
User's Manual

TDLS8000 Tunable Diode Laser Spectrometer Process Gas Measurement Addendum

IM-P-20230411-01

Tunable Diode Laser Spectrometer Process Gas Measurement TDLS8000

IM-P-20230411-01 1st Edition

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1. Overview

1. Introduction

This addendum to the instruction manual for the TDLS8000 was designed to focus on points required to successfully implement the use of TDLS8000 installations for different installation practices for process gas measurements. This experience is based upon installations on a variety of processes making different process gas measurements. This guide is by no means a guarantee of successful implementation, but we hope it aids end users in their application of TDLS units for process gas measurements. Some typical process gas measurements are outlined below.

- Oxygen Measurements in Vent Headers
- Scrubber Inlet/Outlet Monitoring
- Oxygen Monitoring in Vapor Space
- Reactor Inlet/Outlet Monitoring

2. Safety

Please observe all safety precautions listed in the latest revision of the standard TDLS8000 instruction manual IM11Y01D01-01EN including, but not limited to, sections regarding general safety, EMC ratings, Safety Instrumented System (SIS) installation, and usage in hazardous area rated environments as appropriate.

3. Liability

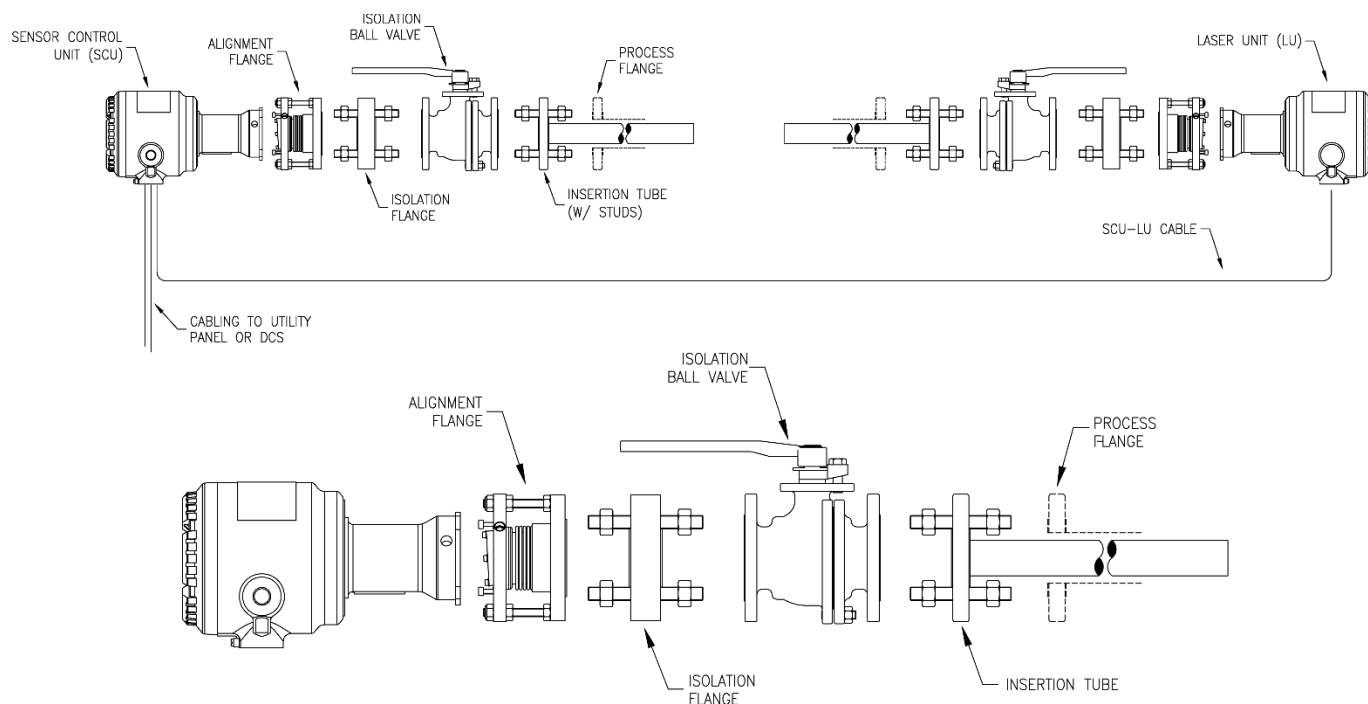
YOKOGAWA shall have neither liability nor responsibility to any person or entity with respect to any direct or indirect loss or damage arising from using the addendum/product or any defect of the addendum/product that YOKOGAWA cannot predict in advance.

2. Additional Hardware Considerations

For installations that are likely to contain particulate and/or condensables consideration should be given to using a smaller 2" 150# ANSI R.F. flange to increase linear purge velocity rates within the nozzle for the same volumetric window purge flow rate or consider the use of insertion tubes to achieve the same effect. Insertion tubes are typically Sch40 1 ½" diameter pipe welded to a flange that bolts directly to the process nozzle. The insertion tube pipe effectively becomes the new process nozzle area and decreases the total purge volume of the process nozzle. This allows for an increase in linear velocity of the window purge, without requiring an increase in window purge supply and has proven effective in preventing particulates from entering the process nozzle and/or process gas coming into contact with the process window. Typically, the insertion tubes are supplied long and cut to length at site to ensure the ends do not protrude into the process.

Isolation flanges are recommended for harsh or aggressive processes, required if pressure exceeds 550kPa and/or if the alignment flange process windows will see direct temperatures exceeding 55°C. Isolation flanges should also be considered if a special material of construction is required for wetted components (available in Monel as standard and Hastelloy C276 and others by request) as the standard alignment flanges are only offered in SS316. All process wetted gaskets are not provided by Yokogawa and should be chosen based on site preference and process material compatibility should be considered.

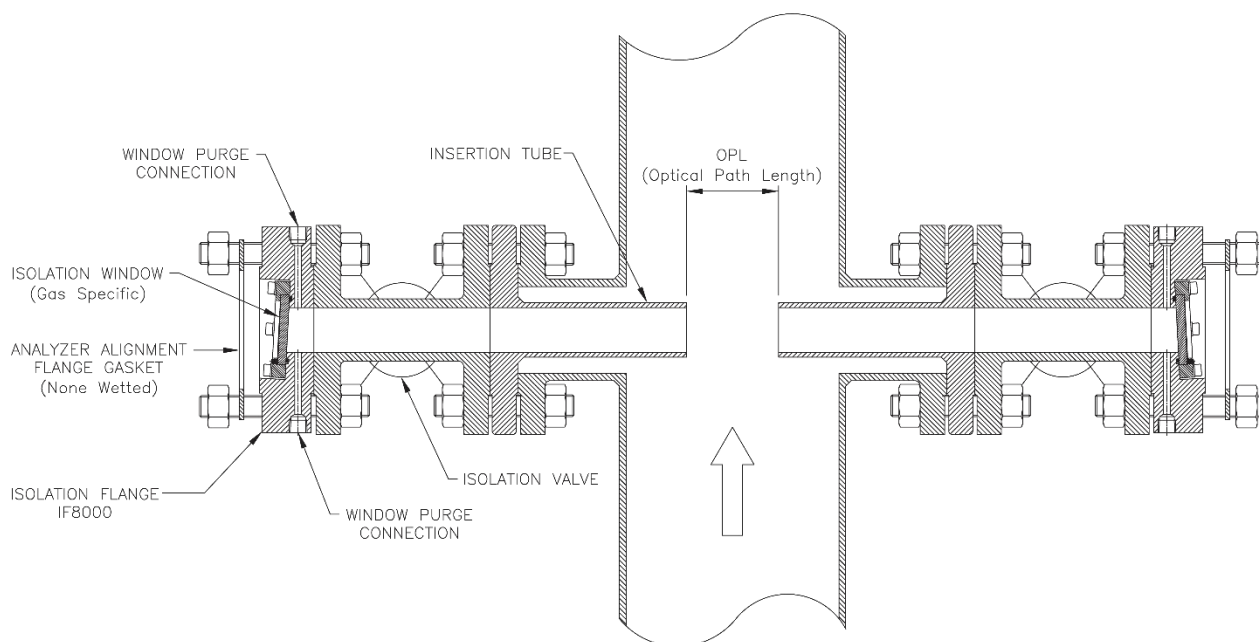
It can be advantageous to include an isolation valve between the insertion tubes and isolation flanges to provide a method to isolate the isolation flanges from process for PM to clean or service the process windows. It is important when adding isolation valves, they be full port valves to reduce the likelihood of obstructing the measurement beam. Consideration must also be taken to the added weight of using insertion tubes, full port isolation valves, and isolation flanges on the process flange to ensure the design maintains adequate alignment. The additional weight can lead to the process flanges moving or sagging over time if not properly braced (see section 4.4 for additional information on nozzle bracing).



3. Different In-Situ Installation Methods

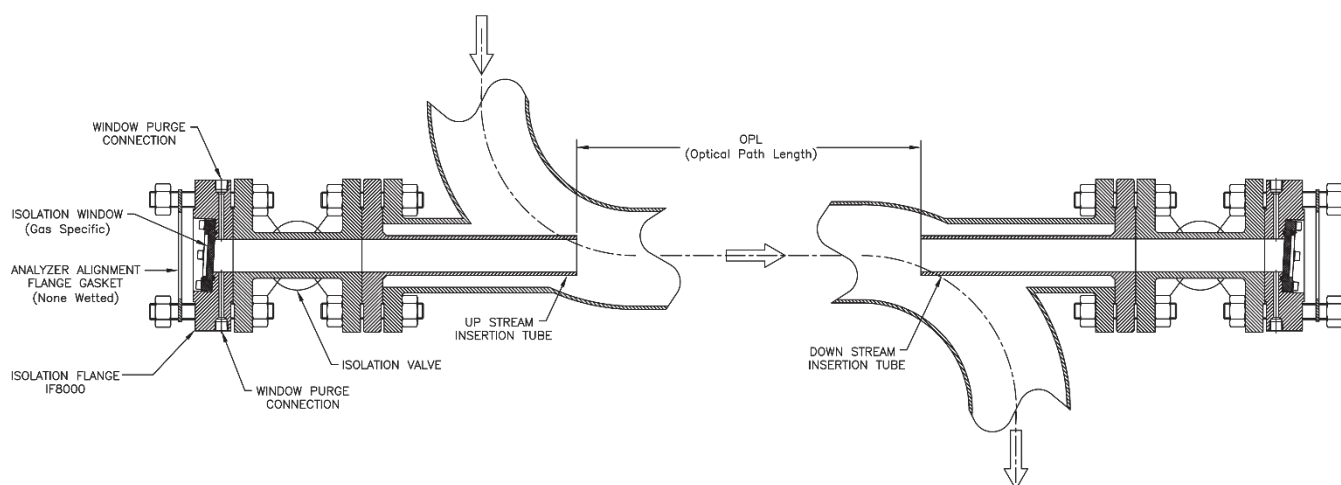
3.1 Non-Axial Installation

A non-axial installation consists of mounting the process nozzles perpendicular to process piping with the measurement being made across the diameter of the pipe. In non-axial installations insertion tubes are used if dust, particulate, or catalyst is of concern. This type of installation is usually the preferred method as it typically requires the least amount of modification, provides the best chances of keeping particulate out of the process nozzles, and provides the easiest window purge optimization. In general, this type of installation typically has the shortest optical path length (OPL) with less sensitivity of the different in-situ installations (discussed in more detail in further sections).



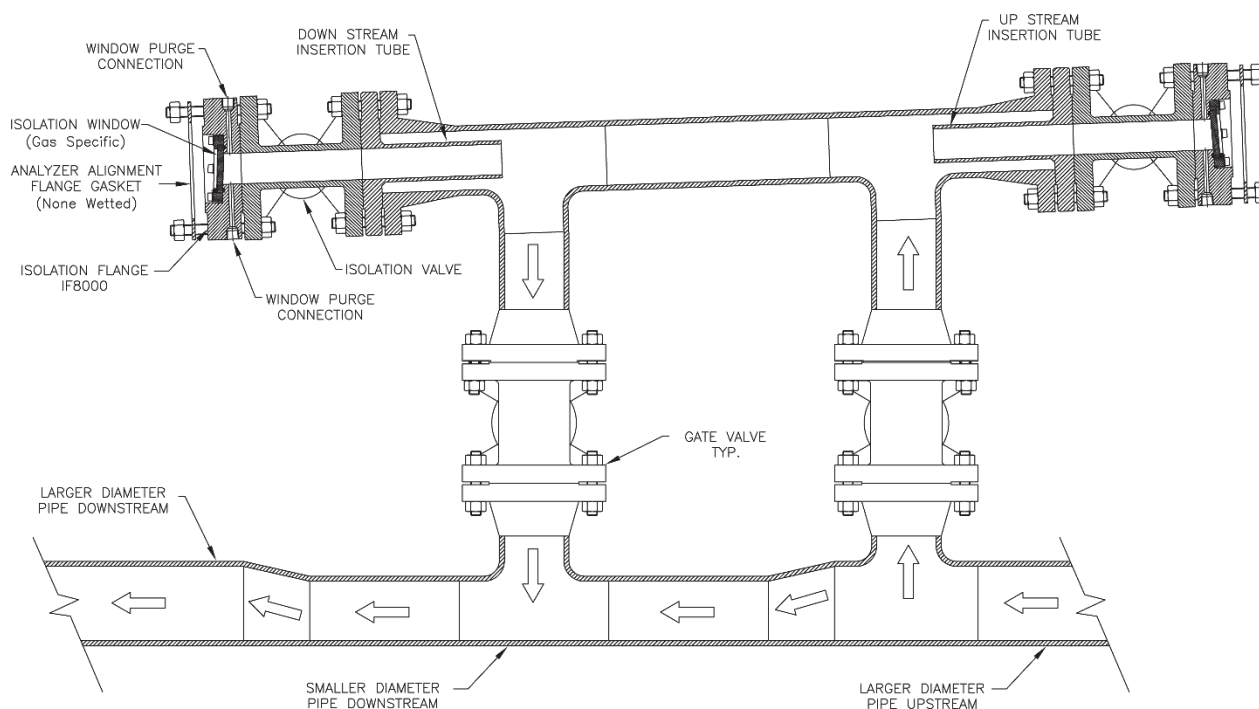
3.2 Bend, Straight Length of Pipe, or Axial Mounted Installation

An axially mounted configuration can be more difficult to implement due to balancing the window purge flow rates. The upstream window purge would be much lower than a non-axially installation, and it would cause some degree of dilution into the measurement path that must be considered. The dilution amount will be dependent on the actual process flowrate and the window purge flow rate of the upstream nozzle. In some cases, the amount of dilution will be insignificant due to high process flowrates in comparison to the window purge flow rate, but should still be taken into consideration. The main challenge with an axial mounted installation is keeping the downstream insertion tube or process nozzle clean. The downstream window purge would need to at least exceed the process linear flow rate to keep process gas out of the insertion tube/process nozzle and maintain a constant optical path length. If particulate is present in the process line, it's very likely the window purge flow rate would need to be higher to achieve a window purge velocity that exceeds the process flow velocity. Achieving an optimized window flow rate can be difficult with this installation type and is very important to maintaining a consistent path length for a reliable and accurate measurement. The LU (laser unit) and SCU (sensor control unit) placement should also be considered with this type of installation. It is preferred that the SCU be mounted on the upstream process nozzle and the LU be mounted on the downstream process nozzle. In the event the process windows (alignment flange or isolation flange if applicable) become fouled, typically it will have a greater impact on the signal quality for the SCU side window.



3.3 Bypass Installation

A bypass installation involves building a bypass section to force process flow from the main process line through a bypass line the analyzer is measuring across. It is always recommended that the bypass line be mounted above the process line as it will reduce the amount of particulate that would make it up the risers and prevent condensables from settling in the measurement area and allowing draining back down into the process piping. A pipe reduction or valve would need to be installed in the process pipe to create backpressure and force flow through the upper measurement area. Valves can also be used on the risers to provide additional control of the flow rate through the bypass line. The upstream window purge would be much lower than a non-axially installation, and it would cause some degree of dilution into the measurement path that must be considered. Similarly, to the axially mounted installation, window purge optimization is going to be crucial for maintaining and accurate and reliable measurement. It is also preferred the SCU side be installed on the upstream side for reasons previously discussed.



3.4 Comparing the Installation Types and Other Considerations

Each of the different installation types come with their own advantages and disadvantages. The non-axial installation will typically require the least amount of modification, the best chance to keep particulate out of the insertion tubes/process nozzles, and easiest window purge optimization. This installation will typically have the worst LOQ (limit of quantification) of the three because it will likely have the smallest OPL. The bend installation will likely have the best LOQ due to the length of pipe it can be mounted on. The bend installation usually requires the most modification, has the highest risk of particulate interfering with the measurement, and a challenging purge flow balancing. The bypass installation provides a middle ground between the two; slight modifications required, improved chances of reducing particulate loading, and an acceptable LOQ. This installation type will still require some window purge balancing. A balance must be maintained when considering the different in-situ installation methods for analyzer response time, analyzer sensitivity, purge balancing, and construction and engineering expenses.

3.5 Other Installation Considerations

In most process measurement streams species with relative low dew points can be present and pose the risk of condensing on the process windows and effecting the signal quality. Alignment and/or isolation flanges can be heat/steam traced and insulated to maintain the process window temperatures above the process stream dew point to prevent condensate from forming on the process windows. Generally, with adequate window purge flow rate this is not required, but should still be considered. It is more common to see this implemented on installations that are not using window purges due to the inability to add purge gas to the process stream and/or the availability of utilities on site. The alignment flange window should not exceed 55°C and the isolation flange window should not exceed 200°C or there is risk of damage and/or failure of the process windows.

4. Installation

1. Process Measuring Point Concerns and Considerations

The following information and criteria should be considered when selecting the installation point with respect to the process conditions:

- **Process Gas Flow Conditions** – Laminar, homogeneous gas concentration distribution conditions across the measurement point are recommended.

For circular ducts/stacks the condition is generally at least three unimpaired diameters (D) before and after a process bend. For rectangular cross-sections, the hydraulic duct diameter (D) is derived from the following:

$$\text{Diameter (D)} = \frac{4 * \text{Cross Sectional Area (A)}}{\text{Duct Circumference (C)}}$$

If neither situation exists or is possible, then distribution of the unimpaired section of duct should be 66% on the inlet side and 34% on the outlet side.

- **Process Gas Temperature** – It is recommended to install the analyzer in a location where temperature fluctuations are minimized. Ensure the analyzer has been selected and configured to suit the maximum operating gas temperature, as this will provide you with the worst case error calculation.

An active temperature input should almost always be utilized in process gas measurements, and is required in scenarios where the process will vary by more than +/-10°C. This signal should be as representative as possible of the process gas temperature the analyzer sees in the measurement path. This signal is most often provided by a 4-20mA signal (either active, for two wire loop power or passive are configurable in the analyzer), but can also be provided via Modbus TCP. For SIL certified applications the input must be 4-20mA.

- **Process Gas Pressure** – It is recommended to install the analyzer in a location where pressure fluctuations are minimized. Ensure the analyzer has been selected and configured to suit the maximum operating gas pressure, as this will provide you with the worst case error calculation.

An active pressure is commonly utilized in process gas measurements and required where the process pressure can vary by more than +/-0.05Bar. This signal should be as representative as possible of the process gas pressure the analyzer sees in the measurement path. This signal is most often provided by a 4-20mA signal (either active or passive are configurable), but can also be provided via Modbus TCP.

Keep in mind that only absolute pressure transmitter signals can be used. This is because the physics behind absorption are only concerned with absolute pressure effects.

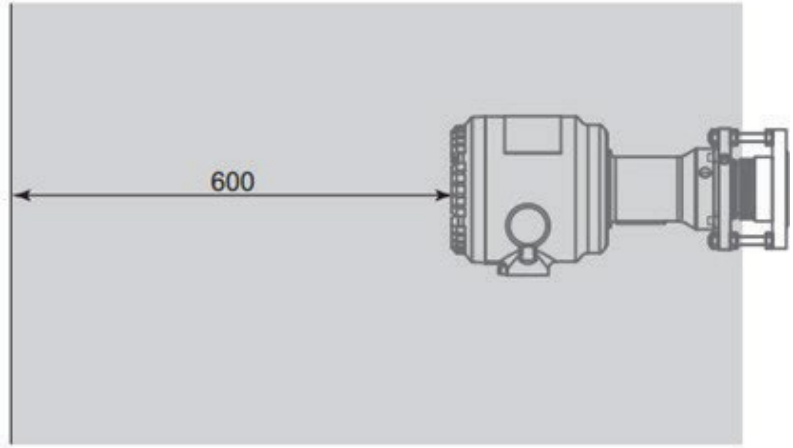
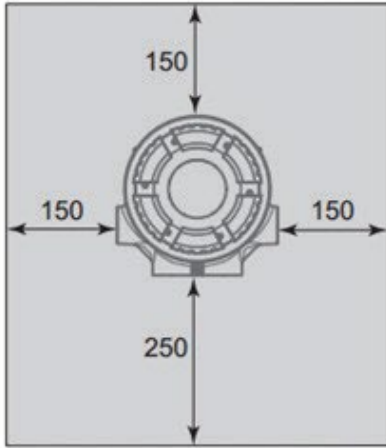
- **Process Dust/Particulate Matter** – It is recommended that the analyzer be installed at a location where dust loadings are minimized. Dust and other particulate matter will reduce the optical transmission of the measuring laser beam. Within certain limits, loss of optical transmission does not affect the measuring however a warning alarm will be initiated when transmission falls below allowable limits. Typically, dust/particulate loading should be < 20g/m³, but this is dependent upon the application, optical path length, and other considerations. Please consult Yokogawa with questions or further details.
- **Window Purge Nozzle Arrangement** – Please consult the instruction manual, or your individual drawing package for nominal flowrates for the optics and window areas.
 - While there is not a specified formula used to firmly set purge pressures and flow rates (due to multiple variables and complexity), the following information is included to help give end users an idea of typical experiences and some guidance regarding this activity.
 - For optics purges the main adjustments made to flow (typically 2.5 L/min) are to ensure timely intervals are set for introducing validation gas to an analyzer, and then purging the validation gas back out with purge gas. The pressure required for this is typically about 5 psig from a utility panel at grade, but can be adjusted to provide adequate motive force for the desired flow rate. The optics area should not be pressurized, and restrictions aside from bug screens or vent tubing as appropriate should not be added to the optics purge outlet.
 - For nominal flow rates window purges please consult the instruction manual or your individual drawing package. Optimizing window purge flow rates will be dependent upon physical analyzer installation method, process flow rate, process pressure, process temperature, particulate loading,....

4.2 Maintenance Clearance

Ensure there is sufficient space for maintenance efforts.

TDLS8000

Unit: mm



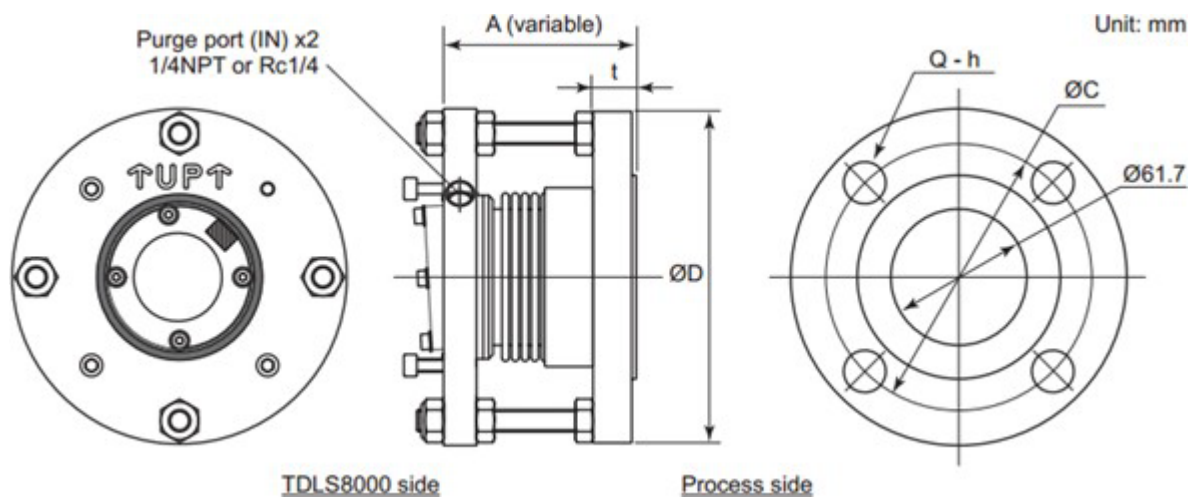
3. Flange Dimensions and Mounting Examples



CAUTION

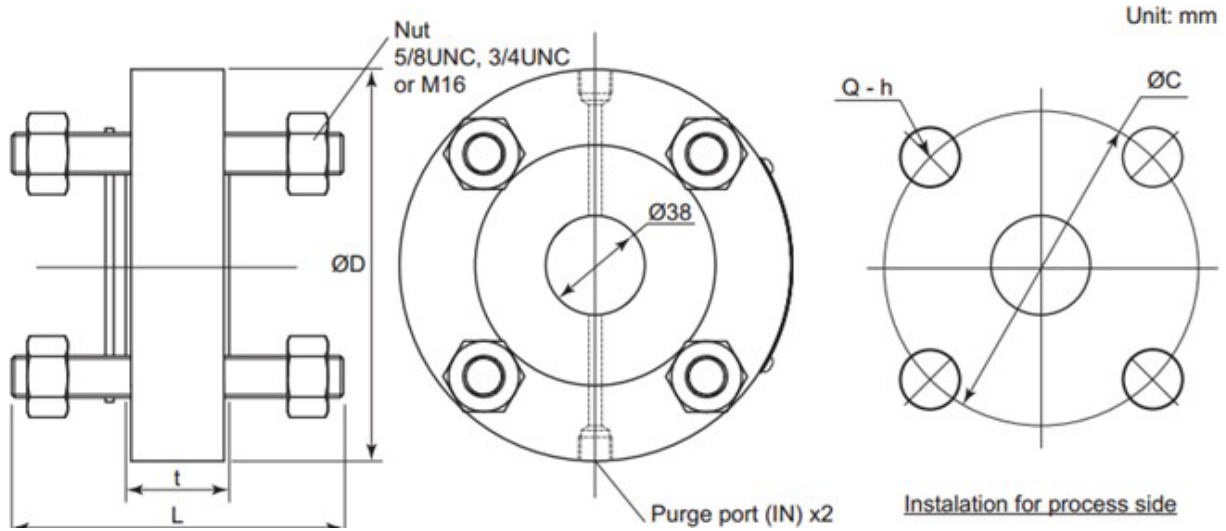
- Start window purges immediately after installing the analyzer to prevent damage to the optics and/or electronics if the asset is in operation. Starting firing before window purges are established will likely cause damage. Remember to ensure the purge lines are clear of all, dirt, oil, water, and other debris before starting the purges to avoid contamination of the optical surfaces and electronics. Guidelines regarding the purges are outlined in the Instruction Manuals..

4.3.1 Alignment Flange:



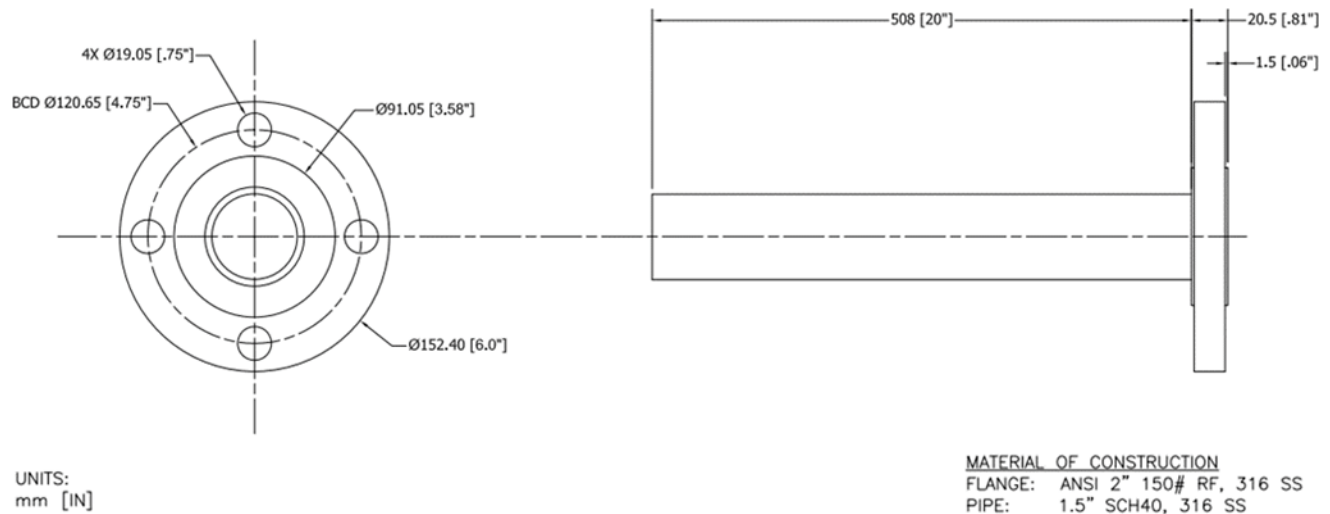
Optics Accessory Code (flange)		Hole QTY Q	Hole h	Hole P.C.D. C	Thickness t	Outside Dia. d	Distance A	Purge Port Q
-U2	ANSI CLASS150-2-RF(Eq.)	4	19	120.7	19.5	150	87	1/4NPT
-U3	ANSI CLASS150-3-RF(Eq.)	4	19	152.4	24.3	190	92	1/4NPT
-U4	ANSI CLASS150-4-RF(Eq.)	8	19	190.5	23.9	228.6	92	1/4NPT
-D5	DIN PN16-DN50-D(Eq.)	4	18	125	18	165	86	Rc1/4
-D8	DIN PN16-DN80-D(Eq.)	8	18	160	20	200	88	Rc1/4
-J5	JIS 10K-50-FF(Eq.)	4	19	120	16	155	84	Rc1/4
-J8	JIS 10K-80-FF(Eq.)	8	19	150	18	185	86	Rc1/4

4.3.2 Isolation Flange (IF8000):

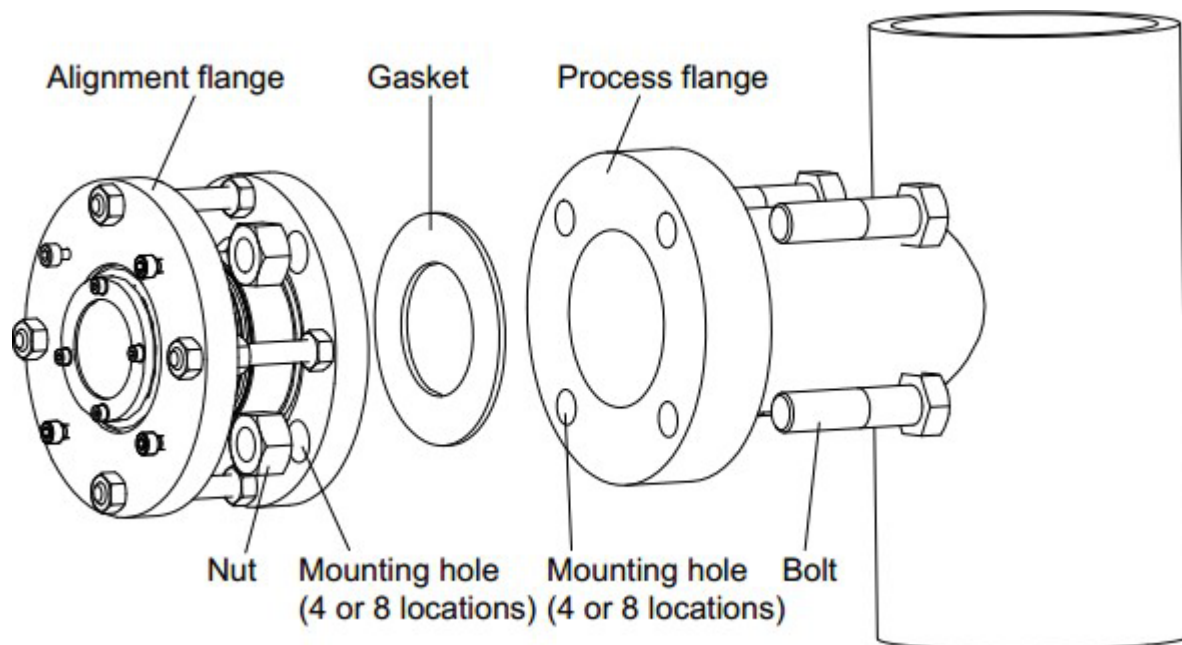


Processor Connection Code (flange)		Analyzer Connection Code (flange)	Hole QTY Q	Hole h	Nut	Hole P.C.D. C	Thickness t	Outside Diameter d	Bolt length L	Purge Port
-21	ANSI CLASS150-2-RF(Eq.)	-21 ANSI CLASS 150-2-RF(Eq.)	4	19	58/UNC	120.7	39.6	150	127	1/4NPT
-23	ANSI CLASS300-2-RF(Eq.)		8	19		127	39.6	165	137	
-31	ANSI CLASS150-3-RF(Eq.)		4	19		152.4	39.6	190	137	
-33	ANSI CLASS300-3-RF(Eq.)		8	19	3/4UNC	168.3	39.6	210	146	
-41	ANSI CLASS150-4-RF(Eq.)		8	19	5/8UNC	190.5	39.1	228.6	137	
-50	DIN PN16-DN50-D(Eq.)	-50 DIN PN16-DN50-D(Eq.)	4	18	M16	125	41.6	165	137	Rc1/4
-80	DIN PN16-DN80-D(Eq.)		8	18		160	41.6	200	137	
-J5	JIS 10K-50-FF(Eq.)		4	19		120	40.6	165	139	
-J8	JIS 10K-80-FF(Eq.)		8	19		150	40.6	185	139	

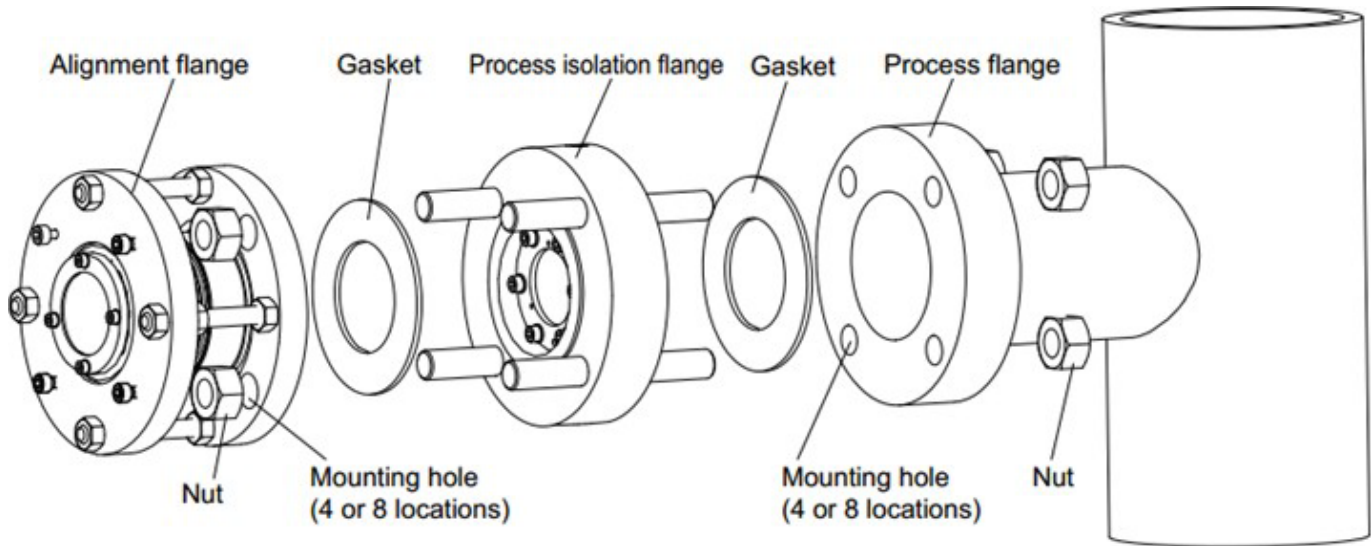
4.3.3 Insertion Tube (shown with a 2"150# process connection):



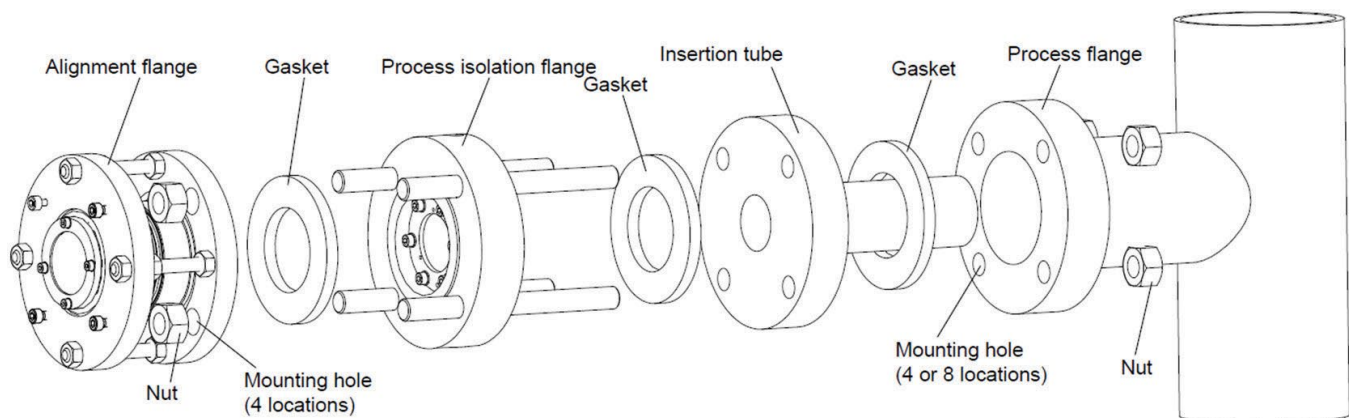
4.3.4 Mounting of Alignment Flange:



4.3.5 Mounting of Alignment Flange with Isolation Flange:



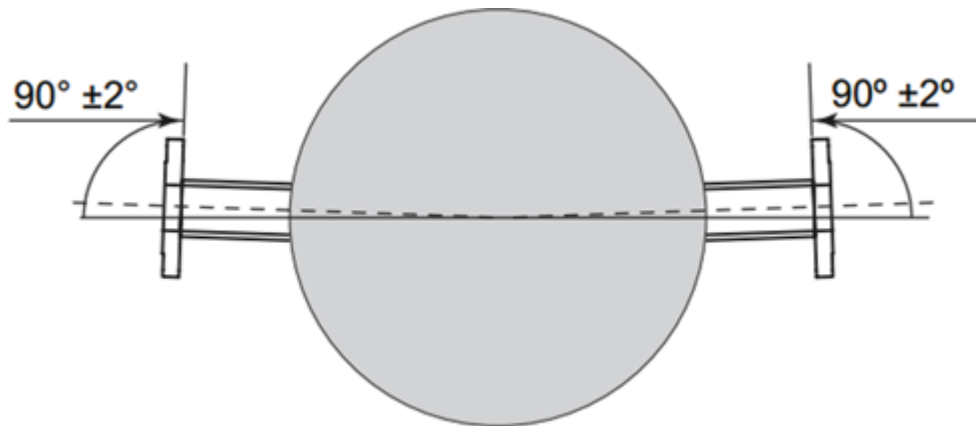
4.3.6 Mounting of Alignment Flange with Isolation Flange and Insertion Tube:



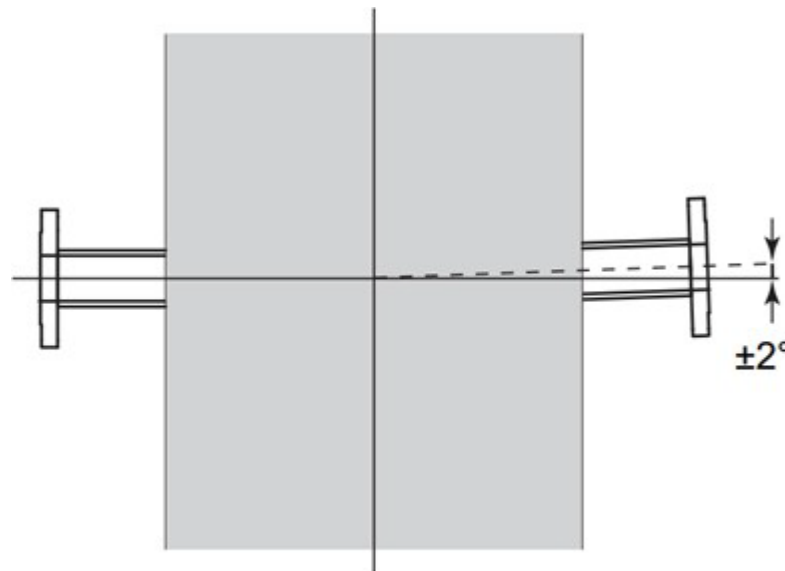
5. Process Connection Construction

5.1 Alignment Angle Tolerance

The SCU and LU have alignment mechanisms that can be used to manually adjust the laser beam direction within vertical and horizontal planes. Make sure that the process flanges are within the tolerances listed below:



Attachment angle tolerance (top view)

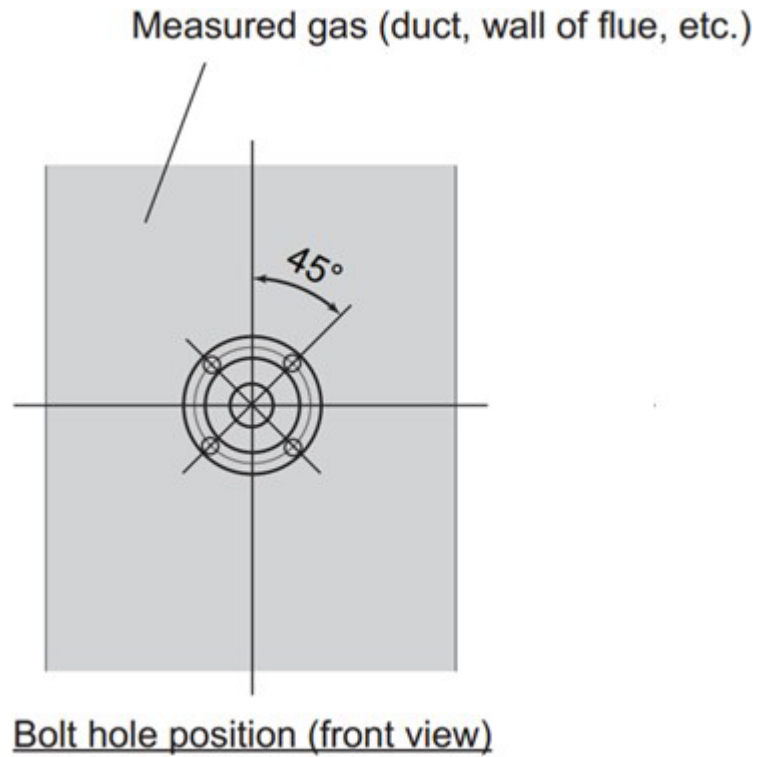


Attachment angle tolerance (side view)

It is important to note that the angle tolerance is determined from flange face to flange face. Extending nozzles too far or the addition of long isolation valves will increase any tolerance errors on the process flange faces, and the outlet of the valve is considered to be the new point of reference.

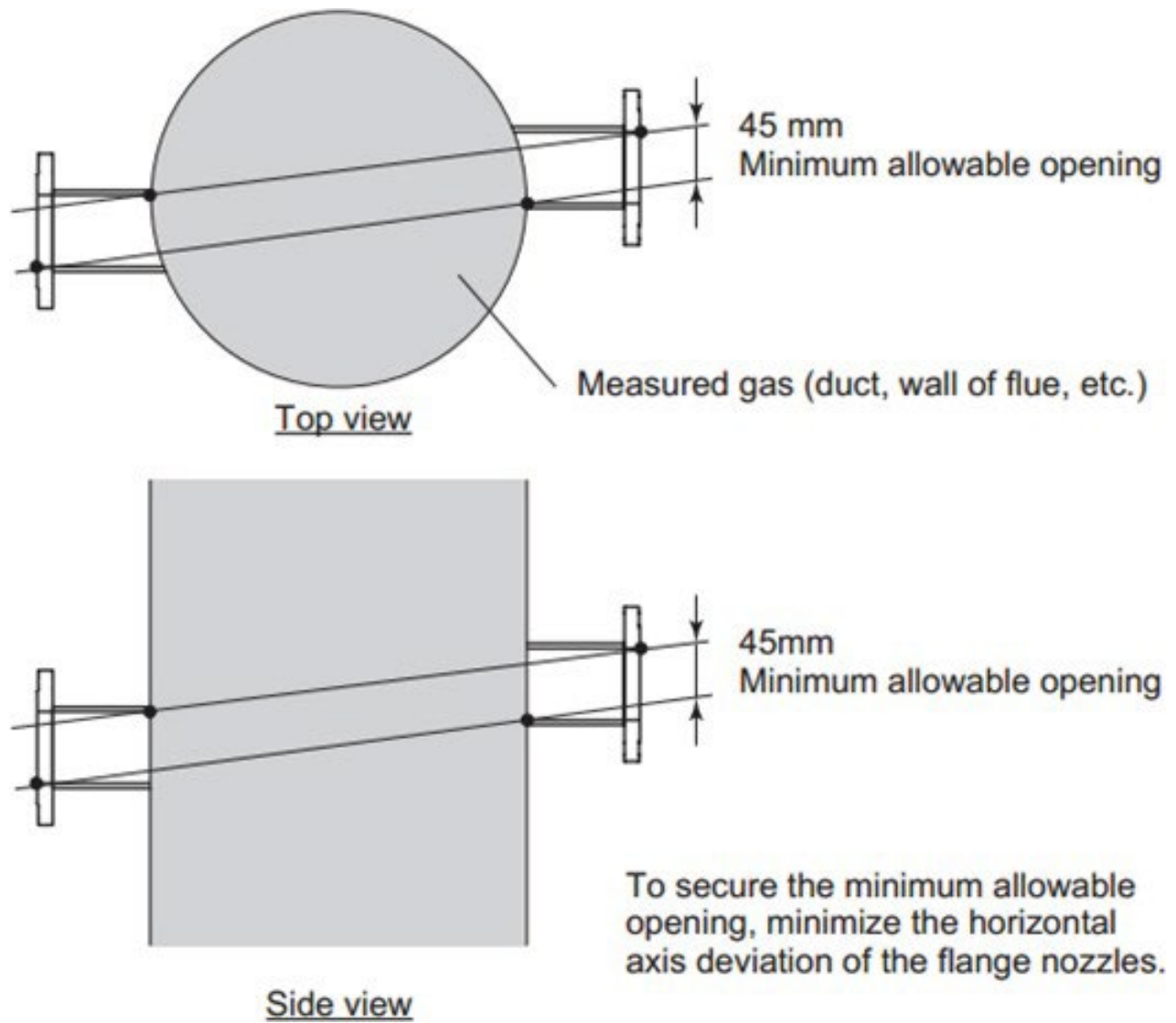
5.2 Bolt Hole Position

The analyzer flange should be welded in a 2-hole/split hole configuration as seen below:



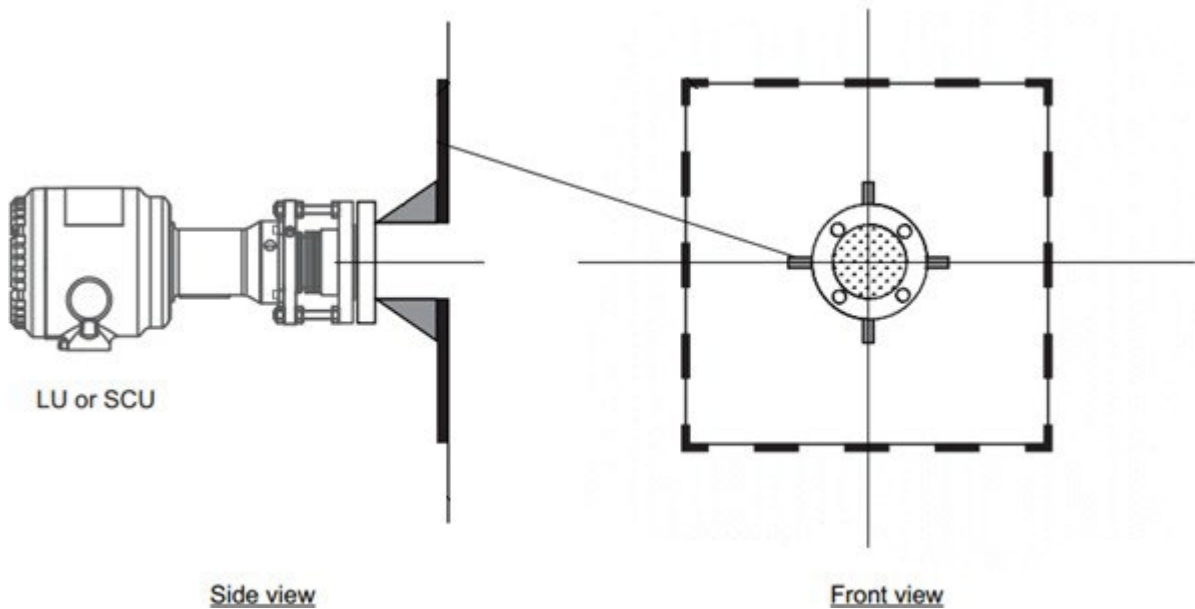
5.3 Short Path Clear Aperture Requirements

For collimated beam applications (< 3 meters) a 45mm minimum clear aperture is required:



5.4 Short Path Flange Reinforcement

Installing nozzles on small process pipes that can move or flex with varying process flow rates in combination with the weight of the analyzer can cause deflection of the beam angle, resulting in transmission loss due to misalignment. For short path installations something similar to the below example using gussets to help support the process nozzle from moving.



The figure above depicts a typical suggestion, but it's ultimately the installer's responsibility to ensure stable satisfaction of our angular and clear aperture requirements under all process conditions.

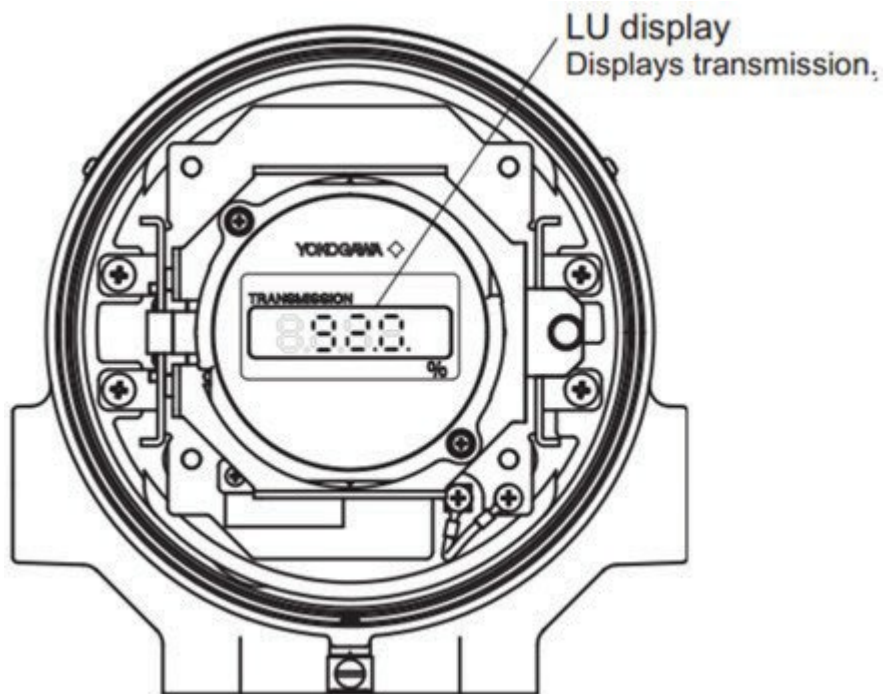
6. Alignment

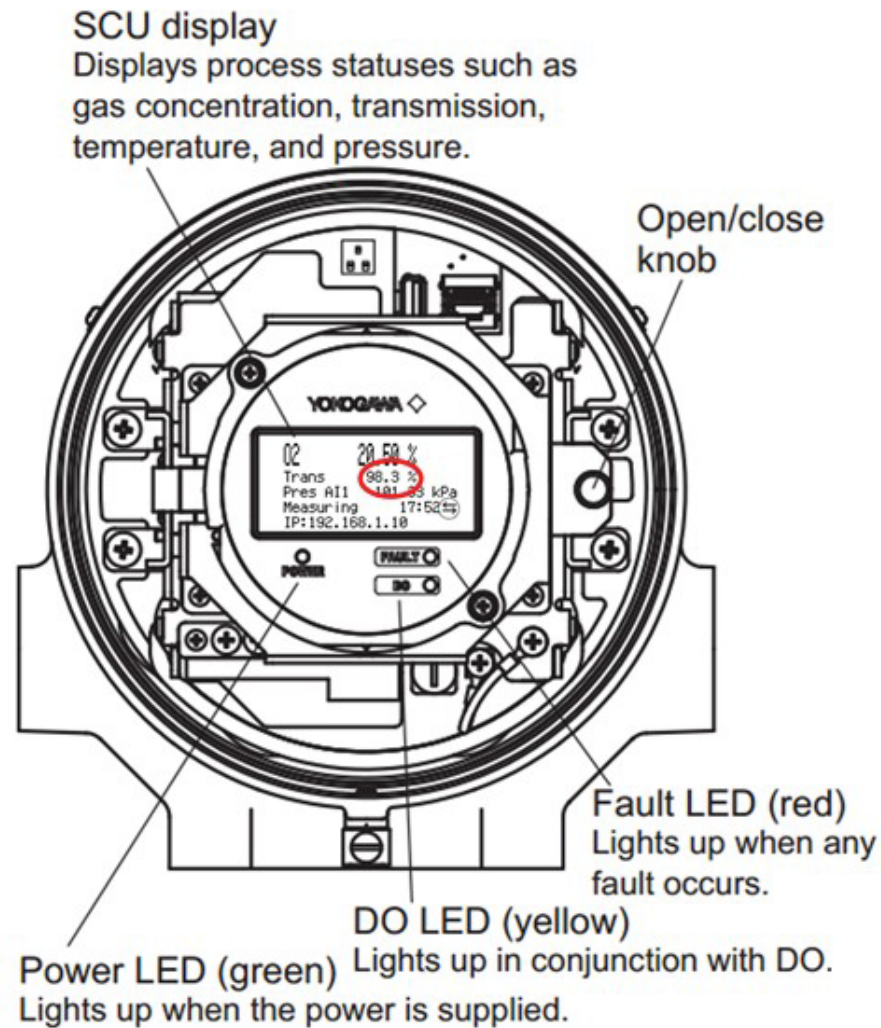
6.1 Before Attempting Alignment

Please consult the manual for all precautions regarding optical axis adjustment including laser safety precautions.

After purges are established (if the process is on) and wiring is complete you may begin to attempt aligning the analyzer. Note that alignment can be performed without a configured HMI by maximizing transmission numbers viewable at either end of the analyzer, but reviewing the detector signal after alignment is complete should be performed as a best practice.

Transmission is viewable on the LU via four seven-segment displays, and viewable on the SCU as "Trans **. **%". The number is updated every analysis period (2-5 seconds typically). Ensure that you pause between making adjustments to wait for the transmission value to update before making further adjustments.



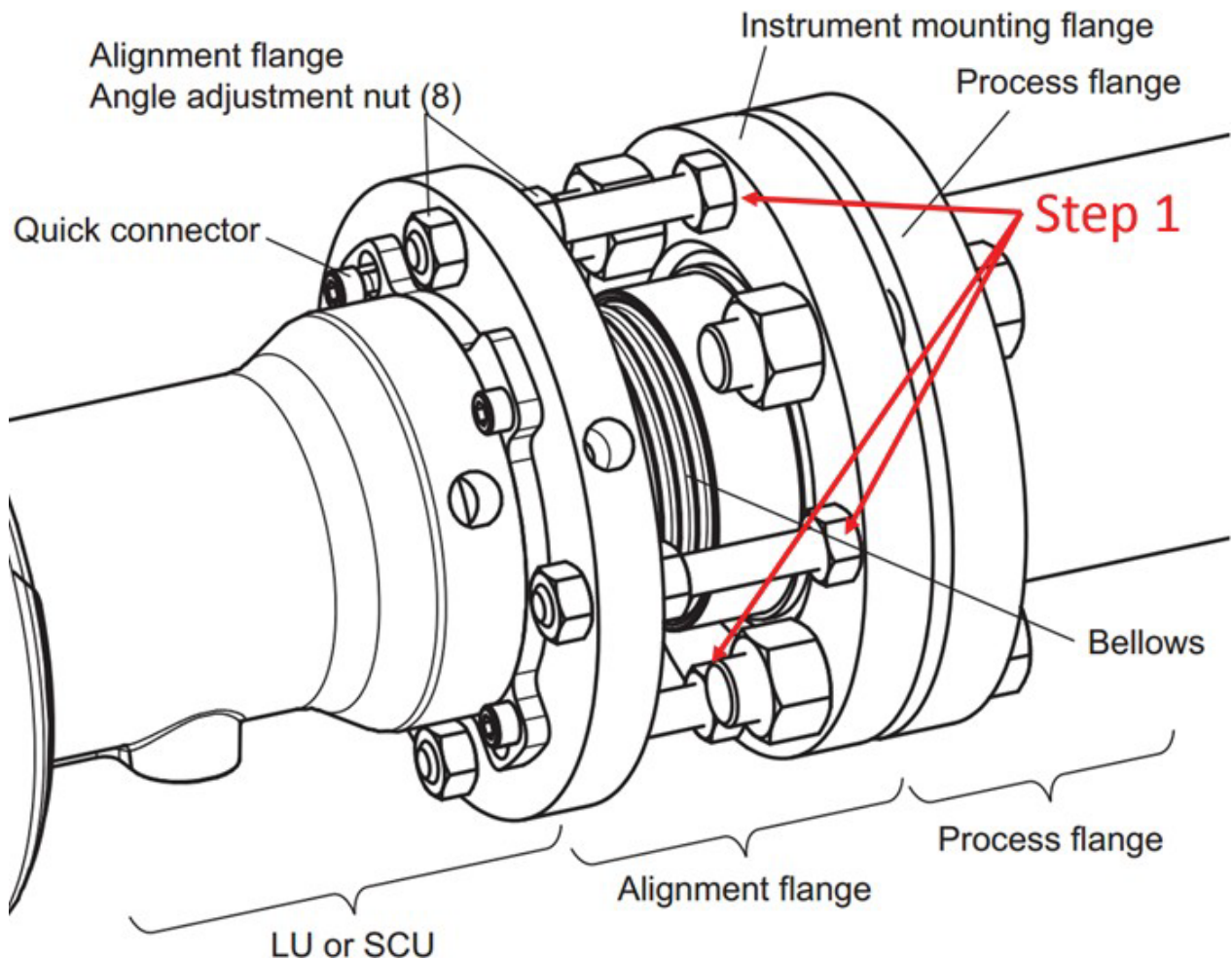


Do not be alarmed if your transmission value seems low, even after alignment is complete. The transmission number in a new analyzer is based upon a factory calibration OPL of 0.66 meters, and installation on longer OPLs or additional accessories such as isolation flanges will reduce the transmission number. It's not uncommon to see single digit or below transmission numbers on long path lengths before the transmission is recalibrated.

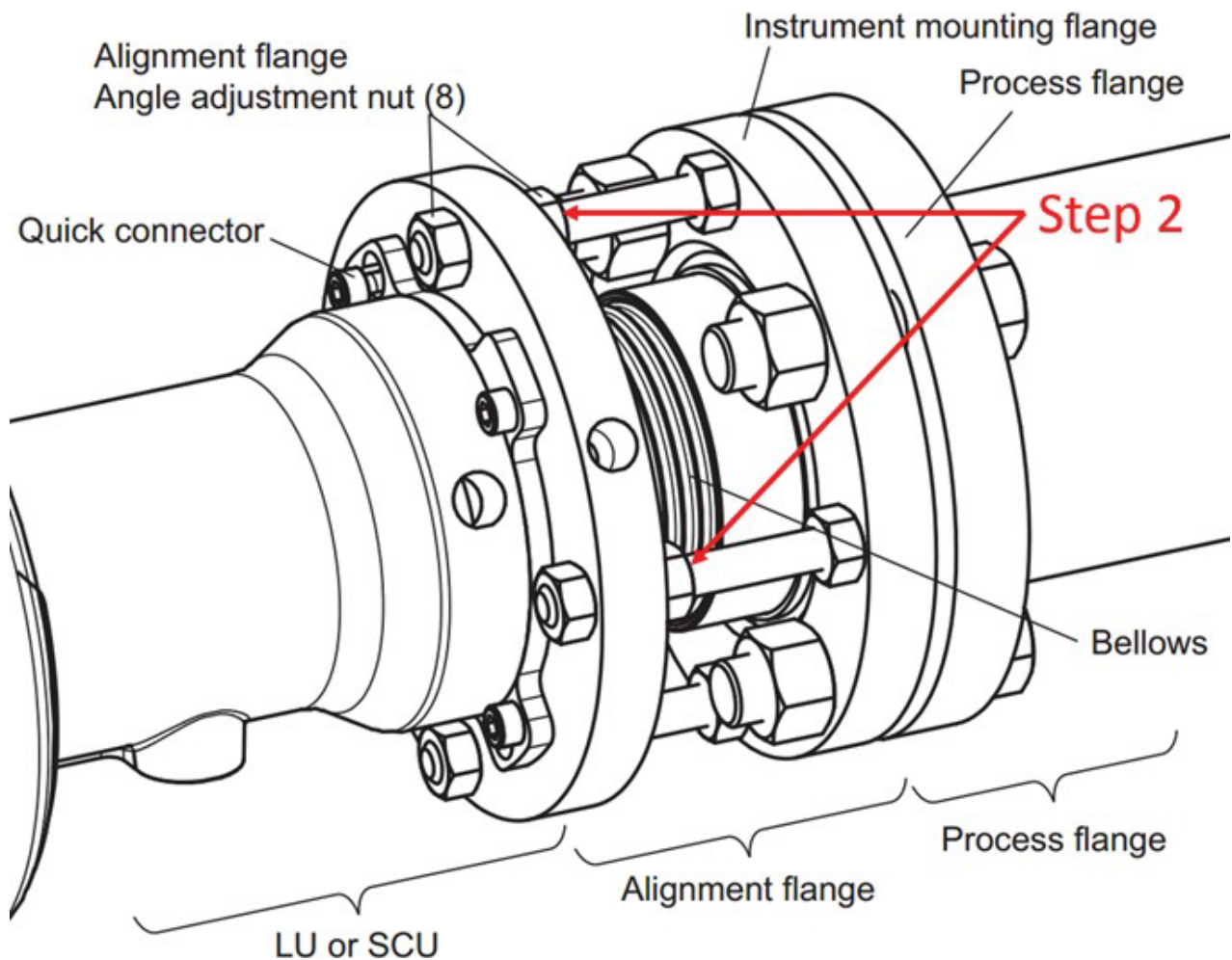
6.2 Short Path Alignment

Please note to work on only one end of the analyzer at a time. It's always best practice to start alignment with the source (LU), then make detector side (SCU) adjustments. After aligning both the LU and SCU you should return to the LU side to repeat alignment, and also return once more to the SCU side for optimal results.

The first step before attempting any alignment is making sure the nuts are tight on the instrument mounting flange which is connected to the process flange. If these nuts are not tight before starting the alignment process then it is possible for the stud to back out of the flange while making alignment adjustments. Note that there will be four nuts to tighten on each side.

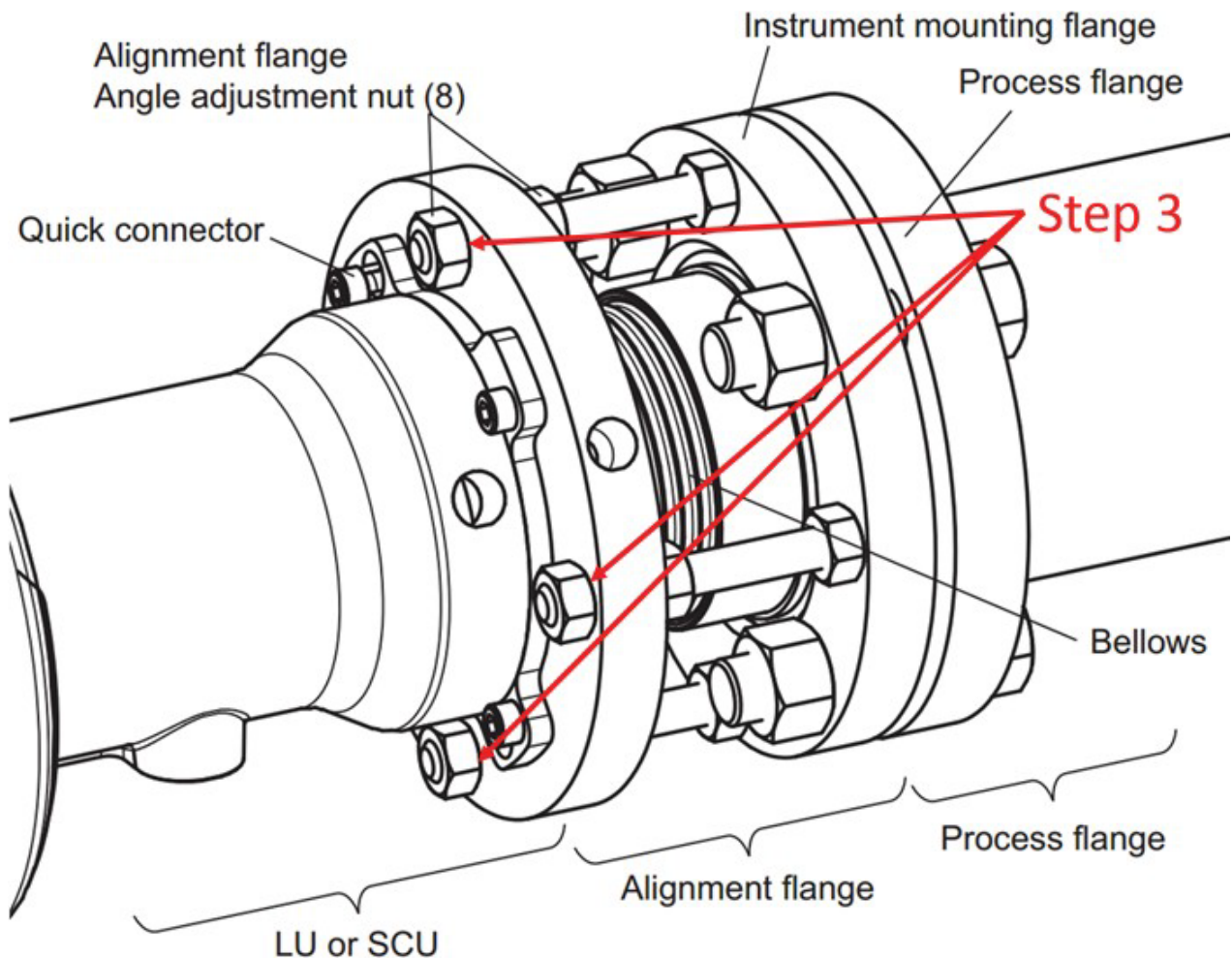


The next step in the alignment process is to loosen the alignment flange adjustment nuts on the back side of the quick connector flange. There are four of these on each side as well.



After the nuts on the backside of the quick connector flange have been loosened it's time to get a rough idea on the general angle the analyzer needs to point to achieve maximum transmission. Please wait for two measurement updates before re-adjusting the angle of the analyzer. You can do this by holding the head of the analyzer and moving it in up-down and left-right motions until you know roughly where the analyzer should point. You can see the orientation it needs to point visually on very short path installations. If you do not see any signal in this step then it may be necessary to check the rough position of the SCU side and adjust it so that it's pointing roughly at the LU. See further below in the guide for more detail on making adjustments to the alignment angle.

Once you have coarsely determined the necessary analyzer orientation you can back finger-tighten the nuts back up against the analyzer's quick connector flange while holding the analyzer in the optimal position to roughly mark the correct flange position. At this point the analyzer's quick connector flange face may no longer be making contact with the nylon lock nuts on the face of the flange. You can tighten the nylon lock washers on the face of the analyzer's quick connector flange so that they're back on the analyzer's flange face. Do not overtighten the nylon lock washers on the flange face, otherwise the nuts/stud may gall.



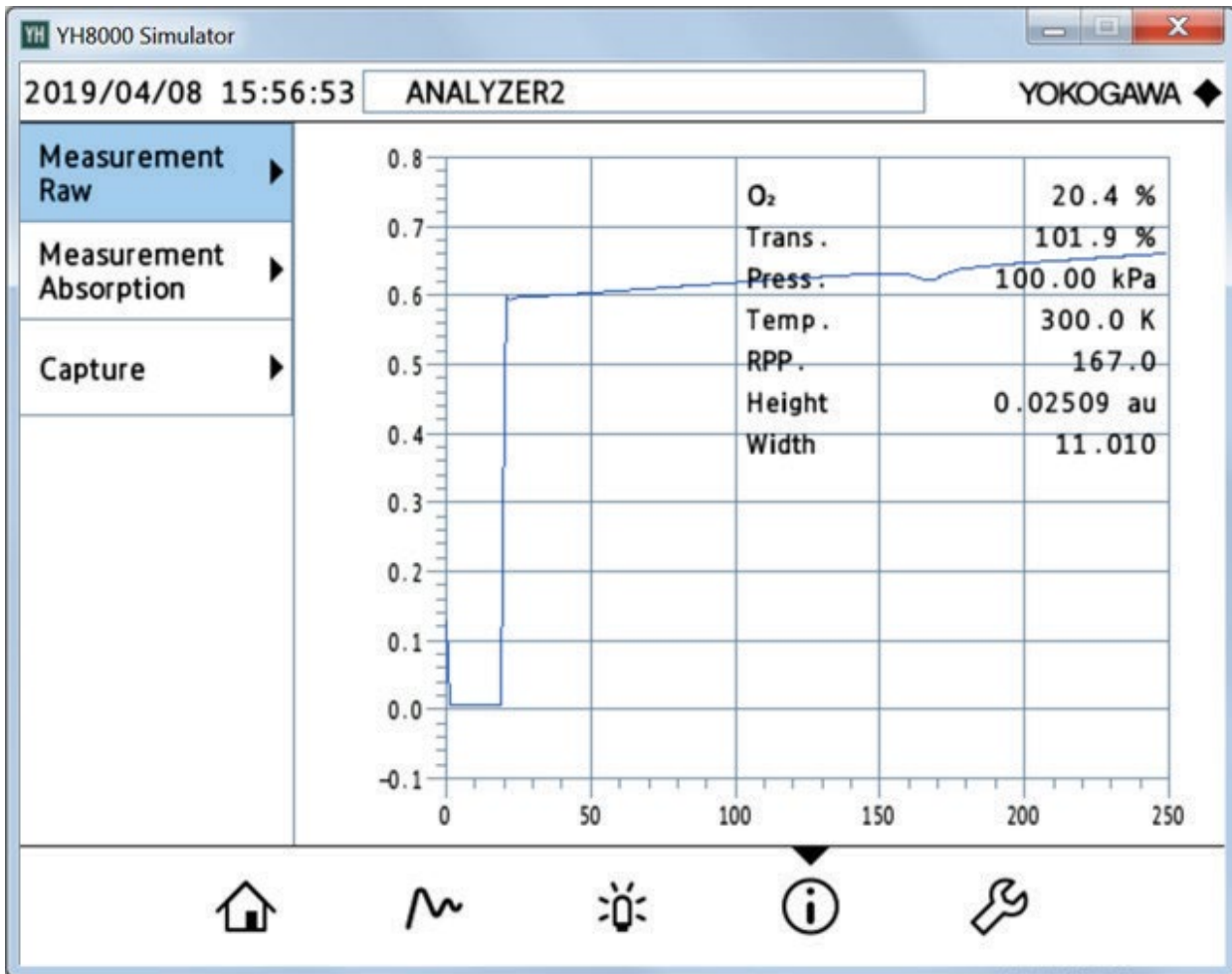
Fine adjustments can now be made.

Fine adjustments are made by separately focusing on horizontal and vertical positions as best practice. To do this, loosen the back nuts on the quick connector flange a couple of turns, taking care not to lose rough positioning, but not leave the nuts so tight that they cause the flange to bind while you're making adjustments to the nylon lock nuts. Focus on only making movements in the vertical direction first by tightening the nylon lock nuts on the top and bottom of the analyzer a quarter of a turn at a time. Remember to wait for two measurement updates between making adjustments, and take care to not let the stainless back nuts bind. After transmission is optimized in the vertical position you can move to aligning the horizontal plane a quarter of a turn at a time. Make sure that the face of the quick connector flange is making contact with the nylon locknuts during adjustment, otherwise when you tighten the stainless back nuts in the end your alignment will be slightly different. After alignment is complete in the horizontal position, repeat the process again in both the vertical and horizontal positions, and finally tighten the stainless back nuts on the back side of the analyzer's quick connect flange.

Now proceed to repeat this on the SCU side of the analyzer once, return to the LU to make a final adjustment, and finally repeat the process on the SCU side of the analyzer to complete alignment.

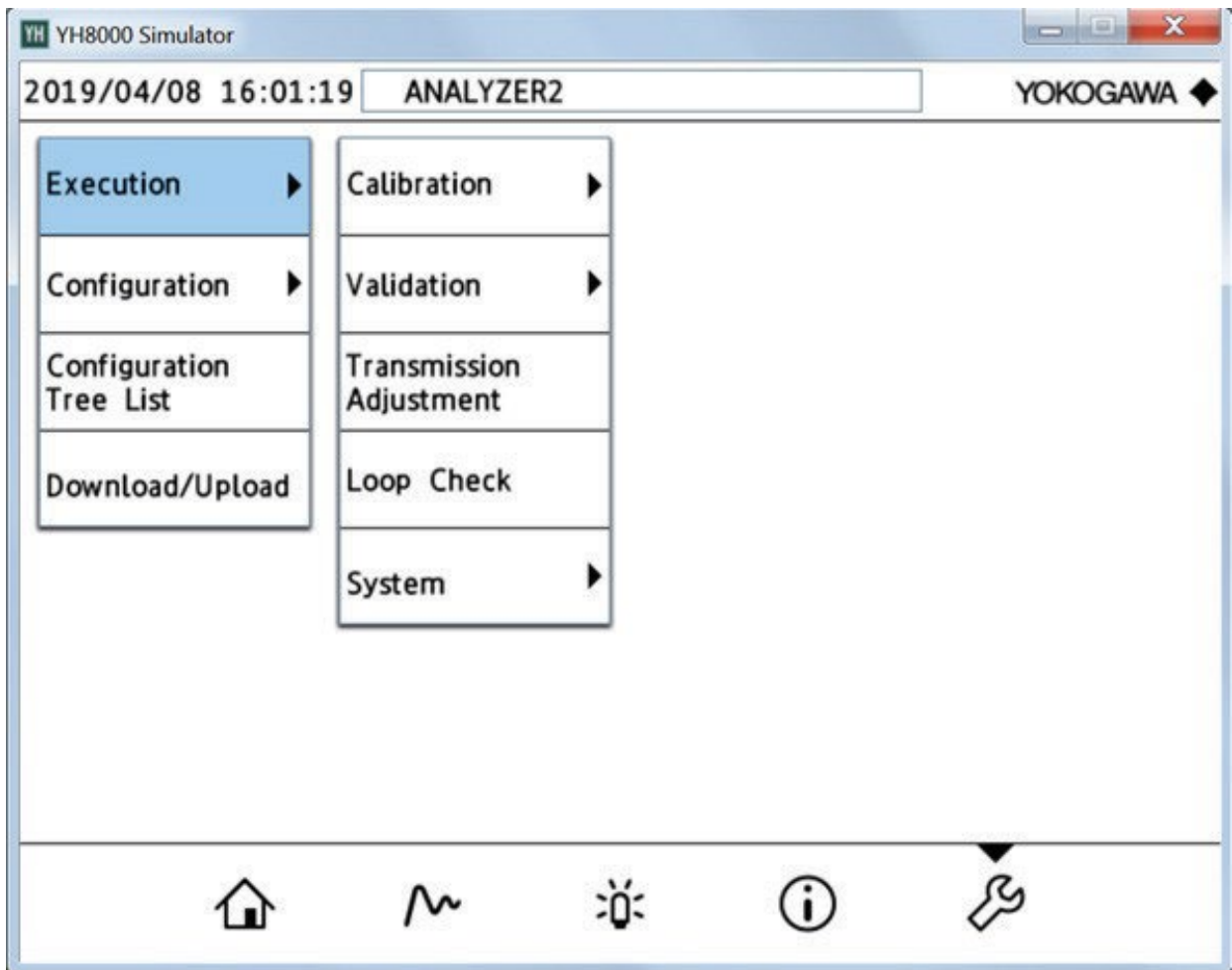
6.3 Calibrating Transmission

After connecting to the analyzer with the HMI or PC-HMI software, check that the detector signal looks good by selecting the information screen and “Measurement Raw” tab.

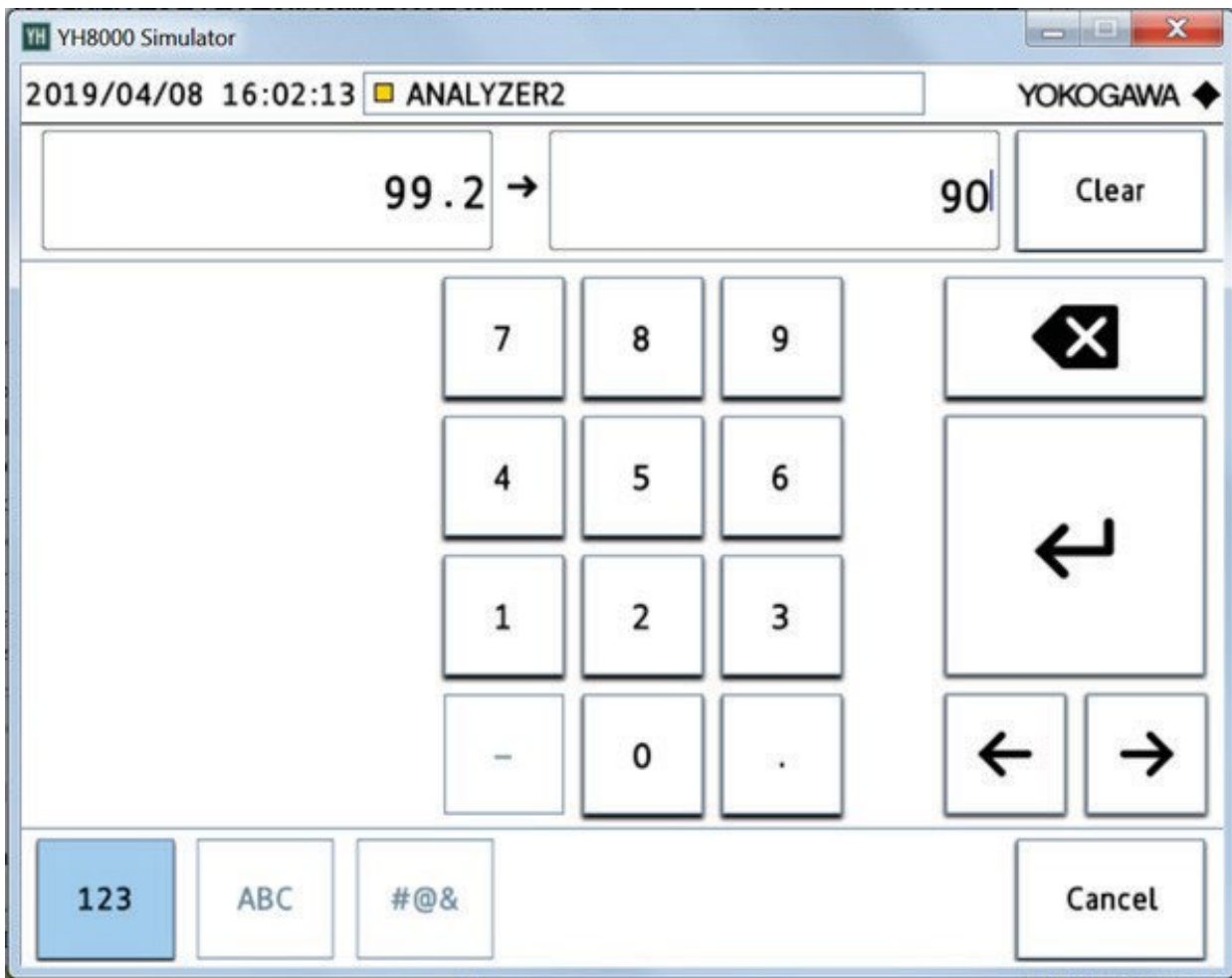


If you do not see at least a 0.2V differential between the lowest and highest parts of the gain curve on the Y-axis then please contact Yokogawa service. If you have a gain curve differential between 0.2V and 0.8V then transmission can be calibrated.

To calibrate transmission click the wrench at the bottom of the screen, enter your user password (default is '1234'), then select Execution and Transmission Adjustment.



A good number to select is 90 for the new transmission percentage. Enter this value then press the enter key to now have transmission calibrated at 90%.



The reprogrammed transmission number will now give a good diagnostic regarding how much signal the analyzer has compared to what the signal was like when the transmission was optimized. It is normal for the transmission to drop when the process is coming up to temperature as there will be some expected mechanical movement. It's important that the signal stays above 20% however. Please contact Yokogawa if the units experience complete transmission loss as an effect of the process starting. If the transmission slowly drops over time when the process is up then there likely is an issue with the windows being coated, and purge rates should be inspected as a result.

Ideally a validation will be performed at the end of this activity to ensure proper peak response.

7. Contact Us

If you feel uncomfortable performing any of the activities outlined in the procedures above or have any questions then please contact us at 1-800-524-SERV (7378) or YCA-support@yokogawa.com.

Revision Information

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■ For Questions and More Information

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