8714i Calibration Verification

The 8714i Calibration Verification diagnostic provides a means of verifying the flowmeter is within calibration without requiring a process shutdown or removal of the flowtube sensor. This is a manually initiated diagnostic test that provides a review of the transmitter and flowtube sensors critical parameters as a means to document verification of calibration. The results of running this diagnostic provide the deviation amount from expected values and a pass/fail summary against user-defined criteria for the application and conditions.

The 8714i Calibration Verification diagnostic can be initiated as required by the application. If the advanced diagnostic suite (DA2) was ordered, then the 8714i Calibration Verification diagnostic will be available. If DA2 was not ordered or licensed, this diagnostic will not be available.

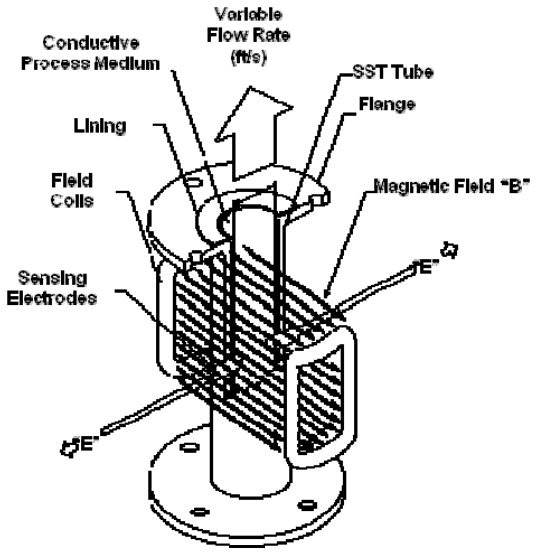
Meter Verification Theory of Operation

Magnetic flowmeters function on the principle of Faraday's Law which states that a conductor moving through a magnetic field will generate a voltage that is proportional to the speed of the conductor. This relationship is described by the following equation:

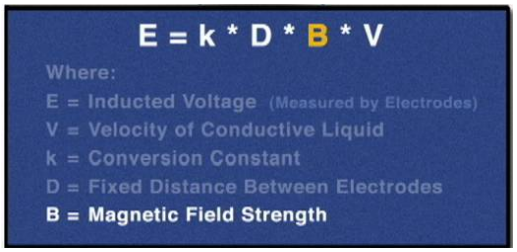
$E = k * B * D * V$ where

E = The induced voltage generated
k = A unit conversion constant
B = The Magnetic Field Strength
D = The distance between the probes picking up the induced voltage
V = The velocity of the conductor

With magnetic flowmeters, the conductor is the fluid that is passing through the flowtube sensor and D becomes the distance between the measurement electrodes which will always be a fixed distance. This means that the relationship between E and B and V needs to be established. This is done through the calibration process which is performed on every Rosemount magnetic flowtube sensor. The calibration process determines a 16-digit calibration number that is unique to every flowtube sensor. This calibration number then describes the relationship between the velocity (V) and the induced voltage (E).



With this, Faraday's equation can be re-written as:



E = C * V where
C = Calibration constant = k * B * D

We have already discussed that k and D are fixed; this means that the only variable that will result in a change in the calibration constant is a change in the magnetic field. Since there are no moving parts to a magnetic flowmeter, and the coil windings and coil current are constant if the meter if functioning correctly, B should not change over time.

By taking a baseline of some basic parameters that describe the magnetic field strength (B) during the calibration process provides a factory reference point to the magnetic field strength at the time of calibration for that flowtube sensor. By comparing measured values taken during the meter verification process to the established baseline parameters and checking for deviations it can be determined if the flowtube sensor calibration has shifted and corrective action needs to be taken.

Establishing the Baseline Comparison – Flowtube Sensor Signature

The flowtube sensor signature describes the magnetic behavior of the sensor. The flowtube sensor signature is taken at the time of calibration and sets values for the ***coil signature*** (a measure of the magnetic field strength) and the ***coil resistance*** (an indication of coil circuit health). One signature value that is not established at the time of calibration is the ***electrode resistance*** (an indication of the electrode circuit health). Because the electrode resistance will be dependant on the conductivity of the process fluid in the flowtube sensor at the time of calibration, the signature of this parameter needs to be done once the meter is installed and the actual process is flowing through the meter.

Establishing the baseline flowtube sensor signature

The first step in running the 8714i Calibration Verification test is establishing the reference signature that the test will use as the baseline for comparison. This is accomplished by having the transmitter take a signature of the flowtube sensor. Having the transmitter take an initial flowtube sensor signature when first installed will provide the baseline for the verification tests that are done in the future. The flowtube sensor signature should be taken during the start-up process when the transmitter is first connected to the flowtube sensor, with a full line, and ideally with no flow in the line. Running the flowtube sensor signature procedure when there is flow in the line is permissible, but this may introduce some noise into the signature measurements. If an empty pipe condition exists, then the flowtube sensor signature should be run for the coils only. Once the flowtube sensor signature process is complete, the measurements taken during this procedure are stored in non-volatile memory to prevent loss in the event of a power interruption to the meter.

Integrally mounted transmitters will come with the flowtube sensor signature already loaded into the non-volatile memory. For integrally mounted transmitters this is a standard part of the calibration procedure. Once the flowtube sensor is installed and the line is filled with process fluid, the user should perform an electrode circuit signature. The electrode circuit signature is not taken at the time of calibration due to the wide variety of process fluids used with magnetic flowmeters.

Transmitters that have been paired to a specific flowtube sensor will also come with the flowtube sensor signature preloaded into the non-volatile memory.

Transmitters that have not been paired to a specific flowtube sensor, or transmitters ordered as a replacement will need to have the flowtube sensor signature established once they are installed in the field.

Understanding the Re-Signature Parameters

When performing a re-signature of the flowtube sensor, there are three signature options available. Note that when a re-signature is done, it overwrites the existing signature values stored in the non-volatile memory.

All
Re-signature all values for the flowtube sensor. This includes the coil signature, coil resistance, and electrode resistance.

Coils
Re-signature the coil values only. This includes the coil signature and the coil resistance. The electrode resistance is not measured.

Electrodes
Re-signature the electrode resistance value only. The coil signature and coil resistance are not measured. A re-signature of the electrodes only should be done for new installations once the flowtube sensor is installed and the pipe is filled with the process fluid.

Understanding the 8714i Test Parameters

The 8714i has a multitude of parameters that set the test criteria, test conditions, and scope of the calibration verification test.

Test Conditions for the 8714i Calibration Verification

There are three possible test conditions that the 8714i Calibration Verification test can be initiated under. This parameter is set at the time that the 8714i Calibration Verification test is initiated.

No Flow
Run the 8714i Calibration Verification test with a full pipe and no flow in the line. Running the 8714i Calibration Verification test under this condition provides the most accurate results and the best indication of magnetic flowmeter health. Under this condition the 8714i tests against the criteria limits entered for Full Pipe, No Flow.

Flowing, Full
Run the 8714i Calibration Verification test with a full pipe and flow in the line. Running the 8714i Calibration Verification test under this condition provides the ability to verify the magnetic flowmeter health without shutting down the process flow in applications where a shutdown is not possible. Running the calibration verification under flowing conditions can cause false fails of the transmitter verification test if the flow rate is not at a steady flow, or if there is process noise present. Under this condition the 8714i tests against the criteria limits entered for Full Pipe, Flowing.

Empty Pipe
Run the 8714i Calibration Verification test with an empty pipe. Running the 8714i Calibration Verification test under this condition provides the ability to verify the magnetic flowmeter health with an empty pipe. Running the calibration verification under empty pipe conditions will not check the electrode circuit health and may result in false fails of the transmitter verification test as empty pipe conditions generate significant background noise during the transmitter verification test. Under this condition the 8714i tests against the criteria limits entered for Empty Pipe.

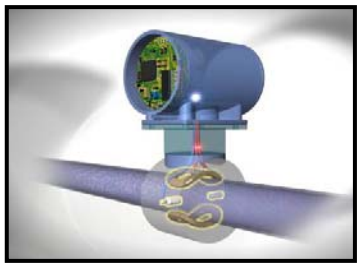
8714i Calibration Verification Test Criteria
The 8714i Calibration Verification diagnostic provides the ability for the user to define the maximum allowable deviation for the transmitter calibration and flowtube sensor calibration verification tests. Deviations results that exceed the established test criteria will cause the test to fail. The test criteria can be set for each of the flow conditions discussed above.

Full Pipe, No Flow
Set the test criteria for the No Flow condition. The factory default for this value is set to two percent with limits configurable between one and ten percent.

Full Pipe, Flowing
Set the test criteria for the Flowing, Full condition. The factory default for this value is set to three percent with limits configurable between one and ten percent.

Empty Pipe
Set the test criteria for the Empty Pipe condition. The factory default for this value is set to five percent with limits configurable between one and ten percent.

8714i Calibration Verification Test Scope



The 8714i Calibration Verification can be used to verify the entire flowmeter installation, or individual parts such as the transmitter or flowtube sensor. This parameter is set at the time that the 8714i Calibration Verification test is initiated.

All

Run the 8714i Calibration Verification test and verify the entire flowmeter installation. This parameter results in the calibration verification performing the transmitter calibration verification, tube calibration verification, coil health check, and electrode health check. Transmitter calibration and tube calibration are verified against the percentage associated with the test condition selected when the test was initiated.

Transmitter

Run the 8714i Calibration Verification test on the transmitter only. This results in the verification test only checking the transmitter calibration against the limits of the test criteria selected when the 8714i Calibration Verification test was initiated.

Flowtube Sensor

Run the 8714i Calibration Verification test on the flowtube sensor only. This causes the verification test to check the flowtube sensor calibration against the limits of the test criteria selected when the 8714i Calibration Verification test was initiated. This test will also verify the coil circuit health, and the electrode circuit health.

		Test Scope		
		All	Transmitter	Flowtube Sensor
Test Condition	No Flow, Full	Flowtube Sensor Cal Test Coil Circuit Test Electrode Circuit Test Transmitter Cal Test	Transmitter Cal Test	Flowtube Sensor Cal Test Coil Circuit Test Electrode Circuit Test
	Flowing, Full	Flowtube Sensor Cal Test Coil Circuit Test Electrode Circuit Test Transmitter Cal Test	Transmitter Cal Test	Flowtube Sensor Cal Test Coil Circuit Test Electrode Circuit Test
	Empty Pipe	Flowtube Sensor Cal Test Coil Circuit Test Transmitter Cal Test	Transmitter Cal Test	Flowtube Sensor Cal Test Coil Circuit Test

Understanding the 8714i Test Results

Once the 8714i Calibration Verification test is initiated, the transmitter will make several measurements to verify the transmitter calibration, tube calibration, coil circuit health, and electrode circuit health. The results of these tests can be reviewed and recorded on the Rosemount Magnetic Flowmeter Calibration Report (00816-0200-4727). This report can be used to validate that the meter is within the required calibration limits to comply with governmental regulatory agencies such as the Environmental Protection Agency or Food and Drug Administration.

Sensor Characteristic	Signature Baseline Values	8714i Measured Values	Deviation	Criteria	Pass/Fail
Coil Signature	19.5	19.6			
Coil Resistance	15.2	15.6			
Electrode Resistance	260.7	245.6			

Sensor Characteristic	Signature Baseline Values	8714i Measured Values	Deviation	Criteria	Pass/Fail
Coil Signature	19.5	19.6	0.51	1%	Pass
Coil Resistance	15.2	15.6			
Electrode Resistance	260.7	245.6			

Viewing the 8714i Calibration Verification Results

Depending on the method used to view the results, they will be displayed in either a menu structure, as a method, or in the report format. When using the HART Field Communicator, each individual component can be viewed as a menu item. When using the LOI, the parameters are viewed as a method using the left arrow key to cycle through the results. In AMS the calibration report is populated with the necessary data eliminating the need to manually complete the report found on page xx.

NOTE
When using AMS there are two possible methods that can be used to print the verification report.
Method one involves taking a PrntScrn picture of the 8714i Report tab on the status screen and pasting it into a word processing program. The PrntScrn button will capture all items on the screen so the image will need to be cropped and resized in order to get only the report.
Method two involves using the print feature within AMS while on the status screen. This will result in a printout of all of the information stored on the status tabs. Page two of the report will contain all of the necessary calibration verification result data.

The verification results are displayed in the following order on the LOI:

Test Condition
Displays the test condition under which the 8714i was performed.

Test Criteria
Displays the maximum allowable deviation percentage before a verification test will fail.

8714i Result
Displays the overall result of the 8714i Calibration Verification test as either a Pass or Fail.

Simulated Velocity
Displays the simulated velocity used to verify the transmitter calibration.

Actual Velocity
Displays the velocity measured by the transmitter during the calibration verification process.

Velocity Deviation
Displays the deviation in the Actual Velocity compared to the Simulated Velocity in terms of a percentage. This percentage is then compared to the test criteria to determine if the transmitter is within calibration limits.

Transmitter Calibration Verification
Displays the results of the transmitter calibration verification test as either a Pass or Fail.

Flowtube Sensor Calibration Deviation
Displays the deviation in the measured coil signature to the baseline coil signature to determine if the flowtube sensor calibration has shifted. This percentage is compared to the test criteria to determine if the flowtube sensor is within calibration limits.

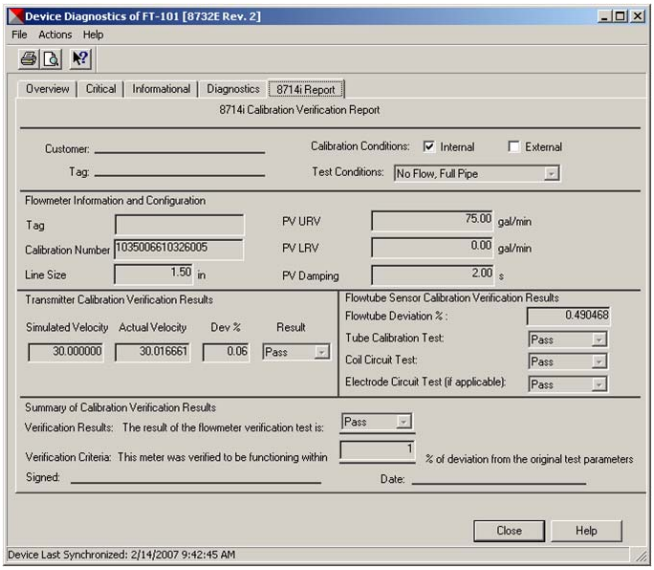
Flowtube Sensor Calibration Verification
Displays the results of the flowtube sensor calibration verification test as either a Pass or Fail.

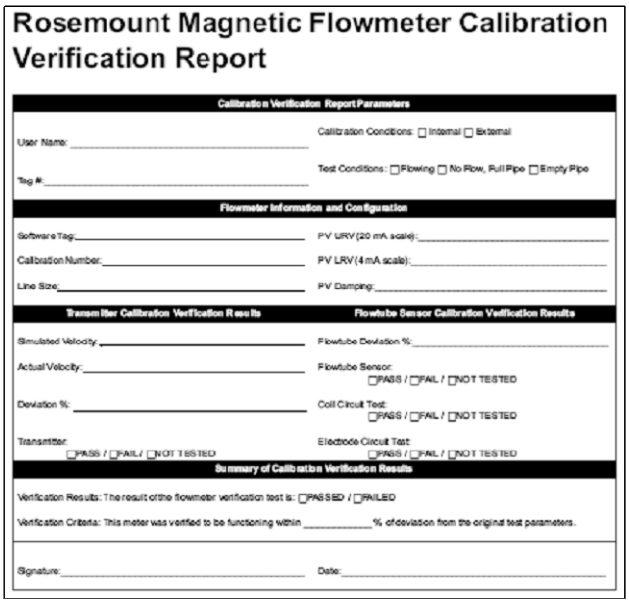
Coil Circuit Verification
Displays the results of the coil circuit health check as either a Pass or Fail.

Electrode Circuit Verification
Displays the results of the electrode circuit health check as either a Pass or Fail.

Meter Verification Report Examples

Once the meter verification diagnostic has completed, it is possible to print a verification report for submission to a regulatory agency or file with the instrument file. If using AMS, the report is populated automatically with the appropriate information. If using a 375 or the LOI, a report is available to fill out manually.





Optimizing the 8714i Calibration Verification

The 8714i Calibration Verification diagnostic can be optimized by setting the test criteria to the desired levels necessary to meet the compliance requirements of the application. The following examples below will provide some guidance on how to set these levels.

Example

An effluent meter must be certified every year to comply with Environmental Protection Agency and Pollution Control Agency standards. These governmental agencies require that the meter be certified to five percent accuracy.

Since this is an effluent meter, shutting down the process may not be viable. In this instance the 8714i Calibration Verification test will be performed under flowing conditions. Set the test criteria for Flowing, Full to five percent to meet the requirements of the governmental agencies.

Example

A pharmaceutical company requires bi-annual verification of meter calibration on a critical feed line for one of their products. This is an internal standard, but plant requirements require a calibration record be kept on-hand. Meter calibration on this process must meet one percent. The process is a batch process so it is possible to perform the calibration verification with the line full and with no flow. Since the 8714i

Calibration Verification test can be run under no flow conditions, set the test criteria for No Flow to one percent to comply with the necessary plant standards.

Example
A food and beverage company requires an annual calibration of a meter on a product line. The plant standard calls for the accuracy to be three percent or better. They manufacture this product in batches, and the measurement cannot be interrupted when a batch is in process. When the batch is complete, the line goes empty. Since there is no means of performing the 8714i Calibration Verification test while there is product in the line, the test must be performed under empty pipe conditions. The test criteria for Empty Pipe should be set to three percent, and it should be noted that the electrode circuit health cannot be verified.

Once the test criteria is established and the flowtube sensor signature values taken, it is suggested to run the 8714i Calibration Verification test to verify that the verification test can provide the desired results. This also serves to provide a baseline as it provides an initial "good" test point to compare to in the event that the verification fails in a future test.

Troubleshooting the 8714i Calibration Verification Test

In the event that the 8714i Calibration Verification test fails, the following steps can be used to determine the appropriate course of action. Begin by reviewing the 8714i results to determine the specific test that failed.

Test	Potential Cause of Failure	Steps to Correct
Transmitter Calibration Verification Test Failed	• Unstable flow rate during the verification test • Noise in the process • Transmitter drift • Faulty electronics	• Perform the test with no flow in the pipe • Check calibration with an external standard like the 8714D • Perform a digital trim • Replace the electronics
Flowtube Sensor Calibration Verification Failed	• Moisture in the terminal block of the flowtube sensor • Calibration shift caused by heat cycling or vibration	• Remove the flowtube sensor and send back for recalibration.
Coil Circuit Health Failed	• Moisture in the terminal block of the flowtube sensor • Shorted Coil	• Perform the flowtube sensor checks detailed in the manual.
Electrode Circuit Health Failed	• Electrode Signature was never performed	• Perform the electrode signature and re-run the verification test
	• Moisture in the terminal block of the flowtube sensor • Coated Electrodes • Shorted Electrodes	• Perform the flowtube sensor checks detailed in the manual.

8714i Calibration Verification Functionality

The 8714i Calibration Verification diagnostic functions by taking a baseline flowtube sensor signature and then comparing measurements taken during the verification test to these baseline results.

Flowtube Signature Values

The flowtube sensor signature describes the magnetic behavior of the sensor. Based on Faraday's law, the induced voltage measured on the electrodes is proportional to the magnetic field strength. Thus, any changes in the magnetic field will result in a calibration shift of the flowtube sensor. Having the transmitter take an initial flowtube sensor signature when first installed will provide the baseline for the verification tests that are done in the future. There are three specific measurements that are stored in the transmitter's non-volatile memory that are used when performing the calibration verification.

Coil Circuit Resistance

The Coil Circuit Resistance is a measurement of the coil circuit health. This value is used as a baseline to determine if the coil circuit is still operating correctly when the 8714i Calibration Verification diagnostic is initiated.

Coil Signature

The Coil Signature is a measurement of the magnetic field strength. This value is used as a baseline to determine if a flowtube sensor calibration shift has occurred when the 8714i Calibration Verification diagnostic is initiated.

Electrode Circuit Resistance

The Electrode Circuit Resistance is a measurement of the electrode circuit health. This value is used as a baseline to determine if the electrode circuit is still operating correctly when the 8714i Calibration Verification diagnostic is initiated.

8714i Calibration Verification Measurements

The 8714i Calibration Verification test will make measurements of the coil resistance, coil signature, and electrode resistance and compare these values to the values taken during the flowtube sensor signature process to determine the flowtube sensor calibration deviation, the coil circuit health, and the electrode circuit health. In addition, the measurements taken by this test can provide additional information when troubleshooting the meter.

Coil Circuit Resistance

The Coil Circuit Resistance is a measurement of the coil circuit health. This value is compared to the coil circuit resistance baseline measurement taken during the flowtube signature process to determine coil circuit health.

Coil Signature

The Coil Signature is a measurement of the magnetic field strength. This value is compared to the coil signature baseline measurement taken during the flowtube signature process to determine tube calibration deviation.

Electrode Circuit Resistance

The Electrode Circuit Resistance is a measurement of the electrode circuit health. This value is compared to the electrode circuit resistance baseline measurement taken during the flowtube signature process to determine electrode circuit health.

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