Ultrasonic Gas Meters for Industrial and Commercial Applications

Ohio Gas Association Technical Seminar
March 27-28, 2014
Objectives

- Technology
- Operation
- Benefits
- Applications
- Approvals and Standards
- Products
Ultrasonic: Basics

- Sound waves
- Acoustic (audible sound)
  - 20 Hz to 20,000 Hz
- Ultrasonic
  - Generally above 20,000 Hz
- Time of Flight
  - Velocity is determined based upon transit time of sound waves
Because of the larger flowing diameter, the profile of the gas can take various shapes. Therefore, multiple path measurements are required to determine the average gas velocity.
Ultrasonic pulses are produced with and against the gas stream. Pulses flowing with the gas velocity speed up; pulses flowing against the gas velocity slow down. The difference is used to calculate the gas speed or velocity within the known area.
Time of Flight Principles

- Piezoelectric transducers generate and detect waves
- Waves travel at the speed of sound of the moving fluid
- Velocity of gas is determined from the transit time of generated sound waves
- Sampling system: Spot measurement repeated at intervals averaging 2 seconds
- Volume (ft$^3$) = Velocity (fps) X cross sectional Area of flow tube (ft$^2$) X sample Time (s)
Ultrasonic Meter Schematic
Ceramic Crystal Operation

- A voltage difference across the faces of the ceramic causes it to oscillate
  - SONIX meters ~ 160 kHz.
- Matching layer amplifies movement, 20 times, and provides an efficient transfer of energy
Operation

\[
T_1 = \frac{L}{C+V} \quad T_2 = \frac{L}{C-V}
\]

so

\[
V = \frac{L}{2} \left( \frac{1}{T_2} - \frac{1}{T_1} \right)
\]

\[
V = \frac{L}{2} x \left( \frac{T_1 - T_2}{T_1 T_2} \right)
\]

- \( T_2 = \) Time of upstream firing
- \( T_1 = \) Time of downstream firing
- \( C = \) Speed of sound in gas
- \( V = \) Velocity of the gas
Ultrasonic Timing

- Time is measured two ways
  - Course measurement - number of clock pulses to receive pulse
  - Fine measurement - calculated by the phase of the final pulse
- The meter has to measure the “time of flight” of the ultrasonic pulse in nanoseconds ($10^{-9}$ sec) to achieve acceptable volume accuracy

$(0.000000001)$
Ultrasonic Timing

Figure 4. The relationship between the transmitted and received ultrasonic signals and the phase shift or delay time.
Speed of Sound Determination

\( T_1 = \frac{L}{C+V} \)

\( T_2 = \frac{L}{C-V} \)

\( V = \frac{L}{2} \left( \frac{1}{T_2} - \frac{1}{T_1} \right) \)

\( V = \frac{L}{2} \times \left( \frac{T_1 - T_2}{T_1 T_2} \right) \)

\( T_2 = \) Time of upstream firing

\( T_1 = \) Time of downstream firing

\( C = \) Speed of sound in gas

\( V = \) Velocity of the gas
Basic Operation Principles SONIX600/880
SONIX2000

4 Main Transducers
SOS Transducer

- Improves Meter Accuracy
- Diagnosis Meter Health
- Provides Tamper and Theft Detection
Basic Operation Principles SONIX600/880

Flow

SOS Transducer
SONIX2000

SOS Transducer
 Calibration

• Dry calibration
  • theoretical calibration
  • if the electronics are bad you don’t know it

• Flow calibration
  • compares the meter against a standard
  • Measurement Canada has regulated that all ultrasonic meters used for custody transfer be flow calibrated at a minimum of 40% of rated capacity
Proving

- Industry standard provers -- sonic nozzle--
  - A known volume is passed through the meter at two flow rates
  - Errors are averaged and calibration value stored into EEPROM
  - Recheck flow measurement at all flow rates
  - Meter identification and calibration are locked into memory
## SONIX Compatible Provers

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<th>Contact Person</th>
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<tr>
<td>Snap</td>
<td>130 Allatoona Dam Road, Cartersville, GA 30120</td>
<td>770-607-7272</td>
<td>Greg Germ</td>
<td></td>
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<tr>
<td>North American Services Group</td>
<td></td>
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<tr>
<td>Measurement Systems</td>
<td>6217 Stoney Hill Road, New Hope, PA 18938</td>
<td></td>
<td>Harry Deutsch</td>
<td><a href="mailto:harry@measurementsystems.com">harry@measurementsystems.com</a></td>
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<tr>
<td>Can-Tronics</td>
<td>16 Harlowe Road, Unit 3, Hamilton, Ontario, CANADA L8W 3R6</td>
<td>905-574-6488</td>
<td>Richard Juszczak</td>
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<tr>
<td>Energy Economics</td>
<td>109 South Street SE, Dodge Center, MN 55927</td>
<td>800-733-2557</td>
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SONIX880
Initial Factors
Speed 117    Spread 0
Speed and Spread Calibration Factors Calculated and Changed with a simple push of a button.

SONIX880
Final Factors
Speed 125     Spread 25
SONIX600 and SONIX880 In Service Performance

• 990 meters from 5 different utilities
• Meters produced from 2002 thru 2007
• Average mileage was 404,600 cf
• Maximum registration was 3,845,900 cf in 5 years
Histogram of Open

**Process Data**
- LSL: -2
- Target: 0
- USL: 2
- Sample Mean: -0.0250355
- Sample N: 991
- StDev: 0.488732

**Observed Performance**
- % < LSL: 0.20
- % > USL: 0.00
- % Total: 0.20
Histogram of Check

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<td>LSL</td>
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<td>StDev</td>
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<table>
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<tr>
<th>Observed Performance</th>
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<tr>
<td>% &lt; LSL</td>
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<tr>
<td>% &gt; USL</td>
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<tr>
<td>% Total</td>
</tr>
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</table>

Sample Mean: 0.119947
Sample N: 990
StDev: 0.382554

Histogram of Check

LSL: -2
Target: 0
USL: 2

% < LSL: 0.10
% > USL: 0.10
% Total: 0.20

Histogram of Check
Ultrasonic Meter Benefits

- No moving parts
- Accurate measurement including very low flows
- Compact size
  - Can fit existing meter installations
- Long term stability and accuracy
  - Eliminates sampling plans
- Health Check
  - Diagnoses meter health, accuracy as well as operating environment.
Health Check Benefits

- Flag
  - Letter displayed on LCD
- Diagnostic
  - Details obtained by interrogating the meter
- Problem Counter
  - Internal count of number of occurrences of operating events
Health Check Benefits

- ‘A’ Flag - Catastrophic Failure
  - EEPROM Checksum Failure
    - RAM index checksum check for match with EEPROM
- ‘A’ Flag is not cleared by power or diagnostic reset
- Meter stops working and needs to be returned to the factory
Health Check Benefits

- ‘b’ Flag - Major Event
  - Significant reverse or negative flow
  - Power reset
  - Fast sample mode entered
  - EEPROM reboot command
  - Air in meter
  - ‘b’ Flag may indicate potential tampering

- Meter continues to operate accurately
Health Check Benefits

- ‘C’ Flag - Major Operational Problem
  - Measurement problems occurring > 128 times per day
    - Unsatisfactory readings
    - Speed of sound (SOS) out of range
    - Rate of change of SOS out of range
  - Date of first and last occurrence, and number of occurrences recorded
  - Diagnostic & power reset clears records
- Meter continues to operate accurately
Health Check Benefits

- ’r’ Flag – Battery Life Warning
  - An ’r’ Flag will indicate that the battery has been installed for 9.5 years of operation.
  - Suggests battery change out at a convenient time.
Health Check Benefits

- ‘F’ Flag – Battery Life Warning
  - An ‘F’ Flag will indicate that the battery has been installed for 11.0 years of operation.
  - Suggests battery change out as soon as possible.
  - Battery life is warranted for 10 years
## Diagnostics

![Diagnostics Window](image)

- **Serial Number:** S163191815  
  **Date & Time:** 24 Apr 2007 12:00  
  **S/W Version:** D23  
  **Flag:** C  

### Problem/Event | Occurrences | Last Date       | First Date       | Comments* |
--- | --- | --- | --- | --- |
Unsatisfactory reading | 22 | 24 Apr 2007 00 hrs | 03 Apr 2007 00 hrs | Pull Meter and Investigate |
Fast sample mode entered | 001 | 24 Apr 2007 12 hrs | | |
EEPROM reboot | 021 | 01 Aug 2005 09 hrs | | This will always be |
Excessive comms access | 001 | 30 Jul 2005 00 hrs | | Investigate Site |
Diagnostics reset | 007 | 02 Apr 2007 15 hrs | | This will always be |

* Double Click Comment Text for Details

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**Customized Diagnostics**
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<th>Problem/Event*</th>
<th>Comments**</th>
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<td>Speed of sound error</td>
<td>Pull Meter and Return to Meter Sh</td>
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<td>Excessive noise</td>
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<tr>
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<td>Watchdog reset</td>
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<td>Reverse flow</td>
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<td>Air in meter</td>
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<td>Power Resets</td>
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<td>Calibration port access</td>
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<td>Fast sample mode entered</td>
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<td>Thermistor fail</td>
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* Double Click Problem/Event to Change The Color

** Double Click Comment Text To Edit
SONIX600 – Industrial and Commercial
• 600 to 1130 Cubic Feet per Hour
• 20 psig Maximum Operating Pressure

SONIX880 – Industrial and Commercial
• 880 to 1625 Cubic Feet per Hour
• 20 psig Maximum Operating Pressure

Obviously smaller and lighter with two centuries of technological advancements.
Size it up
Weight, Freight and Space Benefits

18 - #750 meters = 900 pounds
64 - SONIX880 meters = 720 pounds
(355% more meters at 80% of the weight)
Contamination / Freezing

- The non mechanical platform allows the SONIX meter to be virtually impervious to contamination and freezing.
Contamination / Freezing

- The flow tube inlet is positioned high in the body cavity to virtually eliminate the entrance of foreign material and liquids. This allows the body to act as a sump or drip leg.
Contamination / Freezing

- The body inlet chamber has a cast boss that can be drilled and tapped for an optional drain valve to remove liquids and debris in severe applications.
Well Head Measurement
Meter Set Benefits
Reduced Cost of Installation

- **Standard #800 Class Installation**
- **Parts**
  - 10% reduction in fittings
- **Real Savings is in the labor – 75%**
  - Two men – 1 hours
  - One man – ½ hour
- One prefabricated set, Two connections
Weight Allows One Person Installation
...versus Diaphragm Meters

- Significantly reduces space requirements
- Lighter Weight
- Standardized installation costs under wide range of flow capacities (0.21 – 3,800 scfh)
- Temperature correction (+/-1.0%)
- Programmable fixed factor pressure correction
- Positively records potential “theft of service”
- 60 Day Data Log Standard
- 15 year warranty
Off-Set Swivels for Replacements

- Swap previously installed diaphragm meters that had 11” center to center hubs.
- Black Iron or Galvanized
- 2 ½” Offset on each side
- 1 ½” piping
- 45 Lt Swivel/Nut
- Meter & Swivel Set Kit
Meter Bar for New Installations
Standards & Approvals

- US
  - A.G.A. Distribution Measurement Committee task group working on Technical Note for residential and commercial meters
  - A.G.A. Report #9

- Canada
  - PS-G-06-E

- OIML
  - In working group stage
Canada: PS-G-06-E

- Provisional standard released in March 1998
- Applicable for all ultrasonic meters used for custody transfer
- Key features:
  - Rangeability minimum of 10:1
  - Accuracy of better than ±1.0%
  - Meters must be flow calibrated
SONIX600 – Industrial and Commercial

• 600 CFH at ½ “ W.C. Differential
• 1130 CFH at 2” W.C. Differential

SONIX880 – Industrial and Commercial

• 880 CFH at ½ “ W.C. Differential
• 1625 CFH at 2“ W.C. Differential

SONIX2000 – Industrial and Commercial

• 2000 CFH at ½ “ W.C. Differential
• 3000 CFH at 1.3“ W.C. Differential
Live Pressure Correction and 60 days of hourly data log

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<th>Corr. Idx. (lt*)</th>
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(Double click non-integer Max P or Min P cell to decode.)
(Double click Flag or Summary cell to decode.)

Download Options
- Contract Hour: [00]
- One Day
- Date Range
- All Data

Multiplier: 100

Data Log Date: 3/18/2008

Retrieve Data
Save to File
Clear Data Log
Close

Live Pressure Correction and 60 days of hourly data log
Available Commercial Meters

- Sensus Sonix 600 - 600/1130 cfh – 20 psig MAOP
- Sensus Sonix 880 - 880/1625 cfh – 20 psig MAOP
- Sensus Sonix 2000 - 2000/3000 cfh – 60 psig MAOP
- Approved for Custody Transfer by Measurement Canada and various State Commissions
Questions?