

Flow Measurement Solutions for Thermal Cracking Processes

Single Source for Proven Sensing Solutions

Refineries use thermal cracking processes to meet the demand for distillates and to increase capacity for handling heavy residual oil in order to improve profitability. Higher crude costs force refiners to wring the most out of their feedstock. Delayed coking is a common operation in converting residual oil to profitable products.

GE's Panametrics line of flow products provides refiners accurate and repeatable measurement of residual oil fed into vacuum distillation, coker and cracking units. Ultrasonic meters used in residual oil applications maximize reliability and eliminate the repetitive maintenance needed by other meter types, increasing productivity.

Bundle Waveguide Technology™ provides total repeatability in measuring critical cracking furnace feed velocity rates. This reliability enables operations to reduce cycle times, run at higher coil outlet temperatures, higher pressure and to reduce recycle rates. The cumulative benefit of this technology will increase profit by tens of millions of dollars over the life of the unit.



Applications

- Flow measurement of:
 - Atmospheric distillation bottoms feed to the vacuum distillation furnace
 - Vacuum distillation bottoms feed to the delayed coker fractionator
 - Coker fractionator heavy gas oil recycle to the delayed coker furnace
 - Vacuum distillation unit recycle
 - Heavy gas oil to fluidized catalytic cracking unit
- Mass flow measurement of furnace fuel gas



Ultrasonic Flow Measurement of Residual Oil

Residual oil applications present unique difficulties for instrumentation, requiring flow meters to handle heavy, sour and low-quality oil in high pressure, high temperature applications. Panametrics flow technology succeeds in this harsh environment where other instrumentation fails.

The generation of coke particles created by the thermal cracking process and residual oil recycling makes this application especially difficult for vortex flow measurement technology. Coke fines inhibit the movement of the shedder bar, making frequency measurement for determining flow rate unreliable. This degree of unreliability makes it more difficult to operate the unit and increases the risk of fire, equipment damage and personal injury. These problems require more frequent spalling, which reduces production rates. A flow measurement technology that introduces an obstruction to the flowing furnace pass line can promote plugging, give unreliable information and contribute to furnace coil fouling.

Measuring cracked residual oil flow is especially difficult for differential pressure flow meters. Constriction inherent to wedge flow meters or orifice plates traps chunks of coke that plug furnace pass lines, shut the unit down or trip the furnace. Associated plugging of impulse lines requires significant maintenance.

Algorithms used to control furnace coil fouling can be optimized with GE's Panametrics ultrasonic transit-time flow meters using the Bundle Waveguide Technology™ (BWT™) system, providing accurate and reliable feed flow measurement when measuring residual oil.

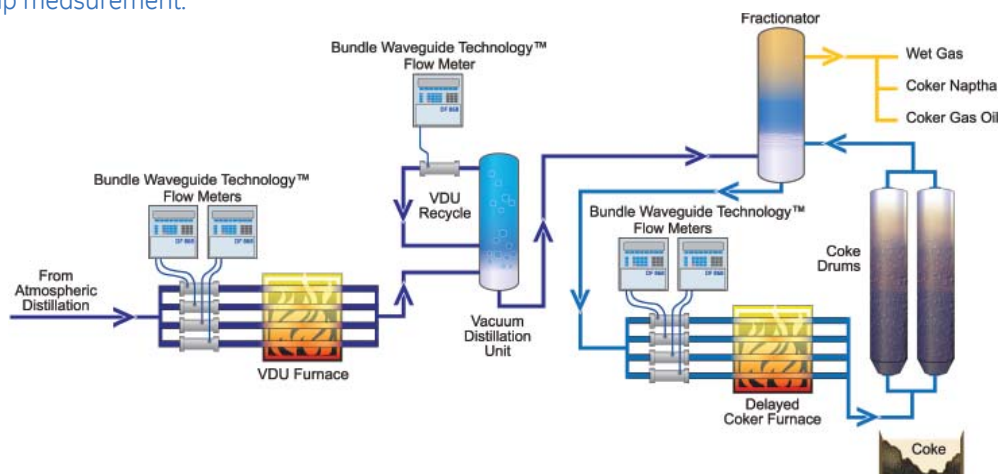
Measuring recycle rate is crucial in determining unit efficiency. Accurate measurement of feed to the fractionator and furnace, and individual furnace pass line flow rate, provides a means of comparable flows as a second, back up measurement.

The use of flushing oil to maintain the impulse lines associated with differential pressure-based flow measurement technology reduces production rate of any thermal cracking process. Consider the number of taps per heater pass line and passes per furnace, as well as the flow rate of the flushing oil into the system. This cumulative volume of flushing oil over the 30- or 40-year life of the unit displaces hundreds of thousands of barrels of valuable heavy gas oil and reduces coker feed capacity—ultimately costing the unit millions in lost production.

Fuel Gas

Controlling a delayed coker furnace is primarily accomplished by monitoring furnace coil effluent temperature. Due to the variability in how fuel gas is produced in a refinery, the energy content of fuel gas can vary. Temperature control of the furnace can be optimized by cascading in a feed forward loop of fuel gas average molecular weight to augment the coil outlet temperature-based feedback loop in the furnace control strategy. Very similar to GE's Panametrics flare gas flow technology used in refineries since the early 1980s, this same technology can provide both volumetric and average molecular weight information in a single flow meter. This measurement is independent of changes in the fuel gas content and is not based on any model composition.

Ultrasonic transit-time flow technology can be used to increase production, improve unit operations efficiency, reduce maintenance cost and reduce risk by providing reliable, repeatable and accurate flow measurement information. GE offers advanced flow measurement technology that excels in these rigorous applications while delivering the lowest cost of ownership.



Location of GE's Panametrics flow meters in a typical refinery

Real World Experience on Furnace Feed Lines

A Texas refinery needed a more reliable technology to measure residual oil into its vacuum distillation and delayed coker units. The goal was to reduce the failures, risks and high maintenance costs associated with its unreliable vortex flow meters. Although ultrasonic flow meter performance in this application was unproven, GE offered a no-risk evaluation with one unit.

GE's BWT System operated so successfully that after only two weeks of trial performance, the refinery installed GE ultrasonic flow meters in place of vortex meters on 16 pipelines—eight 4-inch (101.6 mm) lines into the vacuum distillation unit and eight 3-inch (76.2 mm) lines into the delayed coker furnace.

Despite the presence of coke fines in these thermal cracking processes, GE's Panametrics flow meters have provided reliable and repeatable furnace feed flow rate information since installation in 2001. This high degree of reliability has reduced the risk of shutdown and furnace trips. Risk of fire, equipment damage and personal injury has also been reduced. Since installation of the BWT System for these applications, neither unit has suffered a trip or shutdown due to feed meter problems. Avoiding even one shutdown can prevent significant production loss over the life of the unit.



Flow meters installed on the vacuum distillation column feed



Meter body with BWT system showing redundant path configuration

Cost Savings Analysis

GE Panametrics DigitalFlow™ DF868 liquid ultrasonic flow meters and PanaFlow™ Meter Systems using Bundle Waveguide Technology™ (BWT™) transducers are the cost-saving solution for flow rate measurement of residual oil.

In an application similar to the Texas refinery's, replacing 16 vortex meters with GE ultrasonic flow meters could save almost \$36,000 in annual maintenance costs alone.

Assumptions:

- One vortex meter fails or requires maintenance almost every week
- Ninety percent of those return to operation after a steam cleaning, requiring two operators and four hours of labor with an average labor cost of \$50 per hour
- Ten percent require removal from service, requiring up to five operators, pipefitters and technicians and six hours of labor with an average labor cost of \$50 per hour

	Failures	Hours	Labour \$	People	Cost
Steam Clean	47	4	\$50.00	3	\$28,200
Remove	5	6	\$50.00	5	\$7,500
Annual Maintenance Savings					\$35,700

Benefits of Ultrasonic Transit-Time Flow Measurement with Bundle Waveguide Technology™ System



BWT full bore meter body that will not clog

- No obstruction or pressure drop
- No calibration or maintenance required
- Will not clog from solids in residual oil
- Accuracy, 1% of reading; repeatability 0.5% without recalibration
- High turndown, 1 ft/s to 40 ft/s
- Excellent low-end resolution
- Transducers are removable under flowing conditions
- Single, redundant and triple-redundant configurations available
- Retrofits: match face-to-face of existing meters

Advanced Flow Metering

Low Pressure Drop, No Maintenance

Ultrasonic transit-time technology offers unique advantages over differential pressure and vortex shedding-based technologies. Ultrasonic meters create no pressure drop or obstruction to flow, have no moving parts and nothing to wear out. There is very little maintenance required and the technology requires no recalibration...ever.

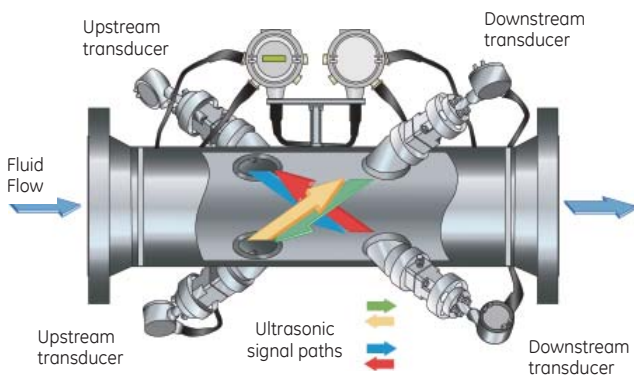
Proven reliability, low maintenance requirements, elimination of the need for flushing oil and better accuracy mean significantly lower cost of ownership when compared to differential pressure or vortex shedding meters.

Transit-time ultrasonic technology can be used on lines as small as three inches in diameter. When used to replace wedge flow meters, GE ultrasonic meter bodies match standard wedge meter elements' face-to-face dimensions. The low velocity accuracy and repeatability of GE's ultrasonic transit-time meters are markedly superior to alternative technologies for this application.

Transit-Time Technology

GE's Panametrics ultrasonic transit-time flow meters are capable of measuring flow rates of many steam, liquid and gas applications for the oil and gas industry. Typical applications require a pair of transducers that are mounted across the pipeline from each other. Each transducer is mounted upstream/downstream of the other. The transducers contain piezoelectric crystal elements encapsulated within a metal housing. The meter's transmitter drives the alternate upstream and downstream transmission of ultrasonic sound pulses between the transducer pair and measures the transit times in both directions.

If there is no flow, the transit times in both directions are equal and the time difference is zero. The greater the velocity, the greater the time difference between upstream and downstream ultrasonic pulse transit times.



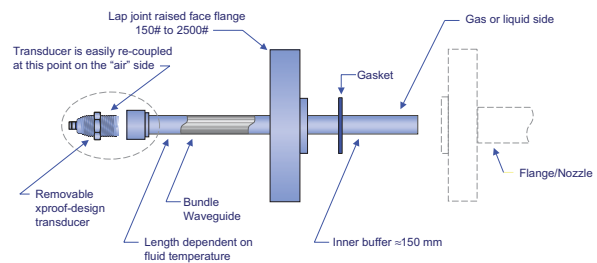
Transit-time flow measurement technique

The time difference is proportional to the velocity of the flowing fluid. Using the path length (P) and axial dimension (L), flow velocity can be calculated directly. Knowing the size of the pipe allows the meter to calculate the volumetric flow rate by multiplying the velocity by the cross section area of the pipe ($Q = V \cdot A$).

Bundle Waveguide Technology™ (BWT) System

The BWT System is a fiber-acoustic bundle comprising tightly packed cylindrical elements that provide a path for the ultrasonic signal to travel from the transducer into the flowing fluid and to the opposite transducer.

The design of the BWT System provides two major advantages. First, flow meter transducers use piezoelectric crystals, which have a temperature limitation. At about 400°F (204.4°C), the crystals can lose their piezoelectric properties from oxygen loss, resulting in permanent transducer failure. Isolating the piezoelectric element of the transducer from the high temperature fluid using a buffer keeps the element near ambient temperature, thus preventing any potential for temperature damage.



BWT system

Second, similar to fiber optic technology, bundling the elements allows transmission of a highly collimated beam of ultrasound into the fluid, producing a high signal-to-noise ratio for robust, stable measurement in the most difficult applications.



BWT removed from coker feed furnace for inspection

The BWT System does not foul and is designed to withstand the extreme conditions encountered in residual oil measurement. The system is proven to operate reliably over many years without requiring maintenance or recalibration. Fouling does not obstruct signal transmission/reception due to the system's high signal strength.



PanaFlow with XMT868i flow meter and transducers

PanaFlow™ Meter System Specifications with Bundle Waveguide Technology™ System

Operation and Performance

Fluid Types

- Liquids: Acoustically conductive fluids, including most clean liquids, and many liquids with entrained solids or gas bubbles.
- Gases: All acoustically conductive gases
- Saturated and superheated steam

Pipe Sizes

2 in to 24 in (50 mm to 600 mm)

Pipe Materials

- Stainless steel (316 SS)
- Carbon steel

Wetted Flow Accuracy (Velocity)

Pipe Size in (mm)	Velocity Range ft/s (m/s)	Accuracy, Volumetric Flow (% of reading)	
		Single Path	Dual Path
2 to 4 (50 to 100)	1.5 to 3.0 (0.5 to 1.0)	±1.5%	-
	>3.0 (>1.0)	±1.0%	-
6 to 24 (150 to 600)	1.5 to 3.0 (0.5 to 1.0)	±1.5%	±1.0%
	>3.0 (>1.0)	±1.0%	±0.7%

Assumes a fully developed flow profile (typically 10 diameters upstream and 5 diameters downstream of straight pipe run for liquids and 20 diameters upstream and 10 diameters downstream of straight pipe run for gases or steam) and single-phase fluids with constant viscosity. Applications with piping arrangements that induce swirl (e.g., two out-of-plane elbows) may require additional straight run or flow conditioning. Accuracy of ±0.5% may be attainable for most meter sizes and applications with process calibration. Dual-path meters are not recommended for wet or saturated steam.

Repeatability

- Liquids: ±0.1 to 0.3% of reading
- Gases: ±0.2 to 0.5% of reading

Range (Bidirectional)

See Installation Requirements Table

Rangeability (Overall)

- Liquids: 400:1
- Gases: 150:1

Measurement Parameters

Dependent upon meter electronics used. Please refer to individual flow meter electronics product data sheets.

Wetted Ultrasonic Flow Transducers

Temperature Ranges

- Liquids, normal temperatures: -310°F to 600°F (-190°C to 315°C)
- Liquids, high temperatures: -310°F to 1,112°F (-190°C to 600°C)
- Gases, normal temperatures: -60°F to 300°F (-50°C to 150°C)
- Gases, high temperatures: -60°F to 500°F (-50°C to 260°C)
- Gases, extended temperatures: -310°F to 842°F (-190°C to 450°C)

Pressure Range

- Liquids: Up to maximum allowable flange operating pressure at temperature or 3480 psi (240 bar)
- Gases: 0 to 2700 psig (1 to 187 bar)
- Gases, extended temperatures: Minimum process pressure required is typically 100 psi (6.9 bar), depending on fluid density

Transducer Materials

- Standard, liquids and extended-temperature gases: 316L stainless steel
- Standard, gases: Titanium
- Optional: Other materials available on request

Meter Body Materials

- 316 stainless steel
- Carbon steel

Area Classifications

- Explosion-proof Class I, Division 1, Groups C&D; Flameproof Ⓢ II 2 G EEx d IIC

Transducer Cables

- Integrated cables: Potted mineral insulated cable or armored cable with ATEX-certified cable glands (for use in Europe)
- Nonintegrated: Please refer to individual flow meter electronics product data sheets.



DigitalFlow XMT868i liquid ultrasonic transmitter

DigitalFlow™ XMT868i Transmitter Specifications

Operation and Performance

Fluid Types

Acoustically conductive fluids

Pipe Sizes

Wetted transducers: 1 in to 200 in (25.4 mm to 5 mm) and larger

Pipe Wall Thickness

Up to 3 in (76.2 mm)

Pipe Materials

All metals and most plastics. Consult GE for concrete, composite materials, and highly corroded or lined pipes.

Flow Accuracy (Velocity)

±0.5% of reading (achievable with process calibration)

Typical Wetted Flow Accuracy (Velocity)

±1% of reading

Accuracy depends on pipe size, installation and whether measurement is one-path or two-path.

Repeatability

±0.1% to 0.3% of reading

Range (Bidirectional)

-40 to 40 ft/s (-12.2 to 12.2 m/s)

Rangeability (Overall)

400:1

Specifications assume a fully developed flow profile (typically 10 diameters upstream and 5 diameters downstream of straight pipe run) and flow velocity greater than 1 ft/s (0.3 m/s).

Measurement Parameters


Volumetric flow, totalized flow and flow velocity

Electronics

Flow Measurement

Patented Correlation Transit-Time™ mode

Enclosures

- Standard: Epoxy-coated aluminum weatherproof Type 4X/IP66 Class I, Division 1, Groups B,C&D; Class II, Groups E,F&G; Class III Flameproof  II 2 GD EEx d IIC T5/T6
- Optional: stainless steel

Dimensions

Standard: Weight 10 lb (4.5 kg), size (h x d) 8.2 in x 6.6 in (208 mm x 168 mm)

Channels

- Standard: One channel
- Optional: Two channels (for two pipes or two-path averaging)

Keypad

Built-in infrared, six-button keypad, for full functionality operation

Power Supplies

- Standard: 90 to 260 VAC
- Optional: 12 to 28 VDC, ±5%

Operating Temperature

-40°F to 140°F (-40°C to 60°C)

Standard Inputs/Outputs

Two 0/4 to 20 mA isolated outputs, 600 Ω maximum load

Optional Inputs/Outputs and Alarms

All analog and digital I/O are available in specific combinations. Consult GE for available option cards.

Digital Interfaces

- Standard: RS232
- Optional: RS485 (multiuser)
- Optional: HART® protocol (available without keypad only)
- Optional: Modbus® protocol
- Optional: Foundation Fieldbus®
- Optional: OPC server
- Optional: Ethernet

Data Logging

- Standard: None
- Optional: Memory capacity (linear and/or circular type) to log up to 150,000 flow data points

European Compliance

System complies with EMC Directive 89/336/EEC, 73/23/EEC LVD (Installation Category II, Pollution Degree 2) and transducers comply with PED 97/23/EC for DN<25

Area Classifications

- Standard: General purpose
- Optional: Weatherproof Type 4/IP65
- Optional: Class I, Division 1, Groups B,C&D; Class II, Groups E,F&G; Class III
- Optional: Flameproof Ex II 2 G EEx d IIC T6
- Optional: Submersible

Transducer Cables

- Standard: One pair of coaxial cables, type RG62 AU, or as specified for transducer type
- Optional: Lengths up to 1000 ft (330 m) maximum

Bundle Waveguide Technology™ (BWT™) System Specifications



Bundle Waveguide Technology System transducers

High Temperature and High Pressure Ultrasonic Flow Transducers

Designation

BWT1

Material

316L stainless steel

Mounting

1 1/4 in straight UN thread

Connectors

- Standard: BNC
- Optional: Submersible

Temperature

-58°F to 212°F (-50°C to 100°C)

Frequencies

- 200 kHz for gases and steam
- 500 kHz or 1 MHz for liquids, depending on the application

Flanged Buffer Assemblies

Service

Liquids, gases and steam

Mountings

Lap joint flange, RF, 1.5 inch, 150#, 300#, 600#, 900#, 1500# and 2500# ANSI

Materials

- Standard: 316L stainless steel
- Optional: Titanium (FTPA/FIPA short buffers only), available to meet EN10243.1.B and/or NACE requirements

Pressure

To maximum allowable flange operating pressure at temperature or 3480 psi (240 bar)

FTPA/FIPA Short Buffers

- Fluid temperature: -310°F to 600°F (-190°C to 315°C)
- Minimum pressure (gas service): typically 100 psi (6.9 bar), depending on fluid density



FTPA extended buffer system (top) and FTPA short buffer system (bottom)

FTPA/FIPA Extended Buffers

- Fluid temperature:
 - Liquids: -310°F to 1,112°F (-190°C to 600°C)
 - Gases and steam: -310°F to 842°F (-190°C to 450°C)
- Minimum pressure (gas service): typically 100 psi (6.9 bar), depending on fluid density

Low-density, low-pressure gases use FIPA buffer assembly. No minimum pressure is required for liquid service. Consult GE for individual application specifications.

Threaded Buffer Assemblies

Service

Liquids

Mounting

1 in NPT

Materials

- Standard: 316L stainless steel
- Optional: Titanium

FSPA Short Buffers

Fluid temperature: -40°F to 212°F (-40°C to 100°C)

FSPA Extended Buffers

Fluid temperature: -40°F to 600°F (-40°C to 315°C)



FWPA extended buffer system (top) and FWPA short buffer system (bottom)

System

Area Classifications

- Explosion-proof: Class I, Division 1, Groups C&D
- Flameproof: Ex II 2 G EEx d IIC T6 KEMA 01ATEX2045

European Compliance

Complies with EMC Directive 89/336/EEC, 73/23/EEC LVD (Installation Category II, Pollution Degree 2), and PED 97/23/EC for DN<25

Pipe Sizes

2 in to 30 in (50 mm to 760 mm), larger sizes upon request

Velocity Ranges

- Gas service: 0.1 to 150 ft/s (0.03 to 46 m/s)
- Liquid service: 0.1 to 40 ft/s (0.03 to 12 m/s)

The maximum flow velocity specification for gases is variable, depending on gas sound speed, ultrasonic path length and gas density (pressure and molecular weight).

Socket-Weld Buffer Assemblies



FSPA short buffer system

Service

Liquids

Mounting

1 in socket weld

Material

Standard: 316L stainless steel

FWPA Short Buffers

Fluid temperature: -40°F to 212°F (-40°C to 100°C)



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