AEROSPACE RECOMMENDED PRACTICE

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ARP 899

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Revised

CONNECTORS AND CONNECTIONS, FLUID SYSTEM - PERMANENT TYPE

1. SCOPE

1.1 Scope - This ARP establishes uniform requirements for permanently attached tube connections for use in aerospace fluid systems.

1.2 Purpose - The purpose of this document is to recommend the design, installation, and test requirements for tubing connectors attached to tubing by methods (brazing, welding, swaging, etc.) which are usually considered to be permanent. Because of rapid and continual changes in the art, this ARP only represents the best information available at the time of issue. This document is intended to be used as a guide, and should be supplemented with a statement of the specific system requirements.

1.3 Classification - Connectors shall meet the tool envelope and clearance requirements specified herein, or other standards approved by the procuring activity. Connectors and connections shall meet, and qualify to, one or more combinations of the following temperatures and pressure conditions:

1.3.1 Fluid System Temperature Ranges (Type)

First letter designates lowest system temperature capability.
Second letter designates highest system temperatures capability.

A	-460F	A	160F
B	-320F	B	275F
C	-240F	C	450F
D	-65F	D	650F
		E	1500F
		F	2000F

EXAMPLE: Type AD is a -460 F to +650 F connector.

Printed in U.S.A.

1.3.2 Fluid System Operating Pressure Ranges (Class)

First number designates lowest system pressure capability.
Second number designates highest system pressure capability.

1	0 psig	1	300 psig
2	2 in. Hg abs.	2	1500 psig
3	1×10^{-8} mm Hg abs	3	3000 psig
		4	4000 psig
		5	6000 psig
		6	10000 psig

EXAMPLE: Class 15 is a 0 psig to 6000 psig connector.

2. APPLICABLE DOCUMENTS

2.1 The following is a list of specifications pertaining to this ARP document. These are included for reference only since this ARP is not limited to these specifications.

2.1.1 Specifications:

Federal

O-F-499	Flux, Brazing, (Silver Alloy, Low-Melting Point)
QQ-S-763	Steel Bars, Shapes and Forgings, Corrosion-Resisting.

Military

MIL-E-5272	Environmental testing, Aeronautical & Associated Equipment general specification for
MIL-S-5002	Surface Treatments & Metallic Coating for Metal Surfaces of Weapons Systems.
MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missile & Ordnance.
MIL-T-6845	Tubing, Steel, Corrosion Resistand (304) Aerospace Vehicle Hydraulic System, 1/8 - Hard Condition.
MIL-B-7883	Brazing of Steels, Copper, Copper Alloys, Nickel Alloys, Aluminum and Aluminum Alloys.
MIL-T-8808	Tubing Steel, Corrosion-Resistand (18 - 8 Stablized) Aircraft Hydraulic Quality.
MIL-T-9047	Titanium & Titanium-Alloy, Bars, Forgings & Forging Stock.

RECOMMENDED TOOL ENVELOPE
TUBE-TO-TUBE CONNECTION

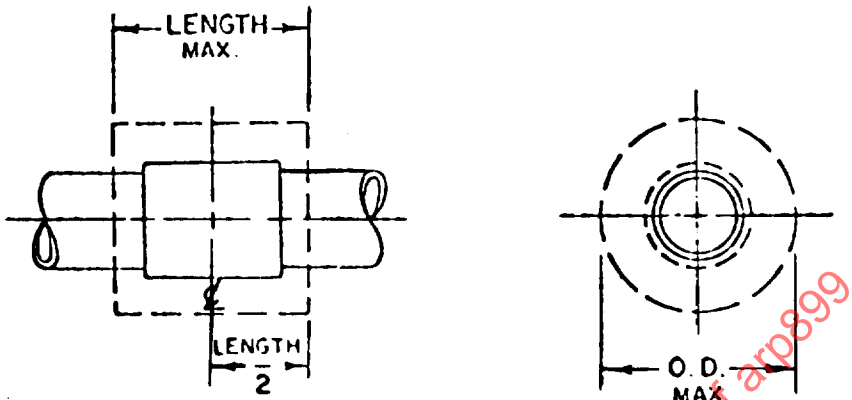
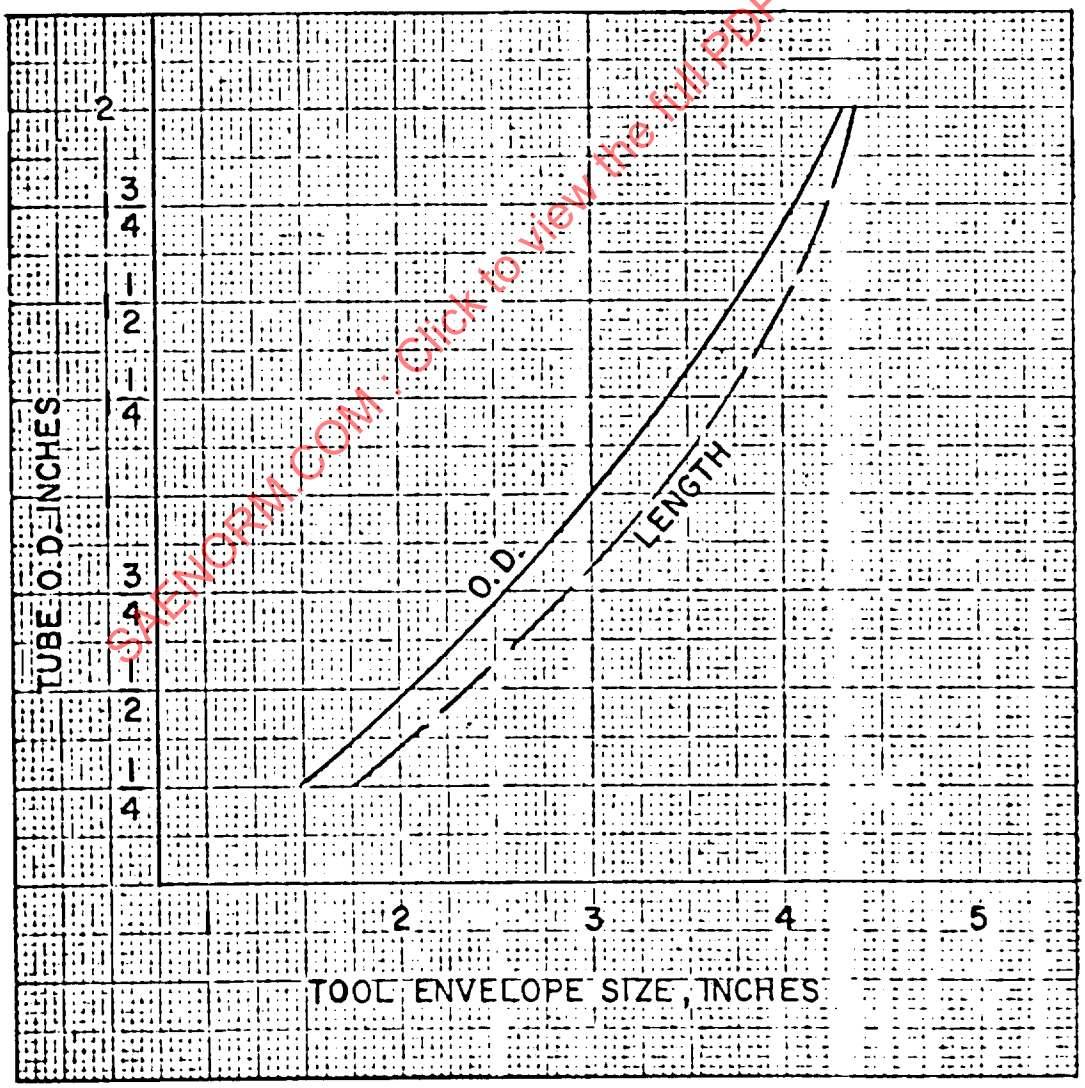


FIGURE 1



TYPICAL BRAZE TOOL

RECOMMENDED TOOL ENVELOPE
TUBE-TO-FITTING CONNECTION

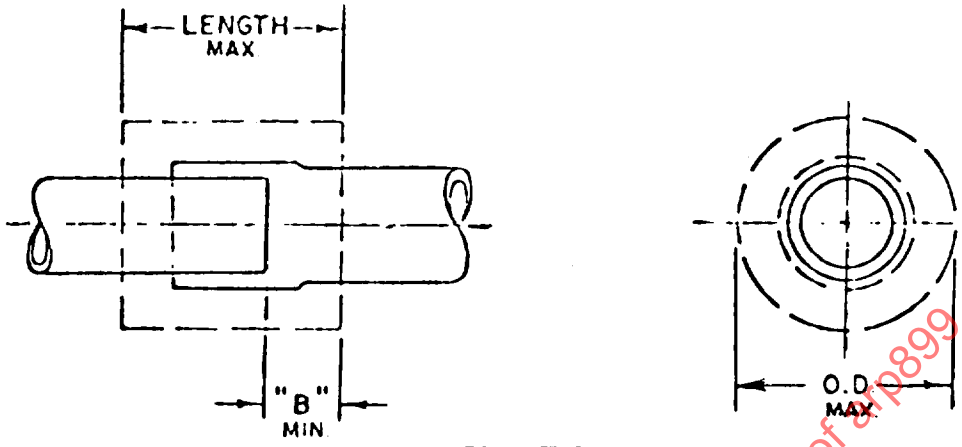
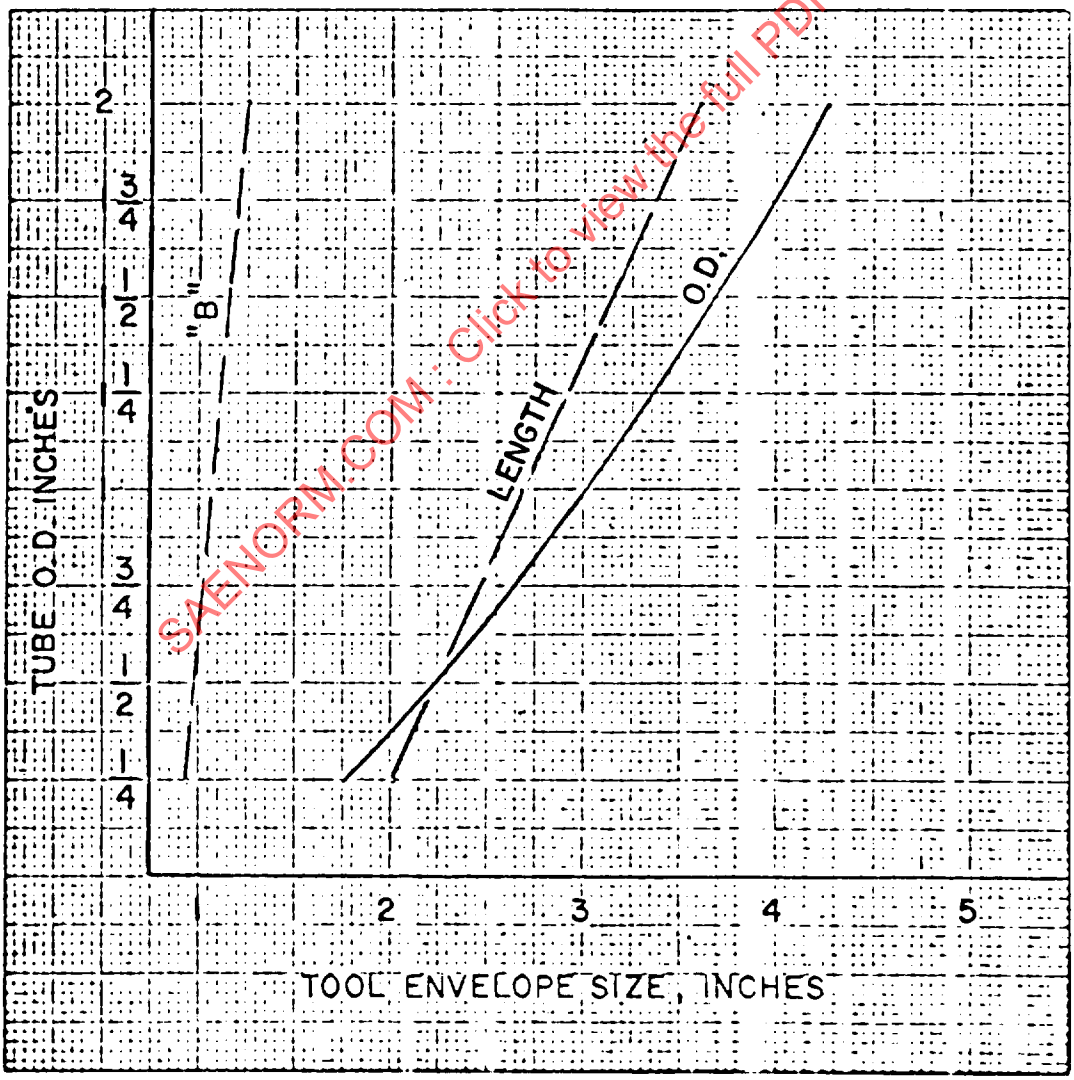


FIGURE 2



TYPICAL BRAZE TOOL

RECOMMENDED TOOL ENVELOPE
TUBE-TO-TUBE CONNECTION

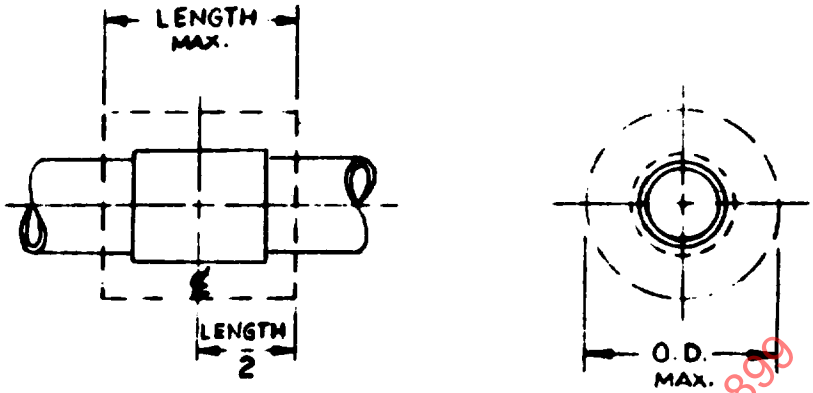
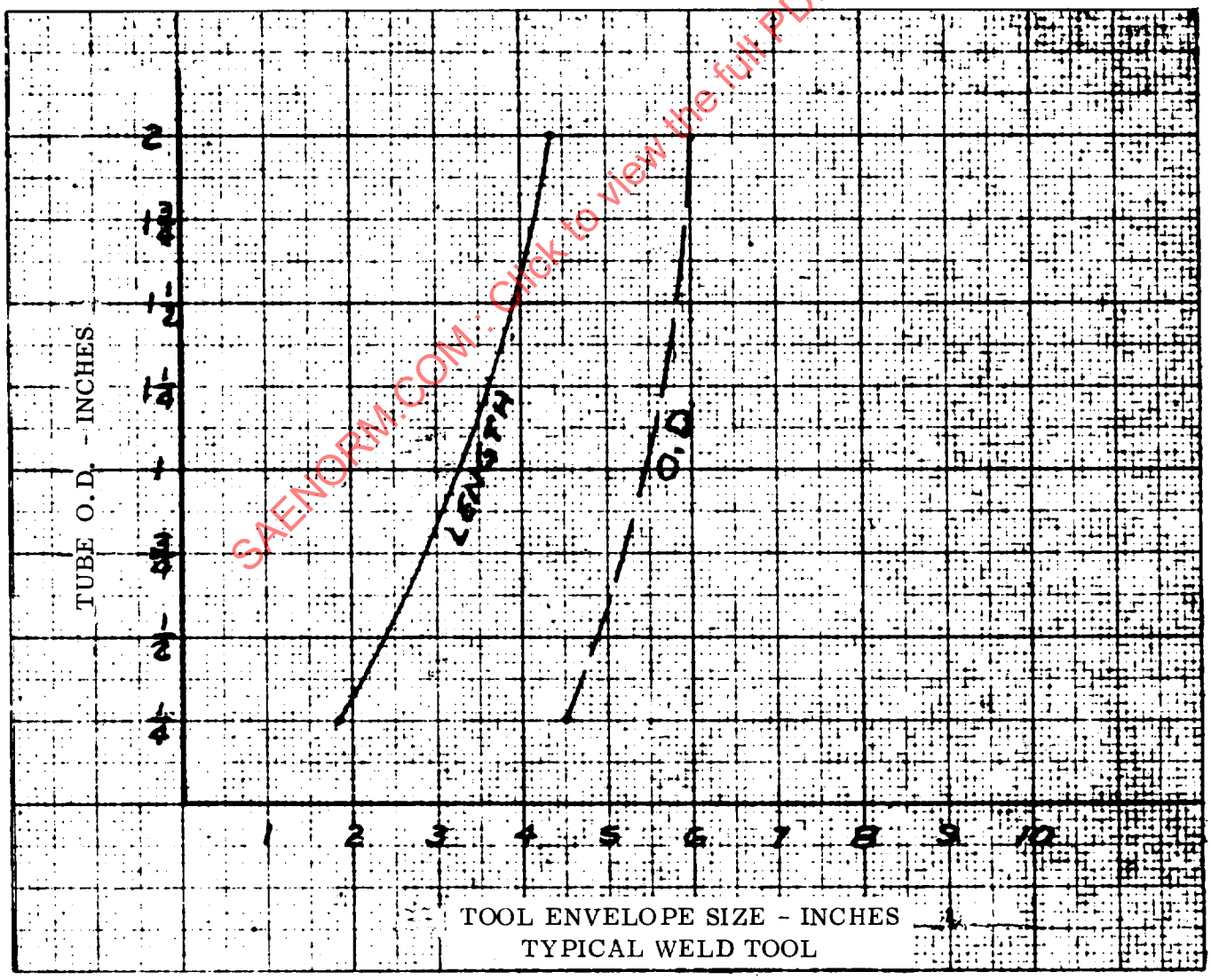


FIGURE 3



TYPICAL WELD TOOL

RECOMMENDED TOOL ENVELOPE
TUBE-TO-FITTING CONNECTION

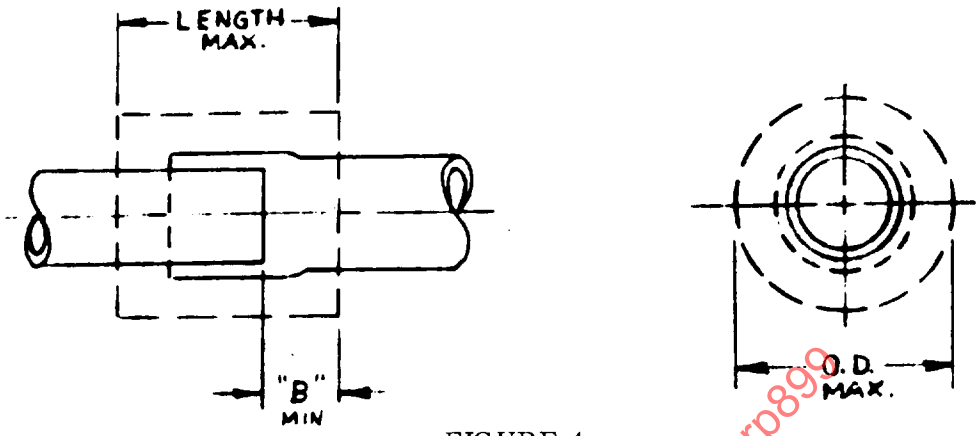
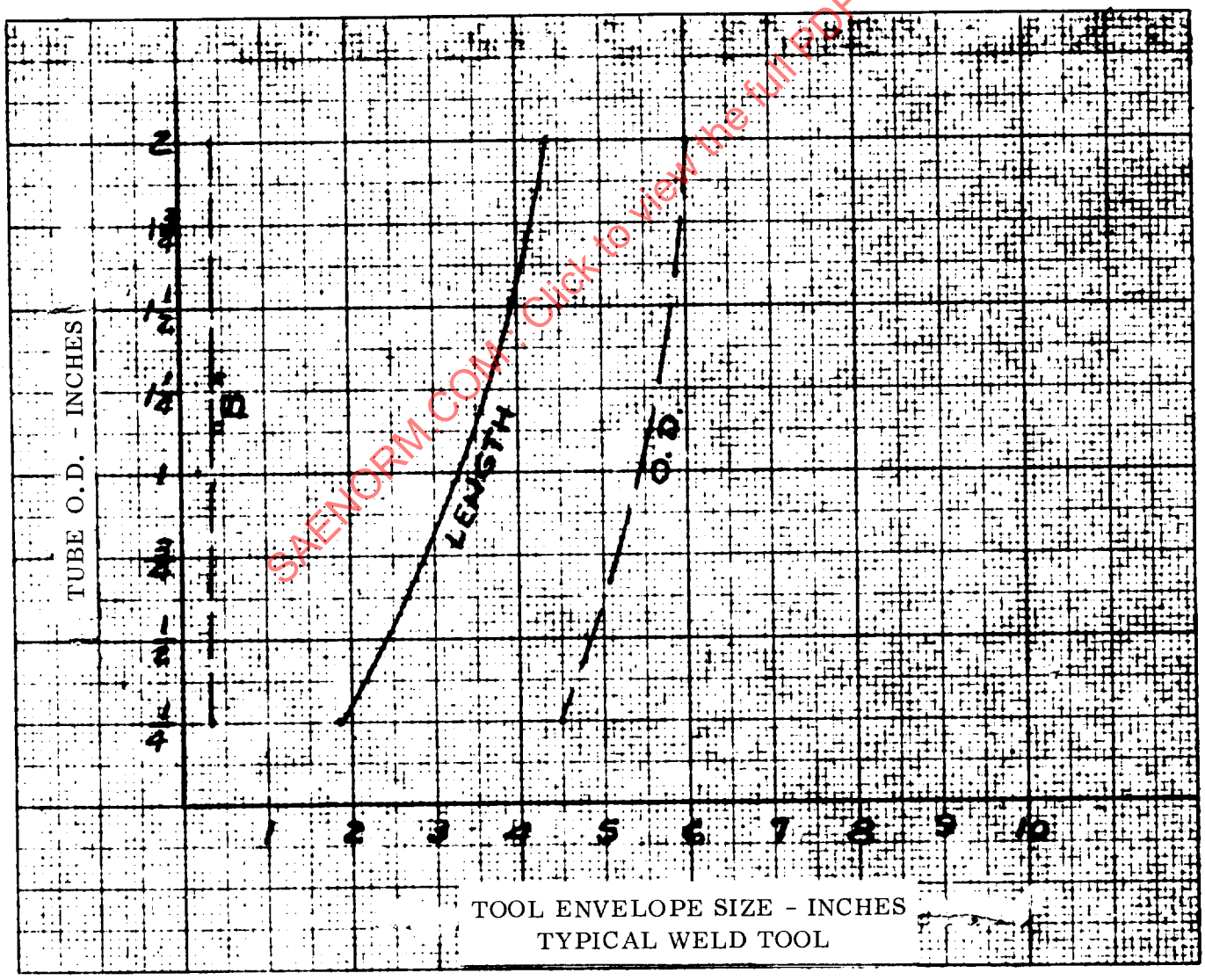


FIGURE 4



SAE

AMS 4928	Titanium Alloy Bars and Forgings
AMS 5554	Steel Tubing, Seamless, Corrosion-Resisting (AM-350)
AMS 5668	Alloy, Corrosion and Heat Resistant Bars & Forgings (Inconel-X)
AMS 5743	Steel Bars, Forgings, Mech. Tubing, Corrosion-Resisting (AM-355)
ARP 603	Impulse Test Equipment for Testing Hydraulic System Components.

Standards:

Federal

No. 151	Metals, Test Methods

Military

MIL-STD-105	Sampling Tables and Procedures for Inspection by Attributes.

2.1.2 Other Publications - The following non-governmental documents form a part of this specification to the extent specified herein.

ARP 598 Procedure for the Determination of Particulate Contamination of Hydraulic Fluids by the Particle Count Method.

(Application for copies should be addressed to the SAE Office)

American Welding Society Brazing Manual - (Library of Congress catalog card number 63-11712)

3. REQUIREMENTS

3.1 Qualified Products - The connectors and attachment processes furnished under this document shall have been tested and have passed the qualification tests specified herein, or as otherwise specified by the purchaser.

3.2 Materials

3.2.1 Connectors - Connectors shall be manufactured from materials suitable for and compatible with the specified system tubing, fluid temperature and pressure.

3.2.2 Filler Material - Filler material, where used, shall be compatible with the performance requirements set forth for connectors and tubing and with system fluid specified by the purchaser. (see 6.2.3)

3.2.3 Flux - Where fluxes are employed, the design of the connector shall be such as to minimize the amount of flux which enters into the tube connection. The supplier shall be prepared to demonstrate that the use of flux does not contribute significantly to the promotion of corrosion and does not raise the level of contamination beyond that specified by the procuring activity. (see 3.7). The flux shall be compatible with the system fluid as in 3.2.2.

3.3 Design and Dimension - Connectors and fittings shall be so designed that tooling and processing to accomplish their installation will require a minimum amount of space * .

3.3.1 Tooling - Joint alignment and joint process tooling required to accomplish the joining of connectors and fittings shall be contained within a minimum amount of space * .

3.3.2 Installation - Tool envelopes * required to install connectors or fittings on tubing in vehicle or system; and to effect repair of the system, or replacement of the fittings within the system shall be kept to a minimum.

3.3.3 Weight - Connector weight shall be held to a minimum. Actual nominal weights shall be shown on the manufacturer's drawings.

3.3.4 Drill Offset - On connectors where the fluid passage is drilled from each end, the offset between the drilled holes at the meeting point of the drills shall not exceed .005 inch, or more than 1% of the nominal tube diameter, whichever is the greater. Angular misalignment between drilled holes shall not exceed one degree.

3.3.5 Reduction in Cross-Section - It shall be possible to pass through the fluid passage a ball whose minimum diameter is listed in Table I for each dash size and corresponding wall thickness, unless otherwise specified by the purchaser.

3.3.6 Heat Generation - Connections fabricated by thermal process shall be designed to permit installation in vehicle systems without heat damage to adjacent structure.

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* For reference only, dimensional envelope ranges of presently available tools are shown in Figures 1 and 2 (Brazing) and Figures 3 and 4 (Welding Tool). These values shall be kept small as possible, consistent with proper operation and performance.

TABLE I

(Minimum) Ball Diameters for Inspecting Inside Diameter

Dash Size	-3	-4	-5	-6	-8	-10	-12	-16	-20	-24	-32	-40	-48
Nom. O.D.	3/16	1/4	5/16	3/8	1/2	5/8	3/4	1	1-1/4	1-1/2	2	2-1/2	3
Wall Thickness													
.028	.084	.156	.219	.281	.406	.531	.625	.844	1.062	1.312	1.812	2.250	2.750
.035	.078	.141	.203	.266	.375	.500	.625	.812	1.062	1.312	1.750	2.250	2.625
.049	.047	.125	.172	.234	.344	.469	.594	.781	1.062	1.250	1.750	2.125	2.625
.065	---	.093	.141	.203	.312	.438	.562	.750	1.000	1.250	1.688	2.125	2.625
.083	---	.047	.109	.172	.281	.406	.531	.719	1.000	1.188	1.688	2.125	2.500
.095	---	.031	.078	.141	.266	.375	.500	.688	.969	1.188	1.625	2.125	2.500
.109	---	---	.062	.125	.250	.344	.469	.688	.938	1.125	1.625	2.000	2.500
.120	---	---	.031	.094	.219	.344	.469	.656	.906	1.125	1.625	2.000	2.375
.134	---	---	---	.062	.188	.312	.438	.625	.906	1.125	1.562	2.000	2.375
.148	---	---	---	.047	.172	.281	.406	.594	.835	1.062	1.562	2.000	2.375
.156	---	---	---	.031	.156	.266	.375	.562	.844	1.062	1.500	1.938	2.375
.188	---	---	---	---	.094	.203	.344	.500	.781	1.000	1.438	1.938	2.250

3.3.7 Contaminant Control - The connectors and attachment process shall be designed so as to minimize generation and/or entrapment of contaminants.

3.3.8 Tube End Preparation - Connectors shall be designed so as to require a minimum of tube end preparation, using standard aircraft quality tubing stock. A slight increase or reduction of tube end diameter by mechanical process is permissible, provided tubing strength and integrity are not impaired, and the requirements of 3.3.4 and 3.3.5 are met.

3.3.9 Wetted Area (Brazed Connections) - Brazed connections shall meet the joint quality requirements of MIL-B-7883 unless specifically designed otherwise. Examination criteria shall be per 4.6.11 and/or 4.6.12.

3.3.10 Weld Integrity - Welds shall be essentially smooth and regular in appearance and be devoid of cracks, inadequate penetration, incomplete fusion, surface pits, oxide folds, and with porosity and inclusions not in excess of specification when examined per 4.6.11.

3.3.11 Material Certification - Records of chemical composition analysis and mechanical property tests showing conformance to applicable specifications shall be made available to the procuring activity inspector for each lot of connectors. (See 6.2.1)

3.4 Surface Treatment - Unless otherwise specified, surface treatment of connectors shall be in accordance with specification MIL-S-5002. After attachment, the connections shall retain their corrosion resistance when subjected to the tests in 4.6.10.

3.5 Identification of Product - All connectors shall be identified in accordance with the following instructions. Marking shall be impressed, embossed, electroetched, or plated without damage to the connector. All marking shall remain legible after the connector is permanently joined to the tubing.

3.5.1 Symbol and Trademark - Unless otherwise specified, all connectors shall be marked with the manufacturer's name or trademark.

3.5.2 Material and Classification Identification - Connectors shall be marked with appropriate material identification, and with the type code letters and pressure class numerals per 1.3.

3.5.3 Part Number- Unless otherwise specified, connectors shall be marked with the manufacturer's basic part number.

3.6 Performance - The connectors, when permanently attached to the appropriate tubing and tested in accordance with the applicable procedures described in paragraph 4., shall be capable of the following performance.

3.6.1 Proof Pressure - Connections shall be designed to withstand a proof pressure of twice the system pressure for five minutes without leakage or permanent deformation. (See 1.3.2 and 6.2.4)

3.6.2 Burst Pressure - Connections shall be designed to withstand a burst pressure of four times the system operating pressure for five minutes without leakage or other failure.

3.6.3 Impulse - Connections shall be capable of withstanding 200,000 hydrodynamic impulse cycles without leakage or other failure, when tested in accordance with 4.6.4.1. Failure of one test sample shall conclude the testing.

3.6.4 Vibration - Connections shall be capable of meeting the vibration environments required by the purchaser, without leakage or other failure.

3.6.5 Flexural Strength - Connections shall be capable of sustaining 10,000,000 cycles of flexure in each of two (2) planes 90 degrees apart without leakage or failure of the connection, when tested in accordance with 4.6.7.

3.6.6 Extreme Temperature Pressure Cycling - Connections shall be capable of withstanding, without leakage or other failure, 50,000 pressure cycles at both of the appropriate minimum and maximum temperatures specified for the part, when tested in accordance with 4.6.4.2.

3.6.7 Thermal Shock - The connections shall be capable of withstanding, without leakage or other failure, three (3) complete temperature cycles when tested in accordance with 4.6.5.

3.6.8 Helium Leakage - The connections shall be capable of meeting, under high vacuum ambient conditions, the leakage requirements defined in 6.2.4.1 when tested in accordance with 4.6.9.

3.6.9 Stress-Corrosion - When tested as specified in 4.6.10 connections shall show no visible pitting, cracking or other evidence of corrosion. Slight staining or discoloration shall not be considered as corrosion.

3.6.10 Additional Performance Requirements - All connections shall meet the qualification (preproduction) tests required per this ARP as well as further requirements that may be deemed necessary to encompass the individual design, as set forth in the control specifications for individual design. (See 4.4)

3.7 Cleanliness - Cleanliness of the connector is essential to ensure proper performance. Care shall be used in the manufacture, handling, assembly, testing, and packaging of the unit to ensure cleanliness. The system as assembled shall have a cleanliness level in compliance with that specified by the purchaser and as defined in Table II.

3.7.1 Cleaning - Components shall be manufactured free of all burrs, slivers, and particles that can be entrapped within the connector and dislodged during usage. Parts shall be furnished in a clean condition as defined by the cleanliness levels specified in Table II and/or as specified by the purchaser.

TABLE II Cleanliness Level Requirements

Level	Maximum Particle Population Size (microns) (Number per 100 ml of test fluid)		Maximum Non-Volatile Residue (mg. per 100 ml of test fluid)
1	above 100	0	1
	85 - 100	1	1
	60 - 85	6	1
2	above 175	0	1
	150 - 175	1	1
	100 - 150	7	1
3	above 250	0	(No requirements)
	200 - 250	1	(No requirements)
	160 - 200	5	(No requirements)
4	175 - 700 (Particles and fibers)	6	2
	above 700 (Particles only)	0	2
	700 - 1500 (Fibers only)	1	2
	above 1500 (Fibers only)	0	2

3.7.2 Area Cleanliness - Assembly, acceptance testing, flushing sealing, and packaging shall be done in an area sufficiently clean to ensure that the capability of the connector shall not be impaired.

4. QUALITY ASSURANCE PROVISIONS

4.1 Purpose - The purpose of testing the connection is to qualify it for the particular design requirements. Approval of straight connections will not automatically qualify all other standard configurations of a given size. Tests on other configurations such as elbows and tees shall be conducted unless otherwise specified by the purchaser.

4.2 Classification of Tests - The inspection and testing of connector and connections shall be classified as follows:

(a) Preproduction tests (See 4.3)
(b) Individual acceptance tests (See 4.4)
(c) Production evaluation tests (Periodic Control) (See 4.5)

4.2.1 Sampling - Sampling for all tests shall be established by the purchaser and may be guided by MIL-Std-105.

4.3 Preproduction Tests - Preproduction tests shall consist of the following:

(a) Destructive pressure tests (See 4.6.8)
(b) Pressure cycling test (Pressure endurance) (See 4.6.4)
(c) Thermal shock test (See 4.6.5)
(d) Vibration test (See 4.6.6)
(e) Flexural strength test (See 4.6.7)
(f) Helium leak test (See 4.6.9)
(g) Stress-corrosion test (See 4.6.10)

4.4 Acceptance Tests - Each individual lot of connectors and connections shall be subjected to the following tests, as applicable:

(a) Examination of product (See 4.6.1)
(b) Chemical composition (See 3.3.10)
(c) Mechanical properties (See 3.3.10)
(d) Connection cut test (See 4.6.12)
(e) Proof pressure test (See 4.6.3)
(f) Destructive pressure test (See 4.6.8)
(g) Strauss test (brazed joints only) (See 4.6.13)
(h) Radiographic inspection (See 4.6.11)

4.5 Production Evaluation Tests - Periodic Control tests and rejection and retest shall be established by the purchaser.

4.6 Test Methods

4.6.1 Examination of Product - Each lot of connectors shall be examined on a sample basis to determine conformance to this specification and the applicable drawing.

4.6.2 General Testing Criteria

4.6.2.1 Preparation of Test Specimens - Specimens shall be prepared in accordance with manufacturers recommended procedures and processes. The purchaser may require certification and/or surveillance of the joining process.

4.6.2.2 Examination of Test Specimens - Connector joints shall be examined to determine conformance to this document and the applicable joining process with respect to workmanship and tube condition adjacent to junction.

4.6.2.3 Test Fluids - Test media used shall be suitable for and compatible with the fluid system temperature and pressure range as specified by the purchaser.

4.6.2.4 Temperature - Unless otherwise specified, all tests shall be performed at room temperature (77 ± 18 degrees F).

4.6.3 Proof Pressure - Fittings and connections shall be pressure tested at a value of two (2) times the system pressure for a period of five (5) minutes without permanent deformation, leakage or other failure. Rate of pressure rise shall be 20,000 ± 5,000 psi per minute. Test media, temperature, and pressure shall be as specified by the purchaser.

4.6.4 Pressure Cycling Test - Six (6) test connectors shall be joined to tubing of the type designated for the material under test, and subjected to the following:

4.6.4.1 Impulse Test - The six (6) test samples shall first be proof pressure tested for five (5) minutes (See 4.6.3). All impulse testing shall be conducted at the rate of 70 + 5 cycles per minute. Each impulse cycle shall consist of a pressure rise from zero pounds per square inch (psi) to surge pressure and drop to zero pressure. The peak surge pressure shall be that required to induce a stress in the tube equal to the endurance limit (for 10, 000, 000 flexure cycles) for the tube material. Hydraulic fluid shall be used as the test medium with a pressure rate of rise of 400, 000 - 500, 000 psi/sec. as indicated by an oscillograph or other electronic measuring device. Impulse testing shall be conducted at a temperature specified by the purchaser and under conditions in accordance with ARP 603 unless otherwise specified. The test fittings shall complete the required impulse cycles per 3.6.3 after which they shall again be proof pressure tested per 4.6.3. There shall be no leakage, deformation or other failure.

4.6.4.2 Pressure Cycling Test - (Gaseous System) - Six (6) assemblies shall be extreme temperature pressure cycle tested, using the approved medium (see 4.6.2.3). All pressure cycle tests shall be conducted at a rate of 15 + 5, -0 cycles per minute. Each pressure cycle shall consist of a rise from 0 psi to 1.25 times working pressure, and a drop to zero pressure. Before and after extreme temperature pressure cycling, the connections shall be tested at system pressure for five (5) minutes without leakage (see 4.6.3). The connections then be subjected to the destructive pressure tests per 4.6.8.

4.6.4.2.1 Low Temperature - Connections shall be exposed to the lowest temperature specified for that type connection at 2 to 10 psig static pressure, until temperature stabilization is achieved, and then subjected to 50, 000 pressure cycles (4.6.4.2).

4.6.4.2.2 High Temperature - Connections shall be exposed to the highest temperature specified for that type connection at 2 to 10 psig static pressure, until temperature stabilization is achieved, and then subjected to 50, 000 pressure cycles (4.6.4.2).