# COMMON INDUSTRY STANDARDS RELATED TO NATURAL GAS MEASUREMENT

Measurement standards are important because they can be used as a framework for buyers and sellers to trust that the transaction is fair. If you have purchased a cubic foot of natural gas, you want to be sure you really received a full cubic foot of gas. For custody transfer, the gas measurement should be trusted by both the buyer and seller to be accurate.

Measurement standards represent 'Best Practice' policy and procedures commonly in use by the industry. Standards represent 'This is what works!'.

Some commonly used gas measurement standards have been developed by:

- AGA (American Gas Association)
- API (American Petroleum Institute)
- GPA Midstream Association (formerly "GPA")

Measurement standards make it easier for buyers and sellers to have consistent expectations when commodities are exchanged. Standards associations such as AGA, API, GPA do not enforce standards, however failure to follow API standards may violate your contract agreements with your buyers and sellers. It is important for a Measurement Technician to know what measurement standards are referenced by the contracts using his/her meters.

A gas contract may list the measurement standards to be used by the meters. Both the buyer and seller must agree on the standards to be used. Consider the following hypothetical contract for example:

**"When and where electronic measurement and flow computers are used, the gas shall have its volume, mass, gravity, composition or energy content, determined and calculated in accordance with applicable AGA standards including, but not limited to, API 14.3.1&2/AGA Report No. 3, latest edition, AGA 8 for supercompressibility, and API Chapter 21.1 latest edition for measurement by electronic flow computers."**

Let's look closely at this contract from the point-of-view of the Measurement Technician who is installing and configuring the gas meter. A good contract leaves little-to-no ambiguity about how the measurement is to be performed. If the buyer interprets the contract requirements differently than the seller, this may lead to expensive and time-consuming disputes.

This example contract references "**API 14.3.1&2/AGA Report No. 3, latest edition**". API 14.3 is an example of a joint standard that is also published by AGA. API 14.3 is the same standard as AGA 3. This standard contains 4 parts. The "**14.3.1&2**" in contract refers to Parts 1 and 2 in API 14.3. There is little ambiguity in this part of the contract. The Measurement Technician can confidently set up his gas meter according to API 14.3 Parts 1 & 2 and know that there is little chance this contract will come into dispute.

Next, this example contract references **“AGA 8 for supercompressibility”**. This part of the contract is a bit more ambiguous and allows room for interpretation. When looking at contracts, room-for-interpretation is a bad thing! We want the buyer and seller to have the same understanding about how their gas will be measured. Consider that AGA 8 contains 2 parts. Part 1 contains 2 equations: Gross and Detail. The Gross equation has 4 methods. Which part / equation / method does the Measurement Technician need to use to meet this contract’s requirements? In this case the Measurement Technician may want to ask for clarification from his company’s Contracts department, or at least inform Contracts about which equation he/she plans to use. As a Measurement Technician, your company’s Contracts department depends on you! If there is a dispute, can you justify that your meters volumes are correct?

How do you install meters that meet your contract requirements? The first step: know what those requirements are. Communication is important between the Measurement and Contracts departments within a company. Contracts should inform Measurement when the contract requirements change. Measurement should inform Contracts when new editions of the measurement standards are published. Our example contract references “**API Chapter 21.1 latest edition”**. Notice specifically where it says: ‘latest edition’. The Contracts department depends on the Measurement department to notify them when there is a new edition of a referenced standard, and what changes in the new edition affect contract agreements.

Our example contract lists some commonly used gas measurement standards:

- API 21.1 - Flow Measurement Using Electronic Metering Systems - Electronic Gas Measurement
- API 14.3 / AGA 3 - Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids - Concentric, Square-edged Orifice Meters
- AGA 8 - Thermodynamic Properties of Natural Gas and Related Gases

Let’s look briefly at the scope of each of these standards, and how they combine to meet our contract requirements.

API 21.1 is a joint standard also published by AGA. API 21.1 is the same standard as AGA 13. API 21.1 covers the following measurement devices:

- Primary devices
- Secondary devices
- Tertiary device

What are these?

The primary device is the source of the flow data. The primary device is the element that creates a differential pressure. Examples include:

- Orifice plate
- V-cone
- Pitot
- Wedge

The secondary device measures the data from the primary device. These sensors usually include:

- Static Pressure
- Differential Pressure
- Temperature

The flow computer is the tertiary device. The tertiary device performs the flow calculation based on the measurements from the secondary devices.

**Primary Devices**

API 21.1 includes many references to API 14.3 standard. API 21.1 suggests using API 14.3 for orifice meters. The relevant standard for orifice primary devices is API 14.3 Part 2, which includes orifice specifications and installation requirements.

API 14.3 Part 2 provides guidance for orifice primary device installations:

- Mechanical tolerances of orifice plates.
- Meter run dimensions.
- Flow straightener (tube bundle) requirements.
- Flow conditioner requirements.
- Orifice meter inspection guidelines.

API 14.3 Part 2 is a "fabrication tolerance" standard. Orifice meters fabricated to API 14.3 Part are not normally expected to be flow calibrated. Instead of calibrating, the orifice must be manufactured to strict dimensional tolerances. Flow proving is common for liquid meters, but not common for orifice gas meters.

Flow orifices are simple devices that provide good repeatability. Two orifices with identical dimensions will reliably match the same measurement. API 14.3 Part 2 strives to provide enough specifications such that two orifices of the same size can generate practically identical flow results. API 14.3 Part 2 provides guidance for mechanical tolerances of:

- Orifice bore dimensions
- Eccentricity (out-of-round)
- Plate thickness
- Plate flatness
- Edge sharpness
- Surface roughness
- Accumulation of contaminants
- Orifice bevel

Manufacturing cannot provide a perfect orifice. There will be some small variations. Provided the orifice is manufactured within the tolerances specified by API 14.3 Part 2, the flow uncertainty can be calculated.

API 14.3 Part 2 specifies meter run dimensions such as straight-run pipe lengths upstream and downstream of the orifice. API 14.3 Part 2 strives to ensure that the fluid flow profile is fully developed and swirl-free. API 14.3 (1 through 4) is an 'empirical' standard based on laboratory measurements that were performed on fully developed fluid flow. Your meter run must provide fully developed fluid flow to the orifice in order get accurate, repeatable measurement.

API 14.3 Part 2 provides guidance on meter run and orifice inspections. The secondary and tertiary devices (sensors and flow computer) cannot detect if the orifice meter run is dirty or damaged. The flow computer always assumes the orifice meter is clean and undamaged. The meter run and orifice must be inspected periodically to verify it really is in good condition.

API 14.3 Part 2 Annex B includes an inspection checklist. This checklist provides guidelines for evaluating the condition of the meter run and orifice plate, for example:

- Verify the meter tube and orifice are clean and free of blockages.
- Pipe and orifice dimensions match those used by the flow computer.
- Orifice edge is sharp, and flat.
- If orifice is beveled, the square edge faces upstream.

**Secondary Devices**

Secondary devices are the sensors that measure the data from the primary device:

- Static Pressure
- Differential Pressure
- Temperature

API 21.1 provides recommendations on the frequency of measurements. Measurements of differential pressure, static pressure and temperature “shall be sampled at least once per second”. It would take a very large amount of storage to save every second of data from the secondary devices. API 21.1 does not require every second of the secondary measurement data (static, differential, temperature) to be saved in the historic records. Instead, API 21.1 requires hourly averages of the live inputs and Integral Value 'IV'.

Integral value is a calculated product of the static pressure, differential pressure and temperature. Integral value can be used to calculate a total quantity for a flow period (hourly log). Without recording every second of live input data, API 21.1 strives to provide sufficient information to audit the daily and hourly quantities. Note: API 21.1 abbreviates 'integral value' for gas meters as IV. This is not to be confused with 'indicated volume' for liquid meters.

Secondary devices are generally expected to be verified and calibrated. This is in contrast to the primary devices which are inspected but not calibrated. API 21.1 requires periodic verification and calibration of the static pressure, differential pressure and temperature sensors.

API 21.1 calibration requirements changed from first to second edition:

- API 21.1 First Edition (1993) required calibration instruments to be NIST-traceable.
- API 21.1 Second Edition (2013) requires 'certified test equipment based on contract/regulatory requirements'.

This change in the API 21.1 calibration requirements is a good example where communication is important between the Measurement department and Contracts department of a company. If the buyer and seller want calibrations to continue to be NIST traceable, it is a good idea for new contracts to explicitly state “NIST traceable calibration equipment”. Contracts department of course must be made aware that this change is necessary. Measurement and Contracts should communicate when there are changes that can affect either group.

**Tertiary Devices**

The tertiary device is the calculation device, usually a flow computer that calculates the flow rate and total volume of gas.

For calculating flow rate, API 21.1 recommends (does not require) using API 14.3 Parts 1 through 4. API 14.3 Parts 1, 3, and 4 provide similar equations but differ slightly in scope:

- API 14.3 Part 1 applies to any clean, single phase, Newtonian fluid in the petroleum and chemical industries.
- API 14.3 Part 3 has some simplifying assumptions but applies only to natural gas.
- API 14.3 Part 4 algorithm was developed from Part 1 equations. Part 4 algorithm requires less computing resources to solve.

To calculate flow rate, the flow computer needs the following inputs:

Live inputs:

- Static Pressure
- Differential Pressure
- Temperature

Pre-configured inputs:

- Viscosity
- Ratio of Specific Heats
- Pipe Diameter
- Bore Diameter

Live or pre-configured input:

- Density

For calculating flow rate and volume:

- API 14.3 equation provides an instantaneous flow rate
- API 21.1 equation integrates the flow rate over time to calculate total quantity.

Notice that density is one of the inputs to the AGA 14.3 calculation. AGA 8 provides equations to calculate gas density and compressibility. AGA 8 is a commonly used calculation for density and compressibility. AGA 8 contains more than one choice for density calculation. Verify you are using the correct equation as specified in your contract agreement. AGA 8 has 2 major parts:

- AGA 8 Part 1 includes the Detail and Gross equations.
- AGA 8 Part 2 is the same as GERG 2008 (European Gas Research Group)

To calculate density and compressibility, the flow computer needs the gas composition (mol% methane, ethane, propane, etc.). The gas composition can be measured live from a chromatograph, or it can be manually entered as part of the flow computer configuration.

API 14.3 is an evolving, improving standard. The equations in API 14.3 Part 1, 3, 4 may not get updated simultaneously. Sometimes the equations can differ slightly. Verify you are using the correct equation as specified in your contract agreement. For example:

- Part 1 updated Expansion Factor in 2013
- Part 4 updated Expansion Factor in 2019

API 21.1 includes requirements for audit and records to be saved by the flow computer. API 21.1 strives to provide records sufficient to:

- Verify daily and hourly flow quantities.
- Verify the flow computer configuration has not been changed or tampered (Event Log).

The Quantity Transaction Records 'QTR', as specified by API 21.1 provides the volume that was calculated by the flow computer. The QTR also provides sufficient data and information to verify and audit the volume calculated by the flow computer. The hourly and daily QTR records include (among other data):

- Timestamp
- Flow quantity (volume, mass and/or energy)
- Differential pressure average
- Static pressure average
- Temperature average

The Event Logs as specified by API 21.1 record any changes that affect flow volume calculations. These changes must be auditable. Examples include:

- Changed orifice bore size

- Changed pipe diameter

API 21.1 specifies that QTR and Event records must be durable. Records must be stored in the flow computer such that they cannot be deleted or altered without detection.

Conclusion

Hopefully this exercise helps illustrate the relationships between some of our common gas measurement standards. API 21.1 is a kind of 'umbrella' standard with requirements for the primary, secondary, and tertiary devices of your electronic gas measurement system. API 21.1 references requirements in API 14.3:

- API 14.3 Part 2 for primary devices.
- API 14.3 and Parts 1, 3, 4 for tertiary devices.

API 14.3 flow equations require density input. API 14.3 does not specify how to calculate density. AGA 8 is a commonly used equation for calculating density:

- AGA 8 Part 1 includes the Detail and Gross equations.
- AGA 8 Part 2 is the same as GERG 2008 (European Gas Research Group)

As a Measurement Technician, it is important to know:

- The measurement standards required by your contracts.
- The requirements specified by those measurement standards.