TDLS8100/8200 Probe Sampling

Tunable Diode Laser Spectrometer

Introduction

Figure 1 below illustrates general architecture utilized in Yokogawa's TDLS probe offerings.

- The laser and detector are integrated into a single optical module.
- The laser exits the optical module, passes through the process window, traverses the process gas measurement area, hits the retroreflector, makes another traverse through the process gas measurement area and optics, and light is received at the photodetector in the optical module.
- In all probe offerings, the process measurement gas area opening 0.5 meters, yielding a total optical path length of 1.0 meters.
- The opposing side of the process measurement area contains slots at the far ends to sweep optics and retroreflector purges.

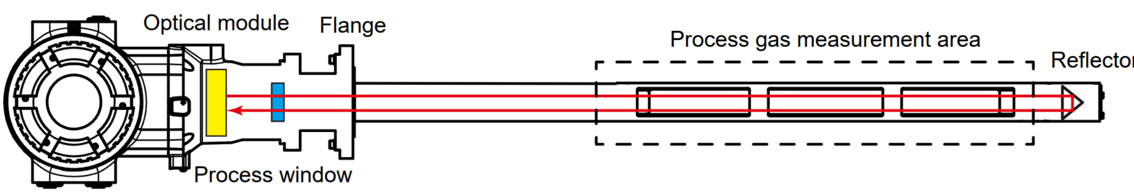

Figure 1

General Installation

As shown in Figure 2, the measurement area openings should face the downstream direction of the process flow, while the slots for sweeping the purge should face the upstream direction. A common concern regarding the above diagram surrounds the speed at which the measured sample would be exchanged with the probe body shielding sample flow in the upstream direction, as common logic would infer that the measurement area in the probe body would remain stagnant.

With sufficient flow established the internal sample area does not remain stagnant however due to vortex shedding. With enough flow across the probe body, low-pressure vortices are created on the downstream side of the body, in which the measured gas will reverse current and swirl into the void. Of course, sufficient flow must be established to create turbulence across the body for this to be valid. Sufficient flow must also be established to permit sweeping of the optics and retroreflector purge on the upstream side of the probe as well. Yokogawa has defined the minimum process linear velocity threshold as 1 meter per second to obtain a successful measurement (+/-2% of reading), with at least 5 meters per second being ideal. The probe has been physically tested in the presence of linear velocities up to 30 meters per second without performance issues. Reading performance increases to +/-1% of reading with process velocities in the range of 5 to 30 meters per second.

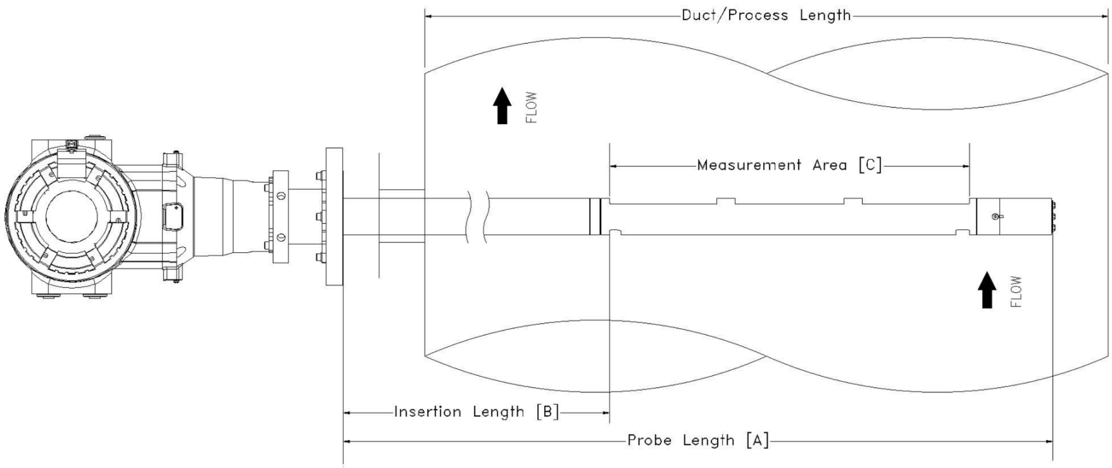

Figure 2

Engineering Design

Another engineering challenge considered aside from aforementioned fluid dynamics, and associated vibration, surrounded thermal stability of the body, optics, and transition area between the measurement gas and purge. Elevated temperatures cannot be only considered from mechanical stability and impact to fluid dynamics standpoints, but also how light is refracted between hot and cold gases, changing the stability of the optical axis if the gradient is not well defined. Our dual wall probe and baffle designs counteract that issue to have a well-defined gas temperature and concentration gradient:

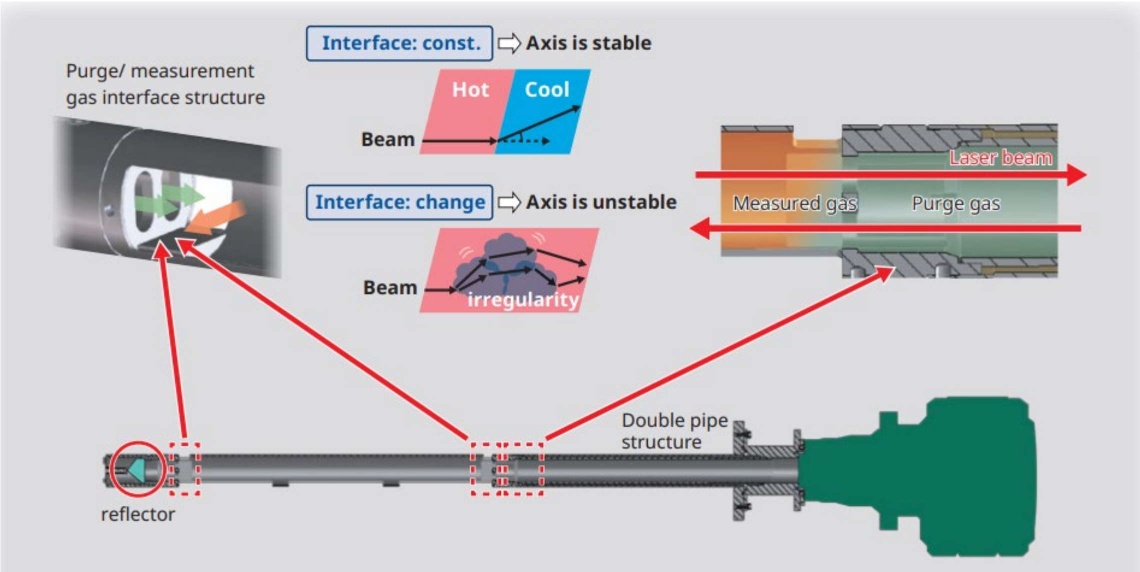

Figure 3

Analyzer Purging

Ideal process window and retroreflector purge rates vary for each application by process flow rate and temperature highlighted in the below table. Naturally purge requirements decrease as temperatures increase due to reduced density, and purge requirements increase as process flow rates increase. The relationship is linear between required purge flows and the varying constraints. Although technically possible to dynamically adjust purge rates as these conditions change, it present somewhat of an economic challenge to cost-effectively automate this function. An acceptable compromise in this circumstance is typically to set purge flows in accordance with typically expected process temperatures and flow rates. Measured concentrations may be slower to respond until minimal process flow rates are achieved, primarily impacting natural draft systems where there is no forced or induced air movement. It also should be noted that the measurement may output false low readings until a suitable process velocity for sweeping purges can be established. Generally, oxygen concentrations are relatively high until operational flow rates are established for combustion systems, and this error is acceptable. It also should be considered that carbon monoxide and methane will also register as false low, which is in the dangerous direction. Startup permissive limits for methane may need to be adjusted to accommodate false low readings if purge flow adjustments for different operating scenarios are not a practical consideration. Carbon monoxide limits should also be considered but may not have the same issues due to the draft established after initial light off. It is worth noting that flameout scenarios typically see very rapid rates of change in both carbon monoxide and methane, and consideration could also be given to incorporating rate of change logic in tandem with finite actionable limits. The example below provides quantitative examples of error for an oxygen measurement, but the percent of reading deviation logic would apply for any gas:

Process Velocity (m/s)	Purge Flow (L/min)	O2 (%)	% of Reading Deviation
0	1	19.63	-6.08
0	2	18.88	-9.67
0	3	18.11	-13.35
0	4	17.65	-15.55
0	5	12.14	-41.91

Table 1

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