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1. Basic Scope of Documents, Introduction

Rev.

This document defines the basic principles of Instrument hook up. It furnishes recommendations about the selection and design of process measurement systems. It covers the entire connection from the process piping to the instrument.
Each measurement technology has its own requirements for achieving suitable performance. Instrument systems are often a compromise between the installed performance and maintainability.
It shall be used as a guideline and deviations from this document may be required on a case-to-case basis. In case of deviations or special requirements which do not correspond with those mentioned below, please contact your line manager or the responsible competence centre.

1.1 Document History / Revision Index

Revision	Description of Change	Data
0	Initial Document	Dec. 2023
1	Several Improvements	April 2025

1.2 Abbreviations

Abbr.	Description
API	American Petroleum Institute
BAM	Bundesanstalt für Materialforschung
BC	Burckhardt Compression
CS	Carbon Steel
DIN	Deutsche Industrie Norm
GWR	Guided Wave Radar
I&C	Instrument & Control
ITP	Inspection and Test Plan
PE	Project Engineer
QA	Quality Auxiliaries
QE	Quality Electrical
RF	Raised Face
RTJ	Ring Type Joint
SS	Stainless Steel
WFC	Wake Frequency Calculation

Abbr.	Description
FT	Flow Transmitter
LI	Level Indication
LT	Level Transmitter
PDG	Pressure Differential Gauge
PG	Pressure Gauge
PDT	Pressure Differential Transmitter
PT	Pressure Transmitter
TW	Thermowell

2. Understanding Instrument Hook-up

Rev.

Instrument hook-up refers to the process of connecting various instruments or devices to a control system or process piping system to facilitate data acquisition, monitoring, and control of a particular process. The instruments can be located directly on the equipment (piping or machine) or on an instrument board.

2.1 Importance of Process Fluid and Type of Hook-up

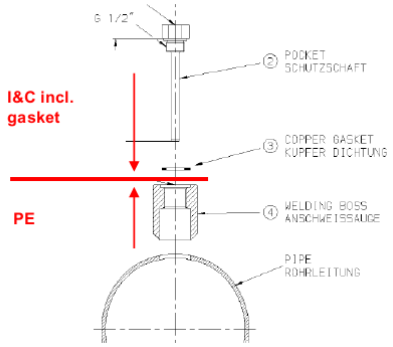
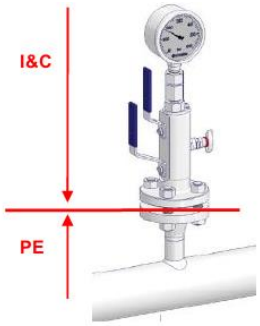
Rev.

The instrument hook-up depends on the process parameter and fluid. Type and design are defined based on these parameters and project requirements which can be very different.

2.2 Breaking point between Process Piping and Instrumentation

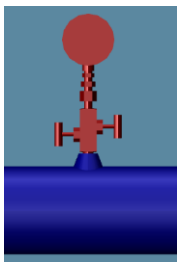
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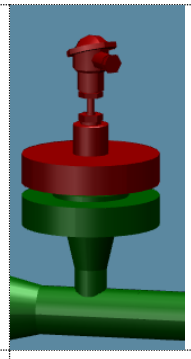
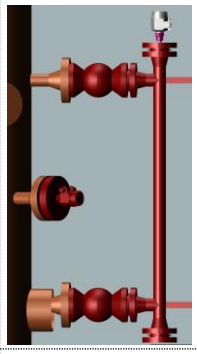
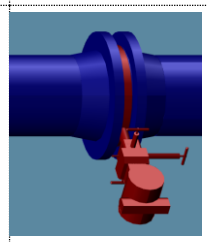
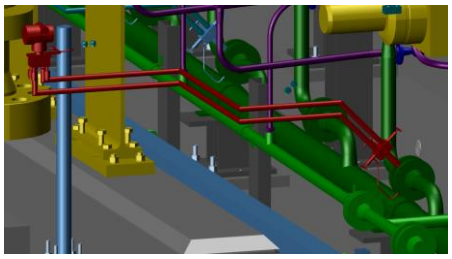
The breaking point between the process piping and instrumentation is defined in ABL_2091297. The breaking point - as red line in below graphics - defines the responsibility split between functions (I&C or PE) in terms of equipment specification and purchasing. In general, the same function is responsible for specification and purchasing.

Temperature Instrument	Pressure Gauge
	

2.3 Starting Point, Content of Instrument Hook-up

Rev.

	Direct mounting	Remote mounting	Content
Pressure			Piping Root Valve Fitting Tubing Manifold Instrument Support

Temperature			Piping Thermowell Instrument
Level (GWR)			Separator, Tank Ball Valve Bypass Chamber Instrument
Level (DP)			Separator, Tank Instrument
Flow (DP)			Piping Orifice Fitting Tubing Manifold Instrument

2.4 Exclusions and Exceptions

- Instruments on Compressor
  -> see "Definition Instrumentation on Compressor", TDO_2044699
- Instruments on Main Drive
- Instruments on HydroCom®
- Instruments on Filter Units

Rev.

3. Incidents and Problems

3.1 Vibration of Heavy Type of Isolations Valves and Heavy Thermowells

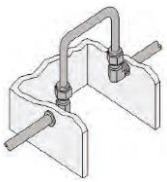
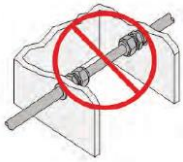
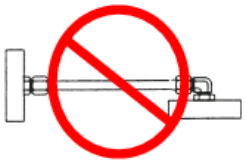
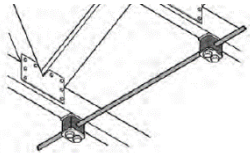
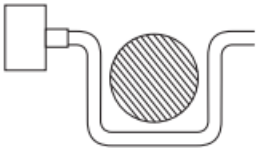
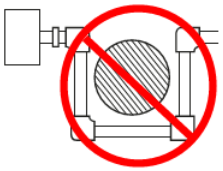


Rev.

On reciprocating compressors vibration on the gas piping cannot be prevented due to the natural behavior of these machines caused through the gas pulsations and oscillating movements. The weight and shape of the instrument hook-ups have a big impact on the vibration levels and therefore on vibration related issues.
Field experience has shown cracks on the welded connection of the flange to the isolating valves or thermowell, especially on smaller process piping, socket weld flanges or on connections with heavy cold insulation.
→ see "Hook-up design guideline" TDO_2036959

3.2 Wrong Layout of Instrument Tubing

Rev.

		Prevent stress, allow expansion. U-bend allows expansion.
		Prevent stress, allow expansion.
		Proper support limits the effects of vibration.
		Tubing shouldn't be used as handrail or footrest.
		Reduce the number of fittings.

		Prevent syphons. Otherwise, for fluid is a drain plug required.

3.3 High Cost of Instrument Hook-up

Rev.

- Remote Hook-up with long tubing lines is getting expensive.
- Special material like Duplex, Super Duplex, Incoloy, Monel, Hastelloy, Tantalum or Titanium can be very costly.
- Quality requirements
- Manifolds, e.g., 3 or 5-way block valves, can be very costly! Up to 15 times more expensive as a "normal" manifold.
- For flow, pipe diameter >12"
- High Pressure

4. Processes and Applications

Rev.

Depending on the process and application, the design of hook up might look different. Hook-up in a toxic process have different requirements as hook-up for an auxiliary system. Therefore design, material and sealing selection vary for different processes and application. For process gas mainly flanged hook-up will apply. In auxiliary system like water- and oil system also screwed hook-up can apply.

4.1 Non – Toxic and Non – Explosive Gases

Rev.

Typical applications are:

- N2 Nitrogen
- Air
- CO2

4.2 Toxic and Explosive Gases

Rev.

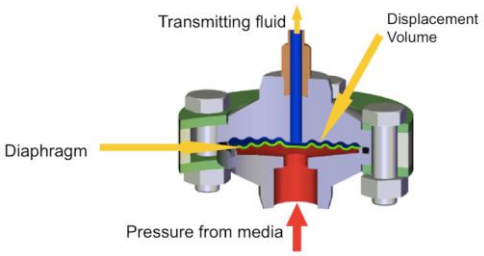
Typical applications are:

- H2S Hydrogen Sulfide in refinery process
- CO Carbon Monoxide
- Cl Chlorine

In refining there are services where additional care is needed:

- Hydrogen Sulfide attack in wet services
- Chloride stress corrosion with stainless steels
- Acid attack
- Hydrogen Permeation

It is recommended that stainless steel not be used with chlorine, aliphatic amines and ammonium containing compounds. To avoid issues with chlorides, especially in near shore environments Inconel 825 (N08825) is being used as a replacement for stainless steel tubing and other piping components. When chloride or hydrogen sulphide concerns exist carbon steel bodies with Hastelloy measuring elements should be considered over stainless construction



Diaphragm seals, also known as chemical seals or remote seals, are used for pressure measurements when the process medium should not come into contact with the pressurised parts of the measuring instrument. A diaphragm seal has two primary tasks:

1. Separation of the measuring instrument from the process medium
2. Transfer of the pressure to the measuring instrument

4.3 Very Corrosive and Difficult Gases

Rev.

Typical applications are:

- O2 Risk of fire, subsequent combustion is more intense.
- H2 Very light and explosive gas.
- H2S Gas compositions with H2S content - Hydrogen sulfide is very dangerous.

4.4 Auxiliary Systems, e.g., Oil and Cooling Water

Rev.

Typical applications are:

- Oil system, cylinder lubrication system.
- Cooling water system.
- Plant and instrument air.

5. Mandatory Rules and Client`s Requirements

Rev.

Special attention shall be taken to the specific process, project requirements. Also, safety and health precautions must be considered.
Testing and venting of pressure instruments must be possible without dismantling.

5.1 Client`s Specification

Rev.

Client's specifications are sometimes very demanding and ask for very special design, type, and brand to be used. This may cause very high cost, especially for pressure instruments with special manifold valves and tubing, ref. section 3.3.

5.2 Piping Class for Process Piping and Auxiliary System

Rev.

The piping class for the relevant process and fluid must be considered. As mentioned in section 2.2 this is the breaking point between the piping (PE) and tubing for pressure instruments (I&C). The first isolating valves refer to the piping class except if threaded connections are used and accepted.

5.3 Process Requirements – Licensor

Rev.

In some specific applications, i.e., LDPE (low density polyethylene), PE/PP (ethylene and propylene recycle compressors) the Licensor requirements must be followed.
For special applications such as Oxygen, Cl, sour or wet H2S the Hook-up requirements may be different to the standard ones. Whenever possible deviations must be checked and agreed during the tender phase or later during project execution.

6. Hook-up Types, Measurements

Rev.

Hook-up basically shows typical installation of an instrument in a correct manner so that the instrument operates properly and prevent issues which could potentially affect the measurement such as liquid trap in gas impulse.

6.1 Pressure

Rev.

Pressure instrument hook-ups gives information about how pressure instrument (transmitter/gauge etc.) are installed/hooked up with the process.

Impulse tubing and fittings are commonly used for pressure Instruments however prefabricated hook-ups, piping hook-ups or hybrid hook-ups (tubing + piping) can be requested by client based on plant philosophy.

Pressure transmitters and **differential pressure transmitters** shall be mounted as close as possible to the sensing points.
Connections between instruments and process shall be as short as possible to provide a good representative measurement of the process condition under surveillance, considering required slopes of impulse tubing, and accessibility. It is expected that pressure taps shall not be made in turbulent zones (elbows, reducers...etc.). Except where required by process.

Joints shall be minimum whenever tubing hook-ups are being used. This is just to avoid the excessive leakage points.

Bellows, spiral bourdon tube and C-type bourdon tube are used as measuring elements for **pressure gauges** with the most common being the C-type gauge.

6.2 Temperature

Rev.

Temperature hook ups gives information about how the temperature instruments (temperature elements, gauges etc.) are installed/hooked up with the process.
Thermowells are used to protect the temperature elements and to allow their replacement during operation. Installing temperature elements in thermowells adds time lag and errors to the measurement. However, by using a spring-loaded fitting so the element firmly contacts the bottom of the thermowell the measurement lags and errors are reduced.

Thermowells vibrate as their natural frequency is approached. This causes them to eventually fracture and fail. Thermowells have been known to fail within minutes upon being subject to destructive vibration. ASME Performance Test Code PTC 19.3 TW provides information and calculation procedures for thermowells. It is a design standard for tapered, straight, stepped shank thermowells.

When possible, **temperature measurements** should be taken on liquid outlet lines.
Thermowell placement should be selected so that they do not conflict with vessel internals such as tray supports, agitator blades, weirs, etc.
Surface mounting sensors are also coming into account whenever thermowell installation is not possible.

6.3 Liquid Level

Rev.

Variety of instruments are available when it comes to level measurement. Level Instruments gives information about how level instruments (Switch, gauge, transmitters etc.) are installed/hooked up with the vessels/tanks/separators etc.

2inch Guided wave radar (GWR) can be used in a variety of services. GWR transmitters are Independent of most liquid properties, especially density and can tolerate a wide range of pressure and temperature conditions. They work well with boiling and turbulent liquids. Since the electronics are top mounted it can be used with open pits or sumps. Common probe configurations are the rigid rod, flexible simplex, twin lead and coaxial. Since they work well in most applications, rigid and flexible simplex probes are preferred.
This method is preferred by BC.

Non-contact radar level transmitter can be used for water tanks. The electronic is top mounted. Installation is easy as the Instrument is very compact. A

Diaphragm seals measurement can be used for liquid measurement. **3-inch** seals are usually connected to the side of a vessel or tank. The measure principle is differential pressure.
Open tanks or vessels are with one connection to the side of a vessel or tank on the lowest (0%) point.
Pressurized tanks or vessels are with two connections to the side of a vessel or tank on the lowest (0%) and highest (100%) point.

Diaphragm seals can be also used when the instrument should be isolated from the process. They are best suited for pressure and level measurements. They are often used in the following applications:

- Slurry or polymerizing services
- Toxic fluids
- Fluids at extreme pressure
- Corrosive Fluids

A bleed ring that has dual flushing connections equipped with valves should be provided to enable calibration and decontamination for maintenance. Diaphragm seals should be installed to permit instrument calibration and process tap cleaning without process liquid release or removing the seal.

Magnetic level gauge installation is the same as for glass level gauges and displacers. They should be easily readable and accessible along their entire length for maintenance. Bottom clearance should be provided for float replacement.

Level Switches can be used if transmitter is not possible to install. (e.g. Crankcase oil level measurement)

6.4 Flow Measurement

Rev.

Flow instrument hook-ups gives information about how instrument is installed on process.

Differential pressure type flow transmitter is used for simple applications like cooling water return flow or leak gas measurement.
The installation of differential pressure flow devices is generally the same regardless of the type of primary element.
Meter run type Orifice assembly preferred for smaller line size as upstream and downstream lengths are taken care in unit itself.
Inlet Distance: ≥2x Pipe Dia. Note 1.)
Outlet Distance: ≥2x Pipe Dia. Note 1.)

A

Direction Liquid:	▲	X	►	X	▼		◄	X
Direction Gas:	▲	X	►	X	▼	X	◄	X

A **magnetic** flow meter measures the volumetric flow of liquids that are electrical conductivity.
A magnetic flow meter consists of two parts; a primary element, installed directly in the process line and a secondary element, the electronic transmitter.
Inlet Distance: ≥5x Pipe Dia. Note 1.)
Outlet Distance: ≥2x Pipe Dia. Note 1.)

A

Direction Liquid:	▲	X	►	X	▼		◄	X
Direction Gas:	▲	X	►	X	▼	X	◄	X

Vortex meters less sensitivity to wear and flow variations than orifice plates. Vortex meters are used in applications that require rangeability and accuracy. Vortex meters are installed inline, and they can be placed in any orientation.
A vortex meter uses a bluff body placed in a liquid or gas stream to generate a vortex train.
Inlet Distance: ≥10x Pipe Dia. Note 1.)
Outlet Distance: ≥5x Pipe Dia. Note 1.)

A

Direction Liquid:	▲	X	►	X	▼		◄	X
Direction Gas:	▲	X	►	X	▼	X	◄	X

Coriolis mass flowmeters directly measure mass flow. For instance, Coriolis meters are effective for refinery gas to fire heaters.
Coriolis meters are used with liquids, including liquids with a limited amount of entrained gas as well as slurries.
Inlet Distance: Not required
Outlet Distance: Not required

A

Direction Liquid:	▲	X	►	X	▼		◄	X
Direction Gas:	▲		►	X	▼	X	◄	X

Ultrasonic flow meters are volumetric meters and are used with liquids, gas, and steam. Accuracy is based upon their nominal flow range.

Inlet Distance: ≥10x Pipe Dia. Note 1.)
Outlet Distance: ≥5x Pipe Dia. Note 1.)

A

Direction Liquid:	▲		►	X	▼		◄	X
Direction Gas:	▲		►	X	▼		◄	X

Variable area meters are used as indicators, transmitters, or flow switches. The meter has a linear scale, are relatively large and a low pressure drop. Variable area meters, also known as rotameters. Small meters are often provided with integral needle valves.
Direct reading variable area meters use glass or plastic tubes. The standard direct reading variable meter has vertical connections but depending upon the design, it might be able to specify end, side, or rear connections.
The float in a metal tube variable area meter is magnetically coupled to an external indicator. The standard metal tube meter has vertical through flow connections, i.e., connections at the top and bottom.

Inlet Distance: ≥5x Pipe Dia. Note 1.)

Outlet Distance: ≥3x Pipe Dia. Note 1.)

A

Direction Liquid:	▲	X	►	X	▼	X	◄	X
Direction Gas:	▲	X	►	X	▼	X	◄	X

Note 1.) For the upstream and downstream straight run, the manufacturer manual must be always consulted. The length depends on measuring principle, supplier and piping layout.

A

7. Location of Instruments

Instruments are installed on package based on customer specific requirements as listed below.

Rev.

7.1 Directly Mounted on Process Piping





In this case, Instruments are directly mounted on process line with minimum quantity of hook up material.

Rev.

7.2 On Small Instrument Boards Close to Process Piping



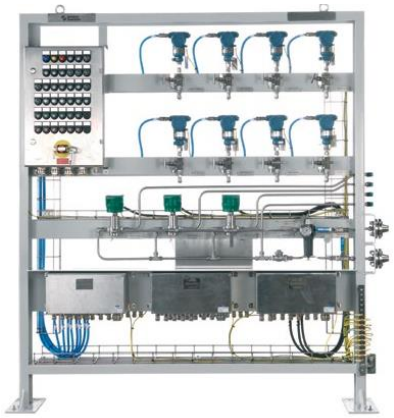
In this case, Instruments are installed on process pipe however mounted on a near instrument board/pipe stand. The instrument is better protected from Vibration and Temperature. This is mostly preffered by the clients and less expensive compared to the large instrument boards.

Rev.



PDT over stages or suction strainer can be also installed directly on site on a support.

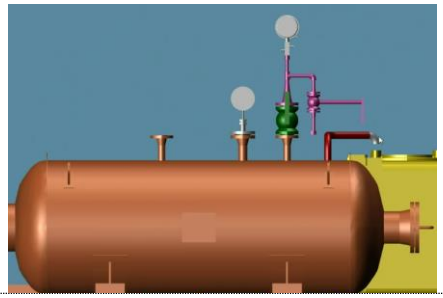
7.3 On Common Instrument Board



In this case, most of the instruments are mounted on common instrument board so that operator can read all the instruments from single place. The instrument is better protected from Vibration and Temperature.
In this solution, more tubing, fitting material is required.

Rev.

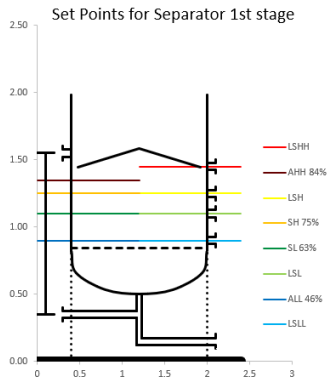
7.4 Instruments on Pressure Vessel



Instruments on the damper makes the damper much more expensive. This solution is by BC not preferred. Also damage on hook-up connection might occur due to high vibration.

Rev.

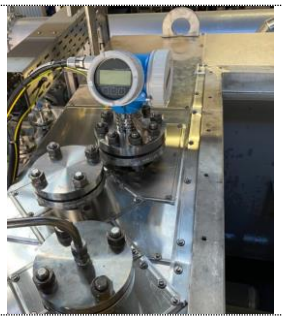
7.5 Instruments on Separator



The position of the instruments on a separator must be calculated by the PEO.
For that an internal calculation tool is existing.

Rev.

7.6 Instruments on a Tank



For oil tanks standard drawings with the shown instrument location are available.
See template drawings:
ZNG 122.354.938 PL2
ZNG 125.606.161 PL4
ZNG 125.607.450 PL4
ZNG 125.607.488 - 491 PL4

Rev.

8. Welding Boss and Threadolet for Threaded Connections

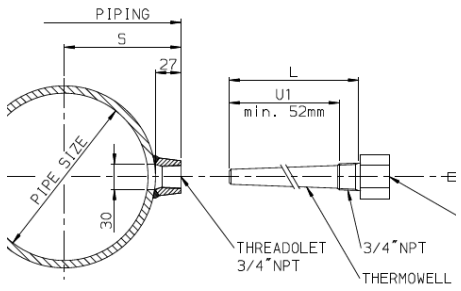
8.1 Type of Thread

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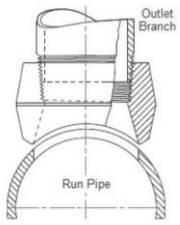
For threaded connections it is important to use the correct welding boss or threadolet.
Basically there are two type of threads used:

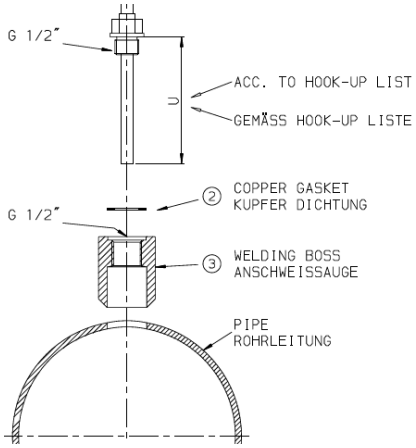
- **NPT conical threads** with sealing tap, i.e., PTFE → mostly threadolets are used.
- **Parallel thread with flat gasket** i.e., Copper, Al or soft iron → with welding boss

Below there are two typical examples for threaded thermowells:

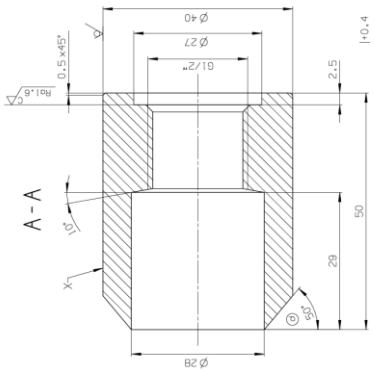


Threadolet NPT ¾"

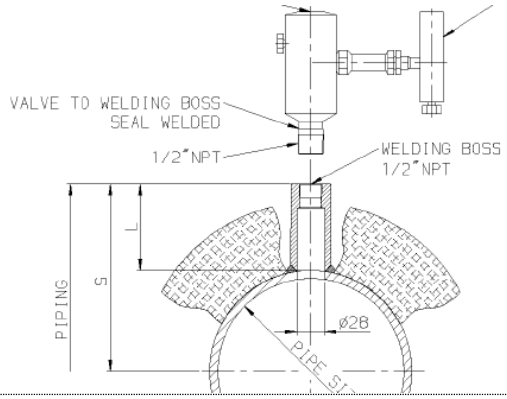




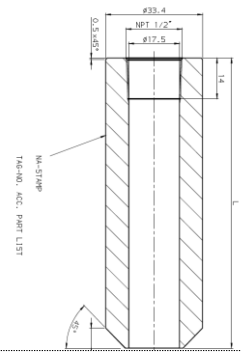
Welding boss G1/2"
parallel thread and gasket



There are special **Long welding bosses** for threaded pressure connection with NPT valve seal welded, typically used for BOG-LNG with heavy cold insulation:



Long Welding boss NPT 1/2"



9. Pressure Instrument – Tubing

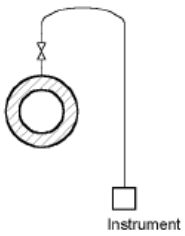
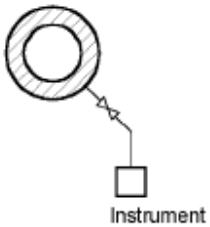
Rev.

Tubes and fittings are used to provide a leak-tight impulse line to the remote installed Instrument. The products are easy to install. A high flexibility is given.

Tubing vs. Piping:

- Bending Quality
- Greater Strength
- Less Turbulence
- Economy of Space and Weight:
- Flexibility
- Tighter Joints
- Better Appearance
- Cleaner Fabrication
- Easier assembly and Disassembly
- Expansive

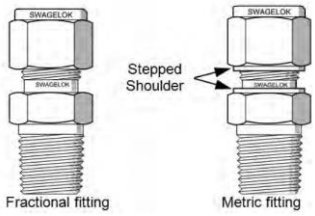
9.1 Tapping Point on Process Piping

					Rev.
	Gas	• Top Tapping • Instrument Upwards • Slope down to pipe • Keep the impulse line as short as practical!			
		Block: Root Valve	Bleed: Manifold		A
	Gas	• Top Tapping • Instrument Downwards • Slope down to instrument 10:1 • Keep the impulse line as short as practical! • For dry gases only. Wet gas not allowed because of the liquid accumulation.			A
		Block: Root Valve	Bleed: Root Valve	Drain: Manifold	
	Liquid	• Below, Side Tapping • Instrument Downwards • Slope down to instrument 10:1 • Keep the impulse line as short as practical! • A tapping from 5 to 7 o`clock is to be avoided			A
		Block: Root Valve	Drain: Manifold		

9.2 Instrument Tubing

Rev.

Impulse lines should be kept as short as possible. Long tubing runs tend to degrade the measurement performance and contribute to impulse piping problems.



BC is using 12mm or 1/2inch tubing for instruments.

The allowable working pressure depends on the tube diameter and wall thickness.

For conical threads glue or Teflon band shall be used. A

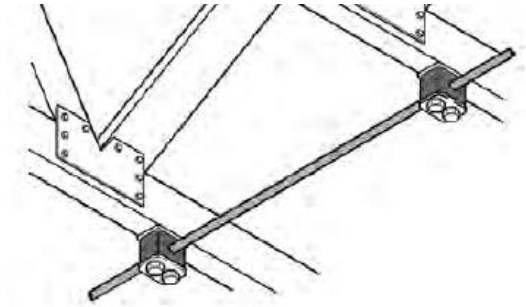
For oxygen, stainless steel tubing can be purchased chemically cleaned and passivated.
-> see "White Book Oxygen (O2)", TDO_2023990
The tubing - fitting interface of the compressor, LIB, oil units is described in a document. A
-> see "Definition of Fitting & Tubing Interface", TDO_2209353

9.3 Tube Clamps

Rev.

Unsupported length of a tube depends on the tube diameter:

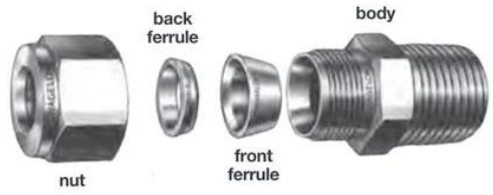
Metric, mm	
Tube OD	Distance between Clamps
4 to 10	0.9m
12 to 22	1.5m
25 to 30	2.1m
Inch	
Tube OD	Distance between Clamps
3/16 to 3/8	3 ft.
½ to 7/8	5 ft.
1 to 1 ¼	7 ft.



Polyamide (PA) clamps are preferred as the oil resistance is much better as the Polypropylene (PP) clamps.
For marine use, on deck, tube clamps with anti-corrosion technology shall be used.

9.4 Instrument Fittings

Rev.



BC is using two ferrule type fittings.

BC is not using:

- Fittings with one ferrule
- DIN fittings (Ermeto)
- Compression ferrule fittings

For oxygen, fittings shall be ordered cleaned and individual bagged.
-> see "White Book Oxygen (O2)", TDO_2023990

9.5 Low Temperature

Rev.

- Low temperature services require expansion loops in their impulse line tubing.
- Process liquids, operated by low temperature does need insulation or heat tracing.

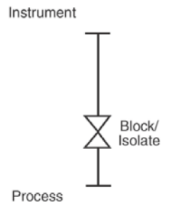
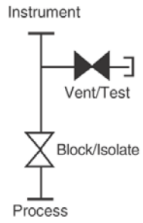
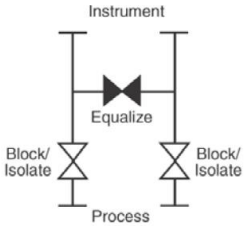
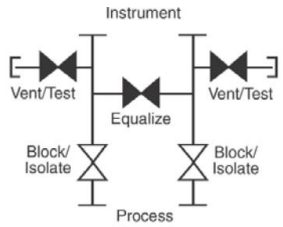
10. Pressure Instrument, Root Valve - Manifold

Rev.

Root valves, manifold valves are fabricated from bar stock. Manifolds are the preferred mounting valve.
A vent allows the release of trapped gas or fluid.

10.1 Area of Application

Rev.

Typical:	Used:		
	Liquid	Root Valves	PT, PDG, PDT LT
		Manifolds	-
	Gas	Root Valves	PT, PDG, PDT LT
		Manifolds	-
	Liquid	Root Valves	-
		Manifolds	PG
	Gas	Root Valves	Can be used for venting of PT, PDT when the tapping point higher is, as the installed instrument.
		Manifolds	PG
	Liquid	Root Valves	FT Not preferred for PDG, PDT
	Gas	Manifolds	FT Not preferred for PDG, PDT
	Liquid	Root Valves	PDG, PDT
	Gas	Manifolds	FT PDG, PDT

10.2 Packing Material

Rev.

As Standard BC is using PTFE packing material for valves. Fluid, pressure, and temperature must be considered.
Optional, graphite packings can be used for higher medium temperature. Or if Fluor is not allowed.

10.3 Handle

Rev.

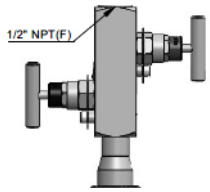
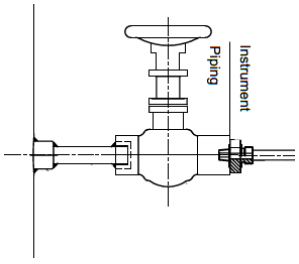
Anti tamper removed manifold valve handles are used to prevent incorrect operating. But this will be not BC Standard.
For correct operation, handles have a colour code:

- Blue: Block valve
- Green: Equalization valve
- Red: Vent valve

10.4 Root Valve

Rev.

The root valve is the first shut – off valve in a sub-header leaving a pipe or vessel to isolate instrumentation from the process. No matter what type of valve; needle valve, gate valve, ball valve.

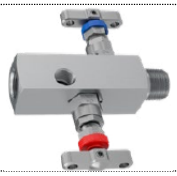
	This **screwed manifold** as root valve is not according to API 602 & 607. Can be used if the piping is also not according to API. It is available in SS. This is a cost - effective solution. BC Std. size: ½"	A
	This **socket or butt-welded manifold** as root valve is not according to API 602 & 607. Can be used if the piping is also not according to API. Typically used for units with heavy cold insulation or oxygen It is available in SS. This is a cost - effective solution. BC Std. size: ½"	A
	This **screwed gate valve** as root valve is according to API 602. It is available in CS and SS. BC Std. size: ¾"	A
	This **socket or butt-welded gate valve** as root valve is according to API 602. Typically used for units with heavy cold insulation or oxygen It is available in CS and SS. BC Std. size: ¾"	A

	This **flanged root valve** gate valve is according to API 602. It is available in CS and SS. BC Std. size: ¾"	A
	This **monoflange** root valve is according to API 607. It is available in SS. This is a very costly solution and not BC standard. BC Std. size: ¾"	A

10.5 Instrument Manifold

Two-way valve manifolds are used for Instruments as PG, PT. One valve acts as the block valve and the second valve is for venting and calibrating

Rev.

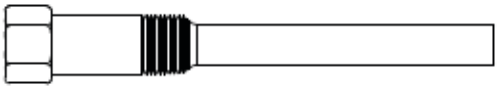
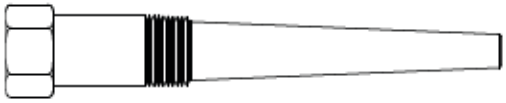
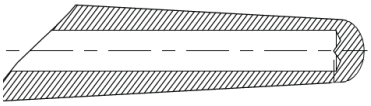
	This is a **remote 2-valve manifold** for Pressure Transmitter It is available in SS. By connecting the manifold to the mounting stand, the transmitter can be removed easily without disturbing the impulse line. This is a cost - effective solution.
	This is a **remote 2-valve manifold** for Pressure Gauge It is available in SS. This is a cost - effective solution.
	This is a **direct mount 2-valve manifold** for pressure instruments, connected by a coplanar flange. It is available in SS. This is a very costly solution and not BC standard.
Five-way valve manifolds are used for differential pressure instruments. The equalizing valve is between the two two-way valves.	
	This is a direct mount 5-valve manifold for differential pressure instruments, flanged to an Emerson coplanar™ Instrument. It is available in SS. This valve must be ordered always pressure tested together with the instrument. This is a cost - effective solution.
Manifolds in use with oxygen must be cleaned and individual bagged. -> see "White Book Oxygen (O2)", TDO_2023990	

11. Thermowells for Temperature Measurements

Here we only cover the Thermowells which are in common use by BC.
Thermowells are used to protect the temperature elements and to allow their replacement during operation.

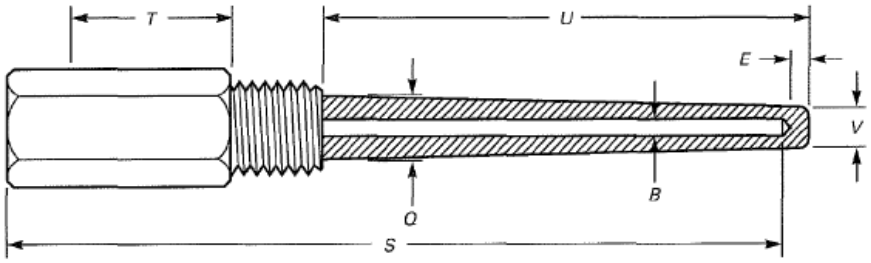
Rev.

11.1 Different Type of Thermowells

		Rev.
	Straight, can be used for liquid	
	Tapered, used for gas	
	A radius on the tip reduces the turbulences and flow resistance. Used for Oxygen (O2).	A

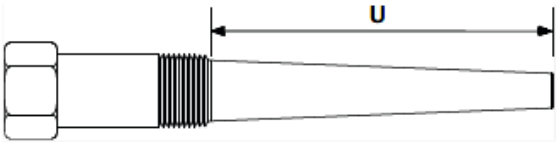
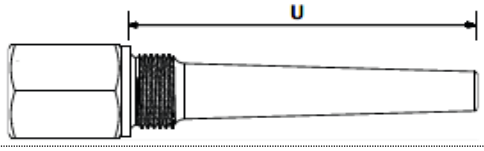
11.2 Terminology

Rev.

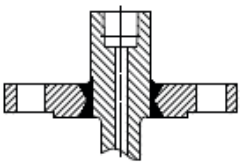
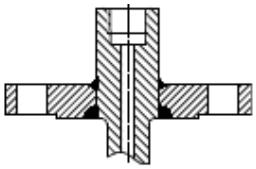
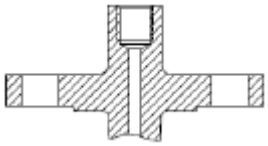


Symbols	Dimension
B	Bore Diameter
E	Tip Thickness
Q	Base Diameter
S	Bore Depth
T	Lagging Extension
U	Insertion Length
V	Tip Diameter

11.3 Threaded Thermowells

		Rev.
	Tapered Threads, self-sealing	
	Parallel Threads, metallic gasket is required	

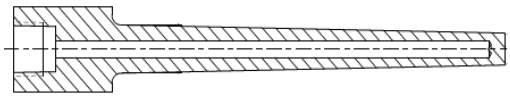
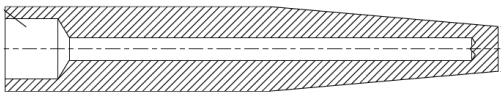
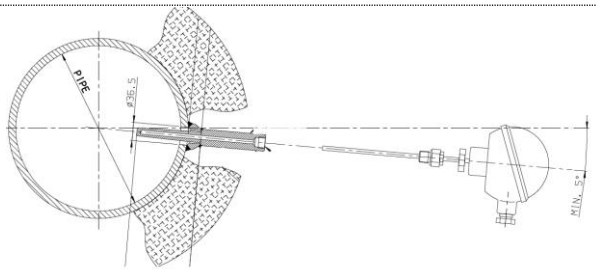
11.4 Flanged Thermowells

			Rev.
			
Full Penetration Weld	Partial Penetration Weld	Forget, No Welds	
Gas, High Pressure	Liquid, Low Pressure	Only on request. High costly	

11.5 Welded Thermowells

Rev.

Welded Thermowell are typically used for units with heavy cold insulation.
For Example: LNG, Suction side 1st Stage

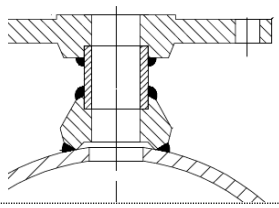
	Socket Weld
	Weld-in
	The thermowell should be downward installed that possible condensation liquid can flow away.

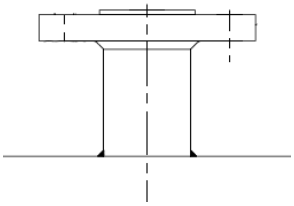
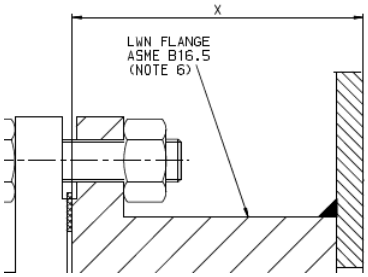
11.6 Length and Wake Frequency Calculation

Rev.

- For the thermowell length calculation a ZVL template in SAP is existing
  -> see ZVL_TSP_INST_HOOK_THWL
- The TW length should be for:
  - Gas: 25…33%
  - Liquid: 33…50%
- For Thermowells used in gas a **W**ake **F**requency **C**alculation (WFC) is recommended.

12. Flanges on Tank und Piping

		Rev.
	Socket weld flanges shall be avoided. It will exist a high risk of possible cracks BC Std. will be welding neck flanges.	A

	Long welding neck flanges on tank and separators: For design pressure ≤ 10bar g, packager is free to use a pipe spool with welding neck Flange.	A
	The dimensioning is shown always including the tank or separator wall.	A

13. Pressure Limits on Process Connection

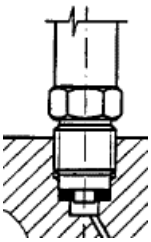
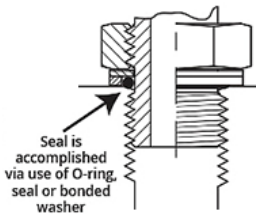
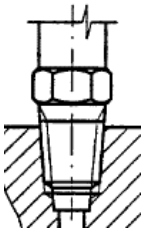
There are different instrument locations possible. Important is to define which instruments must be accessible for the operators.

Rev.

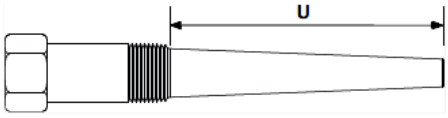
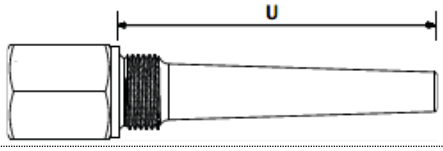
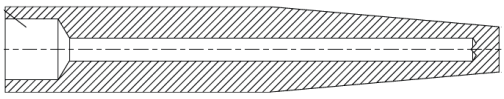
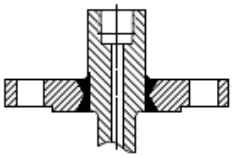
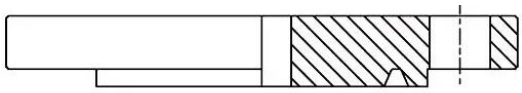
13.1 Pressure Measurement

This chapter is for information. Piping classes and material to be considered.

Rev. A

Thread	**G 1/4" B**	**G 1/2" B**	**M20x1.5**	**G 1/2" A**	**M20x1.5**	**1/2" - 14 NPT**	**1/2" - 14 NPT**	
Norm	DIN EN 837	DIN EN 837	DIN EN 837	DIN 3852-2	DIN 3852-1	DIN EN 837	DIN EN 837	
	ISO 228-1	-	DIN 13	ISO 1179-4	ISO 1179-4	ASME B1.20.1	ASME B1.20.1	
	-	-	-	-	-	Class 3000	Class 6000	
Gasket Material	Cu Alloy	Cu Alloy	Cu Alloy	Cu Alloy	Cu Alloy	-	-	
Working Pressure	≤ 600 bar	≤ 1000 bar	≤ 1000 bar	≤ 160 bar [1.)]	≤ 160 bar [1.)]	≤ 206 bar	≤ 413 bar	A
Picture								
Note 1.)	Design pressure may vary depending of manufacturer or design.							A

13.2 Thermowell

This chapter is for information. Piping classes and material to be considered.	Rev.
	¾" NPT Thread TW shall be used up to: ≤103 bar, Class 1500
	G ¾" Thread TW shall be used up to: ≤103 bar, Class 1500
	Welded TW can be used at: 150 … 2500 lbs
	Flange 1 ½" RF TW shall be used: 150 … 600 lbs, ≤103 bar -> RF
 Ring-Type Joint (RTJ) Thermowell	Flange 1 ½" RTJ TW shall be used up to: 900 … 2500 lbs, ≥103 bar -> RTJ

A

14. Important Aspects for Plant Layout

Rev.

There are different instrument locations possible. Important is to define which instruments must be accessible for the operators.

14.1 Location of Instruments on Process Piping

Rev.

The most economical solution is to mount the instrument directly on the piping or equipment, typically for thermometers or pressure gauges.
Heavy instruments and/or with heavy instrument hook-up shall not be mounted directly on the process piping, ref. 3.1.

14.2 Thermowell Installation, Location

Rev. A

Considerations:

- Pipe Size ≥ 3"
- Distance from other Measuring Instruments
- Possible Vibration
- Maintenance Accessibility

14.3 Location of Instrument Board

Rev.

All instruments which need access during normal operation are mostly installed on an instrument board. During the design of the plant layout and instrumentation it must be evaluated between:

- Individual small instrument board located close to process piping (mostly preferred by the client – most economical solution)
- Common large instrument board located on the foundation and platform.

14.4 Level Instruments on Separator

Rev.

Level instruments such as level switches or PDT level transmitters must be installed directly on the separator.

- In most cases there is a separate standpipe (bypass chamber) with isolating valves on which the LT is installed. This Instrument usually is used for draining control.
- Level instruments for trip functions shall be mounted directly on the vessel and not on a chamber with isolating valves.
- PDT measurement for the liquid level is also possible, but not recommended by BC because of pulsation occurred in the combined damper-separator.

14.5 Wet Application – Propper Arrangement of Instrument and Tubing

Rev.

For wet application (sour or wet H2S) the pressure instruments must be installed above the tapping points that self-draining of any condensation is possible.
This results mostly in small individual instrument boards (ref. 9.1) which must be located at high level. Easy access is not always possible.

15. Material Selection

Rev.

Materials shall be selected based on the process fluid and ambient condition. For the impulse lines and fitting for the pressure instruments it is common standard to use stainless steel grade AISI 316.

15.1 Proper Selection of Stainless-Steel Material

Rev.

For difficult gases and wet application (sour or wet H2S) the right selection of stainless steel is very important.
Materials which, under any process condition, are in contact with process gas water or aqueous condensate shall comply with ISO 15156 or NACE MR0103, as applicable, and the relevant piping class.
If impulse line components cannot be obtained in accordance with these standards (e.g. the rolled thread of some male compression fittings), the principle shall be consulted.
Valve head spindles and/or parts of them in contact with sour fluids shall be constructed from 17-4 PH stainless steel, stellite coated stainless steel, stellite or Hastelloy-C, complying with ISO 15156 or NACE 15156 or NACE MR0103, as applicable.

16. Heat Tracing and Insulation

Rev.

Instrument and their impulse lines often require electrical heat tracing to ensure a usable measurement.
If heat tracing on a skid is required, current self-limited tracers are preferred.
Because of the limited lifetime, heat controller units are not preferred.
Generally, the heat tracing and insulation is not in BC scope.

16.1 When is Heat Tracing Required?

Rev.

- It depends on the ambient temperature.
- It depends on the fluid required temperature.
- It depends on process conditions.

16.2 Insulation

Rev.



Pre - Insulated Tubing and pre - insulated, electric traced tubing is an alternative compared to the field tracing and insulation.

17. Special Application and Requirements

17.1 Oxygen

Rev. A

For Oxygen two very important points must be considered:

- All items must be clean – free of oil and grease. Tubing (impulse lines) must be ordered already cleaned because on site proper cleaning is not possible.
- Nonmetallic material (isolating valve, instrument manifold, gasket, Teflon tape) must be BAM approved.
- Design of isolating valves on process piping – refer to section 3.1. Cracks on piping are very dangerous and can be the root case for a fire, ref. TDO_2023990 White Book Oxygen (O2), section 9.5 stress raisers.

17.2 BOG with Very Low Temperature

Rev.

BOG process normally operates with very low temperatures. Consequently, the process piping has very thick cold insulation. Welded design for temperature and pressure hook-up is the preferred design to prevent any kind of gas-leakage.

- The isolating valves is normally located outside the insulation and is designed with seal welded threaded connection. In some few cased special flanged valves with extended bonnet with bellow was used (very expensive solution), refer to section 8.1
- For the temperature the thermowells are mostly welded-in, refer to section 11.5

17.3 High Pressure Units

Rev.

In high pressure applications like last stages Booster Primary the correct pipe rating must be used to withstand the high pressures. For LDPE projects (BP and Hyper) the standard LDPE hook up shall be used (refer to TDO_2190564).

17.4 Very Corrosive or difficult Gases

Rev.

For corrosive and difficult gases, the material selection is very important. In corrosive petroleum refining environments NACE MR 0103 must be considered and NACE MR 0175 is for material use in H2 containing environments in oil and gas production.

18. Prefabricated Instrument Hook-up

Rev.

As the name calls, these hook-ups are prefabricated than means complete assembly is fabricated at hook-up manufacturer's factory. These are mainly applicable for pressure instruments and DP type Flow Transmitter.
These hook-ups are customer design as per customer's requirements and are available with different end connections and material to suit site conditions. We need to specify our requirements like details of isolation valve, end connections, type of manifold, make and model of Instrument.
These types of hook-ups are compact, prefabricated assembled and pre-tested before installation so the installation time is lower compared to other hook up types.

18.1 Possible Prefabricated Types

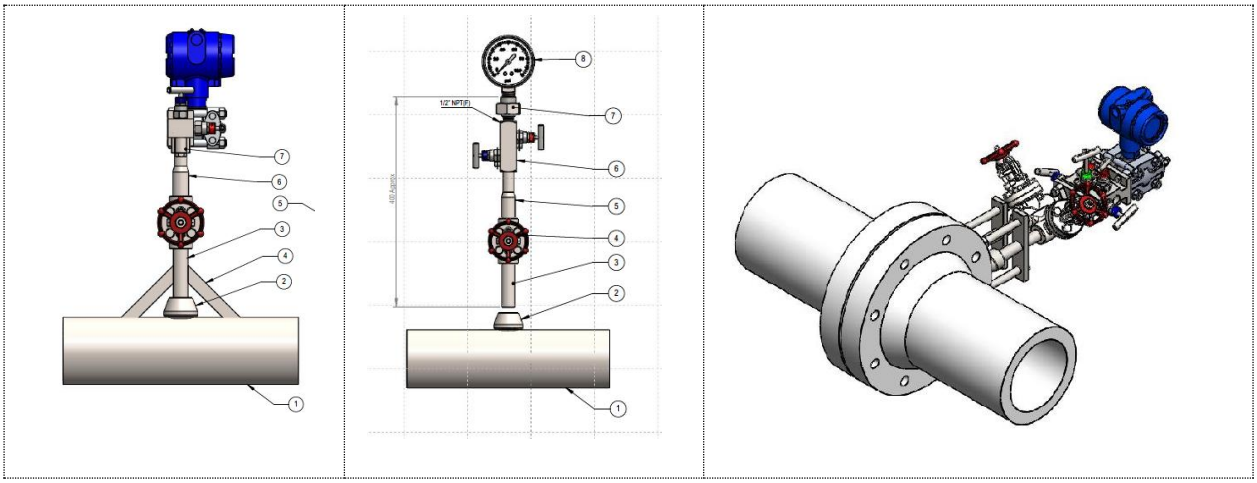
Rev.

These are also available with options such as root valves, monoflange valves, double black and bleed valves etc.

18.2 When to use Prefabricated Types

Rev.

These hook-ups can be applied where space constraints as these are compact units. Also, these can be installed on accessible locations from maintenance perspective.



19. Quality Requirements

Rev.

Hook up shall be mentioned in the relevant ITP. In the QA ITP (auxiliary) at least the root valve must be inserted. In the QE ITP (I&C) the instrument manifold and instrument tubing must be mentioned.

19.1 Minimum Quality Requirements – Standard ITPs

Rev.

Minimum quality requirement for complete root valve is 3.1 certificate for material including 3.1 certificate for seat leak test. For manifold and tubing a 3.1 certificate on material is required.

19.2 Special Points to be taken care.

Rev.

If project specific requirements like PMI etc. must be followed this needs to be mentioned in the ITP as well.
For special applications like oxygen, the material and sealing requirements shall be reflected in the ITP.

20. List of Reference BC Documents

BC Documents			Rev.
ABL	2091297	I&C Hook-up drawings	
TDO	2044699	Definition Instrumentation on Compressor	
TDO	2023990	White Book Oxygen (O2)	
TDO	2190564	Standard Hook up for LDPE (B/P and Hyper)	
TDO	2209353	Definition of Fitting & Tubing Interface	A
ZNG	122.354.938	Crank Gear Oil Tank PL2	
ZNG	125.606.161	Crank Gear Oil Tank PL4	
ZNG	125.607.450	Cooling & Flushing Oil Tank PL4	
ZNG	125.607.488 - 491	Cylinder Lubrication Oil Tank PL4	
ZVL	TSP_INST_HOOK_THWL	Thermowell Length Calculation	

21. List of Reference Standards and Codes

Standards and Codes		Rev.
API RP-551	Process measurement	
API 602	Gate, Globe, and Check Valves for Sizes DN100 and Smaller.	
API 607	Fire Test for Quarter-turn Valves	
ASME B1.20.1	Pipe Threads, General Purpose (INCH)	
ASME B40.1	Gauges – Pressure Indicating Dial Type - Elasting Element	
ASME PTC 19.3 TW	Thermowells	
NACE MR0103	Metallic materials resistant to sulfide stress cracking in corrosive petroleum refining environments	
NACE MR 0175 ISO 15156	Petroleum and natural gas industries — Materials for use in H2S-containing environments in oil and gas production	
DIN EN 837	Pressure Measuring Devices	
DIN 3852-1	Dimension for Metric Fine Pitch Thread	
DIN 3852-2	Dimension for Pipe Thread	
DIN 13	ISO general purpose metric screw threads	
ISO 228-1	Pipe threads where pressure-tight joints are not made on the threads	
ISO 1179-4	Connections for general use and fluid power Ports and stud ends with ISO 228-1 threads with elastomeric or metal-to-metal sealing	

22. Appendix – Typical Examples

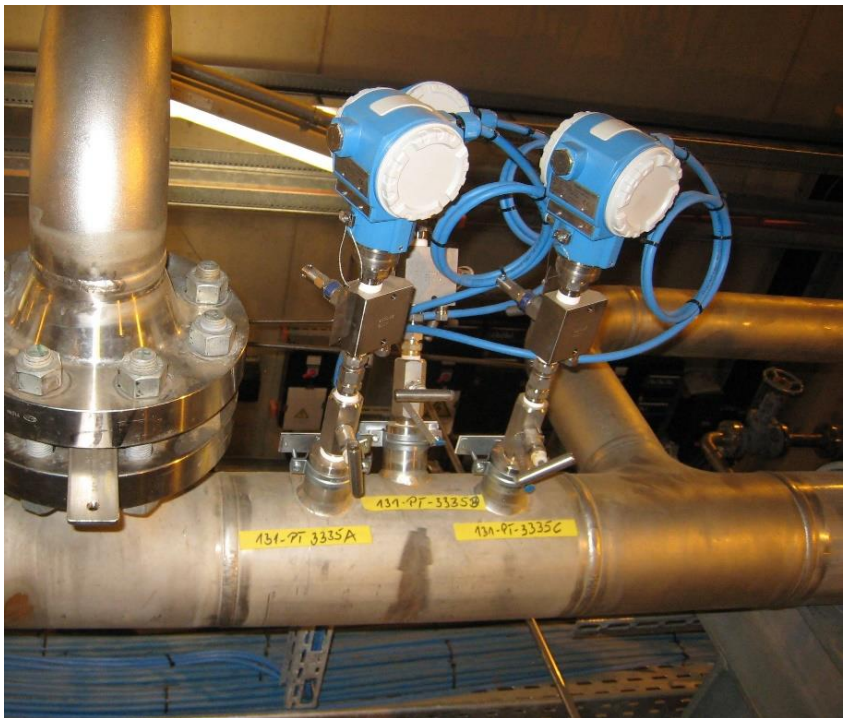
Pressure Instruments

Rev.



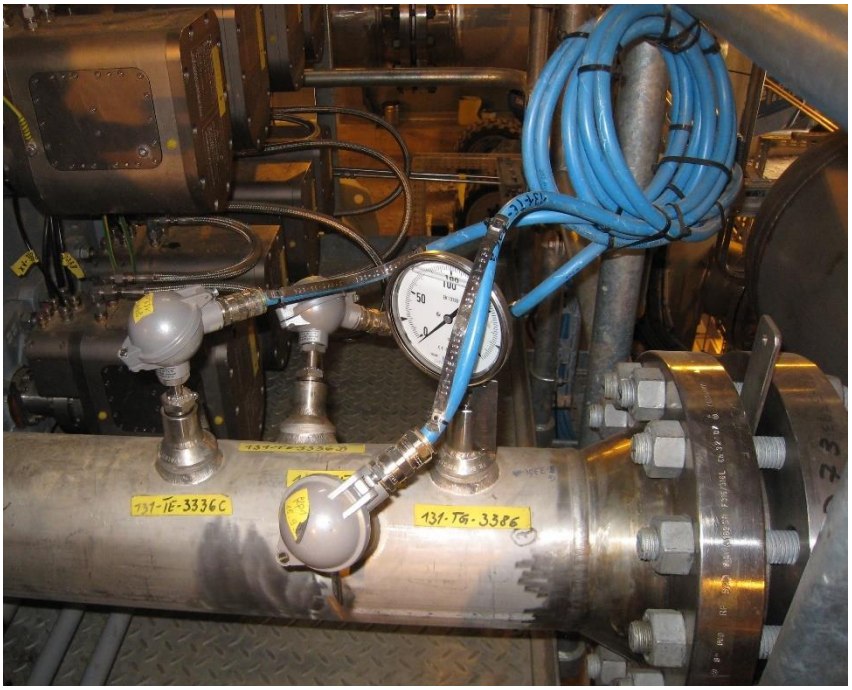


Pressure Transmitter mounted on Instrument board.

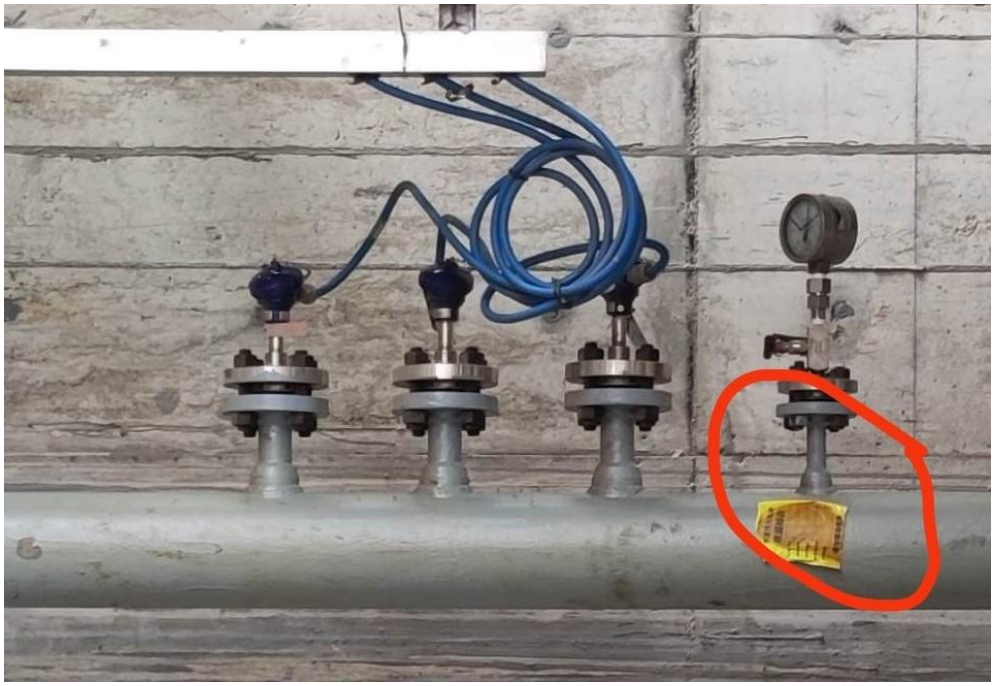


Pressure Transmitters mounted directly on process piping – threaded connection

Temperature Instruments



Temperature Elements/Transmitters and Thermometer mounted in process piping. Threaded connection type.



Temperature Elements/Transmitters and Thermometer mounted in process piping. Flanged connection type.

Level Monitoring

Rev





Level monitoring with transmitter mounted in stand-pipe with flanged isolating valves acc. to piping class. Support for stand-pipe can be added.

Flanged level switch mounted directly on the separator vessel.
Drain system with isolating valves.

A

Typical cracks on small connections to heavy isolating valves

Rev.





Socket weld flanges shall be avoided.