard |

#### 2.1.3 EIA Publications

Application for copies should be addressed to; EIA, 2500 Wilson Boulevard, Arlington, VA. 22201-3834, Tel: 703-907-7500, [www.eia.org](http://www.eia.org).

|            |                                                                                      |
|------------|--------------------------------------------------------------------------------------|
| EIA-364    | Electrical connector/Socket Test Procedures including Environmental Classifications. |
| EIA-364-66 | EMI Shielding Effectiveness Test Procedure for Electrical Connectors.                |

#### 2.1.4 U.S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <http://assist.daps.dla.mil/quicksearch/>.

|                  |                                                                                                        |
|------------------|--------------------------------------------------------------------------------------------------------|
| MIL-STD-2073-1   | Military Packaging, Standard Practice for                                                              |
| MIL-PRF-5606     | Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance                                        |
| MIL-DTL-5624     | Turbine Fuel, Aviation, Grades JP-4 and JP-5                                                           |
| MIL-PRF-7808     | Lubricating Oil, Aircraft Turbine Engine, Synthetic Base                                               |
| MIL-PRF-23699    | Lubricating Oil, Aircraft Turbine Engines, Synthetic Base                                              |
| MIL-STD-1916     | DOD Preferred Methods for Acceptance of Product                                                        |
| MIL-STD-129      | Military Marking for Shipment and Storage                                                              |
| MIL-STD-147      | Palletized and Containerized Unit Loads 40 Inch X 48 Inch Pallets, Skids, Runners, or Pallet Type Base |
| ANSI/NCSL Z540-1 | Calibration System Requirements                                                                        |
| ANSI/ASQC Z1.4   | Sampling procedures and Tables for Inspection by Attributes                                            |
| A-A-59569        | Braid, Wire (Copper, Tin Coated, Silver Coated or Nickel Coated, Tubular or Flat.                      |

### 3. REQUIREMENTS

#### 3.1 Specification Sheets

The individual item requirements shall be as specified herein and in accordance with the applicable specification sheets. In the event of any conflict between the requirements of this specification and the specification sheet, the latter shall govern.

#### 3.2 Qualification

The tubing furnished under this specification shall be product which is authorized by the qualifying activity for listing on the applicable Qualified Products List at the time set for opening of bids.(see 4.3 and 6.8).

##### 3.2.1 Plant Site

Each site or manufacturer's plant site or manufacturers authorized distribution site from which a qualified product is processed, manufactured, finalized and/or shipped shall be listed on the qualified product list (see 3.2).

##### 3.2.2 Provisions Governing Qualification

The provisions governing qualification are specified in SD-6

##### 3.2.3 Reliability

The manufacturer's reliability assurance program for connector accessories and assembly procedures shall comply with the AS9100 Aerospace standard for Quality Management System requirements. Other established and industry recognized quality assurance standards that assure all products produced conform to the contract requirements are acceptable. However, if used, it is the responsibility of the manufacturer to provide evidence of compliance to AS9100. The qualifying activity (QA) authority reserves the right to monitor, measure, and validate compliance at their discretion.

### 3.3 Material

#### 3.3.1 Tubing

The material used to fabricate the tubing shall be of the polymer type specified in the applicable detail specification sheet and shall be formulated to meet the requirements of this specification.

#### 3.3.2 Braid

If braid is specified in the detail specification for electromagnetic shielding, it shall be constructed to provide optical coverage in accordance with A-A-59569 and be applied with sufficient tension so there will be no looseness or bunching of the braid on the tubing.

#### 3.3.3 Helix Wire

Stainless steel per ASTM A313 / Passivated per AMS2700, Method I, Type 6 or AMS-QQ-P-35.

### 3.4 Design and Construction

#### 3.4.1 Convolution Type

The tubing supplied under this specification shall have a right hand helical thread or annular type convolution (see Figure 1). Type 1 = Helical and Type 2 = Annular. The availability of each is noted on the applicable detail specification sheet.

#### 3.4.2 Classes

Class "0" designates a tubing shape having close convolutions with higher flexibility and bend radius characteristics than the standard convolution tubing shape. The availability of each is noted on the applicable detail specification sheet and forms a part of the part identifying part number.

Class "1" designates a tubing shape having standard convolutions with less flexibility and bend radius characteristics than the close convolution tubing shape. The availability of each is noted on the applicable detail specification sheet and forms a part of the part identifying part number.

#### 3.4.3 Drain Holes

Drain holes shall be .110/.05 (2.8/1.3) in diameter and be in a pattern such as helical or spiral at 60° radial spacing on every other convolute. The drain hole shall penetrate the major diameter of the convoluted form. The drain holes shall not penetrate the overbraid if applicable (see Figure 1).

#### 3.4.4 Helix Reinforcement

When helix reinforcement wire is specified, the wire shall be retained in each of the valleys of the convolute tube form and shall meet the performance requirements specified in 4.7.13. The diameter of the wire shall not exceed the maximum outer diameter of the tubing and the minimum inside diameter of the tubing may be decreased .015 (.38 mm) inches maximum from the minimum inside diameter specified on the applicable detail specification sheet (see Figure 1).

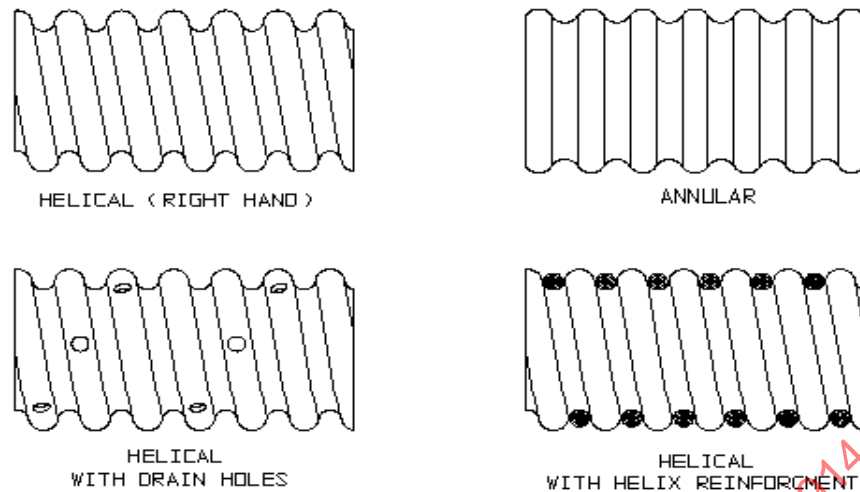


FIGURE 1 - CONVOLUTED TUBING TYPES

### 3.5 Performance Requirements

Tubing shall meet the performance requirements specified herein when tested in accordance with the specified methods of section 4.

### 3.6 Construction Details

When examined as specified in 4.6.1, all construction details - dimensions, tolerances, weights, and convolutions per inch shall be in accordance with the applicable detail specification sheet.

### 3.7 Physical Property Requirements

Physical properties shall be as specified in Table 2. The specific values shall be in accordance with the applicable detail specification sheet.

### 3.8 Workmanship

When examined visually, the convoluted tubing shall be free from internal voids, blisters, bumps, tears, pinholes, longitudinal seams, cracks, foreign matter or other defects that would be detrimental to performance as specified herein and on the individual detail specification sheets.

## 4. QUALITY ASSURANCE PROVISIONS

### 4.1 Responsibility for Inspection

Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the qualifying activity. The qualifying activity reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

#### 4.1.1 Responsibility for Compliance

All items must meet the requirements of Sections 3 and 5. The inspection set forth in this specification shall become a part of the contractors overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the qualifying activity for acceptance comply with the requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the qualifying activity to acceptance of defective material.

#### 4.1.2 Test Equipment and Inspection Facilities

Test and measuring equipment and inspection facilities of sufficient accuracy, quality and quantity to permit performance of the required inspection shall be established and maintained by the contractor. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with ANSI/NCCLZ540-1.

#### 4.2 Classification of Inspections

The inspections specified herein are classified as follows:

- a. Qualification Inspection (See 4.3)
- b. Retention of qualification (4.3.4)
- c. Quality conformance inspection (see 4.4)

#### 4.3 Qualification Inspection

Qualification inspection shall consist of all the applicable examinations and tests performed as specified in Table 2 on the qualification test samples in each size range specified in Table 1. The Qualifying Activity (QA) and the Manufacturer (MFR) shall perform the tests specified. The Manufacturer (MFR) shall also perform the tests specified on the individual detail specification sheet where qualification is desired. A request for qualification shall be made to the qualifying activity and testing shall not begin until authorized (see 6.8). The letter of authorization shall specify the conditions under which the qualification tests shall be performed and specify the number of tested or untested samples required to be submitted with the test results. Samples shall be provided to the qualifying activity at no cost. For each tubing tested the manufacturer shall use materials, manufacturing processes and methods of inspection as would be used to provide the product to a purchaser in accordance with the Quality Conformance Inspection requirements specified herein (see 4.4).

##### 4.3.1 Qualification by Similarity

For parts that differ only in minor details from those submitted for qualification, the manufacturer shall provide data from control drawings which describes the dimensions specified in 3.1 and 3.4. This data shall be tabulated and compared against the dimensional requirements. The extent of qualification testing by similarity shall be specified by the qualifying activity.

##### 4.3.2 Previously Manufactured Stock

Qualified manufacturers and their selling agents or distributors may ship from stock tubing which was manufactured in accordance with previous revision of AS81914 and its detailed specification sheets for a period of 18 months from the date of the last revision of the detail specification provided the approved manufacturer certify to the qualifying activity that the stock is in compliance with the requirements herein.

TABLE 1 - SIZE RANGES FOR QUALIFICATION INSPECTION

| Range | I.D. Inch (mm)                  |
|-------|---------------------------------|
| 1     | 0.188(4.8) to 0.375(9.5)        |
| 2     | over 0.375(9.5) to 0.875(22.2)  |
| 3     | over 0.875(22.2) to 1.250(31.8) |
| 4     | over 1.250(31.8)                |

##### 4.3.3 Sample Size

Unless otherwise specified by the qualifying activity three (3) test samples of no less than ten (10) feet (3.05m) shall be randomly selected from a lot (4.4.2). Each size range specified in Table 1, in each material which qualification is desired shall be provided for qualification testing. Test specimens prepared from the samples selected shall be tested for conformance to the requirements in Table 2. Three (3) specimens shall be tested to each requirement (see 4.3.3). Qualification of any size within each size range specified in Table 1, will qualify all sizes in the same range.

#### 4.3.3.1 Qualification Test Report

The qualifying activity shall provide the manufacturer a data package of all tests performed in accordance with Table 2. The manufacturer shall combine the qualifying activity test data with the manufacturers test data into one final report and submit the final report to the qualifying activity for approval. The manufacturer shall not be considered qualified until receipt of the qualifying activity authorization approval letter. The final test report shall remain on file with the manufacturer for a minimum period of six (6) years.

TABLE 2 - QUALIFICATION INSPECTION

| Inspection                        | Requirement Paragraph | Test Paragraph | QA | MFR |
|-----------------------------------|-----------------------|----------------|----|-----|
| <u>3/</u> Examination of Product  | 3.6, 3.8              | 4.6.1          | X  | X   |
| Stress in psi @ 10% Strain        | 3.7                   | 4.7.2          | X  |     |
| <u>2/</u> Specific Gravity        | 3.7                   | 4.7.3          |    | X   |
| Crush Resistance                  | 3.7                   | 4.7.4          | X  |     |
| Low Temperature Flexibility       | 3.7                   | 4.7.5          | X  |     |
| <u>2/</u> Minimum Bend Radius     | 3.7                   | 4.7.1.3        |    | X   |
| <u>2/</u> Heat Shock              | 3.7                   | 4.7.6          |    | X   |
| Heat Aging                        | 3.7                   | 4.7.7          | X  |     |
| <u>2/</u> Fluid Resistance        | 3.7                   | 4.7.8          |    | X   |
| Flammability                      | 3.7                   | 4.7.9          |    | X   |
| <u>2/</u> Halogen                 | 3.7                   | 4.7.14         |    | X   |
| <u>2/</u> Fungus Resistance       | 3.7                   | 4.7.10         |    | X   |
| Dielectric Breakdown              | 3.7                   | 4.7.11         | X  |     |
| <u>1/</u> Shielding Effectiveness | 3.7                   | 4.7.12         |    | X   |
| Crush Portection                  | 3.4.4                 | 4.7.13         |    | X   |
| Post examination                  | 3.6, 3.8              | 4.6.1          | X  | X   |

1/ Only required for initial qualification.

2/ Only required for initial qualification or if the manufacturer changes their process.

3/ Manufacturer to perform prior to submission to the qualifying activity. The qualifying activity may utilize this data or perform Examination of Product at their discretion.

#### 4.3.4 Failures

There shall be no failures during any examination or test of the convoluted tubing submitted for qualification tests. The agent responsible for qualification testing (see 6.8) shall notify the manufacturer of the failures. The manufacturer shall submit details of the failure supported by corrective action before the qualification agent will initiate any further tests required to assure compliance with this specification.

#### 4.3.5 Retention of Qualification

At thirty-six month intervals the manufacturer shall submit retention qualification data. The qualifying activity shall establish the initial reporting date. Retention of qualification consists of the applicable tests from Table 2, on the sample size specified in 4.3.2. Tested and untested convoluted tubing may be required to be submitted to the qualifying activity (see 6.8) at no cost. Failure to submit retention of qualification shall result in loss of qualification for previously approved products.



#### 4.3.5.1 Retention of Qualification Samples

Three (3) samples from each size range in Table 1 of which the manufacturer is qualified shall be tested. All qualified configurations and materials shall be included as part of the sample. For all other tubing qualified but not being tested the dimensions described in 3.1 and 3.4 shall be extracted from the manufacturer control drawings, tabulated and compared against the specification requirements. This comparison is not required for any tubing size where the manufacturer's control drawing(s) have not changed since the last retention cycle. However, manufacturers shall submit a document certifying compliance to the qualifying activity when a dimensional comparison is not performed.

#### 4.3.5.2 Disposition of Failures

The disposition of failures shall be as specified in 4.3.3.

### 4.4 Quality Conformance Inspection

#### 4.4.1 Inspection of Product for Delivery

Inspection of product for delivery shall consist of the examination of product in accordance with 4.6.1.

#### 4.4.2 Inspection Lot

Unless otherwise specified, a lot shall consist of all the convoluted tubing of the same type covered by one detail specification sheet, produced under essentially the same conditions and offered for inspection at one time.

#### 4.4.3 Sampling Plan

Statistical sampling and inspection shall be in accordance with ANSI/ASQC Z1.4 for general inspection level II. Unless otherwise specified, the Acceptable Quality Level (AQL) shall be 1.0 for major defects and 4.0 for minor defects. Major and minor defects shall be as defined in MIL-STD-1916/ANSI/ASQC Z1.4.

#### 4.4.4 Rejected Lots

If an inspection lot is rejected the contractor shall notify the qualifying activity (see 6.8) immediately of any quality conformance inspection failures which result in a change drawings or process control inspection points. Failure to notify the qualifying activity may result in loss of qualification of that product.

#### 4.4.5 Disposition of Sample Units

Sample units which have passed quality conformance inspection may be delivered on the contract if the lot is accepted and the sample units are still within specified tolerances.

### 4.5 Inspection of Packaging

Sample packages and packs and the inspection of the preservation-packaging, packing and marking for shipment and storage shall be in accordance with the requirements of Section 5.

### 4.6 Methods of Inspection

#### 4.6.1 Examination of Product

The convoluted tubing shall be examined to assure compliance with the following requirements:

- a. SAE-AS specification sheet (see 3.1 ).
- b. Materials (see 3.3).
- c. Design and construction (see 3.4)



d. Marking (see 5.4)

e. Workmanship (see 3.9)

#### 4.6.1.1 In-process Controls

The contractor may use in-process controls to satisfy the requirements listed in 4.6.1. These in-process controls will be subject to review by the qualifying activity (see 6.8) upon request.

#### 4.6.2 Standard Conditions

Standard test conditions shall be  $73 \pm 1$  °C ( $73.4 \pm 2$  °F) and a relative humidity of  $50 \pm 5$  percent.

#### 4.6.3 Conditioning

Unless otherwise specified herein, the convoluted tubing, all test fixtures and measurement gauges shall be maintained at Standard Conditions for 24 hours.

#### 4.6.4 Test Specimens

All test specimens shall be cut from the same inspection lot (4.4.2) or quality conformance sample. Unless otherwise specified, the number of specimens for each test shall be three (3).

#### 4.6.5 Reporting of Test Results

Unless otherwise specified in the applicable test method, test results shall be reported as the average of the 3 values. However, each individual value shall be noted in the test report and shall conform to the specified requirement.

### 4.7 Physical Property Procedures

#### 4.7.1 Construction Details

##### 4.7.1.1 Dimensions

The inner and outer diameters and wall thickness shall be determined in accordance with ASTM D 876, or equivalent method.

##### 4.7.1.2 Weight

A  $12 \text{ inch} \pm 0.031$  ( $304.8 \pm 0.8$ ) length of tubing shall be weighed to the nearest 0.1 gram. Weight per 100 feet (30.5m) of tubing shall be determined as follows:

$$W \times 453.6 \times 100 (30.5\text{m}) = \text{wt per 100 feet (30.5m)}.$$

W = weight of specimen in grams.

##### 4.7.1.3 Minimum Bend Radius

The minimum bend radius shall be determined by pulling a metal slug through a length of tubing, after that tubing has been bent around a mandrel whose radius is equal to the specified minimum bend radius. The metal slug shall be elliptical in shape, its largest diameter 10 percent less than the diameter of the tubing undergoing test. The length of the plug shall be 1.5 times its diameter. The force required to pull the ball through the tubing shall not exceed 3 pounds. See Figure 2.

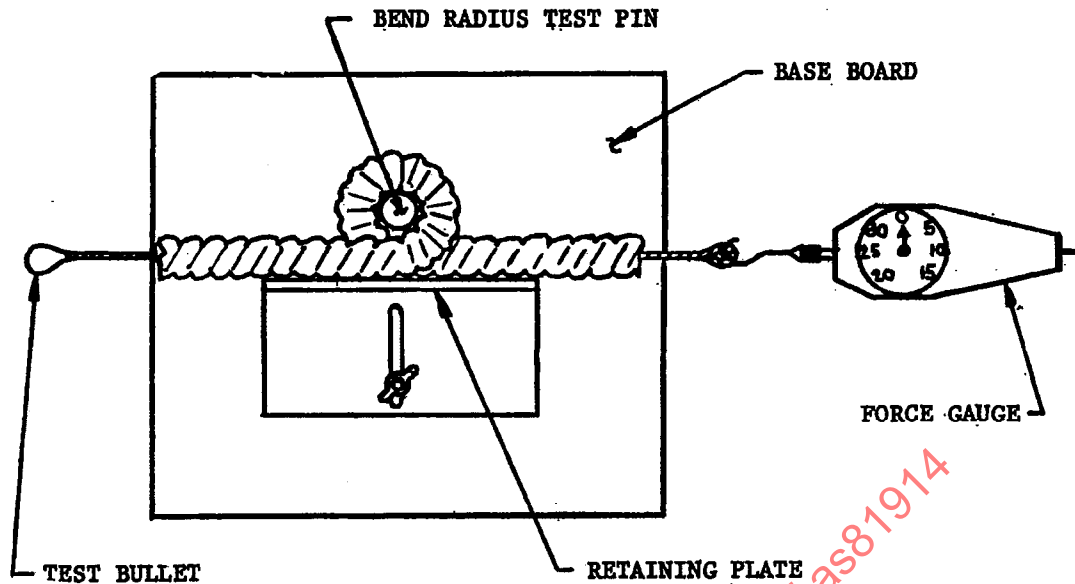


FIGURE 2 – MINIMUM BEND APPARATUS

#### 4.7.1.4 Convolutions Per Inch

The number of convolutions per inch shall be determined by counting the total convolutions in a  $6 \pm .13$  inch ( $152,4 \pm 0,3,3$ ) section of tubing. Convolutions per inch shall be the total convolutions divided by 6.

#### 4.7.2 Tensile Strain Properties

Full sections of tubing shall be equipped with suitable fittings which will prevent slippage. The distance between fittings shall be  $6 \pm 0.13$  inch ( $152,4 \pm 0,3,3$ ) and shall constitute the bench marks for test. The specimen shall be extended to 10 percent strain in an ASTM D 638 tensile apparatus, or equivalent. The tensile stress in psi at 10 percent strain shall be recorded. Individual values shall not deviate more than  $\pm 10$  percent from the average value of the three (3) specimens examined.

#### 4.7.3 Specific Gravity

The specific gravity of the tubing shall be determined using Method A-1 of ASTM D 792.

#### 4.7.4 Crush Resistance

Horizontal crush properties shall be determined using a tensile testing instrument properly modified with a compression cell and two flat metal plates, each at least 2 inches square. The lower plate may be covered with a 600 grit sandpaper or equivalent to help prevent specimen slippage. The rate of compression for all specimens shall be 0.5 inch (12,7) per minute. A  $1 \text{ inch} \pm 0.063 \text{ inch}$  ( $25,4 \pm 1,6$ ) specimen shall be centered horizontally on the lower plate of the modified testing instrument. The specimen shall then be compressed to 75 percent of its original diameter. The force in pounds shall be recorded at each 5 percent compression. The reported values shall be the force in pounds required to compress the tubing 25 percent.

#### 4.7.5 Low Temperature Flexibility

A length of tubing shall be secured to the apparatus shown in Figure 3. The apparatus shall be placed in a cold chamber at  $-54 \pm 1$  °C ( $-65 \pm 2$  °F) and the tubing flexed over the mandrels at the rate of  $15 \pm 2$  cycles per minute. A cycle shall consist of one flex over each mandrel. The number of cycles for each convoluted tubing shall be as specified in the applicable specification sheet. The tubing shall be examined for cracking.

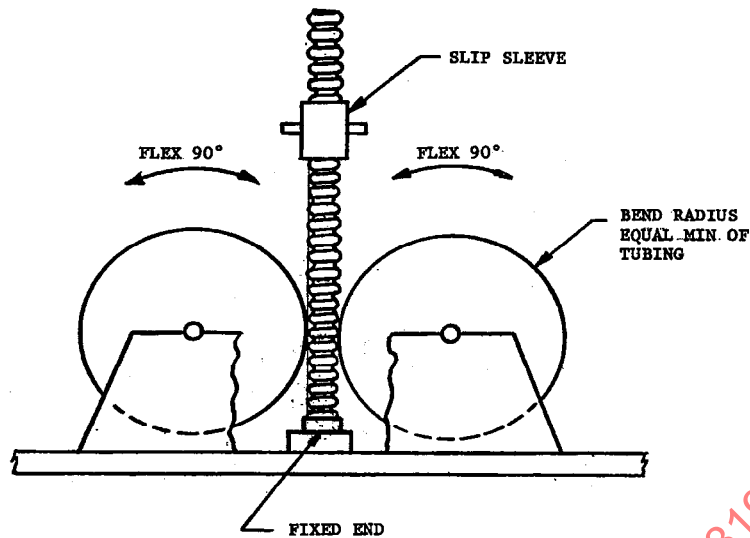


FIGURE 3 - LOW TEMPERATURE FLEX APPARATUS

#### 4.7.6 Heat Shock (Longitudinal change)

Change in length after heat shock shall be determined by placing  $4 \pm 0.032$  inch ( $101,6 \pm 0,8$ ) bench marks on a 6 inch ( $152,4$ ) piece of tubing and then conditioning the tubing in an oven for 4 hours at the temperature specified in the applicable specification sheet. The tubing shall be suspended horizontally by inserting an 8 by 0.125 inch ( $203,2$  by  $3,2$ ) diameter mandrel through the tubing and resting the ends of the mandrel on metal blocks. After exposure, the test assembly shall be removed from the oven and conditioned for 1 hour prior to remeasuring the bench marks. The tubing shall also be examined for any decomposition, cracking and dripping or flowing. Percent change in length shall be determined as follows:

$$\% \text{ change} = \frac{l_2 - l_1}{l_1} \times 10$$

where  $l_1$  = original bench mark length

where  $l_2$  = re-measured bench mark, after exposure

#### 4.7.7 Heat Aging

Three 6 inch ( $152,4$ ) lengths of tubing shall be positioned in an oven as specified in 4.7.6. The tubing shall be conditioned for the time and temperature specified in the applicable specification sheet. After exposure, the tubing shall be cooled to standard conditions and tested as specified in 4.7.2.

#### 4.7.8 Fluid Resistance

Three 6 inch ( $152,6$ ) lengths of tubing shall be immersed in each of the fluids listed in Table 4. The volume of the fluid shall be not less than 20 times that of the tubing. After 24 hours immersion at standard conditions, the tubing shall be removed from the fluid, dried by wiping, conditioned for 45 minutes and then tested as specified in 4.7.2 and 4.7.3.

TABLE 4 - TEST FLUIDS

| Fluid                           | Conforming to |
|---------------------------------|---------------|
| Hydraulic fluid, petroleum base | MIL-PRF-5606  |
| JP-4 fuel                       | MIL-DTL-5624  |
| Lubricating oil                 | MIL-PRF-7808  |
| Lubricating oil                 | MIL-PRF-23699 |
| 5% NaCl                         | ASTM D 632    |
| Deicing fluid                   | AMS 1424      |

#### 4.7.9 Flammability (see 6.5.1)

Flammability shall be determined in accordance with ASTM D 876.

#### 4.7.10 Fungus Resistance (see 6.5.2)

Fungus resistance shall be determined in accordance with ASTM D 1924.

#### 4.7.11 Dielectric Breakdown Voltage

A clean bare copper wire (AWG 12) shall be inserted into, and run throughout the length of a 24-inch piece of tubing. The tubing shall be bent upon a "U" shape and held in that position by tying the ends. A one percent aqueous sodium chloride (ASTM D 632) solution shall be poured into the tubing to within 6 (152.4) inches of the top. The tubing shall be placed in a vessel which contains additional sodium chloride solution. The top 7 (177.8) inches of the tubing, on each side, shall be above the level of the solution. This portion of the tubing shall remain dry during the test. The specimen shall be conditioned 1 hour before applying the potential (see applicable specification sheet) between the electrodes. The solution inside the specimen shall serve as the inner electrode and the solution in the container shall serve as the outer electrode. The voltage shall be increased from 0 to the required potential within 30 seconds and then increase until breakdown occurs. The voltage at breakdown shall be reported.

#### 4.7.12 Shielding Effectiveness

Tubing supplied with braid shall be tested in accordance with EIA-364-66 with the exception that the connector under test (CUT) shall be one continuous shielded convoluted tube.

#### 4.7.13 Crush Protection

Tubing supplied with helix reinforcement wire as defined in 4.4.3 shall provide protection from permanent deformation of the convolute tubing shape when 225 pounds (10.21 kg) is applied, with a footprint of 2 inches (50.8mm) square minimum and held for one (1) minute minimum. Tubing inter diameter shall be 80% minimum of its original diameter after test.

#### 4.7.14 Halogen (see 6.5.3)

The halogen content of the tubing shall be determined by x-ray fluorescence or analytically following an inspection and analysis of the chemical composition of all ingredients used. The tubing material shall be halogen-free and have less than 0.02 percent halogen content.

### 5. PREPARATION FOR DELIVERY

#### 5.1 Packaging

Packaging shall be Level A or C as specified (See 6.2).

### 5.1.1 Level A

The convoluted tubing shall be packaged by method 3 of MIL-STD-2073-1. The tubing may be coiled or wound on spools. When coiled, the tubing shall be encased in a suitable fiberboard container. When wound on spools, the spool shall provide rigid support and shall not distort nor change shape during shipment. The standard length available shall be as specified in the applicable specification sheet.

### 5.1.2 Level C

The convoluted tubing shall be packaged in accordance with the manufacturer's commercial practice.

## 5.2 Packing

Packing shall be Level A, B or C, as specified (See 6.2).

### 5.2.1 Level A

Shipping containers shall contain identical tubing of the same specification sheet, class and size and shall enclose the contents in a snug, tight-fitting manner. Shipping containers shall conform to Class weather-resistant, compliance symbol V3c or V3s, of ASTM D 1974 for gross weights up to 70 pounds (31.7kg) or to Class 2 of ASTM D 5168 for gross weights up to 200 pounds (90.7kg). If more than one spool of coiled tubing is packed into a shipping container, the spools shall be separated both vertically and horizontally by sheets constructed of fiberboard conforming to the domestic class of the applicable container specification. Containers shall be closed and strapped in accordance with the applicable container specification.

### 5.2.2 Level B

Shipping containers shall contain identical tubing of the same specification sheet, class and size and shall enclose the contents in a snug, tight-fitting manner. Shipping containers shall conform to Class domestic of ASTM D 1974 for gross weights up to 70 pounds (31.7kg) or to Class 1 of ASTM D 5168 for gross weights up to 200 pounds (90.7kg). If more than one spool of coiled tubing is packed into a shipping container, the spools shall be separated both vertically and horizontally by sheets constructed of fiberboard conforming to the domestic class of the applicable container specification. Containers shall be closed and strapped in accordance with the applicable container specification.

### 5.2.3 Level C

Packages which require overpacking for acceptance by common carrier shall be packed in exterior type shipping containers in a manner which will insure safe delivery and acceptance of the point of delivery at lowest cost. Containers shall comply with the rules and regulations applicable to the selected mode of transportation.

## 5.3 Unitized Loads

Unitized loads should be used when practical and shall be commensurate with the level of packing stated in the contract or order (See 6.2). MIL-STD-147 shall be used when loads are palletized.

## 5.4 Marking

All markings of packages and shipping containers shall be in accordance with MIL-STD-129 and shall also include:

Date manufactured

Lot, batch or control number

Other markings as required by contract or order