APPROVAL PROCEDURE

FOR

AUTOMATIC TEMPERATURE COMPENSATOR
ELECTRONIC TYPE

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1.0 INTRODUCTION

1.1 Purpose

This approval procedure (AP) describes the necessary tests to perform on the Automatic Temperature Compensation (ATC) function in metering assemblies in order to determine compliance with applicable requirements, as provided in the *Weights and Measures Act and Regulations.*

1.2 Scope

These test procedures apply to metering assemblies incorporating electronic ATCs that cause the registration of volumes measured to be in units corrected to a reference temperature of 15˚C. The electronic ATCs may be part of a meter register, fuel dispenser, flow computer, an individual unit or component, or part of a terminal automation system.

1.3 Applicable Documents

Document Number	Document Title
	Weights and Measures Act and Regulations Sections R236, R258, R270, SVM-2
GN-LP-003	Vocabulary of Technical and Metrological Terms

1.4 Abbreviations and Symbols

ATC	Automatic Temperature Compensation
VCF	Volume Correction Factor
LOE	Limit of Error

2.0 PROCEDURE

2.1 Equipment Requirements

2.1.1 *Standards*

Standard Number	Description / Performance Requirements
N/A	

2.1.2 Other Equipment

Equipment Description	Performance Requirements
Pulse Generator	The maximum frequency output must be greater than the maximum input frequency of the electronic device under test.
Universal Counter	The maximum frequency able to be detected must be greater than the maximum input frequency of the electronic device under test.
Dual Channel Pulser	Dual channel, variable phase, variable output voltage
Stirred liquid Temperature bath	Range of -30˚C to 40˚C, or range of ATC Stability to ± 0.05˚C, Max temperature variation of ± 0.05˚C
Environmental Chamber	Range of -30˚C to 40˚C, or range of ATC Accuracy of ± 1.0˚C, stability to ± 0.2˚C
Reference Thermometer	Range of -30˚C to 40˚C, or range of ATC with Min/Max feature or temperature graphing feature Uncertainty of K=2, ± 0.05˚C
DC Voltage/Current source	Range of 0 mv to 100 VDC, accuracy of ± 0.01% Range of 0 ma to 100 ma, accuracy of ± 0.01%
Resistance Temperature Detector Simulator	Range of 10Ω to 110Ω accuracy of ± 0.004Ω

2.2 Software Requirements

Software Name	Description / Performance Requirements
N/A	

2.3 Environmental Requirements

Temperature	N/A
Humidity	N/A
Pressure	N/A

2.4 Safety Requirements

Refer to the applicable Measurement Canada Health and Safety documentation.

2.5 Set-up

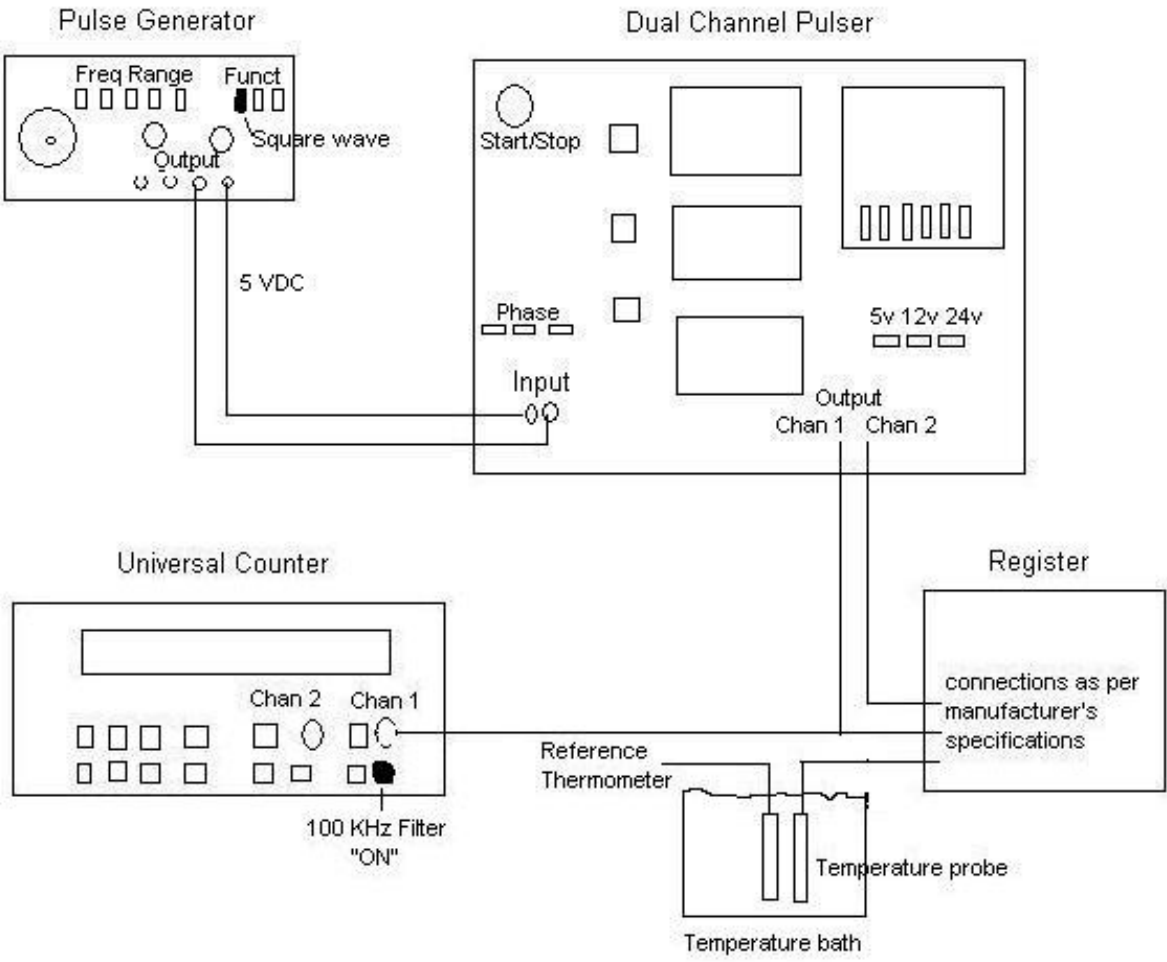### 2.5.1 Systems with Temperature Sensors

Fig.1: Test setup for ATC function with Temperature probe

2.5.1.1 Select the "Square wave" function on the Pulse Generator

2.5.1.2 Adjust the "DC Offset" and "Amplitude" on the Pulse Generator until the Dual Channel Pulser is able to detect and register the pulses on its counters.

2.5.1.3   Select the appropriate "Phase shift" (90˚, 120˚, or 180˚) and "Output voltage" (5, 12, or 24 VDC) on the Dual Channel Pulser as the "Input signal" to the device, following the manufacturer's specifications.

2.5.1.4   Select "Freq & Ratio" for the "Measure" on the Universal Counter. Ensure that the "100KHz filter is ON".

2.5.1.5   With the Pulse Generator and Dual Channel Pulser powered ON and functioning properly, press the "Trigger/Sensitivity" button on the Universal Counter. A series of functions with their current value will appear one at a time. Use the "arrow keys" and "enter" buttons to change the values. Use the "Trigger/Sensitivity" button to move to the next function. Ensure the following values are set to obtain a stable frequency reading:

> Auto Trig   ON
> Level   Adjust to 50 - 70 Pct
> Slope   POS
> Sensitivity   MED or HI

When completed, hit the "Run" button to return to the detection mode.

2.5.1.6   Use tie wraps or "O" rings, secure the device's Temperature Probe next to the Reference Thermometer and place into the temperature bath, maintaining the bottom of both probes in close proximity of one and other without making contact. Probes should be immersed in the bath at the same depth, at least 20 x probe diameters.

2.5.2   *Systems without Temperature Sensors*

2.5.2.1   For systems without temperature probes, simulators will be deployed to generate signals that emulate the probe's response. Depending on the type of probe the system is designed for, a DC current source, DC voltage source or a RTD simulator may be a connected to the device.

2.5.2.2   Follow the instructions in sections 2.5.1.1 to 2.5.1.5.

2.5.2.3   Connect the appropriate temperature probe simulator (current source, or voltage source, etc.) to the device, following the manufacturer's specifications.
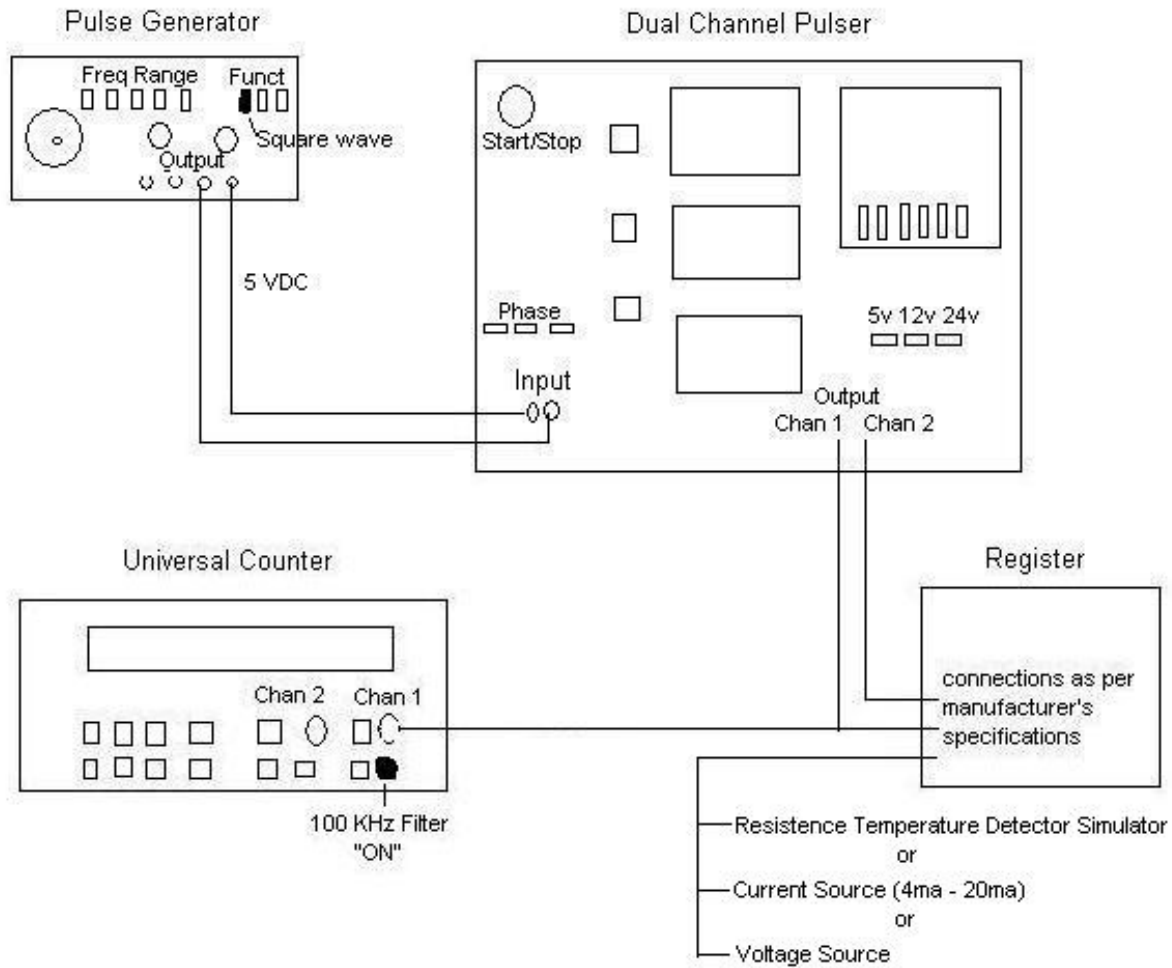
Fig.2: Test setup for ATC function without Temperature probe

2.6   Instructions

2.6.1   Accuracy Test for Electronic ATCs with Temperature Sensors (ie: dispensers)

2.6.1.1   The ATC function is to be tested at 5 different temperatures that span its operating range, as specified by the manufacturer. Divide the ATC range into 5 parts and determine the test temperatures. As an example, if the ATC operates from -30˚C to 40˚C, then tests will be performed at -30˚C, -12˚C, 5˚C, 22˚C and 40˚C. These will be conducted at room temperature and in the environmental chamber at -30˚C and 40˚C.

2.6.1.2   In general, the ATC functions can be classified as a fixed or a programmable type function. Depending on the type of ATC function, different test settings will be established, as follows:

(a) If the compensator/converter has predetermined values for the densities then the following standard values should be used:

Gasoline	730.0 kg/m^3,
Diesel Fuel	840.0 kg/m^3,
Propane	510.0 kg/m^3.

(b) If the density values are programmable, then enter the following values for the programmed table number specified:

API Table 54a	900 kg/m^3
API Table 54b	730 kg/m^3, 780 kg/m^3, 800 kg/m^3, 840 kg/m^3
API Table 54d	900 kg/m^3
ASTMIP 54	510 kg/m^3 (Propane)

(c) If the device accepts values for the cubical coefficient of thermal expansion of liquids, then in order to test the API Table 54c, enter the following values:

API Table 54c	0.001180 @15˚C per ˚C (methanol)
	0.001072 @15˚C per ˚C (ethanol)

2.6.1.3 Depending on the type of ATC function available, enter a value for the predetermined density, or the programmable density or the programmable cubical coefficient of thermal expansion, as above.

2.6.1.4 Set the temperature in the temperature bath to mid point of temperature range specified by the manufacturer. Stabilize the temperature bath until the set temperature has been reached and remains within ±0.05˚C over 5 minutes.

2.6.1.5 Immerse the temperature probe accompanying the device and a calibrated reference probe into the temperature bath to the proper depth. Wait until both temperature readings are stable within ±0.05˚C over 5 minutes.

2.6.1.6 If available, calibrate or adjust (using software features) the temperature probe accompanying the device to read identical to the calibrated reference probe. Note: Probe may only be adjusted once at one temperature only. If adjustments are not available, the temperature probe must read within ±0.5˚C of the calibrated reference probe.

2.6.1.7 If the reference temperature for ATC is adjustable then program the device to correct the volume to 15˚C, otherwise record the preset temperature for ATC.

2.6.1.8 Simulate a delivery using the setup in section 2.5.1 by first resetting the register to zero and then providing a pulse signal to the register (10,000 pulses minimum at the highest specified flow rate). Record the gross and net volume indications, the temperature and density values, the observed calculated Volume Correction Factor (VCF), and the temperature indicated by the Reference thermometer. Record results on the test sheet provided in Appendix C, section 3.3. **Ensure that the resolution of the gross and net volume indications is 1:10,000 or better.**

2.6.1.9 Repeat step 2.6.1.8 to obtain two runs at similar conditions. Record results on the provided test sheet.

2.6.1.10 Depending on the ATC type, repeat steps 2.6.1.8 and 2.6.1.9 at all the density values or the cubical coefficients of thermal expansion listed in step 2.6.1.2. Record results on the test sheet provided.

2.6.1.11 When all densities have been simulated at a given bath temperature, change the bath temperature to the next calculated value in step 2.6.1.1. Repeat steps 2.6.1.3 to 2.6.1.9 at all temperatures calculated in step 2.6.1.1 ensuring that the liquid temperature in the bath has stabilized before conducting any test runs. Record results on the provided test sheet.

2.6.1.12 Set the Environmental chamber temperature to -30˚C or to the lowest temperature rating of the register, whichever is higher. Place the Register into the chamber and allow the temperature to stabilize for 4 hours.

2.6.1.13 Repeat steps 2.6.1.4 to 2.6.1.9 at all 5 bath temperatures calculated in step 2.6.1.1, but at only one density setting. Record results on the provided test sheet.

2.6.1.14 Set the Environmental chamber temperature to 40˚C or the highest temperature rating for the register, whichever is lower. Repeat steps 2.6.1.13.

2.6.2   *Accuracy Test for Electronic ATCs without Temperature Sensors*

2.6.2.1 Complete steps 2.6.1.1 through 2.6.1.3 to determine temperature range and ATC type.

2.6.2.2 In general, temperature probes can usually be classified as a resistance type (100Ω RTD), a DC current type (4 - 20ma), or a DC voltage type. Depending on the type of temperature probe specified, the corresponding simulator will be connected to the ATC function to generate a controlled input signal.

2.6.2.3 Determine the correlation between the temperature reading and the probe raw output, as follows:

(a)   For a 100Ω RTD probe calculate R for each temperature T test point, where:

$$R = 100 \, (1 + \alpha \, (T))\Omega \qquad \text{where} \quad \alpha = \frac{(R_{100} - R_0)}{(100 * R_0)}$$

As an example, for a DIN type sensor

$R_0 = R \ @ \ 0˚C = 100\Omega$

$R_{100} = R \ @ \ 100˚C = 138.5\Omega \qquad \text{and} \ \alpha = \frac{(138.5 - 100)}{(100 * 100)} = 0.00385$

Some equipment can accommodate other types of sensors with α at different values.

(b)   For a 4 - 20ma DC current probe, determine the maximum span allowed and then calculate the DC current for the test points at temperature T as follows:

$$A = \frac{4[4(T) - 5(T\min) + T\max]}{[T\max - T\min]} \ \text{ma}$$

As an example, assume a temperature sensor is specified to be accurate between -50˚C and 110˚C. Therefore the DC current at 10˚C will be:

Tmin = T @ 4ma = -50˚C   span = 110 -(-50) = 160˚C
Tmax = T @ 20ma = 110˚C

$$A = \frac{4[4(10) - 5(-50) + 110]}{[110 - (-50)]} = \frac{4(40 + 250 + 110)}{160} = 10 \text{ ma}$$

(c)   For a DC voltage type sensor, use the same procedure as for the 4 - 20ma DC current probe. Please note that the formulas to determine the voltage at a given temperature will vary from the above equations, depending on the voltage and temperature ranges.

2.6.2.4   Set the simulator temperature to -30˚C or to the lowest temperature specified by the manufacturer, whichever is lower.

2.6.2.5   If the reference temperature for ATC is adjustable then program the device to correct the volume to 15˚C, otherwise record the preset temperature for ATC.

2.6.2.6   Simulate a delivery using the setup in section 2.5.1 by first resetting the register to zero and then providing a pulse signal to the register (10,000 pulses minimum at the highest specified flow rate). Record the gross and net volume indications, the temperature and density values, the observed calculated Volume Correction Factor (VCF), and the temperature indicated by the Reference thermometer. Record results on the test sheet provided in Appendix C, section 3.3. **Ensure that the resolution of the gross and net volume indications is 1:10,000 or better.**

2.6.2.7   Repeat step 2.6.2.6 to obtain two runs at similar conditions. Record results on the test sheet.

2.6.2.8   Depending on the ATC type, repeat steps 2.6.2.6 and 2.6.2.7 for all the density values or the cubical coefficients of thermal expansion listed in step 2.6.1.2. Record results on the test sheet provided.

2.6.2.9   Repeat steps 2.6.2.4 to 2.6.2.8 at the other temperatures calculated in step 2.6.2.1. Ensure that the simulator temperature is calculated properly according to the sensor type. Record results on the provided test sheet.

2.6.2.10   Set the Environmental chamber temperature to -30˚C or to the lowest temperature rating of the register, whichever is higher. Place the Register into the chamber and allow the temperature to stabilize for 4 hours.

2.6.2.11   Repeat steps 2.6.2.4 to 2.6.2.9 at all 5 temperatures calculated in step 2.6.1.1, but at only one density setting. Record results on the provided test sheet.

2.6.2.12   Repeat steps 2.6.2.10 and 2.6.2.11 at a chamber temperature of 40˚C or the highest temperature rating for the register, whichever is lower.

2.6.3   General requirements of Electronic ATCs

2.6.3.1   Complete Appendix A, section 3.1.

2.6.3.2   The tests below are to be performed in conjunction with the General Requirements Checklist presented in Appendix B, section 3.2.

2.6.3.3   Perform a test at a temperature outside the range of the ATC and in the negative direction.

2.6.3.4   During another run, short out the temperature sensor and note response. Return the circuit to normal operation and then disconnect the temperature sensor's electrical circuit. Perform a test and again note response. Record results on test sheet and checklist.

2.6.4   Response time test for Temperature Probe of Electronic ATCs (for devices with built-in sensors)

2.6.4.1   To test the response time of the ATC temperature sensors and the thermowells (if present), two temperature baths will be used. The ATC thermometer probe and thermowell will be moved from one bath to the other, with the response time recorded on the test sheet provided in Appendix D, section 3.4.

2.6.4.2   Set the temperature in bath (a) to 0˚C (or use an ice bath) and that in bath (b) to 20˚C. Allow the temperature of the liquids in both baths to stabilize within ± 0.1˚C.

2.6.4.3   Install the temperature sensor, with or without its thermowell, depending on manufacturer's criteria into bath (a). Allow the ATC thermometer to stabilize within ± 0.1˚C.

2.6.4.4   When the ATC temperature probe has stabilized and is reading near 0.0˚C ± 0.1˚C remove it from bath (a) and place it into bath (b), making sure to start the stop watch as soon as possible after the probe is fully immersed.

2.6.4.5   Simulate a delivery by providing a pulse signal to the register at the minimum rated flow rate. Record readings of the ATC temperature indication on the test sheet provided in Appendix D, section 3.4 at 5 second intervals until a stable reading of near 20˚C ± 0.1˚C is obtained.

2.6.4.6   Repeat steps 2.6.4.2 to 2.6.4.5 two more times. Record results on the test sheet in Appendix D in Section 3.4.

2.6.4.7   Chart results on a single phase. (Temperature vs time)

2.6.4.8   For flow computers, ensure that the sampling frequency is 1 second or less. No testing is required.

2.7 Calculations

2.7.1 Calibration Calculations

N/A

2.7.2 Sample Calculations

N/A

2.8 Pass/Fail Criteria

2.8.1 *General requirements for Electronic ATCs*

Description	Criteria	Reference	Pass–Fail
Classification of Device / System	Refer to Appendix 3.1 "General Requirements - Characteristics of Device/System".	N/A	
General Requirements Checklist	Refer to Appendix 3.2 "General Requirements Checklist ".	R21, R258, R295, SVM-2	

2.8.2 *Accuracy test for Electronic ATCs*

2.8.2.1 All accuracy tests must be within the applicable L.O.E. set out in section 270 of the Weights and Measures Regulations, as provided below.

Item	Column I - Known Test Quantity	Column II - Acceptance Limits of Error	Column III - In-Service Limits of Error
1	test volume shall be in accordance with specifications established pursuant to section 13 for electronic automatic temperature compensators for use with any device or class, type or design of devices	the VCF applied to the gross registration shall be not more than the VCF corresponding to a temperature that is 0.5°C less than the test temperature, and not less than the VCF corresponding to a temperature that is 0.5°C more than the test temperature	the VCF applied to the gross registration shall be not more than the VCF corresponding to a temperature that is 1°C less than the test temperature, and not less than the VCF corresponding to a temperature that is 1°C more than the test temperature

a) System with Temperature sensor
          L.O.E. on Temperature readout: ± 0.5˚C
          L.O.E. on Look up accuracy: VCF within VCF + 0.5˚C & VCF - 0.5˚C

b) System with analog signal input
          L.O.E. on Temperature readout: ± 0.2˚C
          L.O.E. on Look up accuracy: VCF within VCF + 0.2˚C & VCF - 0.2˚C

c) System with smart transducer input
          L.O.E. on Temperature readout: within resolution of display
          L.O.E. on Look up accuracy: VCF within ± 0.05 of true VCF

2.8.2.2 *Presented below is a cross reference table identifying the various correction tables used for temperature correction, based on product grouping.*

PRODUCT DESCRIPTION	VAPOUR PRESSURE @ 15° C.	DENSITY CORRECTION FACTOR	VOLUME REDUCTION FACTOR [CTL]	PRESSURE REDUCTION FACTOR [CPL]
PROPANE BUTANE	>101.325 kPa	ASTM-IP Table 53[1]	ASTM-IP Table 54	API chapter 11.2.2 M
GASOLINE DIESEL	<101.325 kPa	API chapter 11.1 Table 53B	API chapter 11.1 Table 54B	API chapter 11.2.2 M
JET FUEL	<101.325 kPa	API chapter 11.1 Table 53A	API chapter 11.1 Table 54A	API chapter 11.2.2 M
LUBRICATING OILS	<101.325 kPa	API chapter 11.1 Table 53D	API chapter 11.1 Table 54D	API chapter 11.2.2 M

2.8.2.3 Using the appropriate correction factor table above and the test sheet provided in Appendix C, section 3.3, determine whether the ATC meets the applicable limits of error, as presented in section 2.8.1.

2.8.3 *Response time test for Temperature Sensor for Electronic ATCs*

2.8.3.1 The temperature probe must respond to at least 90% of the 20°C temperature change at the minimum rated flow rate:(SVM2-19)

    a)   Within 15 seconds for a motor fuel dispenser, or
    b)   20 seconds for any other type of meter.

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[1]American Society for Testing and Materials (Astm-IP) tables are correct to three decimal points only. When more accurate tables become available, they will be used.

Use the Temperature probe response time test sheet in Appendix D, section 3.4 to determine compliance with the above requirement.

3.0 APPENDICES, WORK SHEETS AND TABLES

3.1 General Requirements - Characteristics of Device / System

1) Temperature Sensors

a) Systems that include a temperature sensor (dispenser)

    i) Sensor Type:
      ☐ 100Ω RTD
      ☐ Other, specify: _____

    ii) Rated temperature range: _____

b) Systems without a temperature sensor

    i) Compatible sensor / transducer:
      ☐ 100Ω RTD   specify rated range: _____ # Wires (3 or 4):_____
      ☐ 4 - 20ma   specify rated range: _____ Max span allowed:____
      ☐ DC voltage   specify rated range: _____ Max span allowed:____
      ☐ Smart transducer specify communication type: _____
      ☐ Other   specify:_____ _____

2) ATC Factors

a) Supported conversions

		Temperature range	Density range
☐	API Table 54a	Temperature range:_____	Density range: _____
☐	API Table 54b	Temperature range:_____	Density range: _____
☐	API Table 54c	Temperature range:_____	Density range: _____
☐	API Table 54d	Temperature range:_____	Density range: _____
☐	ASTMIP 54	Temperature range:_____	Density range: _____
☐	Other _____	Temperature range:_____	Density range: _____

b) Conversion Method
    ☐ Look up tables
    ☐ Algorithm

3) Sampling rates

a) Temperature read frequency: _____
b) Conversion Factor calculation frequency: _____

4) Calibration

a) Can Temperature measurement be adjusted (Y/N):____
b) What are the adjustable parameters:_____
                                     _____
                                     _____

Date: _____   **Project #:** _____

Operator: _____   **Device:** _____

3.2 General Requirements Checklist

Comments

1)	Is the temperature probe interchangeable with others of its type so that the accuracy of the temperature measured is not altered by more than 0.3°C over the temperature range of the ATC? SVM2 -9	☐ N/A ☐ NC ☐ C	
2)	Is the register capable of displaying on demand the temperature as measured by the sensor used with the ATC with an increment not exceeding ± 0.1˚C? SVM2 -8	☐ N/A ☐ NC ☐ C	
3)	Is the register inoperable if the temperature probe or it's electronic circuit is shorted or incomplete? SVM2 -11	☐ N/A ☐ NC ☐ C	
4)	Is there an interlock so that the selection of the product automatically sets the volume correction factor (VCF) where an ATC is used with several liquids? SVM2 -12	☐ N/A ☐ NC ☐ C	
5)	Is the gross volume determined directly from meter pulses and not by calculation from the net volume? SVM2 -5(2)	☐ N/A ☐ NC ☐ C	
6) (a)	Are thermal wells with an inside diameter between 3.3 and 4.5mm installed adjacent to the sensor of the ATC? SVM2 -24(1)	☐ N/A ☐ NC ☐ C	
(b)	Is the test well installed so that it will retain thermal conducting fluid during a test? (if installed) SVM2 -24(2)	☐ N/A ☐ NC ☐ C	

Date: _____   **Project #:** _____

Operator: _____   **Device:** _____

General Requirements Checklist (continued)

<div align="right">Comments</div>

7)	Does the ATC correct the measurement results within the applicable limits of error over the range of liquid temperatures of -30°C to 40°C or over the range marked on the name plate? SVM2 -16 and 17	☐ N/A ☐ NC ☐ C	
8)	When the temperature of a liquid is outside the temperature range of the ATC, is the ATC designed to:		
a)	automatically prevent further deliveries? SVM2 -18(a)	☐ N/A ☐ NC ☐ C	
b)	remain operative where the VCF does not exceed the value corresponding to the temperature of the liquid? SVM2 -18(b)	☐ N/A ☐ NC ☐ C	
9)	Is the temperature sensor used with ATC located less than 1m from the meter, and installed so that: SVM2 -23	☐ N/A ☐ NC ☐ C	
a)	the sensing end of the probe is near the axis of the pipe carrying the liquid? SVM2 -23(a)	☐ N/A ☐ NC ☐ C	
and b)	no valves, pumps or other equipment that may alter the temperature of the liquid are located between the probe and meter? SVM2 -23(b)	☐ N/A ☐ NC ☐ C	
10)	Where one meter used in an assembly for delivering a blend of liquids is equipped with ATC, do all other meters in the assembly have ATCs? SVM2 -27	☐ N/A ☐ NC ☐ C	
11)	Where a meter is equipped with a means of adjustment, does the adjustment apply to both the net and gross registrations? SVM2 -28?	☐ N/A ☐ NC ☐ C	

Date: _____   Project #: _____

Operator: _____   Device: _____

3.3 Test sheet for Automatic Temperature Compensation

Test #	Product Density (Kg/m^3)	VCF Table	A Product Temp (˚C)	B Register Temp (˚C)	Delta Temp (A-B)	C Gross Vol (L)	D Net Vol (L)	Calculated VCF (D/C)	VCF from Tables	Table VCF -1/2˚C	Table VCF +1/2˚C	VCF Deviation (˚C)	Pass or Fail
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													

Date: _____ **Project #:** _____

Operator: _____ **Device:** _____

3.4 Temperature Sensor Response Time Test sheet

Bath A temp:_____ **Bath B temp:**_____
Reference Thermometer:_____ **Reference Thermometer:**_____
Bath A Serial Num:_____ **Bath B Serial Num:**_____

Time (Sec)	Temp recorded after moving probe from bath A to bath B (°C)			Percent Change $\frac{(T - T_A)}{(T_B - T_A)}*100$		
	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
0						
5						
10						
15						
20						
25						
30						
35						
40						
45						
50						
55						
60						

Date: _____ **Project #:** _____

Operator: _____ **Device:** _____