

**FITTINGS, WELDED, HYDRAULIC, TITANIUM AND CORROSION  
RESISTANT STEEL, 20000 kPa, METRIC****1. SCOPE**

This specification defines the requirements for metric weld fittings and machine weldments using an orbiting welding head suitable for use on cold worked 3Al-2.5V titanium and 21Cr-6Ni-9Mn CRES tubing and associated fittings.

**2. APPLICABLE DOCUMENTS**

The following specifications and standards, of the issue in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

**2.1 MILITARY**

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

MIL-STD-109 Quality Assurance Terms and Definitions

MIL-STD-129 Marking for Shipment and Storage

MIL-H-6875 Heat Treatment of Steels, Process for

MIL-I-6866 Inspection, Penetrant Method of

**2.2 INDUSTRY**

AMS 4928 Bars and Forgings, Ti-6Al-4V, Annealed

AMS 4944 Titanium Alloy Tubing, Seamless, Hydraulic 3Al-2.5V Cold Worked, Stress Relieved

AMS 5561 Tubing, Hydraulic, Welded and Drawn, Corrosion Resistant, 21Cr-6Ni-9Mn, High Pressure, Hydraulic

AMS 5656 Steel Bars, Forgings and Rings, Corrosion Resistant 9Mn-20Cr-.5Ni

AMS 5659 Bars, Forgings and Rings, 15Cr-5Ni-0.03 (Cb + Ta) 4 Cu, Con. Elect. Melted

MA 2002 Impulse Testing of Hydraulic Hose Assemblies, Tubing and Fittings

MA 2003 Flexure Testing of Hydraulic Tubing Joints and Fittings

MA 2005 Qualification of Hydraulic Tube Joints to Specified Flexure Fatigue Requirements

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# MA 2060

|               |                                                                               |
|---------------|-------------------------------------------------------------------------------|
| MA 2011       | Fitting End, 24° Cone                                                         |
| MA 2014       | Fitting End, Fluid, Acorn, Standard Dimensions, for Metric                    |
| MA 2040       | Nut, Coupling, Flareless                                                      |
| MA 2061       | Fitting End, Welded Dimensions, Hydraulic 20000 kPa, Metric                   |
| MA 2062       | T-Ring, Tube Weld, Hydraulic 20000 kPa, Metric                                |
| MA 2063       | Tube and Fitting End, Welded, Preparation and Installation, 20000 kPa, Metric |
| MA 2064       | Sleeve, Tube Weld to Flareless Female, Hydraulic, 20000 kPa, Metric           |
| MA 2065       | Union, Tube Weld to Flareless Male, Hydraulic, 20000 kPa, Metric              |
| MA 2066       | Reducer, Tube Weld, Hydraulic, 20000 kPa, Metric                              |
| MA 2067       | Seal Sleeve, Olive to Weld, 20000 kPa, Hydraulic, Metric                      |
| MA 2068       | Union, Port to Flareless, 20000 kPa, Hydraulic, Metric                        |
| MA 2069       | Elbow, 90° Tube Weld, Hydraulic 20000 kPa, Metric                             |
| MA 2070       | Tee, Tube Weld, Hydraulic, 20000 kPa, Metric                                  |
| MA 2071       | Cross, Tube Weld, 20000 kPa, Hydraulic, Hydraulic, 20000 kPa, Metric          |
| MA 2072       | Nut, Olive, Metric                                                            |
| MA 2073       | Nut, Olive, External, Metric                                                  |
| MA 2074       | Seal Ring, Olive, Metric                                                      |
| ANSI/AWS A3.0 | Welding Terms and Definitions                                                 |
| ANSI B46.1    | Surface Texture, Surface Roughness, Waviness, and Lay                         |

## 3. REQUIREMENTS

### 3.1 QUALIFICATION

Fittings furnished under this specification shall be products which have been subjected to and which have successfully passed the test requirements of this specification.

### 3.2 MATERIALS

#### 3.2.1 FITTING MATERIALS

Fittings and other parts shall be made of materials listed in Table I.

#### 3.2.2 FITTING FORGINGS

##### 3.2.2.1 Surface Defects

Forged fittings shall be free from cracks, laps, seams and other defects.

Note: Surface defects may be removed as long as wall thickness requirements are met and as long as defects do not reappear after etching and in penetrant inspection.

TABLE I  
MATERIALS

| TYPE OF PART                 | MATERIAL | CODE | SPECIFICATION                  |
|------------------------------|----------|------|--------------------------------|
| STRAIGHT FITTINGS AND SHAPES | CRES     | P    | AMS 5659*<br>(15-5 PH, H-1075) |
| STRAIGHT FITTINGS AND SHAPES | TITANIUM | T    | AMS 4928<br>(Ti-6Al-4V)        |
| T-RINGS                      | CRES     | C    | AMS 5656<br>21 CR-6Ni-9Mn      |

\*Solution heat treated, aged to H-1075 in accordance with MIL-H-6875 after machining.

### 3.2.2.2 Titanium Forgings

Titanium forgings shall exhibit an equiaxed microstructure. Oxide or other gas contaminated surface scale shall be removed by pickling.

### 3.2.3 TUBING MATERIAL

Tubing shall be in accordance with the requirements of AMS 4944 and AMS 5561 as applicable.

### 3.3 DESIGN AND CONSTRUCTION

Fittings and other parts shall be in accordance with the following standards, as applicable:

|        |        |        |
|--------|--------|--------|
| MA2061 | MA2066 | MA2071 |
| MA2062 | MA2067 | MA2072 |
| MA2063 | MA2068 | MA2073 |
| MA2064 | MA2069 | MA2074 |
| MA2065 | MA2070 |        |

### 3.3. PASSAGES

#### 3.3.1.1 Drill Offset

On fittings 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 0.4 mm.

#### 3.3.1.2 Cross Section

On angle fittings, the cross sectional area at the junction of the fluid passages shall not be smaller than the cross sectional area of the smaller passage.

### 3.4 IDENTIFICATION OF PRODUCT

All fittings shall be identified as follows: Marking shall be etched in a location and in a manner not detrimental to the fitting. Where practical, marking shall remain visible after the fitting is installed.

## 3.4.1 MARKING OF FITTINGS

All fittings shall be etched or embossed with the aerospace standard number, material code letter and the manufacturer's name or trademark. All fittings shall be identified with the basic part number for sizes DN08 and larger. The MA portion of the basic part number may be omitted on sizes DN10 or smaller where space is limited. Markings shall not fall within six millimeters of the weld area.

## 3.4.2 MARKING OF FORGED SHAPES

All forged shapes such as tees, elbows and crosses shall be embossed or etch-marked with the forging manufacturer's trademark, code number or code letter. Markings shall not fall within six millimeters of the weld area.

## 3.4.3 MARKING OF T-RINGS AND SEAL RINGS

The MA2062 T-rings and MA2074 seal rings shall be marked by giving the part number, code letter and manufacturer's name, code or trademark on the package.

## 3.5 PERFORMANCE

Fitting samples in accordance with Table II welded to tubing shall meet the requirements of 3.5.1, 3.5.2, 3.5.3, 3.5.4 below when tested in accordance with the test procedures specified in Section 4 of this document.

### 3.5.1 PROOF PRESSURE

The assembly shall withstand proof pressures of 40000 kPa without leakage or wetting, evidence of permanent deformation or, at separable connectors, other malfunction that would affect assembly or disassembly.

### 3.5.2 IMPULSE

The assemblies shall withstand 200,000 impulse pressure cycles without leakage or external wetting when impulse tested to the requirements of MA 2002.

### 3.5.3 BURST

The assemblies shall not rupture or leak at pressures less than 80000 kPa.

### 3.5.4 FLEXURE

The assemblies shall not rupture, leak or show external wetting when flexure-fatigue tested to the requirements of MA 2003 and MA 2005.

### 3.5.5 GASEOUS LEAKAGE

Assemblies shall pass the gaseous pressure test to the specified system operating pressure without leakage or visible bubbles for five minutes when tested in accordance with 4.6.3.6.

### 3.5.6 REPEATED ASSEMBLY

The test assembly shall withstand eight repeated assemblies when tested in accordance with 4.6.3.7 without occurrence of any of the following defects:

- (a) Leakage at any of the proof pressure tests;
- (b) Leakage or burst at a value less than four times the nominal operating pressure during the burst pressure testing – in case that specimens are used for burst tests also;
- (c) Inability to assemble the fitting to the bottoming or seal interface point by hand;

- (d) Nut deformation preventing engagement of the nut hexagon with an open-end wrench;
- (e) Gaseous leakage following final assembly when tested per 4.6.3.6

### 3.6 WORKMANSHIP

There shall be no imperfections which are detrimental to the service performance. Unless a finer finish is specified on the drawing, machined areas shall be free from burrs and longitudinal or spiral tool marks in excess of 2.5 micrometers  $R_a$  as defined in ANSI B46.1. All other machined surfaces shall not exceed 3.2 micrometers. Unmachined areas, such as forged surfaces shall be free of laps, seams or other defects. Parting lines in forgings shall blend smoothly with the forging body and shall have a finish not exceeding 6.3 micrometers as defined in ANSI B46.1.

## 4. QUALITY ASSURANCE PROVISIONS

### 4.1 RESPONSIBILITY FOR INSPECTION AND TEST

Unless otherwise specified, the supplier is responsible for the performance of all inspection and test requirements specified herein. The supplier may utilize his own facilities or other facilities which have been approved by the user. The user has the right to perform any of the inspection or tests set forth in this specification, as deemed necessary to assure that the parts conform with the specified requirements.

### 4.2 MATERIAL CERTIFICATION

Tests for chemical composition and heat treat condition shall be performed to show conformance with the applicable requirements. Tensile and hardness test shall be performed to verify compliance with the requirements in material specifications under 3.2. Gas content of titanium shall be controlled in accordance with AMS 4928, except that forgings shall comply with requirements under 3.2.2. Records of these tests shall be made available to the user upon request.

### 4.3 INSPECTION LOT

A lot shall consist of all parts of a given part number made from the same batch of material and processed at the same time. The supplier shall maintain a record of inspections applied to each lot.

### 4.4 INSPECTION RECORDS

The supplier shall keep a complete record of all material certifications, examinations, inspections and tests performed to verify conformance to the requirements of this specification. Such records shall be available upon request.

### 4.5 CLASSIFICATION OF INSPECTION

The testing and inspection shall be classified as follows:

- (a) Qualification inspection
- (b) Quality Conformance inspection

### 4.6 QUALIFICATION INSPECTION

#### 4.6.1 SAMPLING INSTRUCTIONS

Qualification inspection shall be conducted for each fitting or part standard as listed in Table II and for the sizes and materials used.

TABLE II  
QUALIFICATION TEST SAMPLES

| PART                     | STANDARD                                                               | QUANTITY | TEST     | PARAGRAPH      |
|--------------------------|------------------------------------------------------------------------|----------|----------|----------------|
| TUBE END                 | MA2063<br>STYLE A,B                                                    | 3        | IMPULSE  | 3.5.2, 4.5.3.3 |
|                          |                                                                        | 3        | BURST    | 3.5.3, 4.6.3.4 |
|                          |                                                                        | 6        | FLEXURE  | 3.5.4, 4.6.3.5 |
| T-RING<br>(TUBE-TUBE)    | MA2062                                                                 | 3        | IMPULSE  | 3.5.2, 4.6.3.3 |
|                          |                                                                        | 3        | BURST    | 3.5.3, 4.6.3.4 |
|                          |                                                                        | 6        | FLEXURE  | 3.5.4, 4.6.3.5 |
| TEE                      | MA2070                                                                 | 3        | IMPULSE  | 3.5.2, 4.6.3.3 |
|                          |                                                                        | 3        | BURST    | 3.5.3, 4.6.3.4 |
|                          |                                                                        | 2        | FLEXURE  | 3.5.4, 4.6.3.5 |
| UNION,<br>SLEEVE,<br>NUT | MA2065, MA2068<br>MA2064, MA2067<br>MA2074<br>MA2040, MA2072<br>MA2073 | 3        | IMPULSE  | 3.5.2, 4.6.3.3 |
|                          |                                                                        | 3        | BURST    | 3.5.3, 4.6.3.4 |
|                          |                                                                        | 6        | FLEXURE  | 3.5.4, 4.6.3.5 |
|                          |                                                                        | 4        | GASEOUS  | 3.5.5, 4.6.3.6 |
|                          |                                                                        | 4        | ASSEMBLY | 3.5.6, 4.6.3.7 |
| REDUCER                  | MA2066                                                                 | 3        | IMPULSE  | 3.5.2, 4.6.3.3 |
|                          |                                                                        | 3        | BURST    | 3.5.3, 4.6.3.4 |
|                          |                                                                        | 6        | FLEXURE  | 3.5.4, 4.6.3.5 |

Note: All specimens shall be proof tested prior to impulse, burst and flexure testing.

#### 4.6.1.1 Test Specimen Preparation

Specimens for burst and impulse tests shall be assembled as illustrated in Figure 1. Flexure test specimens shall be in accordance with MA 2003.

#### 4.6.1.2 Tube Preparation

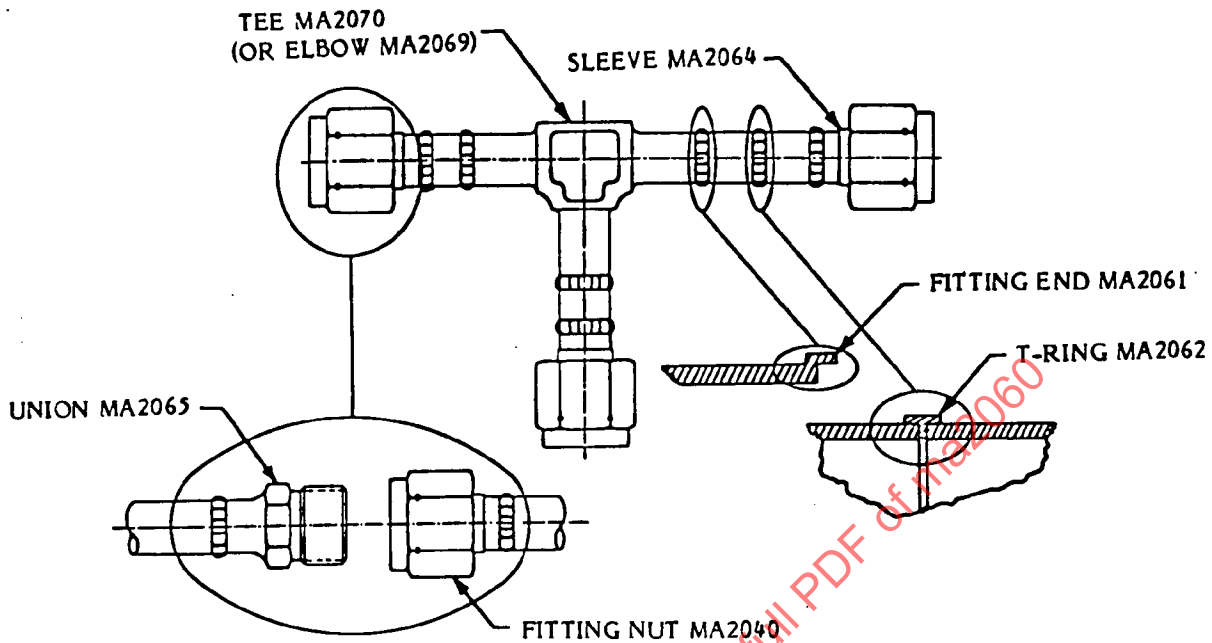
Tube ends to be welded shall be in accordance with MA2063 style A or B, as applicable. Corrosion resistant steel specimens shall be alkaline cleaned or vapor degreased and then thoroughly drained and blown out to remove any remaining cleaning fluid. Titanium tubing shall be alkaline cleaned and then drained and blown out like the CRES tubing. No chlorinated solvents shall be used with titanium. Immediately prior to welding, the tube area that will be exposed to heat shall be solvent cleaned with MEK or acetone, unless specified otherwise.

#### 4.6.2 WELDMENTS

##### 4.6.2.1 Weldbeads

Welds for test specimens shall be smooth and uniform in appearance, with one hundred percent penetration and fusion of the mating tube and fitting end. Undercut, thinning, concavity or overlap at the edge or the weld bead shall be unacceptable. Underfill shall be unacceptable, except that for titanium a local blended underfill of 10 percent of the thinner wall thickness is allowed as long as it does not exceed 50 percent of the weld circumference. Cracks, weld craters or open holes in the weld are unacceptable, except that a local blended depression in the weld tail-out area in the middle of the weld reinforcement width with a maximum of 0.1 mm depth x 0.4 mm diameter is not regarded as detrimental.

Note: Definitions of welding terms, such as undercut, and overlap, are given in ANSI/AWS A3.0.



NOTE: MINIMUM DISTANCE BETWEEN WELDS 75 MILLIMETERS.

#### EXAMPLES FOR BURST AND IMPULSE TEST SPECIMEN (OPTIONAL, COMBINED OR SINGLE)

Figure 1

#### 4.6.2.2 Weld Porosity

Subsurface porosity and inclusions shall not exceed the following items:

- Porosity and inclusions with sharp terminations are unacceptable.
- Porosity and inclusions shall not be closer together than three times the size of the smallest adjacent pore or inclusion in its largest dimension.
- Interconnected porosity, or two or more pores or inclusions which are closer together than the largest dimension of the smaller adjacent pore or inclusion, shall be considered as a single pore or inclusion.
- Porosity and inclusions shall not exceed 1/2 of the wall thickness in their largest dimension or 0.5 mm, whichever is less.
- Porosity and inclusions shall not exceed an accumulated length of 1-1/3 of the wall thickness in any lineal 13 mm of weld.

## 4.6.2.3 Weld Discoloration

For Titanium weldments, the following applies regarding discoloration:

- (a) Bright silver to straw to pale violet is acceptable. Light blue is acceptable only on the base metal, provided it does not contact the weld metal. All discoloration shall be removed when additional welding is to be performed.
- (b) Discoloration removal, when required, shall be done with a suitable abrasive fabric such as Scotch-Brite Type A or S, fine to ultrafine.

## 4.6.3 QUALIFICATION TESTS

### 4.6.3.1 Examination of Product

Prior to testing, the fitting parts and tubing shall be submitted to quality conformance inspection. All criteria which are classified as major shall be measured and recorded. All welded assemblies shall be visually and penetrant inspected and x-rayed in two planes, at a 90 degree angle, for compliance with the requirements under 4.6.2.

### 4.6.3.2 Proof Pressure

Test assemblies shall be connected to a source of pressure and pressure tested to the proof test value of 40000 kPa for a period of five minutes. The test shall be conducted at room temperature.

### 4.6.3.3 Impulse Test

Test assemblies as illustrated in Figure 1 and Table II shall be tested to the requirements specified in MA 2002 for:

|                     |                            |
|---------------------|----------------------------|
| Operating Pressure: | 20000 kPa                  |
| Peak Pressure:      | 30000 kPa                  |
| Temperature:        | Room temperature           |
| Specimen:           | Figure 1 or equivalent     |
| Speed:              | 70 cycles per minute       |
| Rate of Rise:       | 1200000 to 2070000 kPa/sec |

### 4.6.3.4 Burst Test

Test assemblies as described in Figure 1 and Table II shall be connected to a source of pressure. The pressure shall be increased at a rate of 150000 ± 35000 kPa per minute until the assembly leaks or bursts. The tests shall be conducted at room temperature.

### 4.6.3.5 Flexure Test

Samples shall be fabricated and the test shall be conducted in accordance with MA 2003 and MA 2005 as applicable.

### 4.6.3.6 Gaseous Leakage Test

Test fittings shall be solvent cleaned and air dried prior to test, assembled with the use of system fluid or an equivalent lubricant or compound on the thread and sleeve/nut shoulder (unless they have a solid film lubrication) and tightened to the torques specified in MA 2005. They shall then be pressurized with nitrogen to the specified system pressure and this pressure maintained for five minutes while the specimens are immersed in water. Specimens may be pressure tested at room temperature.

#### 4.6.3.7 Repeated Assembly Test

Specimens shall be screwed together and unscrewed eight times. Each of the eight cycles shall include the complete removal of the fitting from the port, and of the tube ends from the fitting. The 24° cone flareless fittings shall be tested to the tightening torques specified in MA 2005, one half of the fitting connections shall be tested using minimum; the other half using maximum tightening nut torques. The two groups must not be mixed. Following the first, fourth and eighth installation, proof tests shall be conducted. Specimens must pass gaseous leakage testing after the eighth installation. The specimens may be used for subsequent impulse and burst tests.

#### 4.7 QUALITY CONFORMANCE INSPECTION

Each lot of fittings shall be subjected to the inspections as listed below.

##### 4.7.1 SAMPLING

Sampling for materials, dimensions, finish and workmanship shall be random in accordance with MIL-STD-105, general inspection level II. Unless otherwise specified in Section 4.8 of this specification, the Accepted Quality Level (AQL) shall be four percent.

##### 4.7.2 PENETRANT INSPECTION

Fitting forgings shall be 100 percent penetrant inspected in accordance with MIL-I-6866 until thirty consecutive pieces of each part number have been found defect free. Thereafter, a sampling plan in accordance with MIL-STD-105, General Inspection Level II shall be applied. Indications of any surface defect within the sample size shall cause rejection of the entire lot. Inspection shall be done after machining, with the option that it may be done before threads and sealing surfaces are machined. Defects may be removed if drawing tolerances are not exceeded and the part passes penetrant inspection after in-process correction.

##### 4.7.3 MICRO EXAMINATION - TITANIUM FORGINGS

A minimum of one sample fitting or forging from each forging lot shall be microscopically examined for compliance with 3.2.2.2 in particular for microstructure and oxide scale.

#### 4.8 CLASSIFICATION OF DEFECTS

##### 4.8.1 CLASSES

Definitions of classes are in accordance with MIL-STD-109. Classes, AQLs, and defect characteristics as defined in MIL-STD-109 are clarified as follows:

TABLE III  
DEFECT CLASSIFICATION

| CLASS   | AQL         | CHARACTERISTIC                                                 |
|---------|-------------|----------------------------------------------------------------|
| MAJOR   | 1.5 PERCENT | LIKELY TO CAUSE MALFUNCTION, OR REDUCING USABILITY OF THE PART |
| MINOR A | 4 PERCENT   | MAY HAVE A SLIGHT EFFECT ON USABILITY                          |
| MINOR B | 6.5 PERCENT | ESSENTIALLY NO EFFECT ON USABILITY                             |

## 4.8.2 DETAIL REQUIREMENTS

### 4.8.2.1 MA2061 Fitting End, Welded Girth Joint, Dimensions, 20000 kPa Hydraulic, Metric

| <u>CLASS</u> | <u>CHARACTERISTIC</u>                                                                                                                                                             |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MAJOR        | A - Outside Diameter<br>B - Weld End Inside Diameter Concentricity, Angularity<br>E - Weld End Depth<br>D - Fitting End Diameter Concentricity, Angularity<br>R - Shoulder Radius |
| MINOR A      | C - Overlap Outside Diameter<br>F - Overlap Length<br>G - Length of Inside Diameter<br>Machining Finish                                                                           |

### 4.8.2.2 MA2062 T-Ring, Tube Weld, 20000 kPa Hydraulic Metric

| <u>CLASS</u> | <u>CHARACTERISTIC</u>                                                                                                                               |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| MAJOR        | B - Weld End Inside Diameter Concentricity, Angularity<br>E - Weld End Depth<br>R - Shoulder Radius Concentricity, Angularity<br>Cleanliness/Finish |
| MINOR A      | A - Outside Diameter<br>C - Inside Diameter<br>Shoulder Thickness                                                                                   |

### 4.8.2.3 MA2064 Sleeve, Tube Weld to Flareless, Female, 20000 kPa Hydraulic, Metric

| <u>CLASS</u> | <u>CHARACTERISTIC</u>                                                                                                                                                                                            |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|              | Ends in accordance with MA2064 and MA2014                                                                                                                                                                        |
| MAJOR        | A - Weld Positioning Length<br>B - Gage Diameter<br>E - Gage Depth<br>H - Acorn Length<br>M - Wire Recess Diameter                                                                                               |
| MINOR A      | A - Center, Acorn Radius<br>C - Acorn Diameter<br>D - Sleeve End Diameter<br>E - Sleeve I.D. Bore<br>L - Shoulder Diameter<br>N - Nut Shoulder<br>P - Sleeve Skirt Diameter<br>T - Radius<br>Cleanliness, Finish |
| MINOR B      | Remainder                                                                                                                                                                                                        |

### 4.8.2.4 MA2065 Union, Tube Weld to Flareless, Male, 20000 kPa Hydraulic, Metric

| <u>CLASS</u> | <u>CHARACTERISTIC</u>                     |
|--------------|-------------------------------------------|
|              | Ends in accordance with MA2011 and MA2061 |
| MAJOR        | B - Weld Positioning Length               |
| MINOR A      | Remainder                                 |