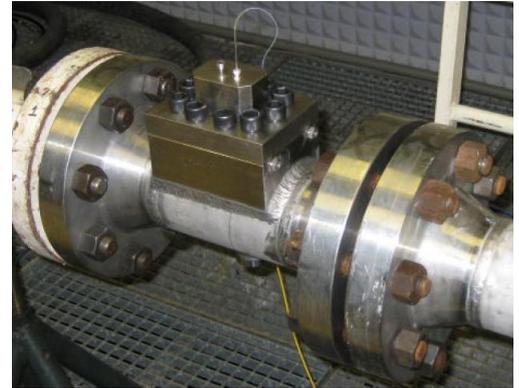
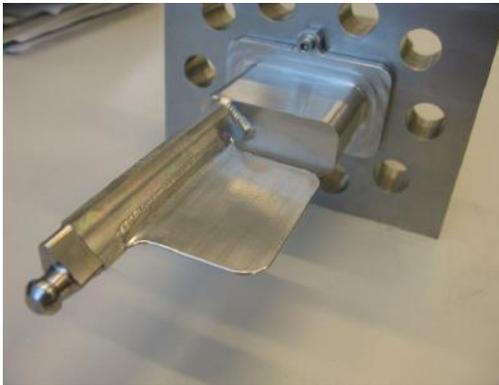


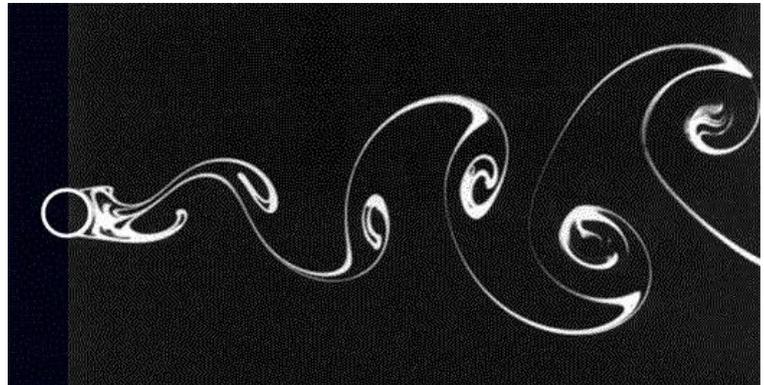
- FBG vortex shedding flowmeter suitable for liquids and gases
- Also measures density from which steam quality and thermal mass flow is derived
- No electronics enables ultra-harsh environment use
- Intrinsically safe operation with ATEX certified SmartScan interrogator
- Numerous meters can multiplex to a single, remote instrument
- Surface, subsea or downhole application
- Designs available for 1" to 12" lines



SmartFlow on a 3" test loop



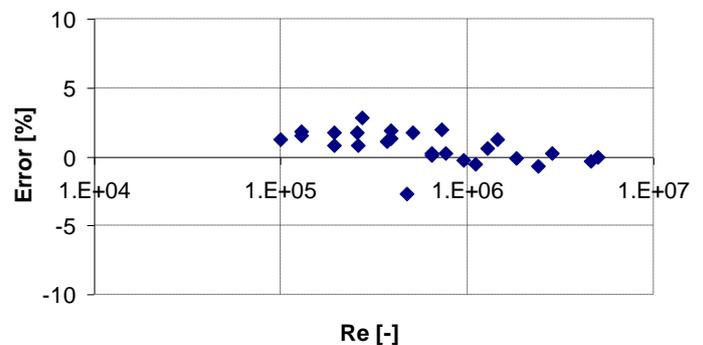
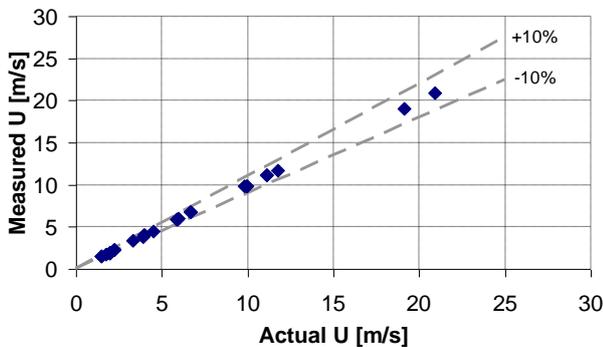
Smart Flow's bluff body and FBG sensor plate



Vortex shedding from a bluff body

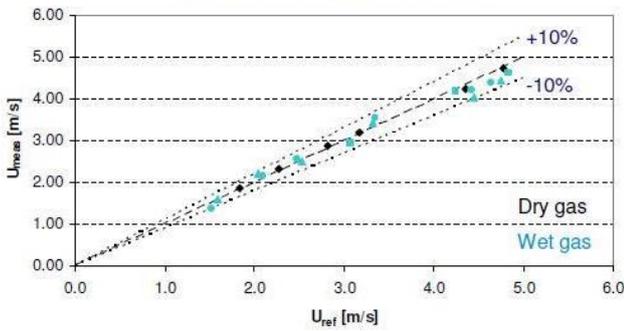
Vortex flowmeters operate by measuring pressure variations associated with vortices shed from a 'bluff body' in the flowline. Traditional devices use piezoelectric sensors which require associated electronics, so limiting their application in harsh and hazardous environments. SmartFlow addresses this limitation by combining vortex shedding flow measurement techniques with FBG sensing advantages. The result is a meter capable of withstanding extremes of temperature, vibration, magnetic field and radiation, whilst operating in hazardous areas without expensive associated Ex rated electronics. This then enables more affordable and practical flow measurement in such applications as steam plants, subsea and downhole oil & gas, LNG flowlines and nuclear reactors.

SmartFlow was tested in dry gas at pressures between 1 and 40 bar, showing linear performance at various pressures and demonstrating good accuracy across a range of Reynolds numbers. The meter was also tested in wet gas at up to 30% mass fraction of liquid, achieving accuracies better than 10% for wet gas.

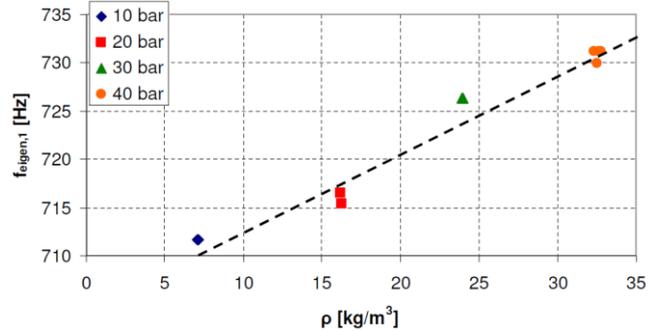


SmartFlow measurement in dry gas and measurement error against Reynolds number

A further, unique SmartFlow feature comes from the FBG data processing scheme. For conventional, electronic based vortex flowmeters, sensor data is typically encoded into a simple 4-20mA signal at the point of measurement, at which point all further, detailed measurement data is lost. For SmartFlow, high frequency signals from the FBG sensors are transferred to the remote instrument and fully analysed for data content. This data was found to contain a signal representing the Eigenfrequency of the sensor plate that correlates directly with the density of the flowing fluid. For steam flow applications, this leads to the highly sought after capability of combined steam flow and steam quality measurement from a single, inexpensive meter.



SmartFlow measurement in dry and wet gas



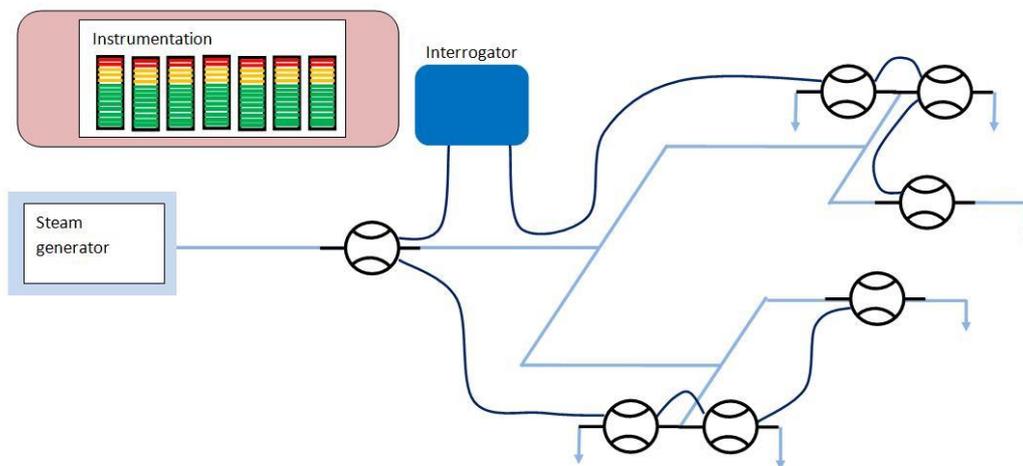
Correlation between Eigenfrequency and fluid density

The multiplexing capability of FBG technology allows for a system wherein dozens of SmartFlow meters across a facility can be simultaneously interrogated with a single SmartScan interrogator, [ATEX certified](#) as required. For use in a surface facility, the interrogator can be located in a safe area control room. For downhole or subsea use, the interrogator can be located in a suitable surface location some tens of kilometres distant from the point of measurement.

Provisional performance highlights (SmartFlow is under continual development so please contact us for updates)

	Unit	Specification
Maximum Operating Pressure	Bar	140
Maximum Operating Temperature	°C	350
Turndown Ratio	-	>15
Measurement error	%	Typ <2 (<10 for wet gas)
Steam quality accuracy	-	10% to 20% *
Pipe size	Inch	1 to 12
Routine maintenance	-	None
Recalibration interval	-	Not applicable
Multiplexing capability	-	Typically 16 flowmeters per fibre Interrogators available for 1 to 16 fibres

* Further details of the steam quality measurement capability is given in the technical paper at www.smartfibres.com/docs/SmartFlow_techncial_paper.pdf



Example SmartFlow Application – Steam Flow and Steam Quality Measurement at Multiple Steam Injection Wells

SmartFlow is a joint development between Smart Fibres and TNO, and its design is protected by TNO patents.