Coulton Instrumentation

Data Sheet

SYSTEM FEATURES

* Manufactured from selected materials
* Special designs on application
* Customised process connections
* Low installed cost with assured quality

SCOPE

The Coulton Red7 Thermowells are designed to meet all possible industrial applications. They can be supplied as a complete measuring assembly with the following sensor types:
* RTD for high accuracy and stability
* Thermocouple for fast response and higher temperatures
* Bimetal and filled-system dial gauges for local indication

Head-mounted transmitters can be fitted to provide 4-20mA transmission with hazardous area certifications and HART communication protocol.

TESTING AND CERTIFICATION

Coulton Instrumentation's Red7 Thermowell range is manufactured and tested in the UK in accordance with the Customer's required standards. Given below is a list of standards which may be included in a quality plan:
- Manufacture to BS EN 10204 2.1 or equivalent
- Material certificate to BS EN 10204 3.1B(C) or equivalent standard
- Certification of bore concentricity
- Hydrostatic pressure test
- Dye penetrant test to BS 6443 and acceptance to BS 2633
- Magnetic particle Inspection to BS 6072
- Ultrasonic test of forgings/welds to ASME V article 23.SA388
- Charpy impact test to ASTM E23 or BS EN 10045
- Brinnell Hardness to ASTM E10 or BS EN 10003-2
- Rockwell Hardness to ASTM E18 or BS 891 with acceptence to NACE MR-01-75
- Intergranular corrosion testing to ASTM A262
- Welder qualification to BS EN 287 or ASME IX
- Weld procedures to BS EN 288 or ASME IX
- Polishing to BS 1449 with assessment to BS 1134

DESIGN

ASME Performance Test Code 19.3 is used by our engineers to design thermowells to the Customer's requirements. Equations in this code are used to perform the 'Murdock' wake frequency calculation. The dimensional detail in these drawings conforms to BS 2765 and BS EN 61152.

MATERIALS

Coulton Instrumentation manufactures the RED7 Thermowell in all commercially available materials including 316SS, 316LSS, 304SS, 310SS, 321SS, Aluminium, Alloy 400, Alloy 600, Alloy 800, Alloy 956, Bronze, Carbon Steel, Ceramic, Cr-Mo, Cu-Ni, Duplex SS, Super Duplex, Hastelloy B/C, Naval Brass, Tantalum, Titanium,.

Materials can be supplied with a certificate to BS EN 10204 3.1B (C) or equivalent. Chemical analysis, mechanical testing and positive material identification is available.

Ultrasonic testing for material defects is offered as standard on forgings. Ultrasonic testing and radiography of other materials is available on request.

Tantalum cladding and polymer coating of all wetted parts are offered for corrosion resistance. Steels with careful selection may be used up to 1100°C. Ceramic assemblies for higher temperatures are available.

RED7 THERMOWELLS

Thermowells and test wells remain in-situ during normal process operation and commissioning. They enable removal of a temperature element for inspection, calibration and replacement during continuous plant operation. Spot checks can also be made on the process temperature by inserting a portable measuring device into a test well without interruption or compromise of the integrity of a process.

Designed to protect resistance temperature detectors, thermocouples and dial indicators, many parameters must be considered in the specification of a thermowell. This data sheet aims to provide a guideline to these considerations and briefly introduce the types of thermowell most commonly used in industry.

CE Mark Approval

STRENGTH VS. MEASUREMENT

A thermowell provides mechanical protection for a temperature measuring device. The optimum design of thermowell allows precise measurement whilst ensuring plant safety. The main design issues are outlined below:

Ideal for Measurement	*Ideal for Strength*
Long Stem Thermometer sensing length is well immersed	**Short Stem** Higher natural frequency allowing higher flow rates
Thin Wall Reduced conductivity loss Faster response	**Thick Wall** Reduced stress Higher natural frequency
High Flowrate Increased heat transfer coefficient Faster response	**Low Flowrate** Lower trailing vortex frequency Lower impact force

SENSITIVITY

A 'lag' time exists between the change in temperature of the process and change in temperature of the sensing element. The system's lag time is affected by the heat capacity of the protecting material local to the sensor and the heat transfer coefficient of the air that surrounds the sensor.

A tapered or stepped reduction in diameter of the well will increase sensitivity. For small diameter probes a stepped bore can also be used, often in conjunction with a step in wall thickness. However, the wall thickness should not be less than 3mm.

THERMOWELL TIP

Four tip designs are available; chamfered, square, round and spherical. A spherical tip is used to optimise the flow profile when high flowrates and high process pressures are encountered. A spherical tip is the Coulton standard.

End thickness 'e' of the thermowell tip is very important in wake frequency calculations. An ultrasonic test gauge is used to measure the end thickness. An X-ray may be taken to check specifically for defects caused during forging.

FLANGES & FITTINGS

Thermowells can be supplied with flanges and fittings manufactured in accordance with ANSI, BS, DIN and JIS standards. Other standards are available upon request.

For thermowells manufactured in exotic materials a stub flange can be welded to the stem to locate a low cost retaining flange.

For test wells a blanking plug and securing chain are fitted.

The Coulton standard instrument connection is $^1/_2$ NPT. Other threads are available from 3 to 40 mm in accordance with the following standards:

Thread	Standard
NPT	ANSI B1.20.1
API	6A
BSPT	BS21
BSP	BS 2779
PG	DIN 40430
METRIC	BS 3643 (1.5mm pitch)

BORE

Thermowells are gun-drilled to suit the sensor stem. The air gap between the wall and probe is kept small to optimise sensitivity. For the industry standard 6mm sensor stem the bore will be 6.2mm unless otherwise specified.

ASME performance test code 19.3 may require that the bore and hence the wall thickness at the supporting end (P1) be increased in high flowrate applications. This increases the resonant frequency of the thermowell.

The bore and stem diameters can be stepped down to ensure minimum wall thickness and air gap over the last 75mm. This will help optimise sensitivity and response time.

HYGIENIC SERVICE

By careful selection of grit size when polishing, Coulton Instrumentation can achieve a mirror finish with an absolute roughness R_A of 0.2 µm. When polishing has not been specified, a good machined finish will be applied.

Thermowells supplied for hygienic service are polished in accordance with British Standard BS1449 / part 2 and are assessed to BS 1134.

WELDING

The weakest point of a thermowell is perceived to be the weld between the flange and stem. This may be a fillet weld for normal applications or a full penetration weld in a heavy duty application.

Coulton will normally make a full penetration weld in accordance with procedures laid down by BS EN 288 and ASME IX. Personnel welding to these procedures are qualified to BS EN 287 and ASME IX. All procedures and certificates are available upon request for approval.

WAKE FREQUENCY

Coulton Instrumentation prepares a wake frequency calculation for each thermowell to ensure that it meets the guidelines set down by the ASME performance test code 19.3. Where necessary, one or more of the following modifications are made:

- Stem shortened
- Wall thickness increased at the supporting end
- Bore increased
- End thickness reduced
- Mechanical support collar fitted

The diameter of any support collar is equal to the bore of the thermowell standpipe. Fitting a collar reduces the unsupported length of thermowell that is immersed and free to vibrate. This collar is normally machined with the stem from a single piece of solid barstock: Three flats are milled on the circumference of the collar to aid installation.

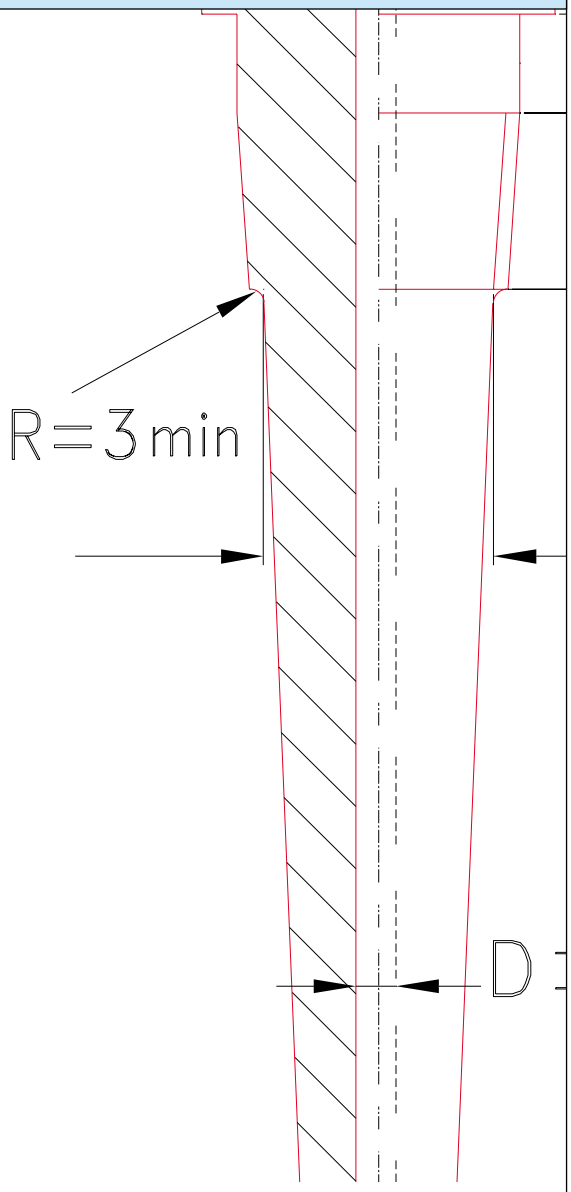
CONCENTRICITY

Concentricity is important to ensure uniformity of measurement and distribution of stress in high flow applications.

A certificate can be provided upon request giving concentricity measurements based upon radiographic or ultrasonic readings.

Radiographic examination will ensure concentricity of the bore to within ±10% of wall thickness. Ultrasonic testing of the wall thickness at any point can measure concentricity to within ±0.2mm.

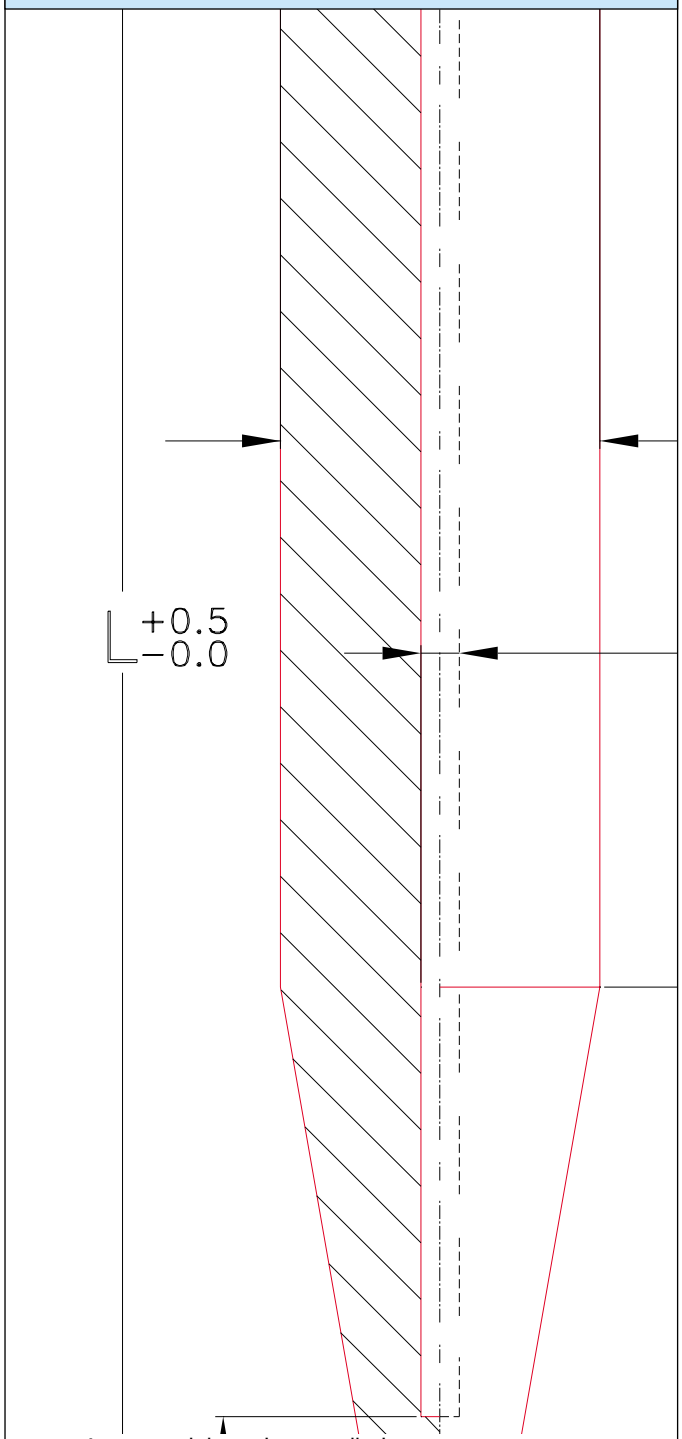
SCREWED CONNECTION



- General purpose. All fluids and flowrates
- Low to medium pressure
- Immersion length ‘U’ 30 to 1500 mm
- Turned from hexagon barstock or round bar with 2 milled flats
- Process connection $^{3}/_{8}$ to $1^{1}/_{2}$ NPT, BSP or BSPT male, M16 to M40
- A flange may be tapped and seal welded to the screwed thermowell stem for integrity at higher pressures without compromise to strength
- Commonly stainless steel stem and carbon steel retaining flange are used for economy

Example shown with spherical tip and flat bottom bore

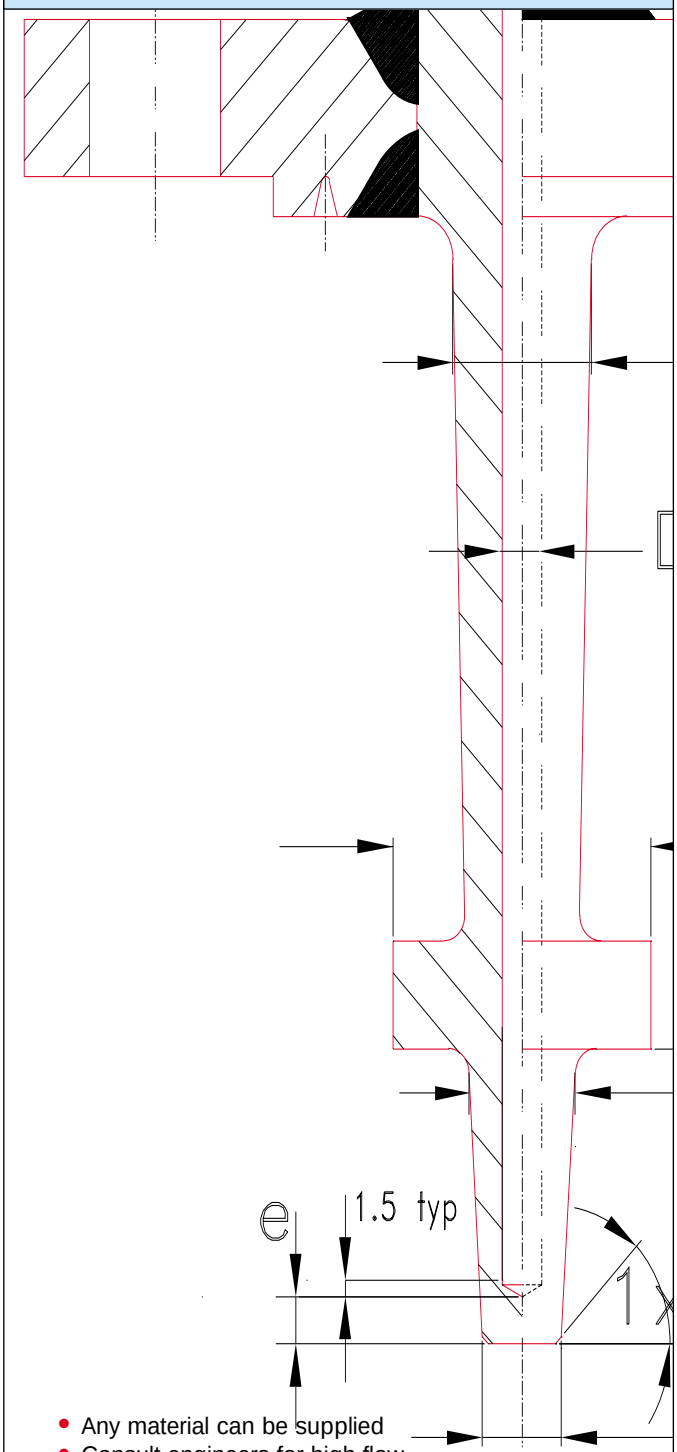
WELD - IN



- Any material can be supplied
- Machined from barstock or single-piece forging
- Commonly used on boilers and in hygienic service
- Any instrument connection threaded male or female
- Length ‘L’ 75 to 1000 mm

Example shown to DIN 43763

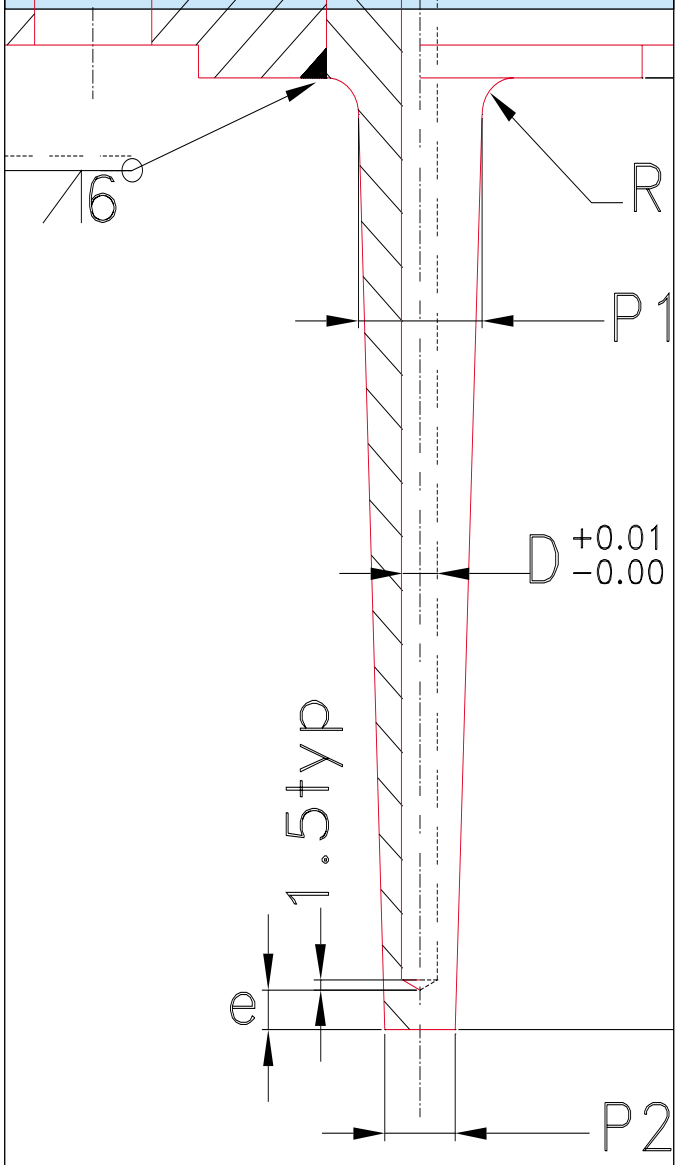
FLANGED WITH FULL WELD PENETRATION



- Any material can be supplied
- Consult engineers for high flow
- Immersion length ‘U’ 100 mm to 1500 mm
- Post-weld heat treatment recommended for sour gas service to NACE MR-01-75

Example shown with high velocity collar, RTJ flange and chamfered tip

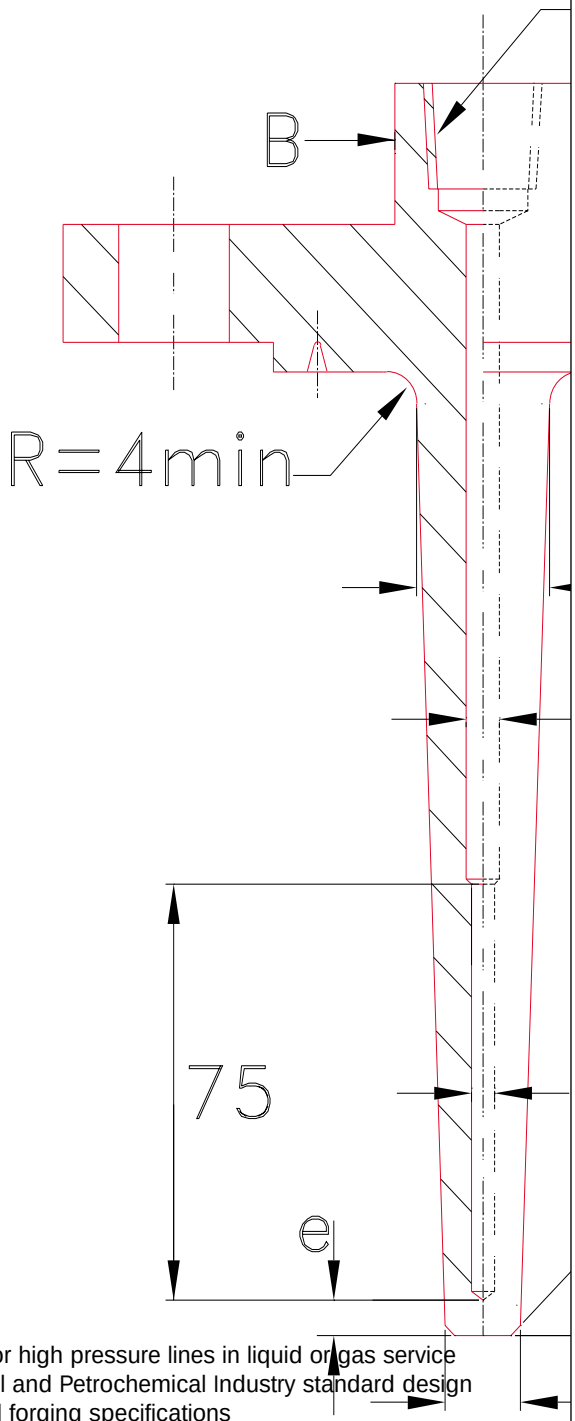
FLANGED WITH SEAL FILLET WELD



- Industrial standard on general process applications
- Low to medium pressure
- Stem turned from round bar
- Immersion length ‘U’ 100 mm to 1500 mm
- All materials including Carbon Steel flange and Stainless Steel stem for economy

Example shown with square tip and ‘V’ bottom bore

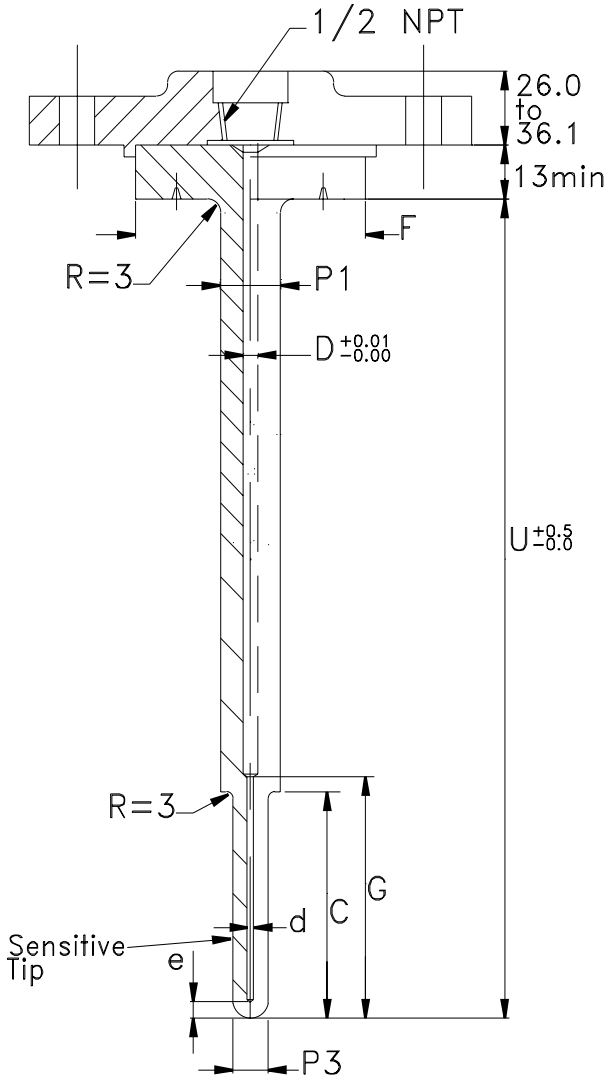
FLANGED FROM SINGLE PIECE FORGING



- For high pressure lines in liquid or gas service
- Oil and Petrochemical Industry standard design
- All forging specifications
- Consult engineers for high flow
- Immersion length 'U', 100 mm to 1500 mm

Example shown with reduced bore diameter, 'd'

FORGED WITH A COVER FLANGE



- Economical design for strength
- All materials available for body
- Carbon Steel backing flange
- 'U' Length 100 mm to 750 mm
- Body turned from single-piece forging or barstock

Example shown with sensitive tip and reduced bore

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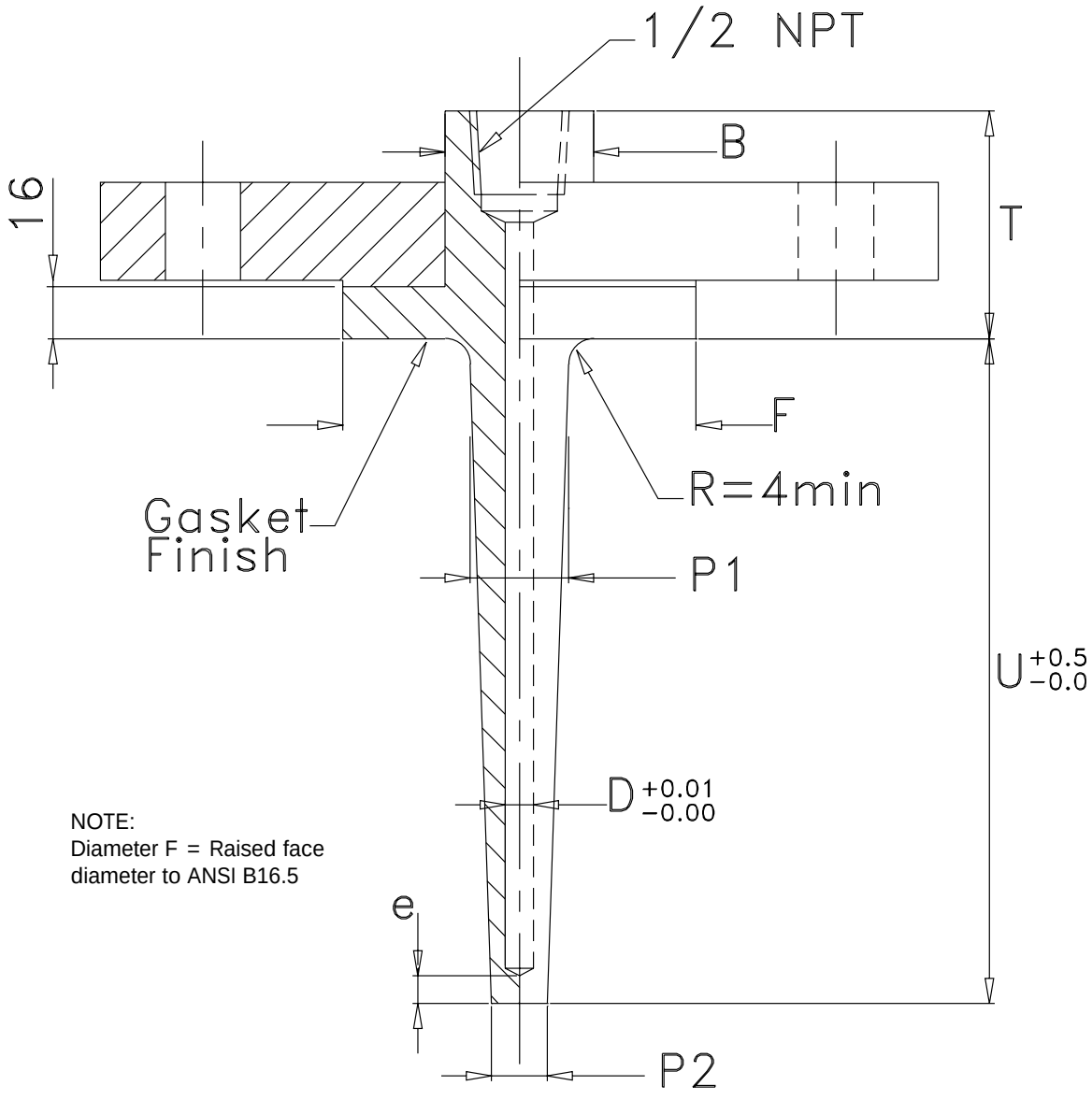
VAN STONE BACKING FLANGE ARRANGEMENT

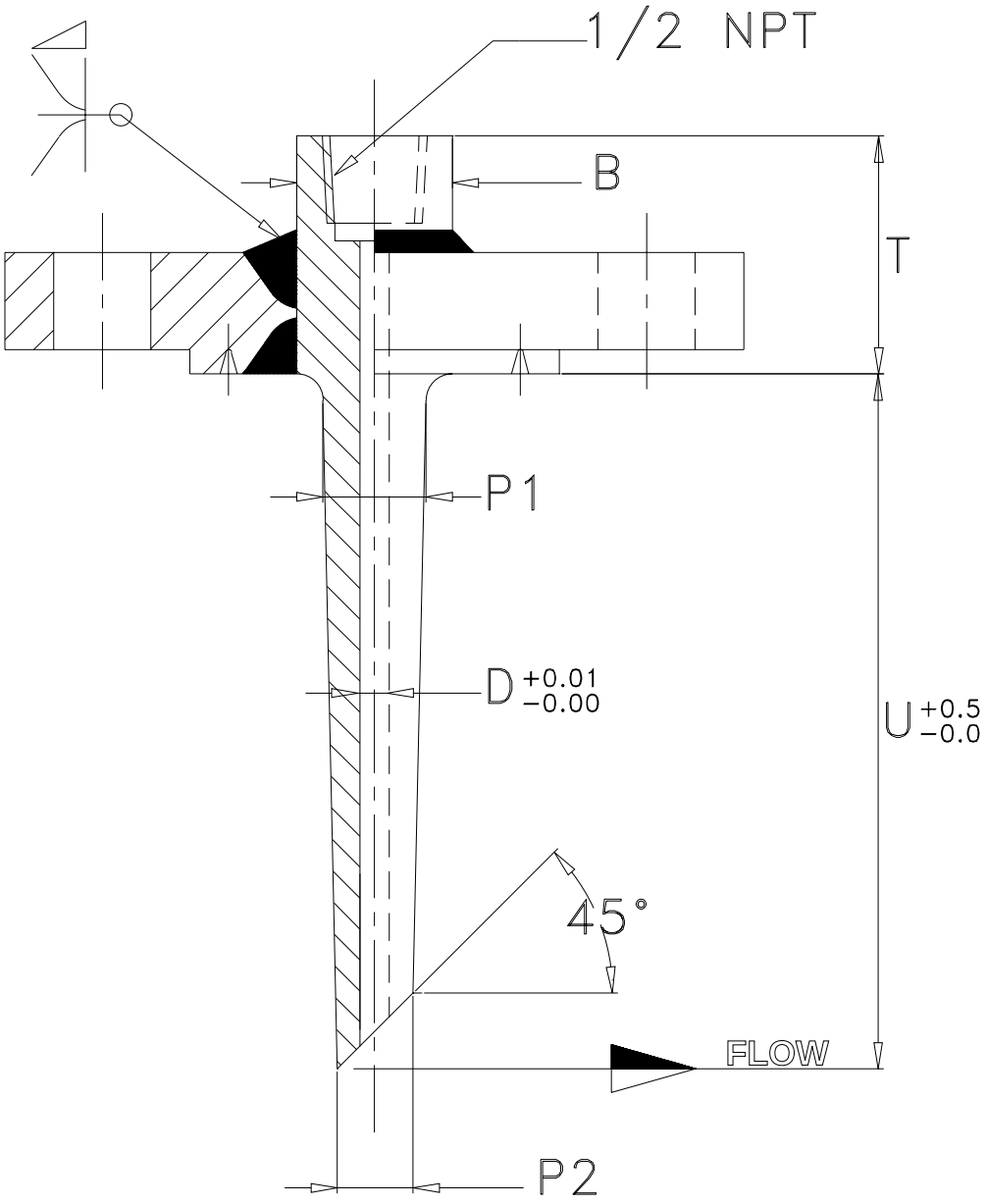


NOTE:
Diameter F = Raised face diameter to ANSI B16.5

- High pressure lines in liquid or gas service
- Oil and Petrochemical Industry standard design
- Body machined from single-piece forging or round bar
- Assembled with slip-on or blind backing flange bored to suit boss diameter ‘B’
- Economical means of making all wetted parts from one-piece construction
- Immersion length ‘U’ 100mm to 1500mm

Example shown with raised face blind backing flange

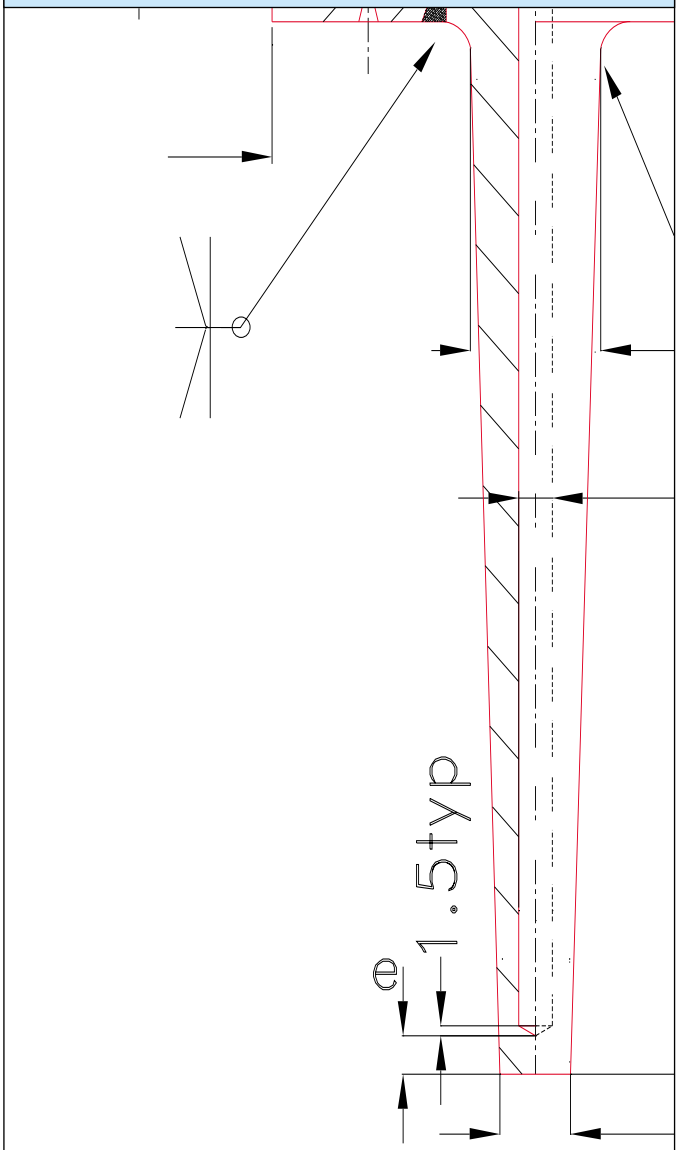
CHEMICAL DOSING QUILL



- Designed and manufactured in the same way as a thermowell
- Quills are supplied with a flow indication plate for precise installation

Example shown with full weld penetration

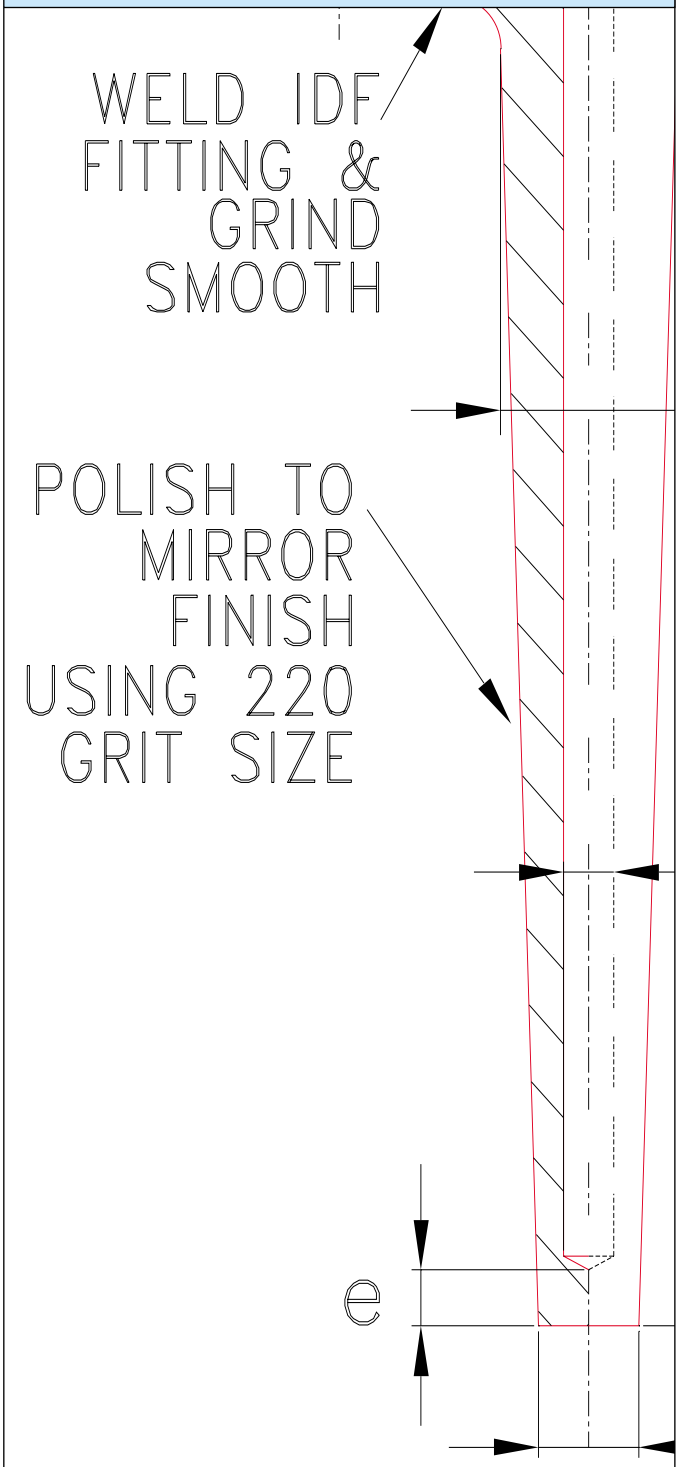
WELDED WITH A COVER FLANGE



- Full weld penetration - dye penetrant tested
- All materials available for stem
- Carbon Steel backing flange
- Economical design for strength
- Immersion length ‘U’ 100 mm to 750 mm
- Post weld heat treatment recommended for sour gas service to NACE MR-01-75

Example shown with tapered stem

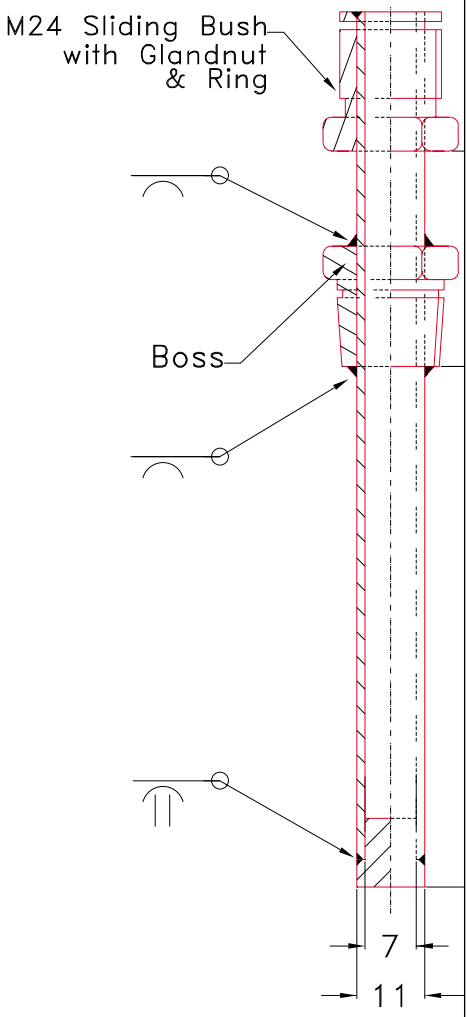
HYGIENIC SERVICE



- Turned from 316 stainless steel bar
- Wetted parts polished to mirror finish
- Process connection IDF or triclamp fitting
- Immersion length ‘U’ 30mm to 1500mm

Example shown with triclamp blank fitting

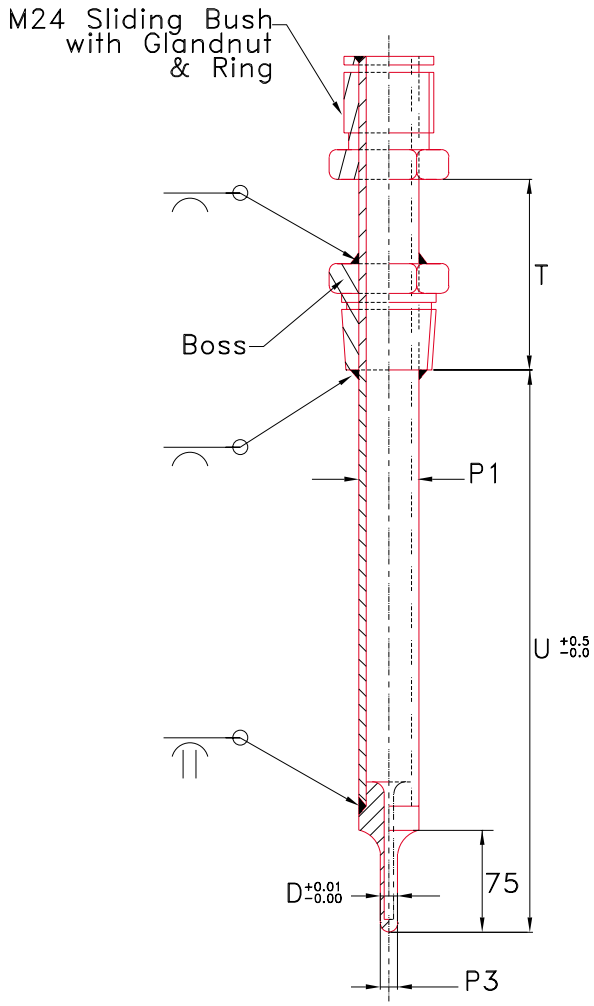
THERMOPOCKET



- Any size of connection can be provided
- 316 stainless steel as standard
- Lowest cost of protection
- Fabricated from seamless tube and threaded boss
- Circulation holes can be drilled to increase sensitivity e.g. Air duct assembly
- Adjustable coupling to vary immersion length
- Immersion length 'U' 30 to 750mm
- Low pressure and low flow applications only

Example shown with welded end plug and boss

THERMOPOCKET WITH QUICK-RESPONSE TIP



- Any size of connection can be provided
- 316 stainless steel as standard
- Low cost protection
- Low to medium flow and pressure
- Suitable for tank temperature measurement
- Consult our engineers for agitated vessels
- Adjustable coupling to vary immersion length
- Immersion length 'U' 100 to 6000 mm
- Fabricated from thick-wall nominal bore pipe and solid-drilled sensitive tip

Example shown for single-point tank measurement

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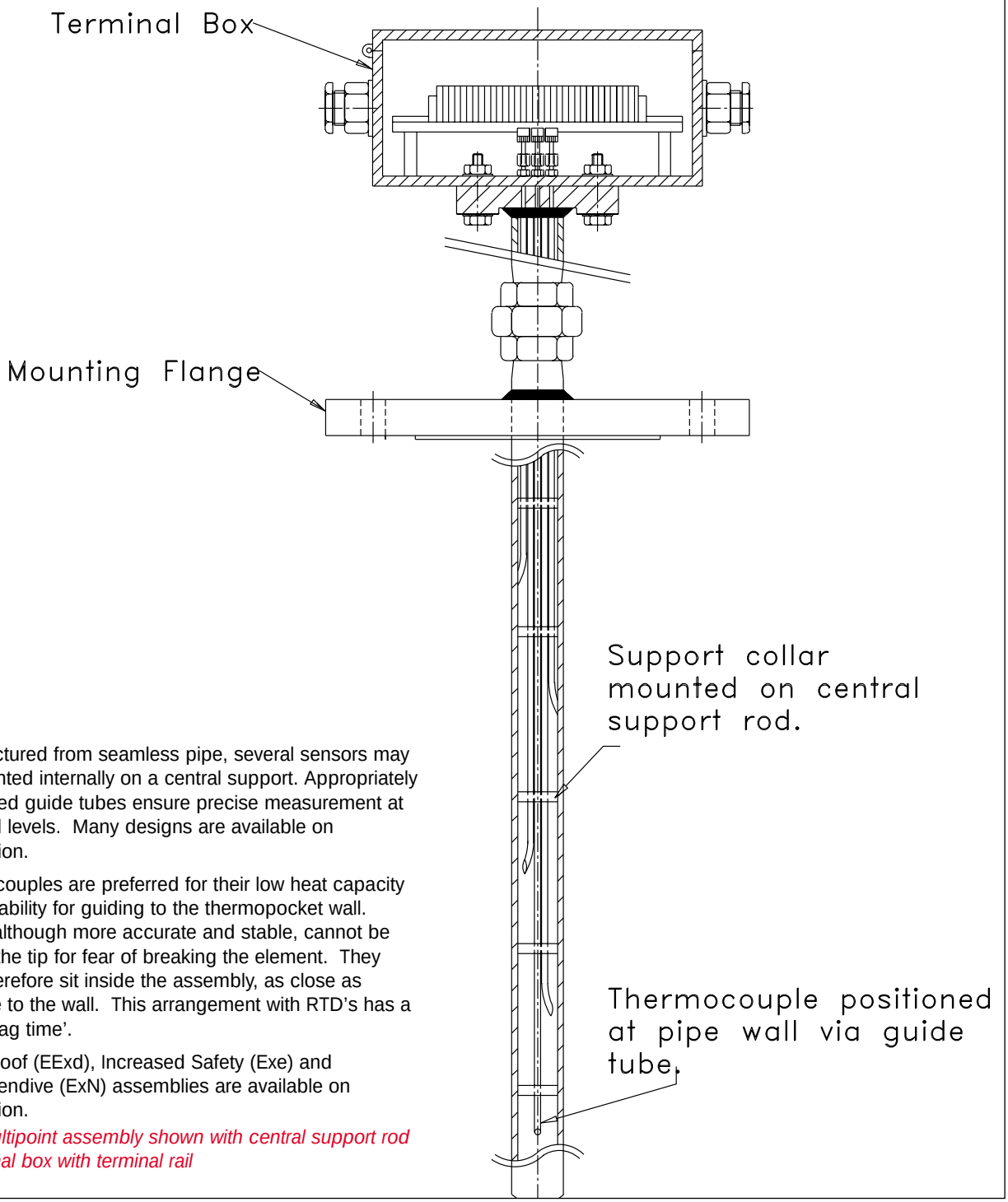
MULTIPOINT



- Manufactured from seamless pipe, several sensors may be mounted internally on a central support. Appropriately positioned guide tubes ensure precise measurement at selected levels. Many designs are available on application.
- Thermocouples are preferred for their low heat capacity and suitability for guiding to the thermopocket wall. RTD's, although more accurate and stable, cannot be bent at the tip for fear of breaking the element. They must therefore sit inside the assembly, as close as possible to the wall. This arrangement with RTD's has a longer 'lag time'.
- Flameproof (EExd), Increased Safety (Exe) and Non-Incendive (ExN) assemblies are available on application.

5-point Multipoint assembly shown with central support rod and terminal box with terminal rail

SPECIAL APPLICATIONS

Radiation Shield
Radiated heat can cause substantial errors, therefore shielding is recommended for some applications. When required, we will weld a radiation shield to the stem. This will be made from layers of the same material as the thermowell.

Ceramic Assemblies
Supplied with a single or double layer ceramic tube with external steel support tube.

Hydrogen Service
The bore of the thermowell can be pressurised with inert gas to reduce degradation of the insulation of the sensor.

Skin Temperature Measurement
Skin temperature measurement of process pipes, heat exchanger fins, motor casings etc. can be made by welding or clamping a heat sensitive pad to the surface. The associated transmitter head or local indicator is usually mounted nearby.

Intrinsically Safe Applications
The thermowell assembly can be supplied complete with a head-mounted intrinsically safe loop-powered transmitter. This transmitter can be traditional 4-20 mA or digital with HART communication. Certification is normally supplied to Cenelec EExia or United States FM requirements. Others are available.

Flameproof Assemblies
The Red7 thermowell assembly can be supplied complete with a flameproof (explosionproof) connection head and thermocouple/RTD sensor. Multipoint assemblies are also available with a flameproof terminal box and glands. Certificates to Cenelec EExd or United States FM requirements are available and others on request.

DIMENSIONS

Stem Tapers, P1 & P2
A tapered thermowell stem offers over a straight stem, improved flow characteristics and increased measuring sensitivity. It is available at no extra charge over that for a straight stem. Standard tapers to suit a 6mm diameter sensor are shown in the table below:

Flange Size	Thread Size	P1	P2
3/4″ or DN20	1/2″ or DN15	16	12
1″ or DN25	3/4″ or DN20	20	16
1 1/2″ or DN40 +	1″ or DN25 +	25	20

Preferred Across Flats Dimension, K
Lengths across the flats of the hexagon of a screwed thermowell for various process connections are detailed below.

Process Connection	Top Connection					
	BSP		BSPT		NPT	
	1/2″	3/4″	1/2″	3/4″	1/2″	3/4″
3/4″ BSP	33	33	33	33	33	33
1″ BSP	41	41	41	41	41	41
3/4″ BSPT	28	33	28	33	28	38
1″ BSPT	38	38	38	38	38	38
M20	33	33	33	33	33	33
M24	41	41	41	41	41	41
3/4″ NPT	28	33	28	33	28	33
1″ NPT	38	38	38	38	38	38

Diameter of Bar, B
The diameter of bar from which the thermowell is originally turned depends upon the top or instrument connection.

Top Connection	Diameter, B
1/2″ or DN15	32mm
3/4″ or DN20	35mm

Extension Length (Flanged Thermowells), T
This dimension is to accommodate the top connection and the process flange. Normally a 'stand-off' will clear the pipe lagging. The thickness of the process flange must be taken into consideration. Typical lengths are given below:

Flange Size	Flange Rating	Extension Length, T
1/2″ to 6″ and DN15 to DN150	ANSI 150 & 300lb and up to PN25	50mm
8″ to 24″ and DN200 to DN600	ANSI 150 & 300lb and up to PN25	75mm
1/2″ to 1 1/2″ and DN15 to DN40	ANSI 600 to 2500lb and PN40 to PN160	75mm
2″ to 5″ and DN50 to DN125	ANSI 600 to 1500lb and PN40 to PN100	100mm
6″ to 10″ and DN50 to DN125	ANSI 600 to 1500lb and PN40 to PN100	150mm

Extension Length (Screwed Thermowells), T
This is a true lagging length dimensioned to clear the process pipe lagging. If a lagging length is not specified then length 'T' will be made equal to zero.

Preferred Immersion Length, U
On standard nominal bore pipes with a stand-off length 150mm, the following are preferred immersion lengths to ensure that the sensor lies within the middle 1/3 of the pipe diameter. It is advisable to standardise on thermowell immersion and stand-off lengths for uniformity and economy of spare parts for assemblies.

Pipe NB	U mm	Pipe NB	U mm	Pipe NB	U mm	Pipe NB	U mm	Pipe NB	U mm
25	165	100	225	250	300	450	450	750	600
40	175	125	225	300	300	500	450	800	600
50	175	150	250	350	375	600	525	900	700
80	200	200	275	400	375	700	525	1000	850

Minimum Length of Process Thread, L
Minimum length of thread by type and size is given below:

Thread	L mm	Thread	L mm	Thread	L mm
3/8″ BSP	19	M16	19	3/8″ NPT	16
1/2″ BSP	19	M20	19	1/2″ NPT	16
3/4″ BSP	19	M25	19	3/4″ NPT	16
1″ BSP	23	M32	23	1″ NPT	19
1 1/4″ BSP	25	M40	25	1 1/4″ NPT	20

End Thickness, e
Unless otherwise specified or determined by calculation, Coulton Instrumentation will make the end thickness (e) 4.5mm.

DETAILS REQUIRED

The following information is required to design the thermowell and manufacture the complete assembly. Blank sizing sheets are available on request. For assistance please contact our Christchurch Office.

Tag No	Name of Measurement

MATERIALS	
Materials specification (BS, ASTM...)	
Stem material	
Surface finish	
DIMENSIONS	
Bore diameters (D) and (d)	
Bore type, flat or 'V' shape	
Immersion length (U)	
Lagging length (T)	
End thickness (e)	
Stem diameters (P1, P2 and P3)	
Tip design	

PROCESS DETAILS	
Pipe size and schedule	
Maximum fluid velocity	
Maximum volumetric flowrate	
Line pressure	
Line temperature	
FOR SCREWED THERMOWELLS	
Connecting thread	
FOR FLANGED THERMOWELLS	
Flange material	
Flange size and standard	
Weld type/forging specification	

Signature	
Company	
Date	

Notes

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Represented by