

Document Title: Procedure for Manufacture of Hydro-Formed Tees (Cold Formed)

1.0 SCOPE

This procedure outlines the process to manufacture CS, AS and SS Hydro-Formed Tees (Cold Formed, 4" NPS to 12" NPS) from Seamless or Welded Pipe Lengths and ensure that all the manufactured fittings comply with stated requirements and are manufactured under controlled conditions.

2.0 POLICY

Hydro-Forming is a specialized type of die forming that uses a high-pressure hydraulic fluid (water) to press room temperature working material into a die. High pressure hydraulic pumps inject water at very high pressure inside the Pipe which causes it to expand until it matches the die.

3.0 METHOD

PRINCIPLE:

In hydro-Forming process, Tee is formed using a combination of internal pressure, axial punches and counter punch into a one-piece and robust fitting.

In the traditional process, forming precision and reliability are low. This Technology aims to ensure high precision, focused reliability and continuous repeatability and avoid / reduce any human errors.

It brings with it numerous benefits in terms of reduction of processing operations, time and total process costs.



Hydro Forming Machine

RAW MATERIALS (refer separate procedures for details):

Pipes are selected after Internal Inspections (Visual, Dimensions, Properties, etc) and cut to the required lengths (refer Machine Manufacturer's Manual for additional details), on Hacksaw or Plasma Cutting Machines. Starting Materials shall be free from burrs, cracks, nicks, gouges, waves, buckles, or other such surface defects that may impede the successful production of the fitting.

Pipes are preferably **Shot-Blasted** before any processing, to ensure it avoids friction with the Die.

Minor (acceptable) surface defects (if any) / fully ground weld seams; can be used as long as they are kept at the Top or Side positions, during manufacturing.

Heat Number punching (preferably low stress) is carried out on each cut length, to ensure traceability is maintained throughout the manufacturing process.

CRITICAL PARAMETERS:

- Formability of the material: it is necessary for the process to work properly and the fitting, does not break during the application of pressure;
- Friction at the interface: the friction between the die and the piece must be properly calibrated/lubricated;
- Machine parameters: these include times, pressures and movements of the axial cylinders that must be set correctly for the effective and efficient production of fittings.

ESSENTIAL VARIABLES:

- Pipe Wall Thickness – same as Fitting Wall Thickness (i.e. within 12.5% fitting tolerance)
- Forming Velocity – set by machine itself, based on 'Pressure of Pressurizing Media'
- Forming Temperature – Room/Ambient Temperature
- Pressurizing Media – Water



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- Approximate Pressure of Pressurizing Media (Pressure Gauge on Inlet – for 12” NPS [CS] 40 to 50 MPa and for 4” NPS [SS] 90 to 100 MPa; Final Pressures are decided by Machine Operator(s) based on Material, Hardness, Diameter & Thickness.

MANUFACTURING:

Job Card is received from the Production Engineer. This details the fittings to be manufactured.

The Hydro-Forming Machine is primed to start manufacturing.

Machine Operator to ensure proper Machine conditions are set (Essential Variables) to avoid Over Thinning, Wrinkles, etc.

The Pipe Cut lengths are loaded in the machine, after application of Lubricant (mixture of Graphite Powder [40%] & Oil [60%]) on its outer surface. At this point, the press is semi-closed and, through the side openings, water is inserted into the pipe to be formed. When the filling is completed (it will overflow from the top side) and the press is fully closed, the lateral cylinders move axially and pressurize the fluid which pushes the material to trace the shape of the die cavity.

The Limit Switches (at the back of the machine) are set to the desired Final Size. This is to ensure that the Axial Cylinders stop at the required height.

The Machine Operator ensures correct pressure at the Pressure Gauge, any further pressure will crack the pipe.

At the end of the process, or after the time necessary to obtain a constant and stable shape, the semi-finished fitting is released from the machine (after opening a valve for emptying all the fluid) at the push of a button. The Semi-Finished fitting is then extracted and directed, if necessary, to the subsequent processing phases.

SAFETY:

All required safety precautions shall be ensured (Safety Shoes, Safety Gloves, Safety Goggles, Safety Helmet, etc).

Specific care to be taken since the Water Pressure is High, especially during release of the die. Avoid standing directly in front OR back of the machine, you can stand at the sides.

SEMI-FINISHED INSPECTION:

The QC Engineer ensures that the first piece meets the Visual and Dimensional requirements of Semi-Finished products. He signs the Job Card (which is used for manufacturing details and clearance) as evidence of this inspection and manufacturing continues. More fittings may be inspected in case of large quantities at regular intervals, to ensure control on the process. Eventually the Job Card is signed off by the Machine Operator, after completion of all activities.

FINAL PROCESSES:

The semi-finished fittings are then forwarded to the Cutting / Machine Shop / Heat Treatment Section / NDT Section / Shot Blasting Section / Rust Preventive application Section / Paint Section, as applicable, for further processing.

Final Beveling operations are generally carried out as indicated (ASME B16.25 / ASME B 16.9), but strictly as per the stated Dimensional Standard.

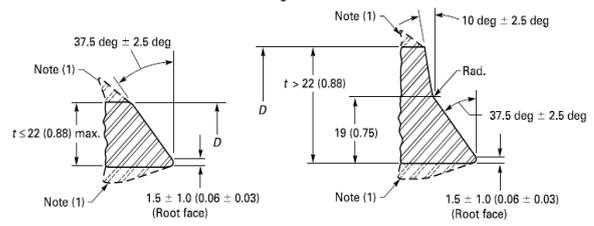
TESTING (refer separate procedures for details):

Samples are drawn from the finished product for Laboratory Testing (Chemical, Mechanical, Hardness, as applicable, as per stated Material Standard).

FINAL INSPECTION (refer separate procedures for details):

Final Visual and Dimensional Inspections shall be completed by Inspection Engineer after Final Machining and Finishing Operations, as per the Standard QAP. Tolerances shall be as per the stated Dimensional Standards.

Table 8-1 Welding Bevels and Root Face



Nominal Wall Thickness, t, mm (in.)	End Preparation
Less than x [Note (2)]	Cut square or slightly chamfer, at manufacturer's option (not illustrated)
x to 22 (0.88), inclusive [Note (2)]	Plain bevel as in illustration (a) above
More than 22 (0.88)	Compound bevel as in illustration (b) above

GENERAL NOTE: In the illustrations, dimensions in parentheses are in inches; other dimensions are in millimeters.
NOTES:
(1) See section 8 and Figure 8-1 for transition contours.
(2) x = 5 mm (0.19 in.) for carbon steel or ferritic alloy steel and 3 mm (0.12 in.) for austenitic steel or nonferrous alloys.



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4.0 PROCESS VALIDATION

Visual and Dimensional (including Ovality, Outside Diameter, Wall Thickness [using Ultrasonic Thickness Gauge], Inside Diameter, Off Angle, Off Plane, Length, Height, etc) Inspections have resulted in compliances with the Standards.

Material Testing (Chemical, Mechanical [Transverse / Longitudinal], Metallurgical, PMI for AS/SS, etc) have resulted in compliances with the Standards.

NDT to be ensured (Liquid Penetrant or Magnetic Particle [Wet Fluorescent Method] Examined) after Final Heat Treat, on the Side Wall Areas, as per relevant ASTM / ASME standards, to ensure ABSENSE of any hairline cracks (refer separate procedures for details). Acceptable tees shall be suitably identified (MPI OK) to indicate compliance.

Since the fittings have been Cold Formed, Heat Treatment (refer separate procedures for details) is MANDATORY to ensure acceptable metallurgy and hardness.

5.0 RESPONSIBILITY

This procedure is the responsibility of the Hydro-Forming Machine Operator and Production Engineer.

6.0 REFERENCES

Machine Manufacturer's Manual

Research Paper on Principles of Tee Joint Hydro-Forming Process by ResearchGate – June 2015

Research Paper on Simulation of Tube Hydroforming Process using an Internal State Variable Model by ICME MSU – April 2015

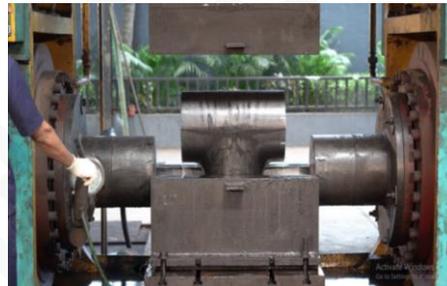
Research Paper on Hydro Formed Tees by Non-Linear Engineering – July 2018

Dimensional Standards – ASME, MSS SP

Material Standards – ASME, ASTM, IS, DIN, EN



Hydro-Forming Tee Manufacturing



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Hydro-Forming Tee Finished



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