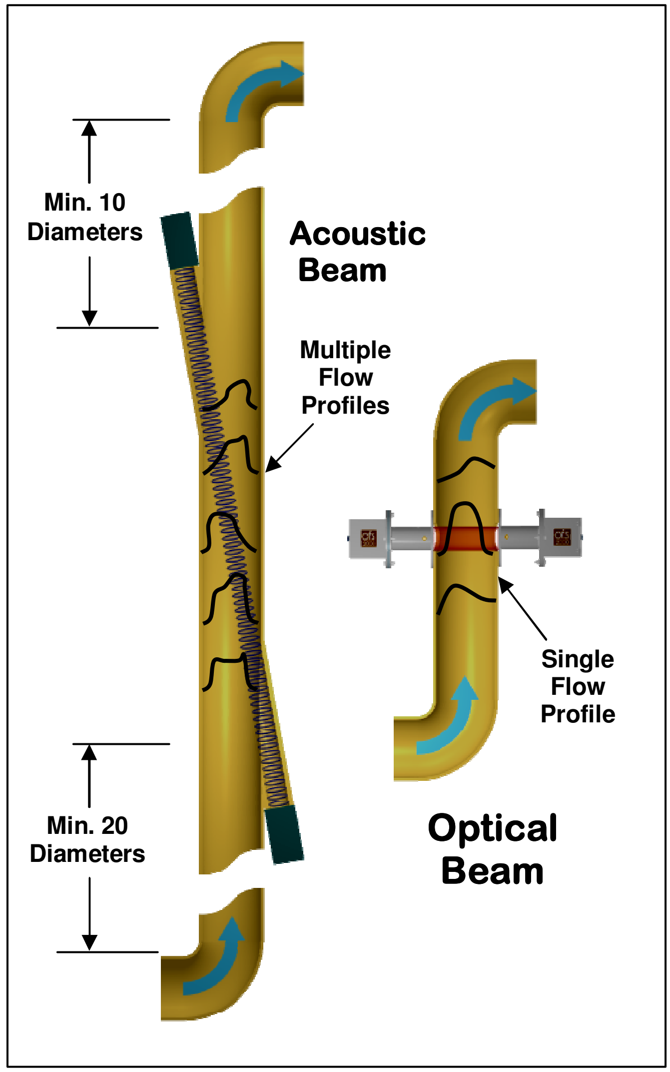
Optical Scientific, Inc.

Pipe & Stack Linear Placement Advantage for OFS

One of the major concerns for installing a flow sensor is the placement requirement for some amount of leading and trailing linear length from bends or flow disturbances in the pipe or stack. Because the flow is constantly changing its profile along the flow path, the best location for any flow sensor is always at the place where the flow profile is well developed (consistent). For different types flow sensors, the placement requirements are different. Most types need very long and straight runs while a few, like the OFS, can tolerate a much shorter linear length.

The figure at right shows a typical pipe installation for two different types of flow sensors. The OFS (using an optical beam) is installed perpendicular to the flow direction. It projects a beam of light across the same cross-section area of the flow. The total amount of flow is the flow speed times the cross-section area at that location.



The OFS provides a line-averaged flow measurement that is most representative to the overall flow profile across that cross-section area. Whereas the ultrasonic flow sensor is required to install at an angle (usually 45^{o}) to the flow. It is clear that the flow profiles change along the flow direction.

The ultrasonic sensor transmits a slant-path sound wave across different cross-section areas with different flow profiles as shown in the figure. It is more sensitive to the profile changes along the path. Therefore, to obtain a representative flow measurement for an ultrasonic sensor, a more uniform (or well-developed) flow profile location is required.

Usually the ultrasonic sensor cannot make a representative measurement unless there is a linear length more than 20 times the pipe diameter leading and 10 times the pipe diameter trailing from the elbow. However, this requirement can be greatly relaxed for the OFS.

Because the OFS light beam shoots across the same flow profile cross-section, the OFS can make accurate representative line-averaged measurements, even for a less developed flow profile.

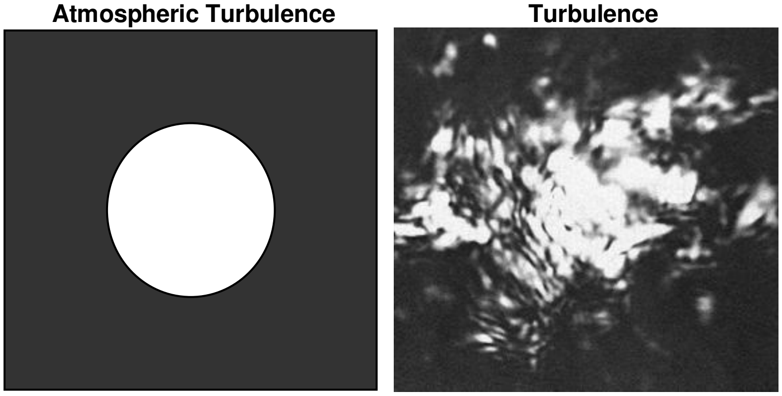
Usually linear lengths more than **two** times the pipe diameter leading and **one** times the pipe diameter trailing are good enough for OFS to make a representative flow measurement. For some extreme cases, OFS were installed right at the elbow of a pipe and provided satisfactory measurements.

OFS Technology Overview

OSI's Optical Flow Sensor technology is based on two concepts:

1) **Optical Scintillation (Light Fluctuation)**
2) **Temporal cross-correlation (i.e. Time of Flight)**

Light *without* Atmospheric Turbulence | **Light *with* Atmospheric Turbulence**



The left-hand picture shows how light behaves without atmospheric turbulence (as in the vacuum of space). The right-hand picture demonstrates the diffusion of light (a.k.a. optical scintillation) caused by atmospheric turbulence, which exists in the air everywhere.

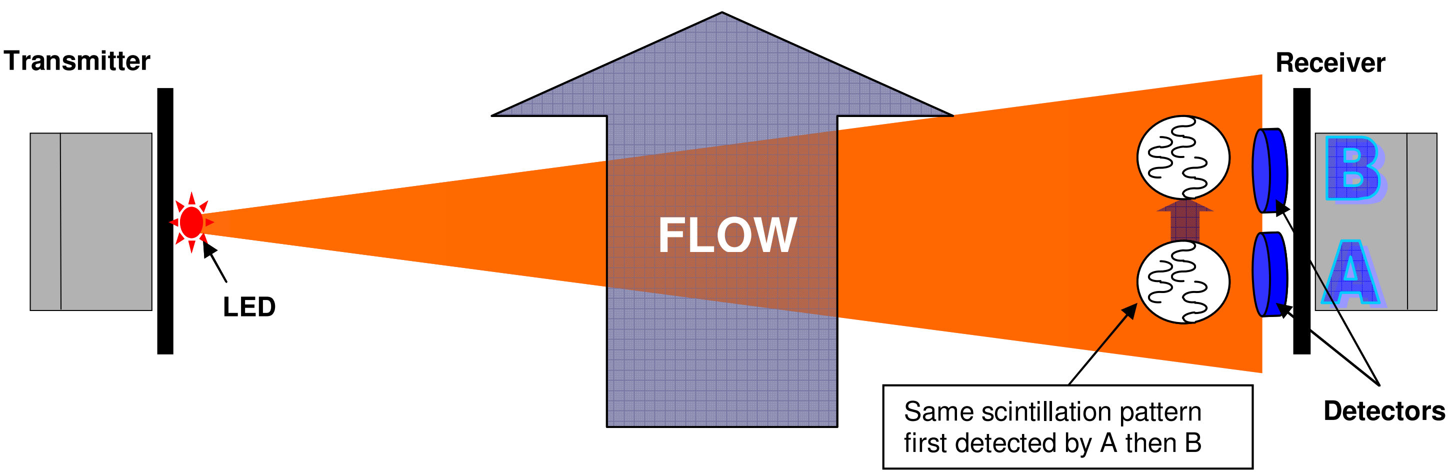
Scintillation **–** the refraction or diffraction of light through air pockets with different temperatures & densities (i.e. atmospheric turbulence).

Optical scintillation induces light fluctuations. This phenomenon is a measurable atmospheric condition. The method employed to measure scintillation has been in use for over **30 years** in atmospheric remote sensing.

Examples of scintillation – the light shimmering off a blacktop road on a hot day or the twinkling of a star at night.

★ ***OFS technology is independent of the media temperature, pressure, humidity & opacity!***

Temporal Cross-Correlation



Temporal Cross Correlation **– A Statistical Method to Measure Time of Flight:** OFS measures the movement of scintillation "cells." Detector A senses the scintillation pattern first and then detector B senses the same pattern as it moves through the beam and past both detectors. OFS measures the ***time*** at which this pattern is detected at each point and knows the ***distance*** between the two detectors. **Using** advanced digital signal processing and temporal cross-correlation, OFS can calculate the ***velocity*** of the flow:

Velocity = distance / time

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