

# Gas Measurement Manual

## PART FIFTEEN

### ELECTRONIC VOLUME CORRECTORS

Prepared by:

Transmission Measurement Committee and Customer Field  
Service and Measurement Committee



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## FORWARD

This manual presents information on electronic volume correctors (EVCs) for installation, operation, calibration, and maintenance of EVCs. This is not a standard for electronic volume corrector (EVC) design. The information is intended to cover only instruments considered auxiliary devices mounted on the gas meter or receiving a direct pulse from a linear flow meter. *This does not include the primary flow measurement device (meter) but does include the integral temperature and pressure correcting devices that are incorporated now as part of the metering assembly.*

## HISTORY AND BACKGROUND

Over the years, mechanical devices have been providing a means for correcting measured gas volume to base conditions of pressure and temperature. Their origin can be traced back to the 1920s when chart recorders were used to record line pressure at the gas meter. These charts would then be read to determine average line pressure so that the volume measured by the gas meter could be corrected to base pressure conditions. Today, very few mechanical chart recorders are still used for volume correction. They may record any metered volume, line pressure or line temperature combination. Another means of gas volume correction emerged during the 1950s. Mechanical instruments mounted on gas meters automatically corrected metered volume to base conditions. They mechanically measured and applied pressure and temperature correction factors to a gear-driven index through linkages and clutches.

Later, mechanical volume correctors were improved by adding an approximating cam for super compressibility correction and a switch contact output to allow connection to separate volume recorders or telemetering devices. The origin of electronic volume correction can be linked to the Supervisory Control And Data Acquisition (SCADA) systems that the gas and liquid transmission companies fielded in the early 1970s. Although electronic measurement and correction were much more accurate than that period's mechanical chart recorders or volume correctors, it was too costly for distribution.

However, this is no longer true. Advances in electronic technology have made it possible to provide cost- effective gas-volume correction in virtually all applications previously supported by mechanical correcting devices. Not only are the electronic volume correctors comparable in initial cost, but they also provide an increase in performance beyond the range of mechanical corrector technology. Performance improvements include increased measurement accuracy, data storage capacities, audit trail memory, better long-term stability, quicker calibration, and a decreased load on the instrument drive shaft.

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## DEFINITIONS

|                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Base condition</b>     | Defined pressure and temperature used in the custody transfer measurement of fluid volume and other calculations. Base conditions may be defined by regulation, contract, local conditions or organizational needs. Base conditions may vary within regions such as: 1) USA, pressure 14.73 psi absolute, temperature 60 °F, as defined by NAESB. 2) Canada, pressure 101.325 kPa absolute, temperature 15 °C. 3) Mexico, pressure 1 kgf/cm <sup>2</sup> (equivalent to 98.1 kPa absolute), temperature 20 °C. |
| <b>Baud rate</b>          | The baud rate is the rate at which information is transferred in a communication channel. Baud rate is commonly used when discussing electronics that use serial communication. In the serial port context, "115,200 baud" means that the serial port can transfer a maximum of 115,200 bits per second                                                                                                                                                                                                        |
| <b>Data log</b>           | It is data collection and storage over period. Sometime in industry refers to as histories, audit trail, event logs etc.                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Form A</b>             | A "Form A" would mean the contacts are normally open when the coil of the relay is not energized or the there is no magnetic field nearby in a reed switch.                                                                                                                                                                                                                                                                                                                                                    |
| <b>Form B</b>             | A "Form B" would mean the contacts are normally Closed when the coil of the relay is not energized or the there is no magnetic field nearby in a reed switch.                                                                                                                                                                                                                                                                                                                                                  |
| <b>Form C</b>             | A "Form C" would have three leads and would have one normally open contact and one normally closed contact. This is also called a "changeover" device because the common contact changes from the normally closed position to the normally open position when the coil is energized in a relay, or a magnetic field is nearby in a reed switch.                                                                                                                                                                |
| <b>Standard Condition</b> | A standard cubic foot of gas is the amount of gas that occupies one cubic foot at base conditions.                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Wiegand Sensor</b>     | Wiegand sensors are magnetic sensors that make use of the Wiegand effect to generate a consistent pulse every time magnetic field polarity reverses and therefore do not rely on any external voltage or current.                                                                                                                                                                                                                                                                                              |

## ABBREVIATIONS

|               |                                                 |
|---------------|-------------------------------------------------|
| <b>ACFH</b>   | Actual Cubic Feet Per Hour (Uncorrected)        |
| <b>AMI</b>    | Advanced Metering Infrastructure                |
| <b>AMR</b>    | Automatic Meter Reading                         |
| <b>CF</b>     | Cubic Feet                                      |
| <b>EVC</b>    | Electronic Volume Corrector                     |
| <b>I/O</b>    | Input and/or Output                             |
| <b>IrDA</b>   | Infrared Data Association                       |
| <b>REV</b>    | Revolution (Rotation).                          |
| <b>SCADA</b>  | Supervisory Control And Data Acquisition        |
| <b>SCFH</b>   | Standard Cubic Feet Per hour (Corrected)        |
| <b>TCP/IP</b> | Transmission Control Protocol/Internet Protocol |
| <b>TEG</b>    | Thermoelectric Generator                        |

# 1 GENERAL

## 1.1 Overview of Electronic Volume Corrector (EVC)

Most meters measure actual (uncorrected) flowing volume. The actual flowing volume varies with pressure/temperature and needs to be corrected to reflect standard conditions (corrected). The value the flowing volume would assume at standard conditions is calculated per the gas laws, as covered in section 1.6 of this document. The corrected volume calculation can be performed by an electronic volume corrector (EVC) using one or more methods specified in reports AGA-7, AGA-5, AGA-8, and NX-19.

In addition to the live volume correction function, an EVC can provide benefits that older mechanical technologies could not, such as increased accuracy, easy calibration, configuration flexibility, simplified maintenance, data storage, and local/remote data communication.

The installation of an EVC vs a flow computer may depend on meter type, customer type (residential/ commercial /industrial), power availability, and cost.

## 1.2 Basic Components

An EVC typically consists of an enclosure, a pulse-input device (for volumetric input), a line pressure transducer, a temperature transducer, a display, electronic circuit boards, communication port(s), and a power supply. An EVC may contain other optional components such as a secondary pressure transducer, status/alarm inputs from other devices, keypad, pulse outputs, communication devices (phone modem, cell modem, etc.). The EVC may be mounted directly to the gas meter (integral mount), directly mounted on the instrument drive of a gas meter, pipe-mounted, pole-mounted, or wall-mounted. Figure 1 shows a typical EVC installation on the instrument drive of the turbine meter and Figure 2 shows a typical installation of integral mount EVC on the rotary.

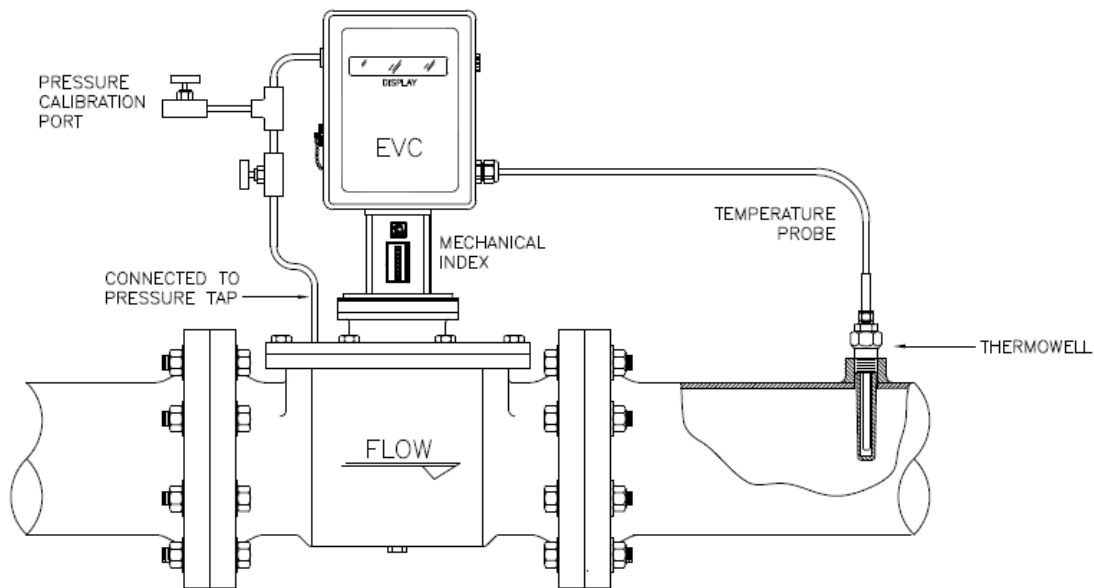


**Figure 1<sup>1</sup>**



**Figure 2<sup>2</sup>**

The enclosure houses the electronic circuit boards, display, keypad, transducers, and communication device, and it provides options for pulse output connections such as circular connectors, cable gland connectors with the required cable length, and maybe conduits fittings. For integrally mounted EVCs, the corrector enclosure is attached to the end cover of the rotary meter with a mounting-bracket that is meter size and type specific.

<sup>1</sup> Image published with permission from AGA.

<sup>2</sup> Image published with permission from Dresser Utility Solutions.

For the instrument drive mount EVC, the index is generally included at the bottom of the EVC enclosure. If the EVC is wall or pipe-mounted, the volume is received via an external pulse input device such as a pulser on the meter. Some examples of an external pulse input device would be the output from an ultrasonic meter or a pulser mounted either on the instrument drive or directly on the accessory unit of a rotary meter.). EVC electronics are housed in a weathertight enclosure (Enclosure type NEMA4X, IP-66 etc.) with adequate venting to prevent condensation from forming inside the corrector housing.

The integrated mount EVC receives volume pulses from the magnetic sensor inserted into the magnet well on the rotary meter. The temperature probe is inserted in the temperature probe well for rotary meters designed for internal temperature measurement. An external type of temperature probe assembled to an armored cable is fitted to the integral EVC for those rotary meters that are not. This temperature probe is then inserted into the gas line or sometimes the rotary meter outlet differential tap for flowing temperature measurement. For flowing pressure measurement, the pressure transducer is connected to the internal port or the rotary meter's external pressure port using a pressure piping kit consisting of a valve, required fittings, and stainless-steel tubing.

The temperature probe can be inserted into the gas pipeline using a thermowell. The pressure transducer, generally connected to the inlet differential tap of the rotary meter, measures the flowing gas pressure.

An electronic circuit board converts the transducer output to an electrical signal.

The EVC display typically shows parameters such as corrected and uncorrected volumes, pressure, temperature, correction factor, flow rate, compressibility, battery voltage, and other pertinent data. Generally, the user can choose which parameters to display in the product user configuration software.

An optional internal/external access to data may be available locally via an RS-232 serial connection, an IRDA interface to a laptop, an app to a smart phone or tablet, or other wireless connection. Communication ports like these can also be used for EVC configuration and calibration.

The electronic circuit board typically consists of one or more interconnected printed circuit boards. A printed circuit board has electronic components, connectors, configuration jumpers (if used), and terminals.

A pulse output and/or analog output signals may be available for interface to other devices/systems. A pulse-out may be configured for Form A, B, or C to provide the pulse-output signal for other field devices.

A communication port allows an external field computer to be connected to the EVC for data retrieval, configuration, or calibration.

Modern EVCs can generally interface with Automatic Meter Reading (AMR) / Advanced Metering Infrastructure (AMI) systems using pulse outputs or serial interfaces. Typical outputs from the EVC include corrected volume, uncorrected volume and/or alarms provided to AMR/AMI devices. For AMI devices, the EVC provides more information using a serial interface. In addition to volumetric information and faults/alarms, AMI systems can also collect information such as pressure and temperature logs.

Power for most EVCs is low-voltage DC, typically provided by batteries installed in the EVC. Other options are Solar supply, AC Power supply, etc.

An EVC for natural gas may face challenges regarding installation in a hazardous location. Physical requirements of mounting, cathodic protection effects, extreme environments, powering requirements, grounding, and stray currents, etc., must be considered for the proper EVC installations.

### **1.2.1 Typical Design for Instrument Drive Mounted EVC**

The EVC may or may not have an uncorrected mechanical counter; however, the EVC will always have the option to display both a corrected and an uncorrected electronic volume reading. The Instrument Drive version accumulates volume via the rotation of the index drive on the meter it is mounted on. Each rotation of the index drive on the meter represents a known volume of gas, known as the meter drive rate. This meter drive rate is configured into the EVC.

The rotation of the index drive can be either clockwise or counterclockwise. The rotation of the meter drive must match the rotation of the EVC index to advance accumulated volume.

The mechanical index read-out is an odometer-type register (For example see Figure 3.), which is typically eight digits. The odometer-type index can be scaled by masking off the least significant right-most digit(s). This allows the odometer to represent 1 cubic foot (CF), 10 cubic feet (DCF), 100 cubic feet (CCF), or 1000 cubic feet (MCF) (typically reading in CCF). Mechanical indexes on the meter are built using different gear ratios to match the meter's mechanical drive rate. Meters have different drive rates of 1, 5, 10, 100, or 1000 cubic feet per rotation. The EVC mechanical index must match the meter drive rate. Alternately, some direct drive mechanical indexes are available with a counter-only mechanism. There should be a permanent label affixed to the index drive of the meter that describes the meter volume per revolution (e.g. *1 REV. = 100 CF*) to ensure that the volume input to the EVC, commonly known as the drive rate, is properly programmed.

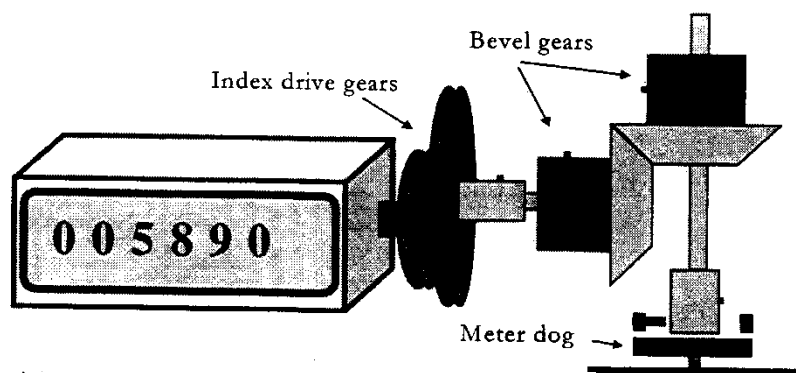


Figure 3<sup>3</sup>

If, for example, the meter delivers 10 cubic feet per revolution and the odometer's right- most two digits are masked off, then the odometer's value would be read in units of 100 cubic feet or 1 CCF.

The meter reading recording system may only allow a certain number of digits, which may require masking the most significant digit. The index should be scaled

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<sup>3</sup> Image published with permission from AGA.

or masked so that the least and most significant digit indicating the volume between readings is less than the volume registered between meter reading cycles. For example, the index has 5 digits showing; the least significant digit is weighted at 1 CCF(100 cubic feet), and the most significant digit represents 10,000 CCF (1,000,000 cubic feet). The index can then keep track of close to 10 million (99,999X 100) cubic feet of gas. The meter capacity between readings must be less than that amount, or the index value will “roll over” the point of the previous reading.

### 1.2.2 Periodic Equipment Verification

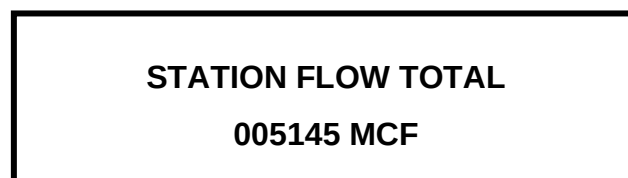
When the EVC is installed, the mechanical uncorrected index reading should match the uncorrected reading on the electronic display of the EVC. During subsequent visits to the meter site, the technician may ensure that the uncorrected mechanical odometer reading matches the reading on the electronic display. If the readings do not match, the technician will investigate the reason for the mismatch and update the uncorrected electronic reading accordingly.

## 1.3 EVC Electronic Display

EVCs incorporate an electronic display for local observation of configuration parameters and volumetric information. To conserve battery power, EVCs may be programmable to turn the display On/Off on a schedule, or on demand. When the display is active, the display will indicate not only current conditions, but may show if any alarms are present.

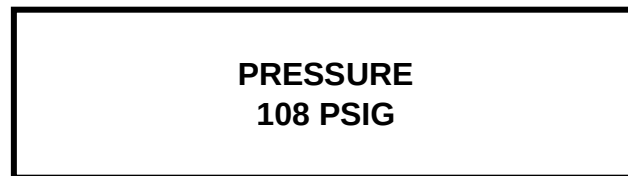
The display typically shows parameter values with appropriate resolution, item identification, and the respective engineering unit. Any available parameters for display may be configurable by the end user to show on the display.

### Example 1:



Parameters available on the display can be selected via a menu or scroll mode. A typical setup might include continuous volume accumulation, flow rate, pressure, temperature, flow constants, current-day volume accumulation, and the previous-day volume accumulation. These items may be accessible to the customer in a read-only mode, with no or limited security login required.

#### Example 2:



If the display is a touch screen or a local keypad is included, additional items such as alarms, events, configuration constants and calibration values, may be available for display to authorized users. Multiple security levels may allow the viewing only or viewing/setting of additional parameter values.

## 1.4 Configuration

### 1.4.1 Overview

The ability to configure and reconfigure EVCs allows them to be adapted to various changing requirements.

Specific measurement data requirements and different meters and customer sites create variations, even within a single utility. The need for flexibility and ease of changing data requirements has grown dramatically with deregulation and gas transportation contracts.

### 1.4.2 Configuration Methods

“Configuration,” as applied to EVCs, refers to setting measurement units, scaling factors, display options, and other parameters that match the individual instrument to the specific measurement application.

Configuration is achieved by one or more of the following methods:

- Connecting a computer to a serial port on the EVC and using a software program supplied by the manufacturer.
- Connecting a hand-held terminal supplied and programmed by the manufacturer to a serial port on the EVC.
- Using an integral keypad and/or display.
- Connect via Integral Bluetooth or serial Bluetooth device.
- Parameter changes via the AMI network.
- Connect using an Infra-Red adapter. (IrDA)
- Changing switch or jumper settings on the circuit board.

The configurability of EVCs allows one instrument to be used in several different metering applications. Configuration information can be stored in a Template to allow identical configuration of several EVCs. Passwords can be set to prevent unauthorized configuration changes. Configuration changes are saved in event logs.

### **1.4.3 Wake-Up Interval**

EVCs located in areas without a source of electrical power usually are battery-powered. To reduce the frequency of changing batteries, EVCs use power-conservation techniques. One of these techniques is to spend most of the time in a low power “sleep” condition and to wake up periodically to make measurements. Two methods are used to determine the wake-up period: timed wakeups and meter pulse-initiated wake-ups.

A benefit of the timed wake-up technique is that it allows exact determination of power usage to predict battery life. The pulse wake-up technique initiates a measurement and calculation once every meter rotation, or it may be set to a user-configurable number of meter rotations for further power reduction. The advantage of pulse wake-up is the exact volume weighting of the correction factors. During periods of heavy gas usage, more frequent measurements and calculations are made.

The latest devices have hardware that optimizes power consumption, resulting in battery conservation. Many devices will take pressure and temperature measurements based solely on time. Also, Wiegand sensor technology has gained popularity and provides a higher-resolution measurement of gas volume.

#### **1.4.4 Constant Flow Parameters**

A constant-flow parameter is any value that affects the quantity calculation. It is not associated with the property or state of the flowing gas and does not change frequently. Linear meter pulses-per-unit volume factor, base pressure, and base temperature are examples of constant-flow parameters.

#### **1.4.5 Compressibility/Data Input Frequency**

Compressibility, specific gravity, and heating value may be introduced into the calculation as a combination of constant values, sampled inputs, or calculated values. Specific gravity and heating value may be entered from an analysis.

A maximum frequency for updating the variables will minimize the uncertainty associated with constant values and sampled inputs.

#### **1.4.6 Configuration for AMR/AMI and Modbus Inputs**

EVCs can be configured for Pulse Output for AMR/AMI devices natively or by adding a Pulse Output board. The EVC can be configured to pulse the device at a selectable rate, typically from 1 CF per pulse to 10,000 CF per pulse. The AMR/AMI pulse device is generally set up to report Corrected pulses, Uncorrected pulses, and possibly an Alarm Channel from the EVC. An exact match of the Pulse Output rate and the rate programmed in the AMR/AMI device is imperative to reflect consumption accurately.

AMI devices may also collect registers directly from the EVC through serial communications. Unlike pulse-counting devices, these communication devices report the values in the registers directly to the backend system.

EVCs may include Modbus capability. Modbus registers in the device could be configured to access registers using Modbus and collected with an appropriate software program using the Modbus protocol.

### 1.4.7 Recorded Variables

In addition to taking pressure, temperature, and volume measurements, EVCs can measure, calculate, and store many variables for data log reports and verification of configuration and calibration. For periodic data logs, statistical intervals may be configurable to the minute and the month. Multiple data logs may be available for individualized programming. Among some variables that can be measured and stored are the following:

- (a) Corrected and Uncorrected Volumes
- (b) Correction Factors
- (c) Compressibility Calculations
- (d) Gas Composition
- (e) Gas Pressure
- (f) Gas Temperature
- (g) Ambient Temperature
- (h) Scaling Factors
- (i) Units of Measure
- (j) Average, Minimum and Maximum Statistical Values
- (k) Dates and Times of Minimum and Maximum Statistical Values\
- (l) Differential Pressure (meter health or filter health)
- (m) Alarm Values
- (n) External Inputs
- (o) Interval Max/Average Dial/Flow Rates
- (p) Delta A (dual rotor turbine meters)
- (q) Battery Statistics
- (r) Device Identification Numbers
- (s) Hourly, Daily and Monthly Values
- (t) Pulse-Output Configuration
- (u) Serial Communication Configuration
- (v) Data Storage Configuration
- (w) Calibration Information
- (x) Firmware Version

Flexibility of configuration allows an EVC to be stocked for general use, then configured for different meter sizes and meter drive rates.

#### **1.4.8 Local Display/Keypad**

Many devices will allow reading of data and changing the configuration using a built-in or proprietary display/keypad. The parameters displayed may be configurable by an operator. An operator can scroll through parameters using a magnet or push button. There may be an auto-scroll option available for the EVC display. Configuration or calibration changes may be password protected.

#### **1.4.9 Interval Data Storage Configuration**

Some EVCs have memory storage in which the measured and computed variables can be stored at timed intervals. Common storage intervals are 24 hours, 1 hour, and may be configurable at another interval.

Storage of measured variables can also be triggered by other events or configuration changes.

The “data logs” or reports can be generated from the stored data. These “data logs” can be configurable. Some “data logs” configurations may allow for storage of useful data outside of data collected for billing purposes.

Interval average should match the billing interval. Care should be taken that interval averages less than hourly should match billing interval.

Storage of measured variables can also be triggered by other events such as alarms, serial access, changes etc.

#### **1.4.10 Non-Measurement Items**

EVCs may be configurable to monitor, and alarm with other parameters not used in the gas measurement process. This may include additional pressure measurement with an addition of a transducer, voltage measurement, or external switch inputs. The device may also be configurable to control an external/internal communication device.