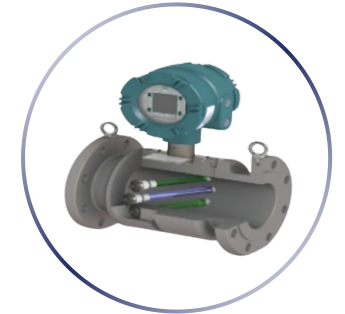
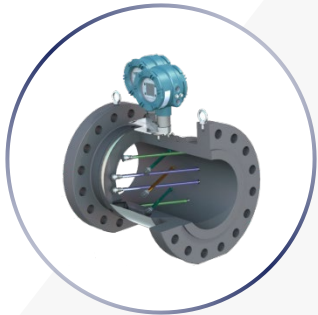
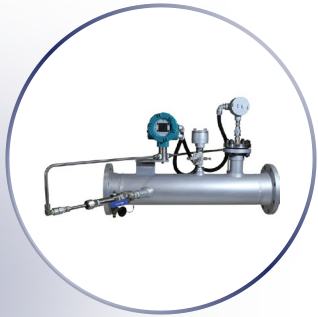


# Beyond the Flow Rate

Ultrasonic Diagnostics in  
Production Measurement

Phillips - 2026



# We Are Looking at the Wrong Number

## WHAT OPERATORS SEE

The reported volume



FLOW RATE  
**12.847**  
MMSCFD

Operators obsess over the reported volume.

The real story is hidden in the diagnostics.

## WHAT THE DIAGNOSTICS REVEAL

The true story behind the measurement



**GAIN**

Signal amplification and strength



**SNR**

Signal-to-noise ratio of each path



**SOS**

Speed of sound stability and consistency



**VELOCITY RATIOS**

Agreement between acoustic path velocities



**TURBULENCE**

Flow stability and turbulent energy



**PROFILE FACTOR**

Velocity profile shape across the pipe

The reported volume is only the visible output of a much larger measurement system.



# PRODUCTION MEASUREMENT IS DIFFERENT

*Multiple Influences. Dynamic Conditions. Measurement Uncertainty.*

## INSTALLATION COMPROMISES

- Limited straight run
- Elbows, valves, reducers, tees
- Distorted velocity profile



## NEAR HYDROCARBON DEW POINT

- Small changes in P or T can cause condensation
- Intermittent liquid formation



## VARIABLE COMPOSITION

- Changes in heating value and gas properties
- Affects speed of sound and density



## LIQUID DROPOUT

- Intermittent liquid in the flow
- Affects acoustic signal
- Causes path-to-path differences



## ULTRASONIC METER

## VARIABLE RATES

- Wide turndown
- Changing flow regime
- Affects velocity profile and integration



## PULSATION

- Pressure fluctuations from compressors, separators, etc.
- Causes velocity instability



## PRODUCTION ENVIRONMENT



Many factors act simultaneously. Their combined effects create uncertainty in the measurement.

**Diagnostics**  
reveal the story.  
**Interpretation**  
builds confidence.



The challenge is **not** measuring flow.  
The challenge is **understanding** whether the flow measurement remains **trustworthy**.



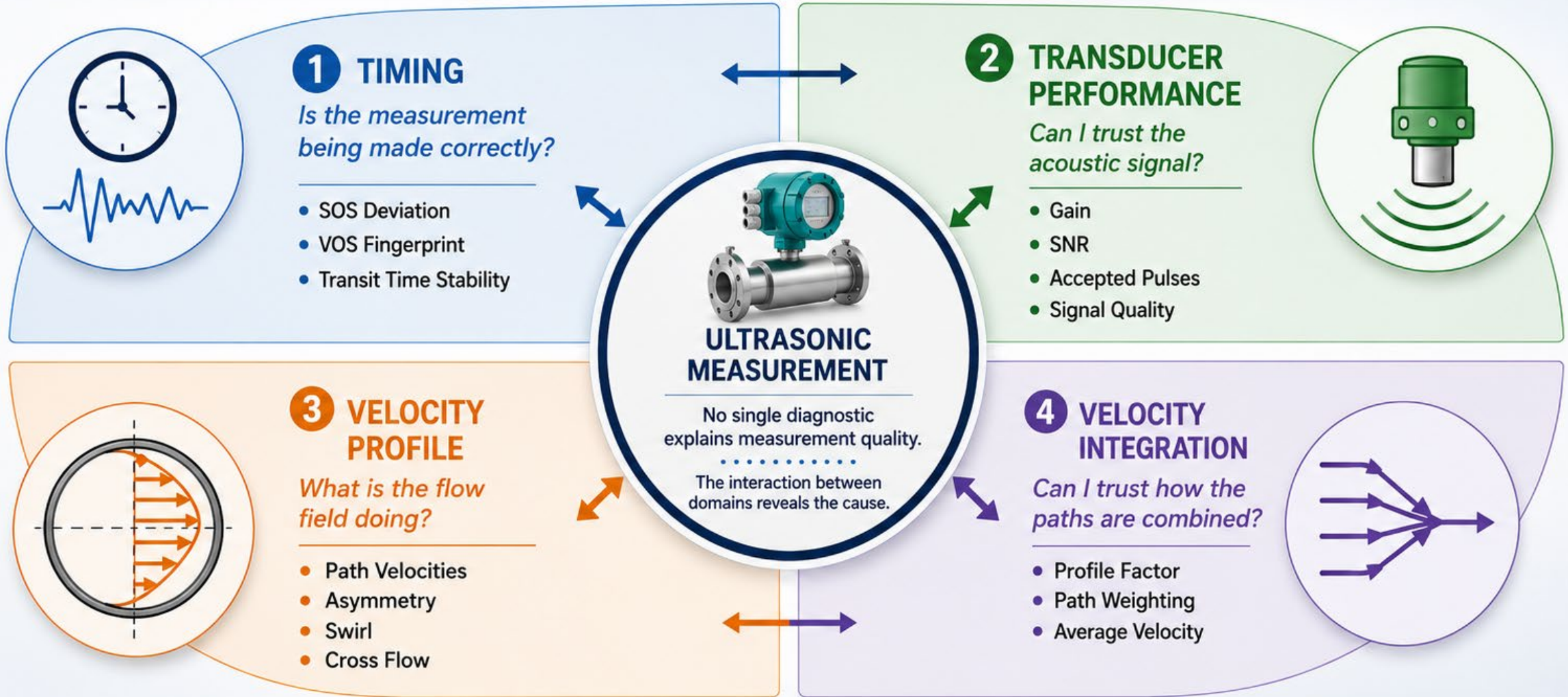
Diagnostics are the key to understanding what is really happening in the pipe.



# THE FOUR DIAGNOSTIC DOMAINS

*The foundation of modern ultrasonic meter diagnostics*

PRCI established these four domains as the fundamental building blocks of USM diagnostics.

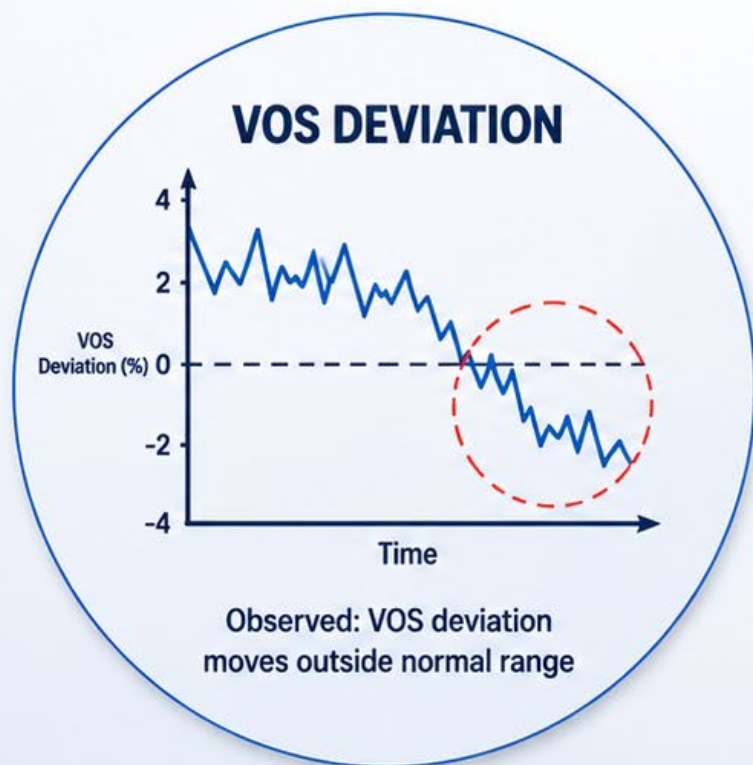


Real-world conditions affect all domains simultaneously.  
The cause is revealed by the pattern across domains.



# WHY SINGLE DIAGNOSTICS FAIL

*One signal can be caused by many different physical conditions.*



**ONE  
DIAGNOSTIC.  
FOUR POSSIBLE  
CAUSES.**



## **TIMING ISSUE**

Errors in transit time measurement caused by electronics drift, clock instability, or synchronization problems.



## **COMPOSITION CHANGE**

Variations in gas composition alter the speed of sound and acoustic properties of the gas.



## **LIQUID LOADING**

Intermittent or increasing liquid in the flowpath changes acoustic attenuation and path velocity.



## **THERMAL STRATIFICATION**

Temperature differences across the pipe create velocity variations through local changes in gas density.





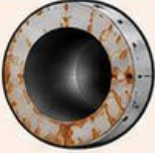





**THEREFORE:**

**SINGLE-VARIABLE INTERPRETATION IS DANGEROUS.**

PRCI research confirms that the same VOS deviation pattern can be produced by multiple, very different flow conditions (Zanker, 2011).

# FROM DIAGNOSTICS TO DIAGNOSTIC PATTERNS

*Individual diagnostics show symptoms. Patterns reveal causes.*

DIAGNOSTIC	 LIQUID	 PULSATION	 FOULING	 DISTORTION
 SNR	↓	↔	↓	↔
 GAIN	↑	↔	↑	↔
 VELOCITY RATIO	↑	↑	↔	↑
 SOS	UNSTABLE	UNSTABLE	↔	↔



No single parameter identifies a condition.  
**PATTERNS DO.**



Higher than normal



Lower than normal



No consistent change

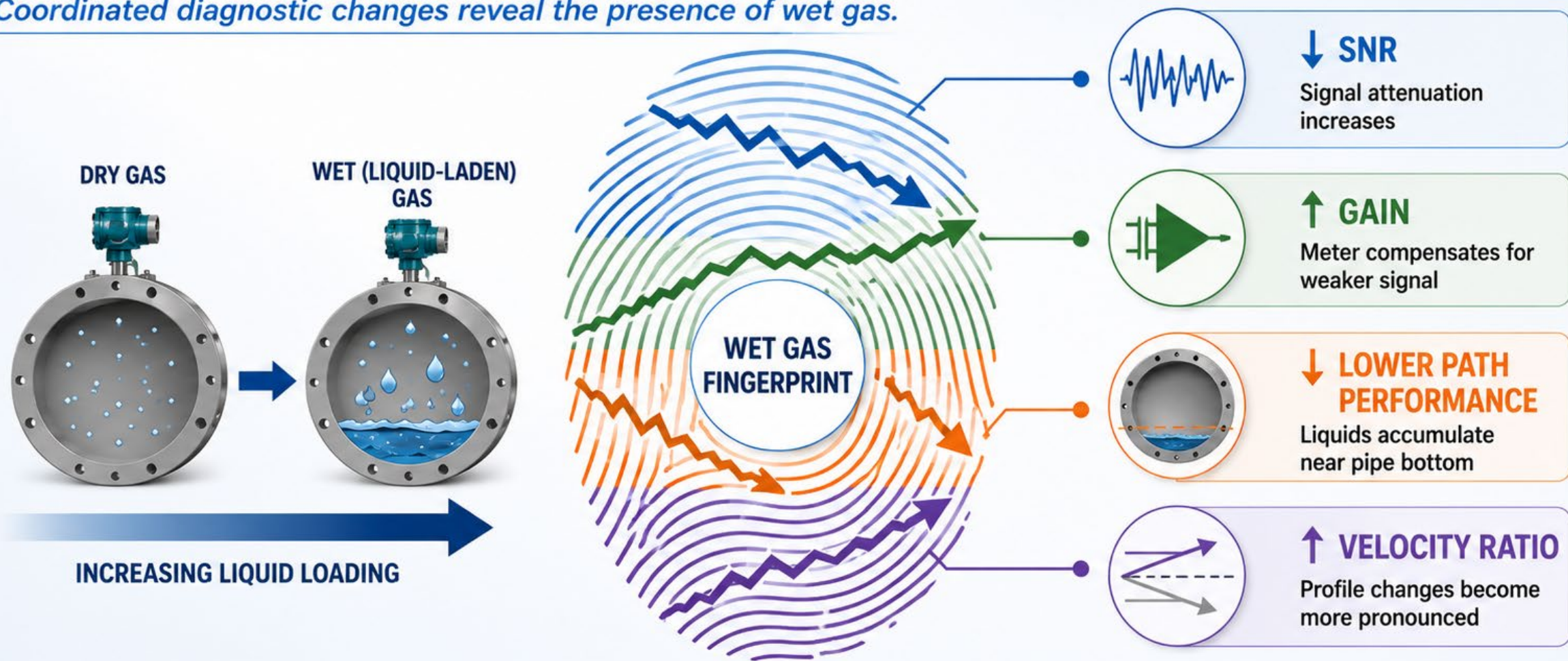
Unstable

Fluctuating / inconsistent



# PATTERN #1 – LIQUID LOADING

*Coordinated diagnostic changes reveal the presence of wet gas.*



**Wet gas rarely changes only one diagnostic.**  
The fingerprint emerges when multiple diagnostics change together.

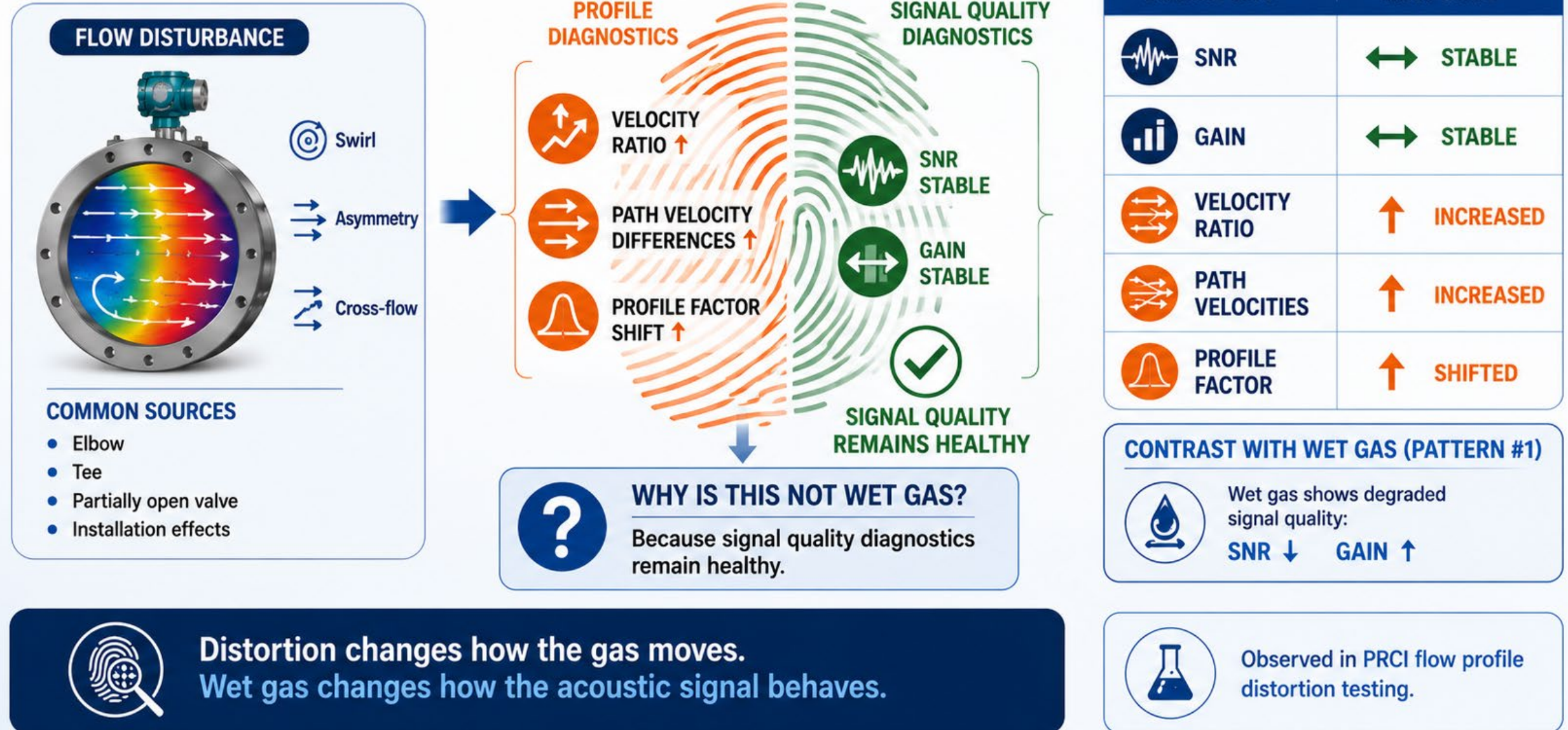


Observed in controlled wet-gas testing  
(Harman et al.)



# PATTERN #2 – VELOCITY PROFILE DISTORTION

*Not every profile disturbance is wet gas.*





# PATTERN #3 – TRANSDUCER DEGRADATION

*When the signal changes but the flow does not.*

## DEGRADING ACOUSTIC PATH

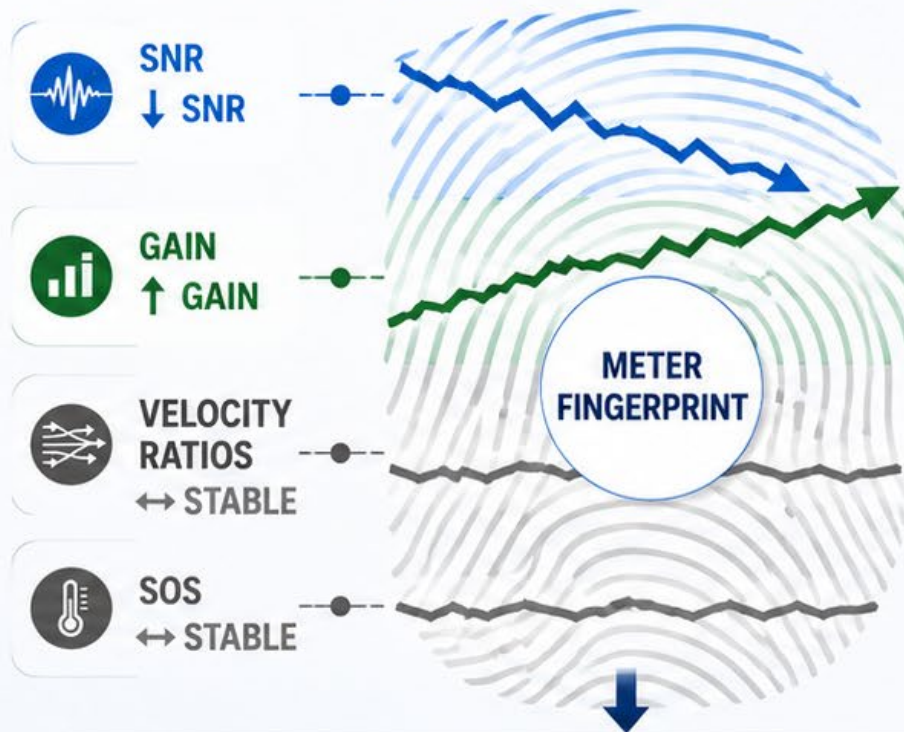
HEALTHY  
TRANSDUCER

DEGRADED  
TRANSDUCER



- Coating / fouling buildup
- Aging piezo element
- Moisture ingress
- Electronics degradation

## DIAGNOSTIC FINGERPRINT



## WHY IS THIS NOT A FLOW PROBLEM?

Flow diagnostics remain stable.  
Only signal quality changes.

DIAGNOSTIC	RESPONSE
SNR	DECREASING
GAIN	INCREASING
VELOCITY RATIO	STABLE
SOS	STABLE

## CONTRAST WITH WET GAS (PATTERN #1)

WET GAS	VS.	TRANSDUCER DEGRADATION (PATTERN #3)
SNR ↓		SNR ↓
GAIN ↑		GAIN ↑
VELOCITY RATIO ↑		VELOCITY RATIO ↔
SOS ↔ / UNSTABLE		SOS ↔



Same signal response.  
Different diagnostic pattern.



**FLOW CONDITIONS AFFECT MULTIPLE DOMAINS.**  
**TRANSDUCER DEGRADATION AFFECTS THE SIGNAL ITSELF.**



## INTERPRETATION:

Meter issue.  
**Not** flow issue.



# PATTERN #4 – PULSATION

*A condition that can masquerade as wet gas.*

### PULSATION SOURCES



Reciprocating Compressor



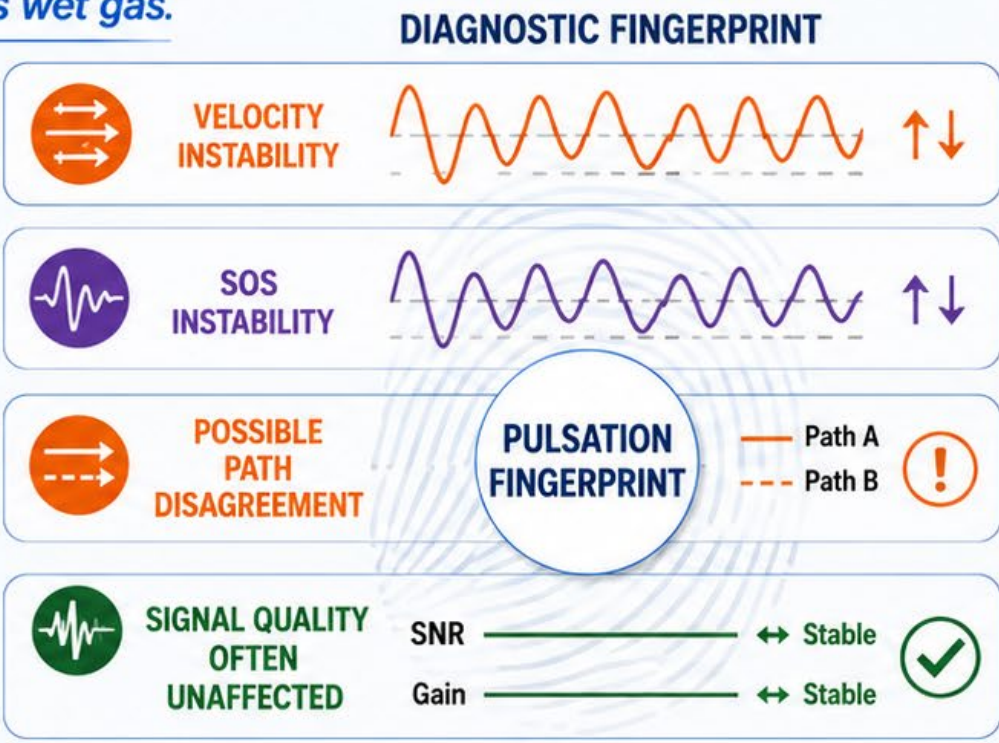
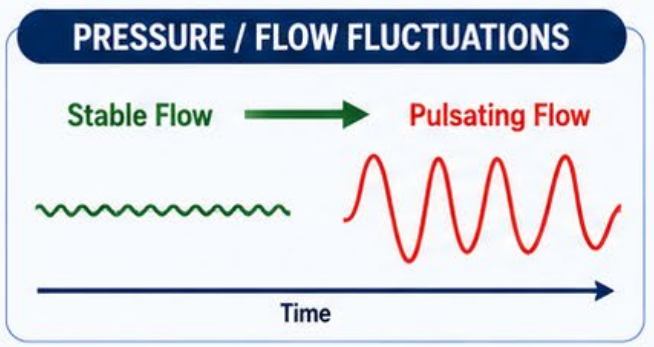
Control Valve Hunting




Separator Cycling








Compressor Cylinder Loading





### WHY CAN THIS LOOK LIKE WET GAS?

Because unstable velocity and SOS can resemble liquid-induced effects.

DIAGNOSTIC		RESPONSE
	SNR	↔ STABLE
	GAIN	↔ STABLE
	VELOCITY RATIO	↑↓ UNSTABLE
	SOS	↑↓ UNSTABLE
	PATH AGREEMENT	↔/↑↓ VARIABLE

### WET GAS vs. PULSATION


DIAGNOSTIC	WET GAS (PATTERN #1)	PULSATION (PATTERN #4)
SNR	↓	↔
GAIN	↑	↔
VELOCITY RATIO	↑	↔/↑↓
SOS	UNSTABLE	UNSTABLE

**THE DIFFERENCE IS SIGNAL QUALITY.**



## PULSATION CHANGES THE TIMING OF THE MEASUREMENT.

## WET GAS CHANGES THE ACOUSTIC SIGNAL.

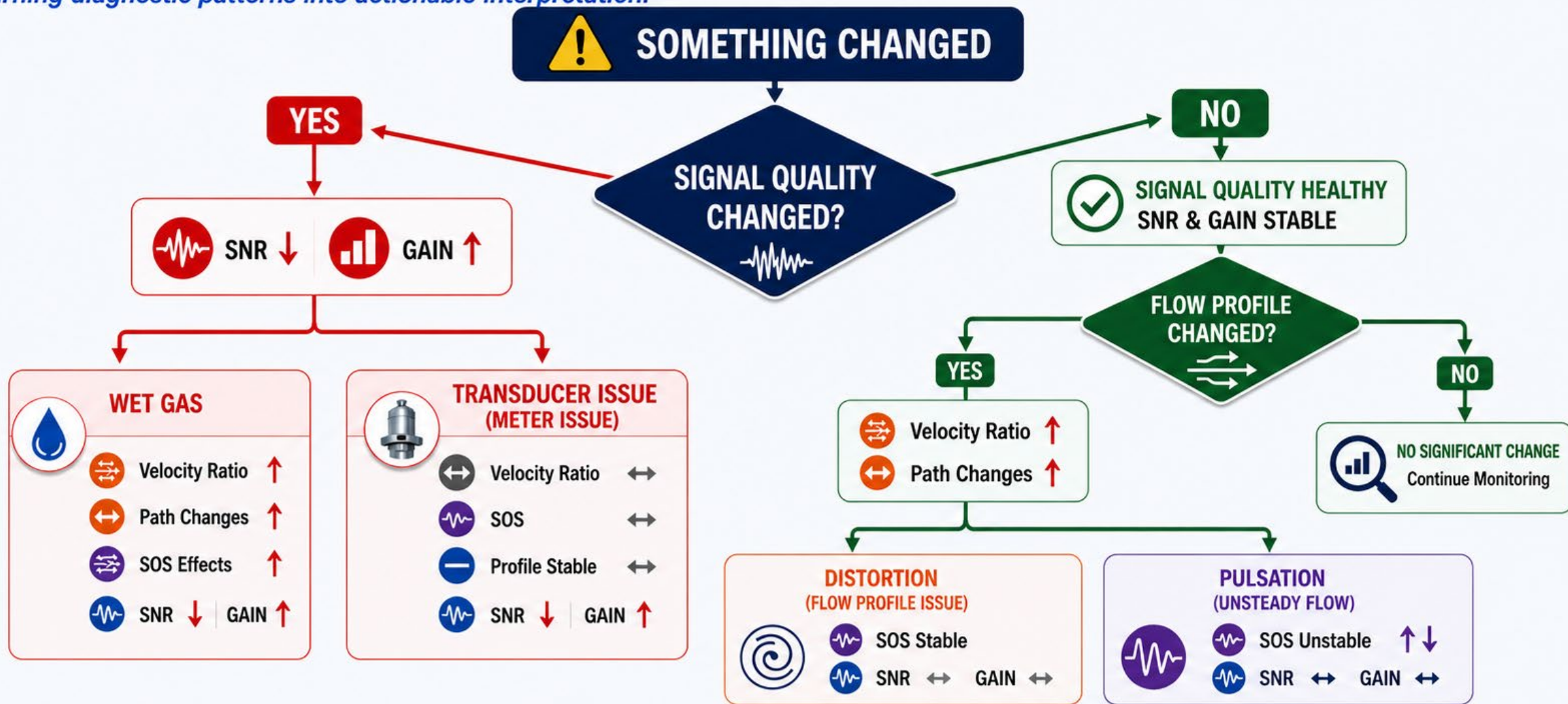


Pulsation can **mimic wet gas** if viewed through a **single diagnostic**.



# THE DIAGNOSTIC DECISION TREE

*Turning diagnostic patterns into actionable interpretation.*



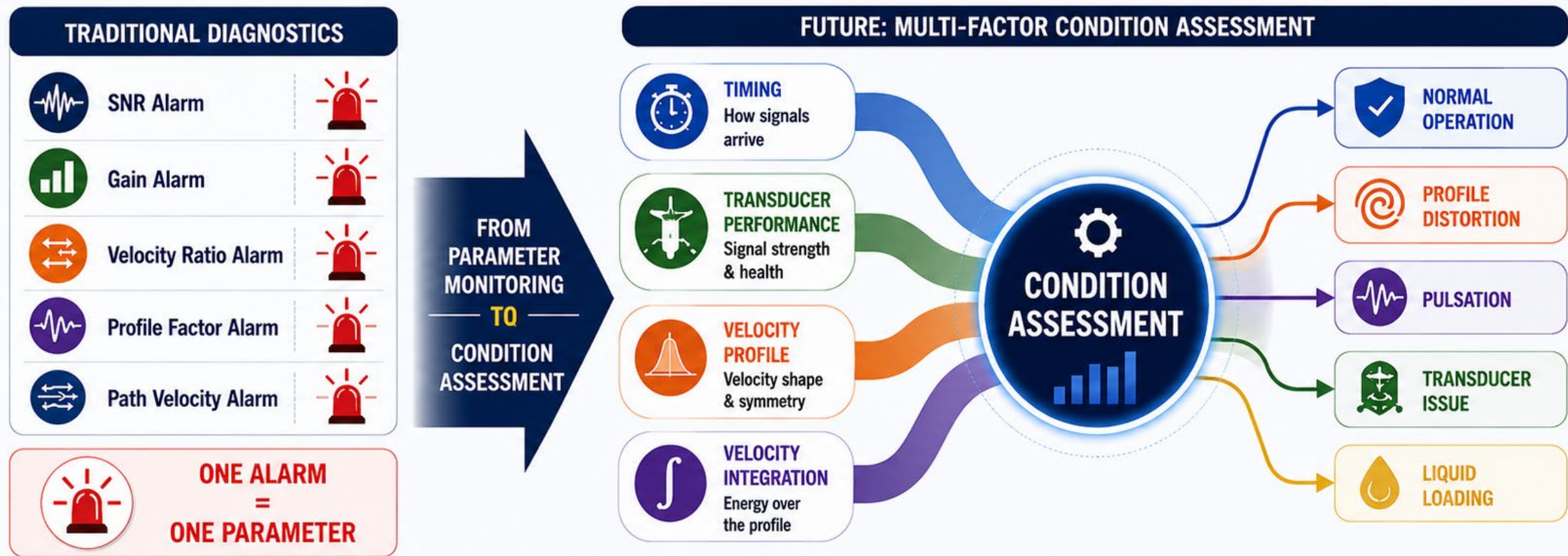
THE ANSWER IS NOT IN A SINGLE DIAGNOSTIC.  
**THE ANSWER IS IN THE PATTERN.**





# THE NEXT EVOLUTION OF USM DIAGNOSTICS

*Moving from parameter alarms to condition assessment.*



THE FUTURE IS NOT MORE DIAGNOSTICS.  
**THE FUTURE IS UNDERSTANDING RELATIONSHIPS  
 BETWEEN DIAGNOSTIC DOMAINS.**



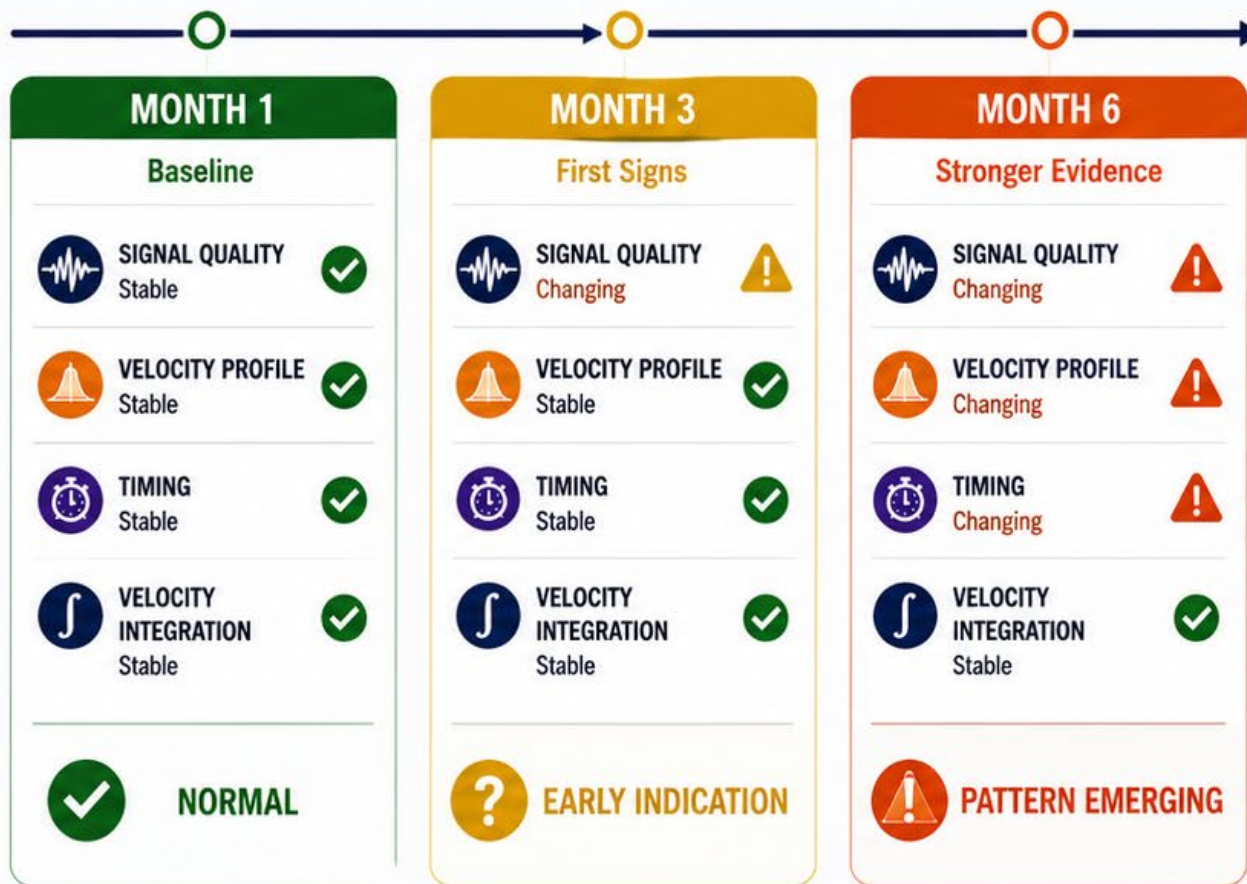
Multi-factor interpretation  
 delivers clearer insight and  
 earlier understanding.



# CASE STUDY: WHAT CHANGED?

Applying diagnostic pattern recognition.

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## WHAT HAPPENED?

**?**

- Meter Issue?
- Profile Distortion?
- Pulsation?
- Liquid Loading?

Use the evidence to determine the most likely condition.



NO SINGLE DIAGNOSTIC IDENTIFIED THE CONDITION.  
**THE PATTERN REVEALED THE CAUSE.**



Looking at the pattern across domains provides the insight.

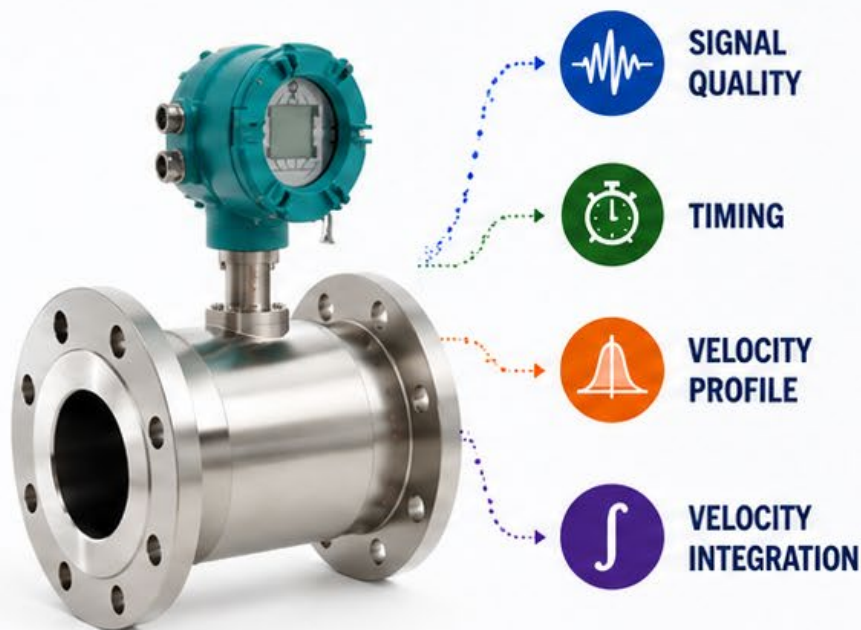
*Patterns provide clarity. Actions drive results.*



# THE FUTURE: DIAGNOSTICS AS VIRTUAL SENSORS

*Using diagnostic information to understand the process—not just the meter.*

We already use ultrasonic diagnostics to assess meter health.



**TODAY**

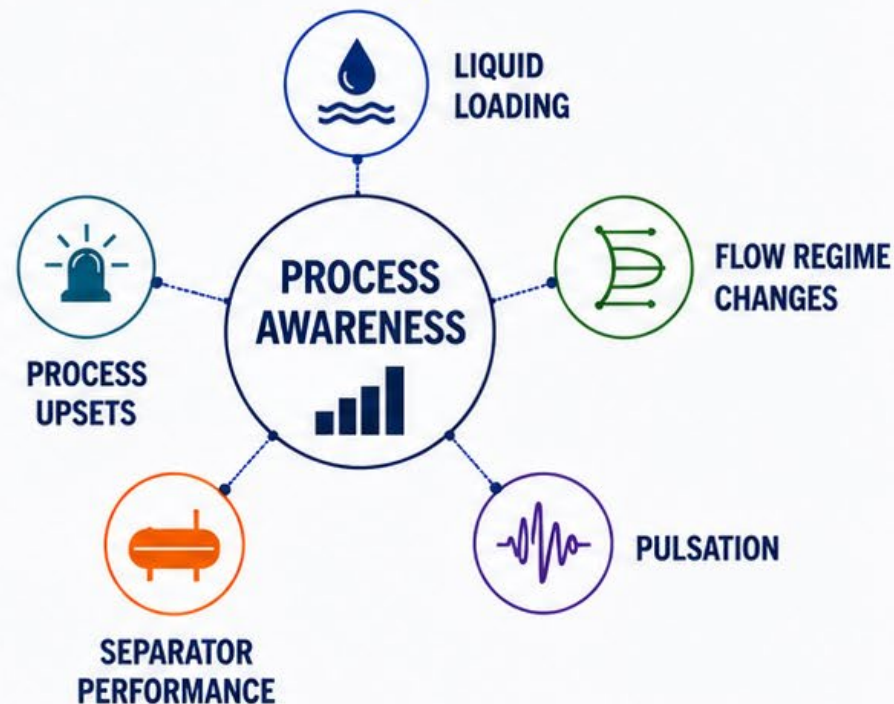
Diagnostics assess **meter health.**



**TOMORROW**

Diagnostics assess **flow conditions.**

The next step is using diagnostics to assess flow conditions.



THE OPPORTUNITY IS NOT MORE DIAGNOSTICS.  
**THE OPPORTUNITY IS EXTRACTING MORE  
INFORMATION FROM DIAGNOSTICS.**



Diagnostics contain a wealth of information. The future is turning that information into process insight.



# CONCLUSIONS

*Beyond the flow rate.*

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1

Diagnostics are more valuable than the reported flow rate alone. ✓

2

Production environments require continuous interpretation. ✓

3

Single diagnostics identify symptoms. ✓

4

Diagnostic patterns identify causes. ✓

5

The future of ultrasonic measurement is condition awareness. ✓

FLOW RATE



SIGNAL QUALITY



TIMING



VELOCITY PROFILE



VELOCITY INTEGRATION



CONDITION AWARENESS



FLOW RATE



DIAGNOSTICS



PATTERNS



CONDITIONS



PROCESS AWARENESS



THE MOST IMPORTANT NUMBER  
MAY NOT BE THE FLOW RATE.

IT MAY BE WHAT THE  
DIAGNOSTICS ARE TELLING YOU.



# The TMCO Wewoka, OK Team



The USA Flag is a mural on one of the TMCO buildings!