IN-PROCESS CARBURIZING HEAT TREATMENT FOR LOW ALLOY STEEL (AISI 4715) COMPONENTS, 95KSI YIELD, CVN AT -20F AND -40F

Rev	Reason of Change	Date	Made By	Reviewed By	Approved By	Status
0	Initial release	18-05-2018	AS	AS	KKD	Released

Summary: The specification covers the processing requirements for carburizing heat treatment of AISI 4715 Alloy Steel and other specified Low Alloy Steels. It also defines the mechanical property requirements after heat treatment.

1.0 SCOPE

The specification covers the processing requirements for carburizing heat treatment of AISI 4715 Alloy Steel and other specified carburizing Low Alloy Steels. It also defines the mechanical property requirements after heat treatment.

2.0 PROCESS REQUIREMENTS

Stop-off paint shall be applied on surfaces depicted with bold lines in Appendix 1 (all non-race ends.) Note: Only Pressure Pumping approved stop-off paint may be used. Currently only Condursal 710 and Conduron G55 are approved.

1. Immediately prior to masking the supplier shall bake all components at 900F for one hour.

2. Components shall be air cooled.

3. To ensure the baked/cleaned parts are not touched with bare hands, associates shall wear clean gloves at all times when handling the parts.

4. The supplier shall use Isopropyl Alcohol to thoroughly wipe clean all surfaces of the components to be masked.

5. Supplier shall ensure all associates have proper knowledge and skill to meet all Pressure Pumping requirements, particularly: proper and consistent application of approved stop-off paint, and, proper handling/racking of components to prevent any/all nicks, dings, scratches, etcetera to the stop-off paint that might lead to leakage during the carburization process.

6. Stop-off paint shall be thoroughly mixed per the manufacturers recommendations throughout the masking process. Note: Condursal 710 and Conduron G55 may be thinned up to 4% using manufacturer specified thinner.

7. The supplier shall apply the first coat of stop-off paint using Condursal 710 per the manufacturer's recommendation(s). Complete and thorough coating of the area to be masked is required.

8. Following the first coat the masked components shall be dried for a minimum of two (2) hours. Before applying the second coat the supplier shall ensure the components are dry to touch.

9. The second coat of stop-off paint shall be applied using Conduron G55 per the manufacturer's recommendation(s). Complete and thorough coating of the area to be masked is required.

10. Following the second coat the masked components shall be dried for a minimum of two (2) hours. Before further processing is completed the supplier shall ensure the parts are dry to touch.

2.2 Parts with stop-off paint coverage dimensions shown as "A" in Appendix I shall be assembled with threaded plugs before heat treatment. Plugs shall have threads coated with high-temperature nickel based anti-seize compound and be screwed in hand tight before coating end with stop-off paint. Parts with stop-off paint coverage dimensions shown as "D", "E", or "F" in Appendix I shall be assembled with rings or plugs after coating with stop-off paint.

2.3 The carburizing temperature shall be 1675^0F to 1750^0F for 4715 Alloy Steel. The carburize-diffuse procedure is preferred.

2.4 The maximum case carbon content shall be at the surface of the parts and shall be from 0.75% to 0.85%.

2.5 At the completion of the carburizing cycle, the parts shall be furnace cooled to the hardening temperature of 1525^0F to 1575^0F and held at that temperature for a minimum of one (1) hour and oil quenched. The environment shall be controlled such that surface carbon content of the parts is maintained within that specified for carburizing.

2.6 After quench, parts shall be washed free of oil and other heat treating debris and tempered at 435^0F to 465^0F for a minimum of two (2) hours and air cooled. Double tempering may be used.

2.7 All stop-off paint remaining after the heat treatment process shall be removed from the parts. All masked areas shall have uniform color after masking is removed.

3.0 MECHANICAL REQUIREMENTS

3.1 The carburized surface hardness of the parts shall be 57 to 62 HRC (or 88.7 to 91.1 HR15N or 79.6 to 82.3 HRA) after heat treatment. Each batch of parts shall be hardness tested on the carburized surface using the sampling plan.

3.2 The surface hardness of the masked area shall not exceed RC46. There shall be no carburized case within masked areas. All parts with 602, 1002, 1502, or 2002 male sub ends shall be hardness tested on the OD behind the male sub shoulder in at least one spot as close to male sub shoulder as equipment allows.

3.3 When a sacrificial forging is used as the qualification test coupon (QTC), tensile and impact test specimens shall be removed from the location shown in Appendix II. Core property test specimens shall be taken at mid-radius of tubular sections and shall be free of any case. Barstock QTC's shall be a minimum of 5 inches long and bored-out to approximate the average wall thickness of the finished parts they represent.

3.4 The total case depth shall be 0.050 to 0.060 inches.

3.5 Required tensile properties of the core shall be as follows:

(a) Tensile strength (min.): ..... 119 ksi
(b) Yield strength (min.): ..... 95 ksi
(c) Elongation in 2" or 4D (min.): 15%

3.6 Desired core hardness is 28 to 32 HRC and is for information only. Values not meeting this requirement shall not be cause for rejection of the parts.

3.7 Charpy V-notch impact (CVN) energy values at test temperature of -208F (-298C):

Full size 10 x 10 mm specimens:

Minimum average energy for set of 3 specimens:.....31 ft-lb (42.0J)
Minimum energy for single specimen of set:.....23.6 ft-lb (32.0J)*
Lateral expansion:.....Report actual values
Percent shear:.....Report actual values

Reduced size 10 x 7.5 mm specimens:

Minimum average energy for set of 3 specimens:.....25.8 ft-lb (35.0J)
Minimum energy for single specimen of set:.....19.4 ft-lb (26.3J)*
Lateral expansion:.....Report actual values
Percent shear:.....Report actual values

Reduced size 10 x 5 mm specimens:

Minimum average energy for set of 3 specimens:.....20.7 ft-lb (28.1J)
Minimum energy for single specimen of set:.....15.5 ft-lb (21.0J)*
Lateral expansion:.....Report actual values
Percent shear:.....Report actual values

*One specimen of set only.

Reduced size 10 x 2.5 mm specimens (for 1" size swivel joints only):

Minimum average energy for set of 3 specimens:.....10.3 ft-lb (14.0J)
Minimum energy for single specimen of set:.....7.9 ft-lb (10.7J)*
Lateral expansion:.....Report actual values
Percent shear:.....Report actual values

*One specimen of set only.

Charpy V-notch impact (CVN) energy values at test temperature of -40ºF (-40ºC):

Full size 10 x 10 mm specimens:

Minimum average energy for set of 3 specimens:.....20 ft-lb (27.1J)
Minimum energy for single specimen of set: .....15 ft-lb (20.3J)*
Lateral expansion:.....Report actual values
Percent shear:.....Report actual values

Reduced size 10 x 7.5 mm specimens:

Minimum average energy for set of 3 specimens:.....16.7 ft-lb (22.6J)
Minimum energy for single specimen of set: .....12.5 ft-lb (16.9J)*
Lateral expansion:.....Report actual values
Percent shear:.....Report actual values

Reduced size 10 x 5 mm specimens:

Minimum average energy for set of 3 specimens:.....13.3 ft-lb (18.0J)
Minimum energy for single specimen of set: .....10.0 ft-lb (13.6J)*
Lateral expansion:.....Report actual values
Percent shear:.....Report actual values

*One specimen of set only.

Reduced size 10 x 2.5 mm specimens (for 1" size swivel joints only):

Minimum average energy for set of 3 specimens:.....6.9 ft-lb (9.4J)
Minimum energy for single specimen of set: .....5.2 ft-lb (7.1J)*
Lateral expansion:.....Report actual values
Percent shear:.....Report actual values

*One specimen of set only.

If material tested at -40ºF has charpy V-notch energy values which meet or exceed the values listed for -20ºF, the tests at -20ºF are not required.

4.0 OTHER REQUIREMENTS

4.1 100% of all packing bores and packing faces shall be polished to a "bright and shiny" finish.

4.2 Sealing surfaces shall be free of scratches, nicks, dents, or other damage which cannot be removed by light polishing. 100% of all packing faces and

packing bores shall be polished after heat treatment and before inspecting packing bores with plug gauge. It is understood that removal of "base" material from packing bore (ID) during polishing is minimal.

4.3 100% of all packing bores shall be inspected with correct diameter plug gauge per Table 1. Parts that have packing bore that will not gauge with required plug gauge shall be clearly marked with an "X" on the OD of the female ball race end of the part. All packing bores and packing faces shall be polished and gauged a minimum of two times (two "polish and inspect" cycles) prior to marking the part with an "X".

4.4 100% of all 2" and 3" components with a female ball race shall be measured to determine the ovality, i.e. Egging. The OD of the female ball race ends shall be measured to determine the maximum and minimum diameters. The difference in these values shall equal the amount of egging. The distortion that occurs during heat treatment shall be continuously improved so that Egging is minimized. Parts that are Egged more than 0.015" shall be clearly marked with an "E" on the OD of the female ball race end, followed by the amount of Egging in thousandth's of an inch, e.g. E20 represents a part that is Egged 0.020".

Parts that are Egged more than 0.015" shall be plug tempered by a procedure created by the heat treater in order to reduce Egging to 0.015" or less.

4.5 All parts that do not conform to above inspection requirements shall be clearly segregated/separated from conforming parts.

4.6 Straightness of long tubing parts shall be within 0.025 inches per foot. Parts shall be straightened prior to final tempering.

4.7 Parts not meeting requirements of this specification require written approval by SARA SAE prior to any rework above the tempering temperature.

TABLE 1

Swivel	Plug Gauge Diameter (in)
1" LS-15	1.493
1.5" LS-15 and 2" LS-20	2.048
2" LS-15	2.497
3" LS-15	3.373
Articulating Frac Arm Inner Seal	3.373
Articulating Frac Arm Outer Seal	4.372

APPENDIX I

The chart below defines the stop-off paint coverage areas for Triple Step and Long sweep components with end connections. Dimensions are in inches.

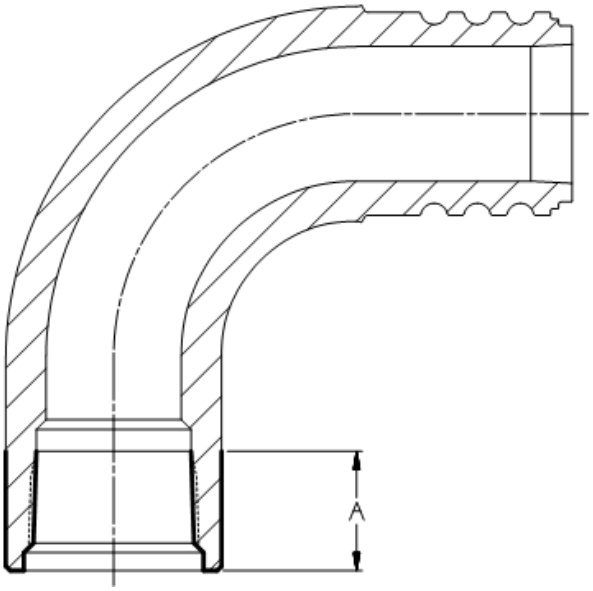
		Nominal Size				
End Connection	Dimension*	1"	1-1/2"	2"	3"	4"
Line Pipe Thread	A	1.66	1.56	1.74	2.56	
Figure 602/1002 Male Sub	B			2.50	2.75	2.75
Figure 602/1002 Female Sub	C			1.88	2.25	2.25
Figure 1502 Male Sub	B	2.12	2.50	2.50	2.75	3.62
Figure 1502 Female Sub	C	2.00	2.25	2.25	2.25	2.75
Figure 1505 Male Sub	B				3.00	
Figure 1505 Female Sub	C				2.25	
Figure 2002 Male Sub	B			2.88	4.25	

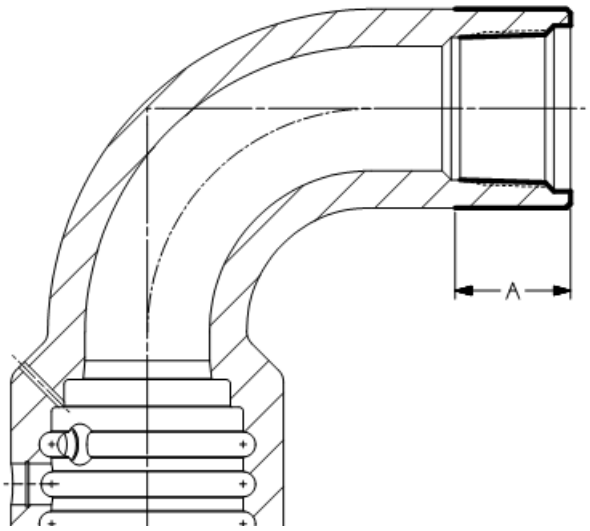
End Connection	Dimension*	Nominal Size 1"	1-1/2"	2"	3"	4"
Figure 2002 Female Sub	C			2.00	2.75	
Pacemaker Pump Adapter	D			4.00	4.00	
Dowell Discharge Port	E			4.25	4.25	
Howloc Hub	F				6.00	
C-Hub	G				2.00	
Swing Nipple with Beveled end	H			1.50		
Figure 602/1002 Male Sub (W6 pc only)	I			3.68		4.39
Figure 1502 Male Sub (W6 pc only)	I	3.26	3.93	3.74	4.11	6.74

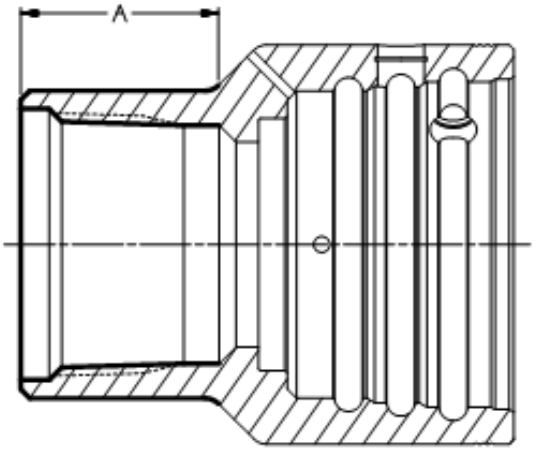
End Connection	Dimension*	Nominal Size 1"	1-1/2"	2"	3"	4"
Figure 1505 Male Sub (W6 pc only)	I				4.11	
Figure 2002 Male Sub (W6 pc only)	I			3.25	6.74	
Figure 1502 Male Sub (W6 pc only)	J				1.75	
Triple step + Male Ball Race	K				0.65 (Max.) 0.32 (Min.)	
Triple step + Male Ball Race	L					0.40 (Max.) 0.10 (Min.)

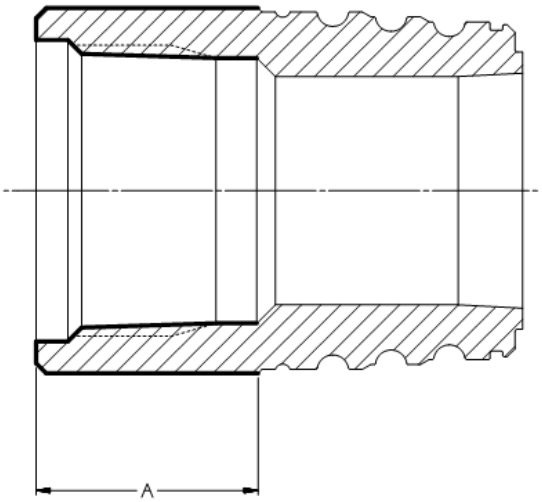
*Tolerance ±0.25 inch; unless specified otherwise. See figures on following page for definition of the letter dimensions. The areas shown with bold lines shall be covered with stop-off paint.

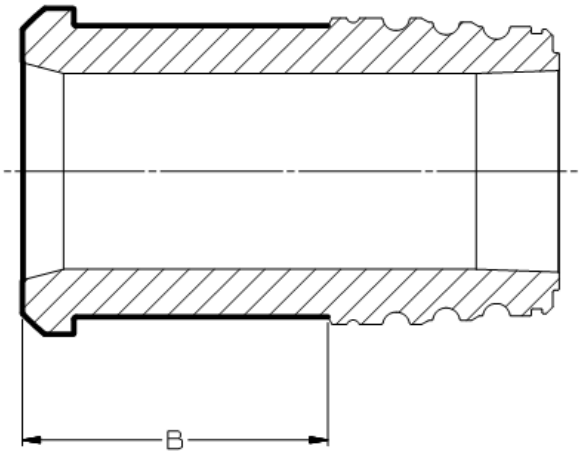
APPENDIX I (continued)

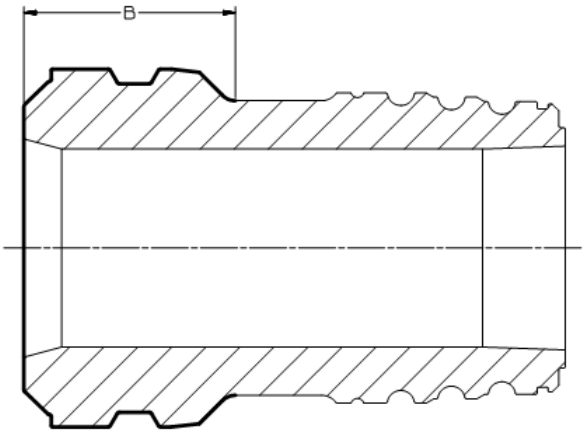




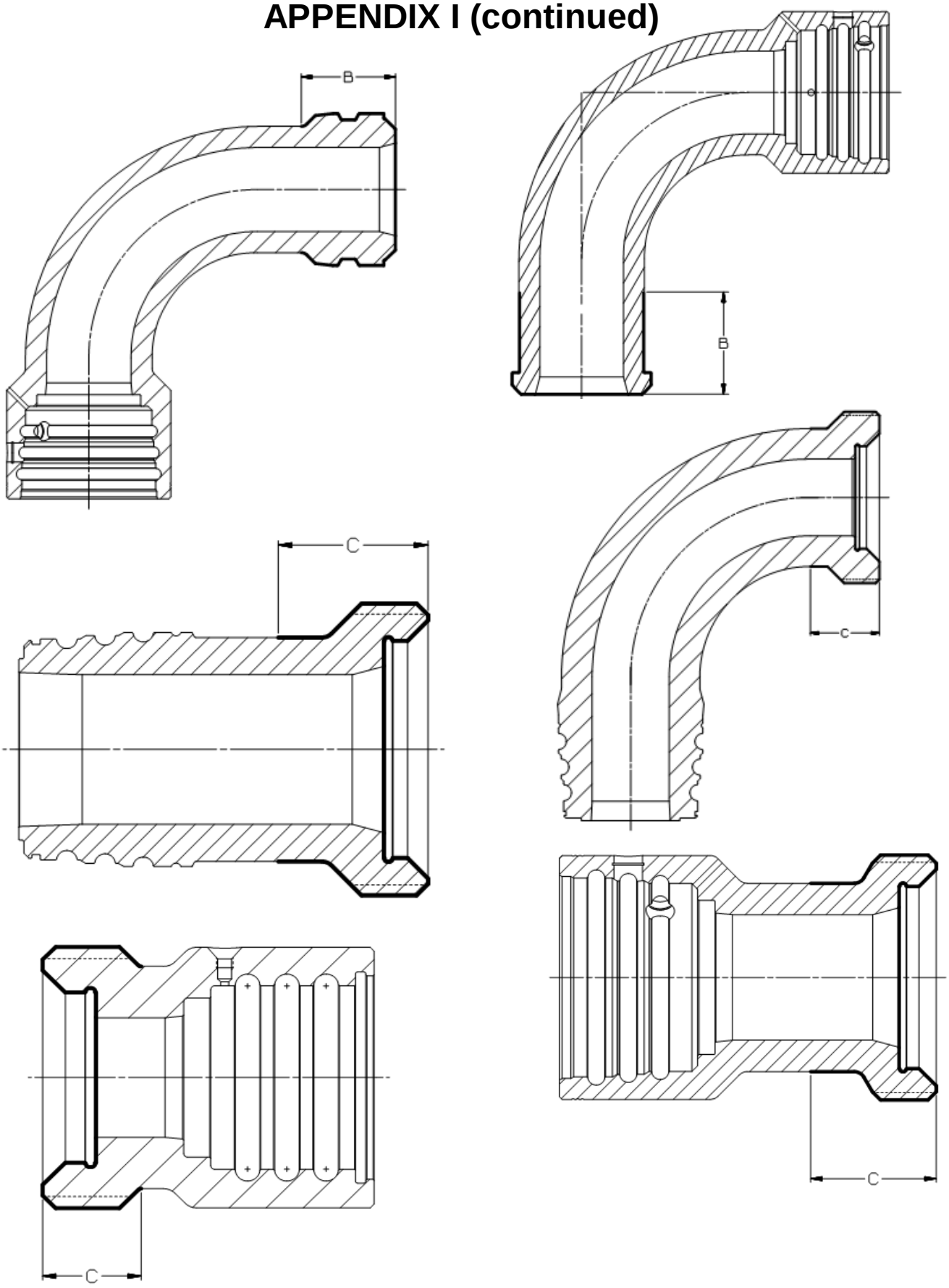




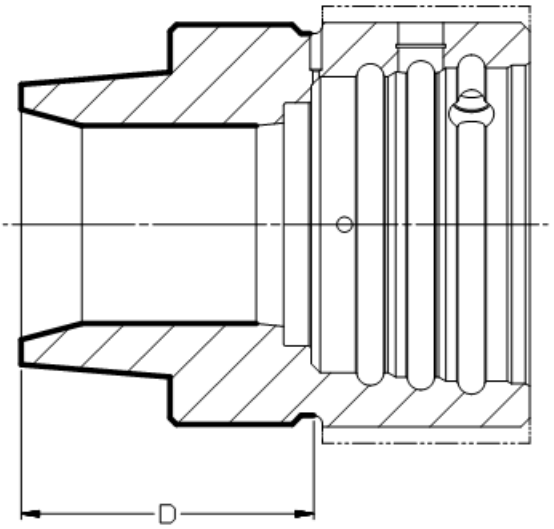


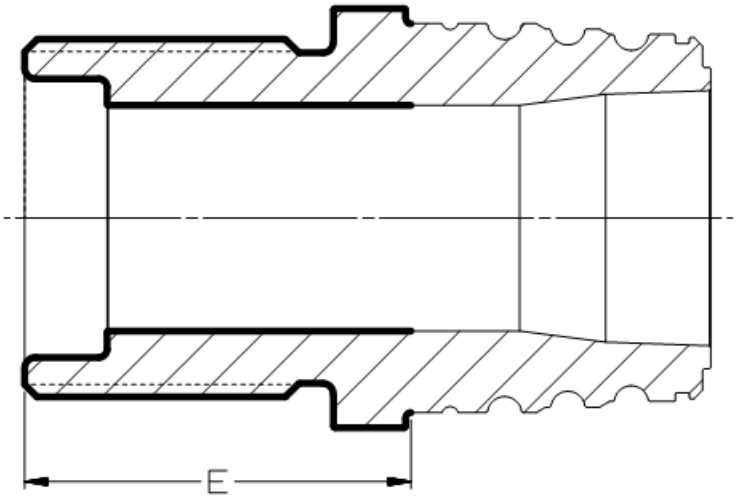


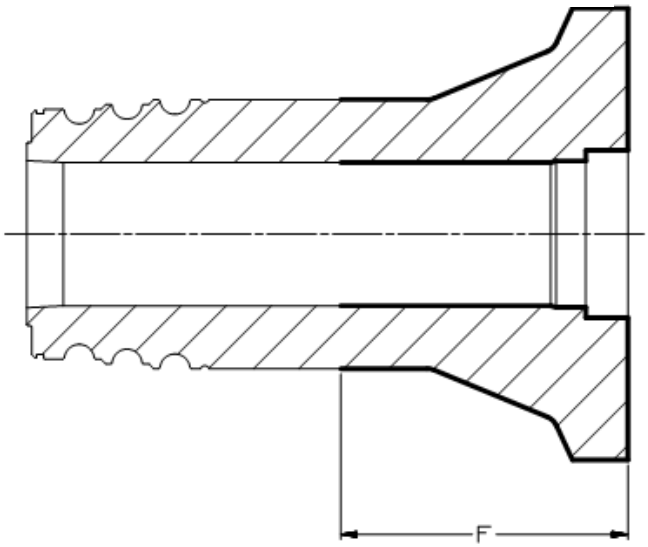
APPENDIX I (continued)

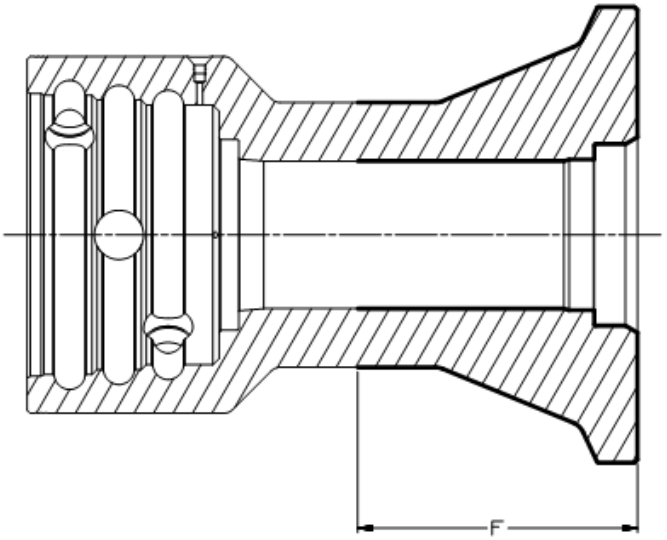


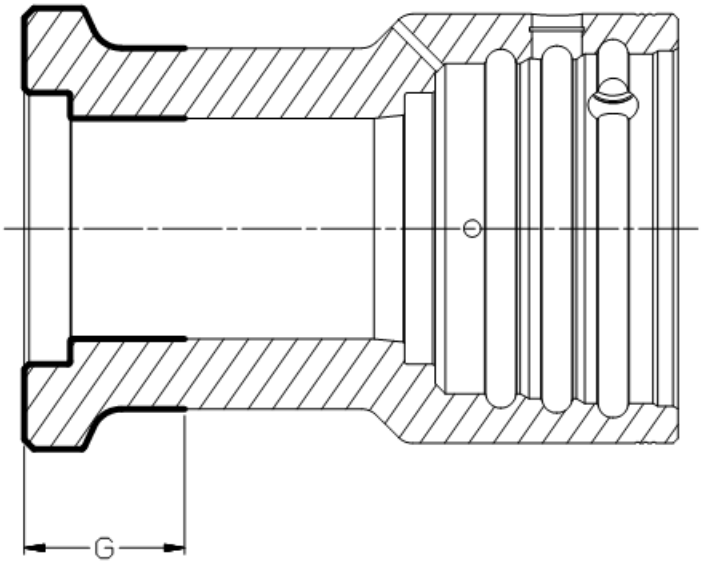
APPENDIX I (continued)

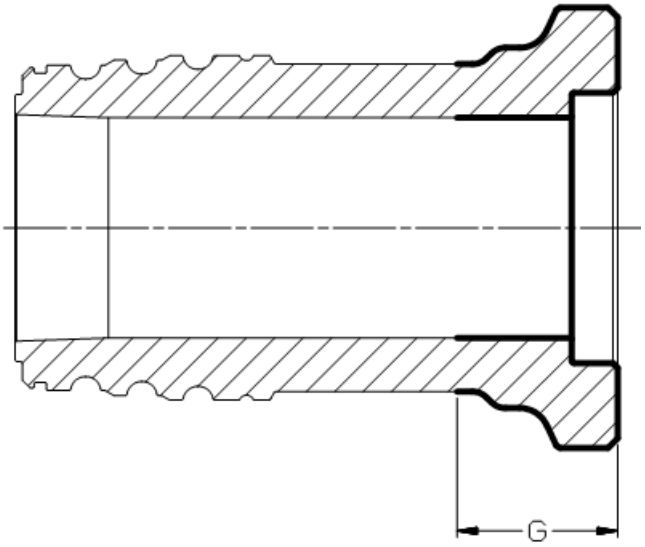


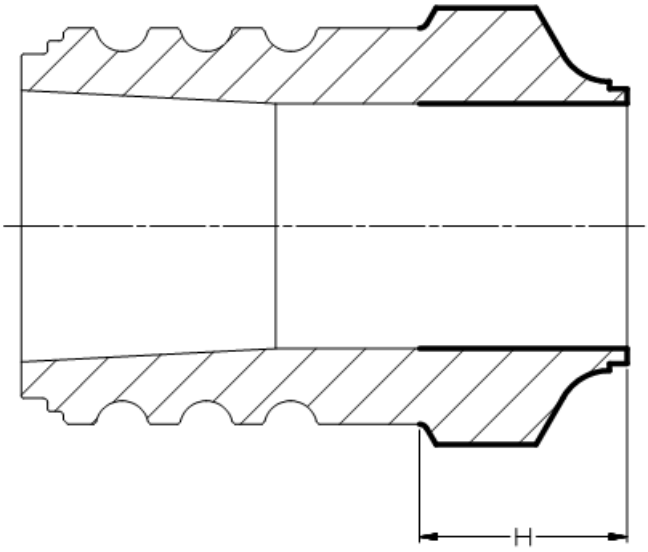


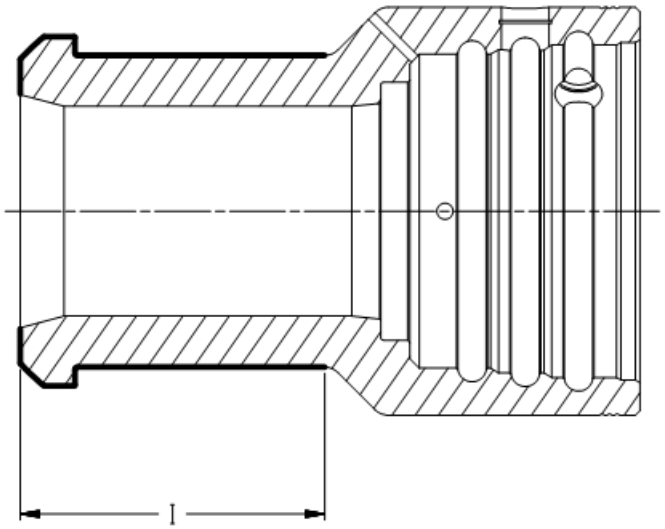


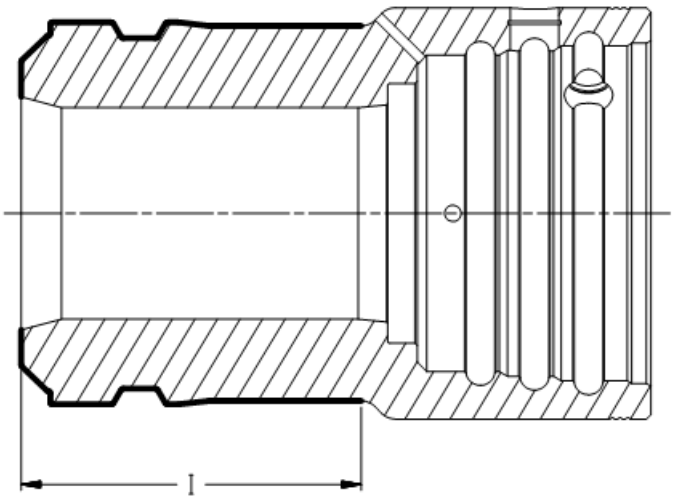


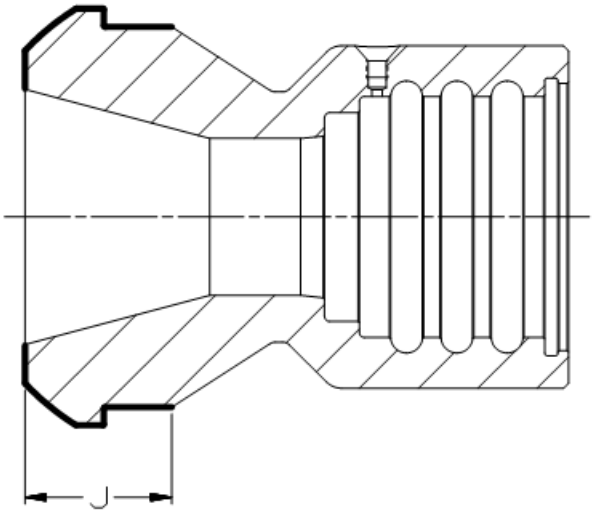


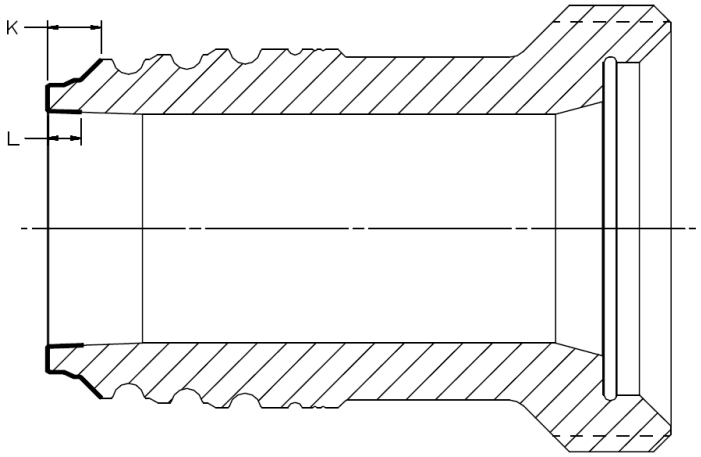


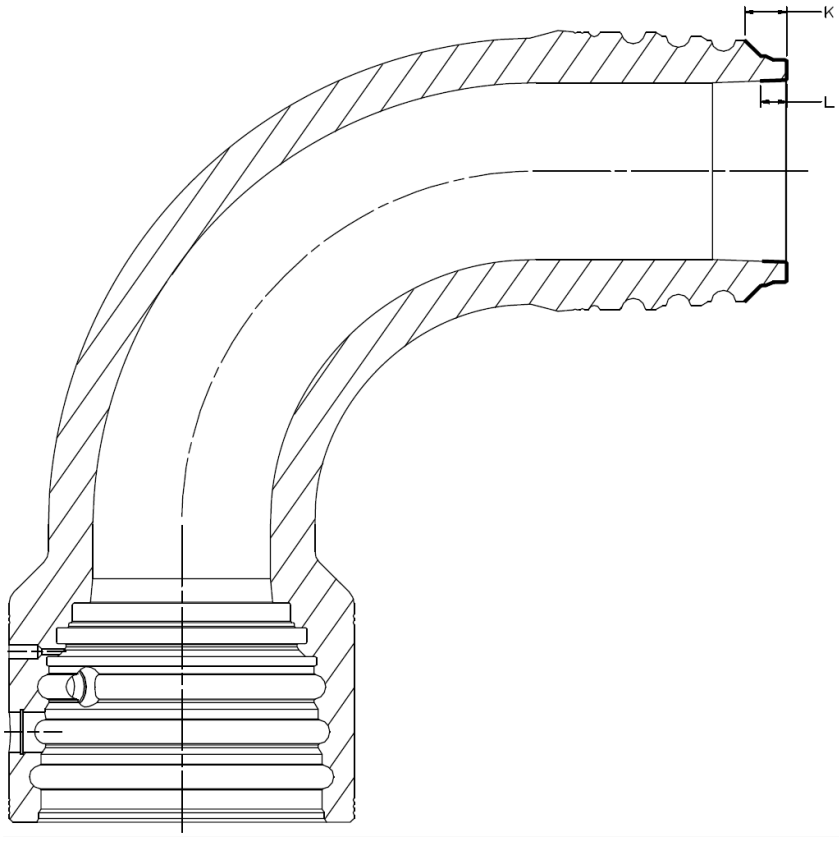

H


I


I

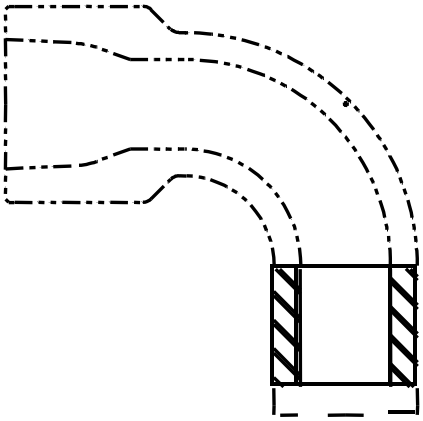

J


K
L

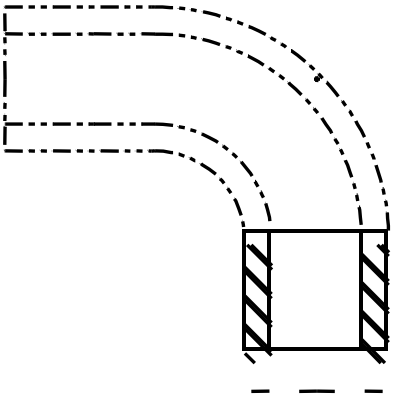

K
L

APPENDIX II

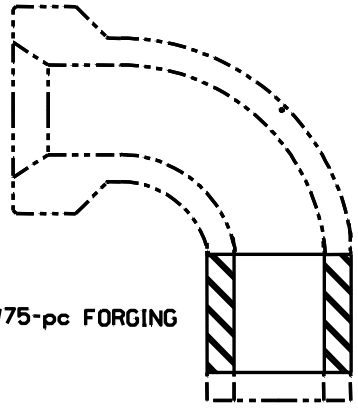
The figures below depict the approximate location for removal of tensile and charpy impact test specimens from TripleStep and Longsweep sacrificial forgings after heat treatment.



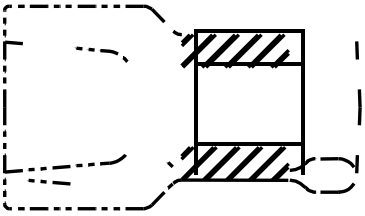
2-pc & 4-pc FORGING



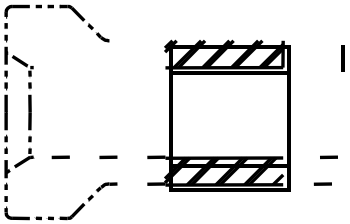
58 & 5-pc FORGING



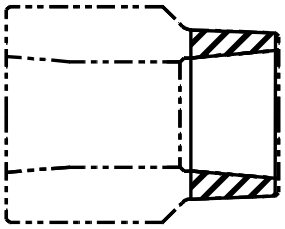
W75-pc FORGING



W6-pc FORGING



W73-pc FORGING



6-pc FORGING