Appendix B

National Type Evaluation Technical Committee (NTETC)
Measuring Sector

October 2 - 3, 2009, Clearwater, Florida
Annual Meeting Summary

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Measuring Sector Annual Meeting
Meeting Summary

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Chairman, Mr. Mike Keilty, Endress and Hauser, opened the meeting by welcoming participants and asking for introductions. Mr. Keilty also described the purpose of the Measuring Sector (hereafter referred to as the "Sector") and others contributed insights on how the Sector interacts with other committees in the National Conference on Weights and Measures (NCWM). Mr. Keilty also described procedures for commenting on issues during the meeting and indicated that, should an item be presented for an official "vote" during the meeting, only those listed on the "voting members" list provided by the NCWM will be recognized.

Accompanying this summary as "Appendix A" is a list of "Action Items" agreed to at the meeting.

Carry-over Items:

1. Table of Key Characteristics of Products in Product Families for Meters Table

Source: Carryover Item – 2007 and 2008 Measuring Sector Agenda

Purpose: For the past several years, the Sector has been working to revise the "Product Family" tables in NCWM Publication 14 (Pub 14) with the goal of clarifying the tests to be conducted and products to be referenced on an NTEP Certificate of Conformance (CC) based on NTEP testing. This item is included on the agenda to allow for review of a recent revision to the tables and to determine what additional work is needed.

Background: At its 2006 Annual Meeting, the Sector established a small work group (WG) tasked with developing proposed changes to the Product Families for Meters table in NCWM Pub 14 to help improve consistent application and ease of use of the table. In 2007, the Sector heard a progress report from the WG and considered a number of proposed revisions (see the 2007 meeting summary for details). The WG also noted additional work was needed to list the various liquids, describing their viscosity, specific gravity, and conductance.

At its 2008 meeting, the Sector was asked to consider another proposal from the WG, consisting of (1) a proposed table listing product families/groups along with typical product names and corresponding viscosities and specific gravities; and (2) a proposed revision to the product families table outlining test requirements for different meter types within each product family. The Sector also discussed the categorization of liquid CO_2 and the inclusion of milk and dairy products under separate agenda items.

After considerable review and discussion and on-screen editing of proposed variations of the table, the Sector reached a consensus on the format of the table, agreeing to divide the information into three tables: Table C.1. Tests to be Conducted (identifying tests to be conducted); Table C.2. Product Family Table (outlining product families broken down by meter technology and referencing tests from Table C.1.); and Table C.3. Typical Product Family Characteristics (listing typical products in each product family and the viscosity and specific gravity of each). At the end of the meeting, there was general agreement that the proposed revisions represent major improvements, while acknowledging that additional work was needed (see 2008 Sector Summary for additional details).

At the conclusion of the 2008 meeting, the Sector once again agreed that a consensus had been reached on the general revisions to the format, but that additional content changes are needed. Based on a reluctance to wait an additional year to implement the corrections already agreed upon, Sector members present agreed that additional revisions should be made and the Sector balloted. Following the 2008 meeting, Mr. Keilty prepared and distributed a ballot. The results of the vote indicated a lack of consensus for the additional changes proposed.

Recommendation: Based upon comments received as a result of the ballot and additional research on product characteristics, Sector Chairman Mr. Keilty developed a revised version of Policy C. Product Families for Meters (including revisions to the three "product family" tables) for consideration by the Sector in September 2009. This version was distributed as an attachment to the 2009 Sector Agenda (see Appendix B) and Sector members were asked to review the draft and consider it for inclusion in the 2010 edition of NCWM Pub 14.

Discussion: At the 2009 Sector Meeting, Mr. Keilty reviewed the history of the item and then described key features of the most recent version Policy C. Product Families for Meters that was included with the 2009 Agenda. Mr. Keilty noted that:

(1) Table C.1. (Tests to be Conducted) tests are identical to the current Pub 14;
(2) Table C.3. (Typical Product Family Characteristics) is an extraction of the products and their characteristics;
(3) There were some items that need to be addressed. For example, the Sector agreed to add "juices and beverages" to the table last year, but this didn't show up in Pub 14.
(4) In Table C.3., there was originally a question about the abbreviations for centipoises and the abbreviation now appears as "cP" with P capitalized because it is an abbreviation of a proper name.
(5) The breakout of the terms in the remainder of Table C.3. were taken from current version of Pub 14.
(6) References are closer to branded chemical names.
(7) Additional data in the agrichemicals area that people provided to Mr. Keilty are included.
(8) Additional information is still needed in defining "crop chemicals."
(9) Additional items need to be corrected, such as the addition of the "juices and beverages" categories.

Mr. Keilty suggested that the Sector begin its discussion of this item by first focusing on the format of the proposed table and then discussing its contents. Many positive comments were made regarding the format. Some questioned how to handle products that are not presently referenced in the table. Mr. Steve Patoray, Consultants on Certification, questioned the use of the term "normal liquids," noting its meaning is not clear.

Some questioned why different metering technologies are treated differently. For example, "normal liquids" for mass flow meters encompasses a much wider range of products than do other technologies. Mr. Keilty and Mr. Will Wotthlie, Maryland Weights and Measures, pointed out that for technologies new to the type evaluation program, more testing is required until data and NTEP experience with the technology illustrates expected performance for given product groupings. For example, when NTEP first began testing with turbine meters, the number of tests and flow rates were greater than for other technologies, which were more familiar to the NTEP program. As experience with turbine meters increased, NTEP broadened the coverage that could be obtained with a given test. An additional reason for the variation in how meter technologies are addressed in the table relates to how a given meter technology is affected by product characteristics. For example, changes in viscosity may affect one meter technology more than another meter technology. Others reiterated that the goal in establishing the "product family" table(s) was to minimize the amount of testing required by identifying groups of products which would give similar test results. For example, testing with one or two products from the group would illustrate performance similar to what would be expected for other products in the group.

Mr. Rich Miller, FMC Technologies, commented that the basic format and approach used in the table seems to have originated with PD meters; the Sector is trying to fit other meter technologies into the same format without acknowledging that some of the criteria do not make sense for those technologies. He further commented that meter technology should not matter; the criteria should be based on performance and the criteria should be applied equally across all meter technologies. Mr. Rich Tucker, RL Tucker Consulting, observed that the "normal liquids" seem to be causing some confusion for people, noting that the term only appears to be significant for mass flow meters and perhaps clarifying that term might eliminate some of the concerns. He also observed that the current criteria have been in Pub 14 for years; the current effort is to attempt to make the table more manageable and, if there are concerns about the criteria, perhaps this needs to be worked on and brought back as a separate proposal. Sector Technical Advisor, Ms. Butcher (NIST Weights and Measures Division) noted that, since the format seems acceptable to many, footnotes regarding the application of the term "normal liquids" might be used as an interim measure to allow the current criteria to be more easily applied, and alternative proposals could be developed as a separate effort to address concerns about inconsistencies found in other sections of the current criteria. The Sector discussed the use of the term "normal liquids" at greater length without coming to any resolution on how to address its use.

In the course of discussing the criteria and format of the tables, several people suggested that a better approach might be to separate the tables by technology. Mr. Patoray and Mr. Henry Oppermann (Weights and Measures Consulting) both offered to develop alternative formats and presented them to the Sector on the second day of the meeting. Mr. Keilty and Ms. Butcher agreed to make modifications to the three proposed tables in an attempt to clarify the use of current terminology.

On October 3, Mr. Patoray and Mr. Oppermann each presented alternative versions of the table which they had developed for two different metering technologies. The Sector reviewed the alternative prepared by Mr. Patoray and the alternative prepared by Mr. Oppermann as well as modifications to the existing proposal prepared by Mr. Keilty and Ms. Butcher.

Comments indicated that most prefer the approach in which technologies are addressed in separate tables, though Mr. Miller expressed disappointment that technologies are broken into separate tables and treated differently. Mr. Mr. Wotthlie noted that the version prepared by Mr. Oppermann appears to be the easiest to use, also noting that the ascending order of the product by specific property values is more relevant to the metrologically significant factors. Participants noted that additional work is needed to further develop an alternative table that combines or includes this approach and format, and a small work group was formed for this purpose as described in the "Decision" below.

Decision: Of three alternative versions of the table presented to the Sector during its 2009 meeting, the approach in which technologies are addressed in separate tables was viewed as a more appropriate approach.

[Technical Advisor's Note: An example of this format is illustrated in Appendix C in a draft prepared by Mr. Oppermann and further revised and reformatted by Mr. Keilty. This work is still in progress and the draft in this appendix is provided only to illustrate the general format agreed upon.]

Mr. Keilty will continue to shepherd this work, coordinating with those who have expressed interest in this issue and welcoming additional input from other Sector members. Work will be done to integrate the separated technology proposal with that presented at the 2009 Sector meeting. This newly edited version will be circulated among Measuring Sector members and discussed with those members who are able to attend the January 2010 NCWM Interim Meeting. Based on any comments received, additional revisions may be made prior to presenting a revised draft to the Sector at the 2010 Sector meeting. The goal is to develop a version for inclusion in NCWM Pub 14 in which it is easy to understand which tests and procedures must be followed for type evaluation testing.

2. NTEP Checklist for Hydrocarbon Gas Vapor Meters in Sub-metering Applications

Source: NTEP Director

Purpose: California Division of Measurement Standards (CA DMS), working with members of industry, has updated a draft checklist for hydrocarbon gas vapor meters in sub-metering applications. This item is included on the Sector agenda to allow for an update on this work and to discuss further action required by the Sector.

Background: At its 2006 meeting, the Sector was asked by the NTEP Committee to consider and develop a checklist for residential hydrocarbon gas vapor meters. These devices will most likely be used for sub-metering. At that meeting, the Sector heard that several states had recently contacted NTEP regarding these devices. California already has type evaluation and certification of these devices in their state. The Sector was asked to review the procedures used by California (which were included as Appendix D of the 2006 meeting agenda) and rework them into a format acceptable for NCWM Pub 14. The Sector agreed at that time that the best approach for developing a Pub 14 checklist for Liquid Petroleum Gas (LPG) vapor meters would be the utilization of a WG made up of technical experts and other interested parties. Mr. Dan Reiswig (CA DMS), was to provide a list of vapor meter manufacturers to be contacted for participation in the WG.

At its 2007 meeting, the Sector reviewed a draft presented by the California NTEP laboratory and agreed that the California NTEP laboratory and the NTEP director would continue to develop this checklist for presentation and discussion at the next Sector meeting.

At its 2008 meeting, the Sector, at the suggestion of the NTEP Measuring Laboratories, raised the question of whether or not there is interest in developing this checklist, particularly given the small number submitted for evaluation in the past and the availability of California's certificate as an alternative. Since the bulk of work remaining was in the reformatting of the checklist, the Sector agreed that the CA NTEP Laboratory will work to reformat the checklist into a Pub 14 format. Norman Ingram (CA Division of Measurement Standards, NTEP Laboratory) agreed to coordinate with Mr. Maurice Van Puten (meter manufacturer) and Jim Truex to work on this issue between now and the next Sector meeting.

A copy of a revised draft checklist was distributed to the Sector prior to its 2009 Meeting; a copy of the draft checklist is included in Appendix D to this summary. At its 2009 meeting, the Sector revisited the need to include a checklist for these devices in Pub 14. Mr. Oppermann, who noted he had experience testing these devices prior to his career at NIST, questioned the need for a separate checklist. Others questioned where they would fall in the product family table and what test criteria would apply. Mr. Reiswig noted that the meters recently tested are of a different technology than previously encountered. Mr. Keilty asked the Sector to consider the general question of whether or not the checklist is complete and ready to move forward and whether or not the checklist references anything that isn't currently referenced in NIST Handbook 44.

Decision: While some Sector members present at the meeting have tested these devices, there were no manufacturers of these devices present at the Sector meeting. The Sector heard no specific comments on the checklist and, hearing no real opposition, decided to forward the checklist to the NTEP Committee for their consideration.

The Sector agreed that Ms. Tina Butcher, NIST Technical Advisor, would forward the HydroCarbon (HC) Vapor Meter Checklist developed by CA to the NTEP Committee by November 1, 2009, for their consideration for inclusion in NCWM Pub 14.

3. Testing Meters Made of Different Materials

Source: California NTEP Laboratory – Carryover from 2007 Measuring Sector Agenda

Purpose: For the past several years, the Sector has been discussing the issue of how to assess variations in meter materials in conjunction with type evaluation testing. A key point of contention in these discussions revolves around changes to meter materials from that used in the meter evaluated during type evaluation. The NTEP laboratories would like more definitive criteria to help them assess when changes to meter materials are metrologically significant to the extent that additional testing should be required in order for the new material to be covered on the NTEP CC. Meter manufacturers generally believe that changes in materials should be left to the judgment of the manufacturer since they must ensure continued meter performance for their customers and, as the designers of the meter, they well understand and take into consideration product and environmental applications and adjust materials accordingly to meet the needs of the end application. The issue is further complicated by the lack of definitive criteria that would guide the NTEP laboratories in making a decision about which meter materials should be selected for testing to be representative of a range of materials. This item is a continuation of past discussions by the Sector on this issue.

Background: The Sector reviewed this issue at its 2007 and 2008 meetings, but was unable to reach a consensus on the item. The Meter Manufacturers Association had also prepared a white paper in which they noted that it is the manufacturer's responsibility to ensure that a meter meets type, noting the long history of meter compliance and also that NIST Handbook 44 is not intended to differentiate between measurement technologies, only the intended application. They also pointed out questions to be answered in order to make an informed decision on this issue include: (1) Is there a real world problem that requires a solution by inclusion of a new section in NCWM Pub 14 specifically aimed at materials?; and (2) Is there an inequity in the market or facilitation of fraud?

At its 2008 meeting, the Sector had extensive discussion over specific examples of meter sizes, product applications, and component materials. There were clearly divided opinions regarding how these combinations should be addressed. Manufacturers generally seemed to feel that component materials relative to the intended meter

application are a design issue and should be left to the manufacturer to address, particularly since they will ultimately be responsible for ensuring that the meters work accurately and their customers are satisfied. Some NTEP laboratory representatives were comfortable with the idea of allowing the marketplace to take care of this issue, whereas others were not, particularly citing their feeling of responsibility in attesting to the accuracy of what is listed on a CC. However, it was clear that all laboratories felt the need for additional guidance in how to handle variations with regard to the amount of testing required and on how to handle listing materials information on the CC to ensure consistency among all of the laboratories.

The Sector was unable to reach any consensus on this issue; however, the Sector acknowledged that the issue is not going to be eliminated from the Sector's agenda. Criteria (whatever that may be) regarding how to address materials must be included in Pub 14, and guidance needs to be given to the NTEP Laboratories to ensure this issue is consistently addressed for all evaluations.

Recommendation: The Sector was asked to reconsider this issue and attempt to reach a resolution. The original proposal first considered at the Sector's 2006 meeting is included for reference along with an excerpt of the discussion from the Sector's 2008 discussion of this item.

Original Proposal from 2006 Sector Meeting:

The following proposal was offered as a possible solution. The Sector reviewed the proposal for possible forwarding to the NTEP Committee for inclusion in Publication 14.

Proposal: Add a new Section F. to the Publication 14 Technical Policy as follows and renumber subsequent sections:

U. Meters Made of Different Materials within the Same Family

When multiple meters made of different materials within a meter family are submitted for evaluation all meters will be tested with at least one product from each product family to be included on the CC and at least one meter will be tested with the range of products required in the Product Family Table for the meter type (e.g., positive displacement, turbine, mass meter, etc.) submitted for evaluation.

Excerpt from Item 3 of the 2008 Measuring Sector Final Meeting Summary:

Discussion: Steve Patoray described (from his perspective as past NTEP Director) the scenario discussed at the 2006 and 2007 Sector meetings. He noted that materials used in devices are considered metrologically significant for weighing applications and questions were raised about whether or not materials are metrologically significant for metering applications. Some had suggested that using criteria similar to that used by Underwriters Laboratories might be considered. He indicated that many were uncomfortable with the concept of defining a "worst case" scenario for particular materials. He further noted that the question was raised of where to stop in the examination of device components: the body of the meter, or the seals, or other location? Manufacturers indicate that these questions are all part of the design process and inherent with assembling a device intended for a given application. Steve concluded his overview by noting that a key question is whether or not additional testing is needed based on variations in the materials used in the metering system and further commented that it is not likely that a field official will be able to determine these differences by visual examination. The inspector just needs to have confidence that the meter they are examining is covered by the CC. An overriding concern of NTEP is to ensure that the evaluation is fair and that the requirements are being applied consistently to all manufacturers. At present, NTEP has no guidance on how to handle these different scenarios.

Allen Katalinic (NC) commented that while changes to significant components of a meter will make a difference, there are many parts in a meter where changes will not have any metrological impact. Mike Frailer (MD) noted that a key difficulty on the part of the evaluator is in assessing how to consistently assess whether a given change is metrologically significant, and Jim Truex (NCWM NTEP Director) noted that this depends on how one defines "metrologically significant." Paul Glowacki (Murray Equipment) commented that Jim's point touches on the basic issue, which is how to define what changes can be made without reevaluation. A manufacturer may be confident that a change in material will not affect a meter's performance; however, an evaluator may not agree and may

require re-evaluation. There have to be some guidelines because, at present, Paul feels as if every CC is a negotiation and what is applied to one company may be different than what is applied to another company. Tina Butcher (NIST WMD) commented that the technical policies in Publication 14 strive to minimize the amount of testing required for a manufacturer to list the maximum number of devices on a CC. She stated that, for the NTEP laboratories, key questions are: (1) whether the laboratories and NTEP management have adequate information to enable them to assess when additional testing is needed in order to list particular variations on the CC, and (2) how they can make that assessment consistently from manufacturer to manufacturer and from laboratory to laboratory. NTEP has developed experience with some basic types of changes to devices through trial and error and in consulting with manufacturers; the laboratories are asking for specific guidelines with regard to materials variation. Mike Keilty noted that manufacturers submit a sample(s) of a device in good faith and expect a rigorous evaluation; however, manufacturers are concerned that the amount of testing not be expanded beyond what is economically feasible.

Relaying discussions from the NTEP laboratory meeting prior to the Sector meeting, Jim Truex commented that the laboratories also have a dilemma in assessing how to avoid "horror stories" such as experiences with E85 while establishing reasonable guidelines. Jerry Butler (NC) also noted that, while many manufacturers such as those who have long participated in NTEP Sector meetings and evaluations are conscientious and laboratories may trust their judgment, laboratories are seeing an influx of equipment from sources (sometimes off shore) with which they have had little experience and whose manufacturers sometimes have little if any experience with legal metrology requirements, let alone U.S. requirements. This concern was echoed by other laboratories who also noted confidence in manufacturers participating in this discussion, but recognized that policies must be in place to ensure fair treatment. Several manufacturers commented that the industry will take care of substandard products produced by competitors by bringing such instances to NTEP's attention; reputable manufacturers cannot afford to allow substandard products to undercut the market when they themselves are expending the resources needed to comply.

The Sector also had some discussions about replacement parts and how these affect metrological integrity, with some members noting that field officials are unable to determine when non-metrologically equivalent or inferior components are used by visual examination. Several members commented that this is not something that can be prevented by increased evaluation at the type evaluation level, but is rather addressed by performance testing in initial and subsequent verification. In addition, the manufacturer is equally concerned about unauthorized substitutions since this can affect the reputation of their product. In that same vein, a manufacturer would not make a change in materials unless he is confident that the change would not affect the performance of the device in his customer's application. Rodney Cooper (Actaris) pointed out that reputable manufacturers police themselves to ensure their customer's continued confidence. Norm Ingram (CA) pointed out that manufacturers have designed these products and know from experience what will work, so perhaps the best approach is to allow them to make these changes and allow the marketplace to take care of itself. Norm did note, however, as did Dan Reiswig (CA), that even if the issue is tabled, the laboratories still need guidance on how to consistently approach proposed changes with regard to issuing CCs.

Dmitri Karimov (Liquid Controls) and others pointed out that NTEP has largely relied on the integrity of the manufacturer in reporting changes to devices and that, in many cases, NTEP or a field official would never be able to tell the difference. For example, if a rotor is changed, there is no reasonable way that weights and measures officials can determine that the clearances are different. In addition, NTEP has also relied primarily on the manufacturer to provide guidance on when a particular change is metrologically significant. With regard to material, the manufacturer's concern is in making sure that the materials are compatible with the product being measured in the application. Sector Chairman Mike Keilty (Endress and Hauser) questioned how conformity assessment might factor into this issue and contribute to resolving some of these questions.

Rich Tucker (RL Tucker Consulting) echoed an earlier comment by Norm Ingram, noting that most manufacturers change materials because of the products with which the meter will be used. When a manufacturer finds through experience that a particular change creates problems, manufacturers make adjustments accordingly to ensure continued performance. Rich even noted there were instances when NTEP passed a material in an evaluation and that material later proved to be problematic. The majority of the time materials issues will resolve themselves and most of the testing requirements imposed by the product families table are going to address any question about materials.

The Sector also discussed numerous examples of specific materials and their effect on metering of different product types; however, these discussions provided no insight on how to best address the materials issue. Steve Patoray reminded the Sector that its purpose is to advise the NTEP administrator, and Publication 14 will only be changed if the NTEP Committee agrees with the Sector's recommendations.

Will Wotthlie (MD) commented that the laboratories are putting their reputation on the line by issuing a CC and saying that it covers everything listed on the CC; the laboratories want to have confidence that the devices will work and field officials are, in turn, relying on that assurance. Will also questioned why NTEP is needed if the feeling is that everything in the field will take care of itself. Mike Keilty noted that a balance needs to be achieved between a system that can be practically executed and one that will still provide confidence; manufacturers are concerned about expanding testing beyond what is economically feasible.

Will Wotthlie suggested that an alternative is for the labs to simply list what is tested on the CC under the testing conditions section; however, some manufacturers indicated they want to continue to list materials of construction on the CC under the "Standard Features and Options" section. Jim Truex noted that a CC is not meant to be a marketing tool. Tina Butcher commented that, in its early days, NTEP decided that only metrologically significant things should be listed on the CC. If this position is to be maintained, then the Sector needs to decide whether or not to include the metals on the CC if all options are covered. If the Sector concludes that the material is not significant, then perhaps a statement needs to be included in Publication 14 to that effect. She also reminded the Sector that the laboratories are not only trying to assess whether or not a new variation in material can be covered on the CC, but also how to determine which of two meters to select for testing when they are made of different materials.

Some members, including NTEP laboratory representatives as well as manufacturers, stated that if the materials feature or attribute is not metrologically significant, it doesn't belong on the CC; the information can be listed in the test conditions, but not on the front of the CC under the "Standard Features and Options." Dmitri Karimov questioned why the information would be listed in the test conditions if it isn't metrologically significant. Others noted that this record of the test conditions may eliminate the need for additional testing should policies change at a later date. Jim Truex also pointed out that if the information is to be listed on the front of the CC, it will be necessary for the laboratory to determine the "worst case" scenario with regard to materials.

At present there is a great variation among existing CCs with regard to how materials are referenced. Steve Patoray noted that there are differences in how manufacturers request this information be reflected on their CCs; some want various model numbers listed, including different materials. Some believe that the only thing that should be listed on the CC is the product application for which the meter is approved, not the materials. Jerry Butler (NC) questioned why the manufacturers want to list all of these different products on the CC, commenting that it is up to the manufacturer and the customer to make sure the meter is right for the application. He further noted it would be helpful to have materials construction identified through the model designation.

Questions were raised by the manufacturers and laboratories about how CCs will be handled until the Sector can reach an agreement with regard to testing requirements for materials variations. Jim Truex reiterated that the purpose of a CC is not a marketing tool. Jim indicated that, as NTEP Director, he is not comfortable with listing all these different features unless the laboratory has tested them. Without taking a position on whether or not "materials" are considered a metrologically significant feature, Jim indicated that, for consistency purposes, NTEP will not list materials in the standard features and options; however, the information will be listed in the test conditions for the meter(s) tested during the NTEP evaluation(s). He noted this will be an administrative decision to ensure consistency. In response to a question about whether eliminating the reference to materials of construction in the "standard features and options" section would affect existing CCs that presently list this information, Jim stated that no changes would be made until the CC is being revised for other reasons.

After extensive debate on the first day of the meeting without resolution, the Sector returned to the discussion the following day with little additional progress. At that point, Mike Keilty noted that there are manufacturers who have product materials listed on their CCs and those who do not have the materials listed. He commented that, in establishing guidelines, the Sector has tended to draw a broad brush across metering technologies and, in many instances, treated them as the same even though people know they are not made the same way. Manufacturers generally make the materials of the meter to be compatible with the product to be measured and manufacturers

may take different approaches in ensuring this compatibility. Andre Noel (Neptune) pointed out that some meters are made of different materials for different product applications, and the change in product necessitates an additional evaluation. Andre noted that a manufacturer can't make a meter out of bronze, for example, and use it to meter a caustic material because it will fail. Manufacturers take the product application and other application details into account when designing and choosing a meter for a given application and will relay this information to the customer with regard to where the meter can be used. Andre further noted that this becomes a question of liability for the manufacturer since the customer will hold the manufacturer accountable. Some members also made note that the materials may be more significant for some meter technologies than for others.

The NTEP laboratories are asking for guidance to ensure consistency, but the Sector seems to be at an impasse with regard to how to provide that guidance. The Sector was not able to agree upon and general guidance that would assist the laboratories in understanding material construction and its impact on device performance. The laboratories need to be comfortable that the testing they have conducted supports the variations listed on the CC. Dennis Beattie (Measurement Canada) observed that the issue seems to focus on the question of how the materials affect the definition of what constitutes a "family" of devices. He also pointed out in response to an example of a manufacturer choosing a lighter material for a vehicle-mounted than a stationary application that some materials such as aluminum respond differently to changes in temperature.

Discussion: At its 2009 Meeting, the Sector once again spent considerable time discussing this issue.

Mr. Dmitri Karimov (Liquid Controls) advised that a number of manufacturers present, met separately just prior to the second day of the Sector meeting to discuss this issue. He reported that most manufacturers felt that the issue should be dropped from the Sector's agenda.

Mr. Reiswig (CA) and Mr. Wotthlie (MD) commented that, if the item is dropped, then this would mean that the NTEP laboratories would test what is submitted and list the material on the NTEP Certificate under the test conditions. Mr. Miller, (FMC) clarified that listing the material on the NTEP CC was not the intent of the manufacturers' position. He stated that materials of construction should not be considered a metrological issue. He noted that the premise of the manufacturers' arguments in past discussions of this issue is that, if the meter is misapplied in the application, then the customer is going to come back to the manufacturer to resolve the problem. The manufacturers should be looked to as the experts since they are the designers of the meters and understand what must be done to ensure continued compliance in different applications. He also questioned whether the meter would pass the NTEP test to begin with if the materials weren't suitable for the application.

Mr. Jerry Butler (NC), pointed out that failures from improper material selection do not always arise in the limited space of time involved in an NTEP test. As stated by NTEP laboratories and others in previous discussions of this issue, Mr. Butler reminded the audience that NTEP evaluations include meters manufactured by companies who are not as conscientious as the manufacturers present at this meeting and who are not familiar with the process and requirements for legal-for-trade applications. It is largely with these manufacturers that the concerns lie and weights and measures officials rely on the NTEP laboratories for the credibility of the NTEP CCs. Mr. Rodney Cooper (Actaris) stated that the manufacturers believe that this should be up to the manufacturers to control. The Sector had similar discussions about companies that "clone" meters covered by existing NTEP CCs, but that don't use the same (appropriate) materials. Mr. Gordon Johnson (Gilbarco) noted that if manufacturers are competing with clones, they will go out of business.

Mr. Miller reiterated that a key point with this issue is that this is really a question of a misapplication of the meter. If the meter with the right materials is not selected for the application, then problems can arise. For example, if a meter with carbon steel bearings is selected to measure water and the meter eventually failed, it was a misapplication of the meter. It is not the meter design itself that is a problem, but rather the selection of the meter materials for that product application.

Mr. Patoray Consultants on Certification), pointed out that meter failure can also arise from other factors such as other influences or components in the system. Manufacturers will work to resolve the problem, but the problem is not always the meter or its materials. He reminded the Sector that this entire issue was raised because some manufacturers were advising NTEP of materials changes and were subjected to additional NTEP testing. Others made materials changes, but did not notify NTEP of the changes and were not subjected to additional NTEP testing.

This inconsistency led to the inclusion of this issue on the agenda. He also noted that the CCs should reflect a clear definition of type and that differences should be noted in some manner on the CC such as in the model designation.

Mr. Mike Frailer (MD) reiterated that the NTEP laboratories are looking for additional guidance to assist them in determining when a change is metrologically significant and would, therefore, require additional testing. Mr. Wotthlie pointed out that, if this item is dropped from the agenda entirely, the labs will revert to their previous approach of conducting additional testing when a materials change is made; this is not something that is desirable for the manufacturers.

Ms. Butcher (NIST) questioned whether, if the materials are changed based on the product application, wouldn't the NTEP laboratories have done testing with different materials when the tests were done for the different product applications. Couldn't this tie to the product family table? The manufacturers present indicated that testing of different materials by virtue of testing different product applications would generally be the case. Mr. Patoray noted that this is also a reason that there is concern about the product family table; that the current table was developed for a specific technology, positive displacement meters. Mr. Reiswig (CA) observed that he doesn't oppose changes to the product family table, particularly if it would help provide uniform information about the effect of material changes.

Mr. Wotthlie (MD) pointed out that the product family tables were actually further broken down several years ago based on an effort led by Ms. Charlene Numrych (LC) and involving other manufacturers. With regard to the materials issue, we can't seem to get all manufacturers to agree that materials are metrologically significant. Mr. Paul Glowacki (Murray Equipment) noted that the manufacturers were asked to identify what guidelines and criteria they could accept; however, the manufacturers may be going too far in one direction for the regulators' comfort. He noted that the manufacturers want clarity and also discussion about what defines "metrologically significant" rather than focusing only what is metrologically significant with regard to product families and materials.

Sector Chairman, Mr. Keilty (Endress and Hauser), questioned whether this issue should be dropped since it has been on the agenda for an extended period of time without resolution and no data has been provided to move the issue in any direction. Mr. Miller, (FMC), indicated that they are willing to provide data, but noted that eliminating product subcategories in the product family tables might eliminate some of the issues related to materials.

After discussing this issue at great length and examining various aspects of the points raised earlier in this discussion, the Sector concluded that this issue will not reach resolution by continuing to discuss it at the Sector meetings alone. They agreed that it would be better to form a small work group of interested parties who can focus their attention on trying to come up with a solution to this issue using the expertise available within the various metering technologies. Mr. Oppermann (Weights and Measures Consulting) pointed out that this topic is related to the product family topic in Agenda Item 1. The two topics should be discussed together since both are focused on trying to identify and define what constitutes metrologically significant factors.

Decision: The Sector agreed to form a work group, the "Metrologically Significant Characteristics of Technologies Work Group," to arrive at a uniform, appropriate, and clear approach for initial, subsequent, and additional tests for the performance of a device technology. The following people agreed to serve on the work group:

Chair:	Mr. Rodney Cooper
Co-Chair:	Mr. Rich Miller
Work Group Members:	Mr. Marc Buttler
	Mr. Paul Glowacki
	Mr. Mike Guidry
	Mr. Gordon Johnson
	Mr. Dmitri Karimov
	Mr. Henry Oppermann
	Mr. Steve Patoray
	Mr. Dan Reiswig

The work group was tasked to:

(1) Create a short list of features/options affecting the metrological characteristics of each device technology by December 15, 2009;
(2) Prepare a one-page analysis that briefly documents and provides the rationale for including each metrological characteristic in the list (referenced in task 1) by December 15, 2009;
(3) Review the first draft list of significant constituents and condense that list to only relevant characteristics;
(4) Prepare a final list for a work group meeting during the NCWM Interim Meeting by January 15, 2010.

Should revisions be needed prior to presenting an updated draft of Policy C. to the general Sector membership, the WG could potentially meet again at the July 2010 NCWM Annual Meeting in addition to completing additional work through electronic communication in the interim period.

4. Add Testing Criteria to NTEP Policy U "Evaluating electronic indicators submitted separate from a measuring element"

Source: California NTEP Lab

Purpose: Since 2007, work has been underway to develop a checklist to evaluate electronic indicators submitted separate from a measuring element. This item is included on the Sector agenda to allow for an update on this work and to discuss further action required by the Sector.

Background: At its 2007 meeting, the Sector heard that Section U of the NTEP Policy in NCWM Pub 14 allows for testing an indicator separate from a measuring element. However, specific test criteria had not been developed for this section. The Sector heard a recommendation to develop and add specific criteria for testing an indicator separate from a measuring element to this section. The California NTEP Laboratory recommended using Canada's test criteria as a guideline for developing the tests outlined in 2007 Sector Agenda Appendices A, B, and C.

The Sector agreed the California NTEP laboratory should lead a WG to develop a specific test procedure and ready the document for review at the 2008 Sector meeting. Members of the WG selected at the 2007 meeting were Mr. Dave Rajala (Veeder-Root Company), Mr. Miller (FMC Technologies), Mr. Maurice Forkert (Tuthill Transfer Systems), Mr. Karimov (Liquid Controls), Mr. Cooper (Actaris Neptune), and Mr. Ralph Richter (NIST WMD).

At the 2008 Sector meeting, Mr. Reiswig (CA DMS) reported that he had developed and circulated an initial draft of criteria for separate indicators and a lot of additional input was provided by manufacturers and Measurement Canada were significant contributors to the development of the draft (See the 2008 Sector Meeting Summary for details). Sector Chairman Mr. Keilty asked for a renewed commitment from the WG volunteers and asked if others were interested in participating. The WG made plans for additional meetings to further develop the draft.

A copy of the draft criteria to date was included as an attachment to the Sector's 2009 meeting agenda and appears as Appendix E to this summary.

Discussion: At the 2009 Sector meeting, Mr. Reiswig provided an update to the Sector on progress to develop criteria for separate electronic indicators. He reported that the draft checklist provided to the Sector follows the general format of Pub 14 and the main test procedures are at the end of the document. The procedure specifies tests for applying specific pulses over a range of temperatures and the procedure allows the laboratories to simulate the effects of changes in temperature. Mr. Reiswag noted that he has worked with Measurement Canada's type evaluation laboratory and has completely revised the document from the previous versions based on the collaborations with Canada. The current draft should be viewed as a starting point for the NTEP procedure.

Since the Canadian procedure and test criteria are well developed for testing indicators separately, some questioned the needed to undertake a major project to develop criteria for NTEP testing, suggesting that an agreement to accept Canadian test data be pursued instead. Others noted that the turnaround time for Canadian tests are about six to seven months and the NTEP process is much faster, so pursuing NTEP testing would be beneficial. The Sector discussed how arrangements between NTEP and Measurement Canada for accepting test data are designed to work.

Mr. Patoray, (Consultants on Certification and former NTEP Director) provided information and an explanation on how such arrangements generally work. In the case of a "one-way" agreement, where the Canadian test criteria are more stringent, testing is performed to the more stringent requirements and then the test data is forwarded to NTEP.

Questions were raised about the readiness of the checklist for inclusion in NCWM Pub 14. The Sector agreed that some additional work is needed and suggested that a small work group be formed to further develop the checklist. One additional question to consider is whether or not the checklist would apply to indicators across all technologies and applications.

Decision: The Sector agreed to the following.

- A small work group comprised of the following individuals is to further review and discuss the checklist.

Work Group Members:	Mr. Rodney Cooper (Actaris)
	Mr. Maurice Forkert (Tuthill Transfer Systems)
	Mr. Dmitri Karimov (Liquid Controls)
	Mr. Rich Miller (FMC Technologies)
	Mr. Dave Rajala (Veeder-Root)
	Mr. Ralph Richter (NIST WMD)
Checklist Developer:	Mr. Dan Reiswig (California)

- The work group will provide input to Mr. Reiswig (CA) at least one month prior to the March 2010 NTEP Laboratory Meeting. Mr. Reiswig will provide this input to the Measuring Laboratories. One additional question to consider is whether or not the checklist would apply to indicators across all technologies and in all applications.

- Following the March 2010 NTEP Laboratory meeting, Mr. Reiswig will modify the draft checklist based on feedback from the NTEP Measuring Labs.

- Mr. Reiswig will provide a copy of the draft checklist to the NIST Technical Advisor by the end of August 2010 to allow for distribution to the Sector one month prior to the Fall 2010 Sector Meeting.

- Following the fall 2010 Sector meeting, Mr. Reiswig will work with Sector Technical Advisor Ms. Butcher (NIST) to update the draft checklist to reflect the comments from the Sector.

- Assuming the checklist requires no further modification or review by the Sector, Ms. Butcher will submit the checklist to the NTEP Committee to consider for inclusion in the 2011 version of NCWM Pub 14.

New Items:

5. Policy C - Product Family Table – Change in Upper Limit for Oxygenated Blends – Note 4

Source: Mr. Johnson, Gilbarco, Inc.

Purpose: Underwriters Laboratories (UL) has modified the upper limit for oxygenates in oxygenated fuel blends specified in its standard UL87A Edition 5. A proposal has been submitted by the Sector to change a reference in the "Product Family" tables to correspond with the revised UL upper limit. This item is included on the Sector agenda to allow input and discussion by the Sector on the proposed change.

Background: Mr. Johnson (Gilbarco, Inc.) submitted information to the Sector regarding changes to the upper limit specified by UL on oxygenates in oxygenated fuel blends and proposed changes to NCWM Pub 14 to reflect those changes. Mr. Johnson noted that UL recently issued UL87A Edition 5. This standard details the tests and

specifications needed to list dispensers for Ethanol and Ethanol blends. The 5th edition specifies three major gasoline fuel categories:

(a) Gasoline for Use as Automotive Spark-Ignition Engine Fuel, ANSI/ASTM D4806 (Up to E10) (Current)
(b) Gasoline/ethanol blends with nominal ethanol concentrations up to 25 % ethanol (E25) (NEW)
(c) Gasoline/ethanol blends with nominal ethanol concentrations above 25 % (E85) (Current)

When the EPA set the new ethanol limits, "standard gasoline" will include more ethanol. This affects all gasoline motor fuel dispensers currently in use. Typically the need to re-calibrate a dispenser's meter is seen when adding ethanol to the motor fuel. The ethanol acts as a solvent washing away gasoline varnish and the meter may shift its calibration point.

The following additional information regarding the fifth issue of UL's Outline Subject 87A is provided for the Sector's reference:

UL SUBJECT 87A
OUTLINE OF INVESTIGATION FOR POWER-OPERATED DISPENSING DEVICES FOR GASOLINE AND GASOLINE/ETHANOL BLENDS WITH NOMINAL ETHANOL CONCENTRATIONS UP TO 85 PERCENT (E0 – E85)
Issue Number: 5 AUGUST 10, 2009

Summary of Topics

This Fifth issue of Outline Subject 87A contains requirements pertaining to a new rating option. This new option will include an E25 rating along with the original E85 rating. This addition will allow for products to carry the lower rating when they are not intended for use with higher blends of gasoline/ethanol. New requirements have been added for blending options in dispensers. This required a new test, the Blending Cycling Test, which addresses the cycling of ethanol blends inherent in this type of use. Various editorial changes have also been included to address testing with one sample rather than two when evaluating for the E25 rating and other editorial changes have been made for clarification.

The Sector was asked to review NCWM Pub 14, Technical Policy C. Product Families for Meters, Note 4 in the product families table, which currently states:

"Gasoline includes oxygenated fuel blends with up to 15 % oxygenate"

(Note: This footnote appears in Table C.2. Product Family Test Table in the revised version of the Tables currently under consideration by the Sector in Agenda Item 1.)

The Sector was asked to consider changing the oxygenated fuel blends from 15 % to 25 %. The new note 4 would read:

"Gasoline includes oxygenated fuel blends with up to 25 % oxygenate"

Discussion: At the 2009 Sector meeting, Mr. Johnson (Gilbarco) outlined the history of this issue, noting that UL has made several significant changes to UL 87 (to include an alternative fuel standard) as a result of a push by EPA to coincide with a federal mandate to increase the levels of ethanol in vehicle fuel. The old standard for gasoline (15 % oxygenate) was revised this year to specify a 10 % limit. Mr. Johnson noted that the old standard of 15 % was not selected based on any equipment data. UL also revised the standard to create a third category which allows up to a 25 % blend. Mr. Johnson stated that his company is currently is recertifying its dispensers up to E85, 10 %, and 15 % and will mark the dispensers as such. He expressed concern regarding what will happen to existing dispensers when used for deliveries of 25 %. Previously, UL put out a statement that it was up to the local fire marshal accept the electrical system for use with 15 %. There is a program to buy back some 30-year old equipment. Some dispensers that are currently in use (standard pumps) were never UL rated or weights and measures approved for E85. Mr. Johnson stated that ethanol tends to wash out the sediment resulting in the dispenser giving away some product. He proposed changing the current reference in Pub 14 from 15 % standard to

25 %, noting that he has no data to illustrate the impact of the change. He indicated that both Gilbarco and Wayne are completing tests for E85, but no tests have been conducted for 25 %. There is not enough ethanol in production at the moment and he foresees a gradual increase in the amount of 25 % fuels. He is concerned that the limits will go above 15 % and if weights and measures apply the 15 % limit currently referenced in NTEP CCs, then all dispensers will be tagged and place out of service.

In its discussion of this issue prior to the 2009 Sector meeting, the NTEP Measuring Laboratories took the position that it is acceptable for a device to be used with product up to 15 % oxygenate with testing of only gasoline; however, for blends above this percent, the device must be retested with the higher percentage blends. Mr. Wotthlie (MD) noted concerns on the part of the labs that there is no data available to illustrate the impact on the dispenser's performance of the higher blends. Mr. Butler (NC) also commented that some in the room believe that higher blends should be considered an alcohol and that alcohol and gasoline are treated differently in the current product tables. Several lab representatives also commented that, if a supporting statement can be obtained from UL, EPA, and other relevant bodies to say there will not be a problem with the existing dispensers, they might be able to accept the 25 % limit.

Decision: After discussing this issue, the Sector was unable to reach agreement on the propose change. The Sector expressed its appreciation to Mr. Johnson for information regarding recent changes to the upper limit that Underwriters Laboratories (UL) has specified for levels of oxygenates in oxygenated fuel blends. The Sector agreed that this should remain an information item on the Sector's agenda.

6. Electronic Linearization for Positive Displacement Meters

Source: Mr. Maurice Forkert, Tuthill Transfer Systems

Purpose: The Sector received a proposal to establish more definitive criteria for electronic linearization internal to positive displacement meters. This item is included on the Sector's agenda to allow for review and discussion of proposed criteria.

Background/Recommendation: Mr. Forkert (Tuthill Transfer Systems) submitted a request for the Sector to consider adding criteria to NCWM Pub 14 for electronic linearization internal to positive displacement meters, noting that there is apparently no regulation for this feature. Mr. Forkert suggested considering Measurement Canada's "Approval Procedure for Linearization Functions Incorporated in Measuring Systems" (Document Number VO-AP-037) as the basis for the criteria, provided there is no objection by Measurement Canada or copyright violation by doing so.

A copy of Mr. Forkert's letter proposing this addition along with the Measurement Canada document was included as an attachment to the Sector's 2009 Agenda and is included in Appendix F to this Summary.

Mr. Forkert suggested the following revisions to the Measurement Canada document:

- **Section 1.2. Scope**

  Add paragraph to the "Scope" of the document as shown below. This paragraph would bring electronic output PD meters, turbine meters, etc. that do not have a shaft output on equal requirements as other meters that currently incorporate electronics in the measuring device.

  1.2 Scope

  This procedure applies to pulse processing electronic devices incorporating the linearization of the pulse per unit volume versus pulse frequency. This includes all flow computers, electronic registers, correction devices and supporting software external to the measuring device. The tests verify the proper functioning and accuracy of the linearization schemes.

For processing electronic devices incorporating the linearization of the pulse per unit that is within the measuring device, the results of the device accuracy and endurance tests will verify the complete measuring device capabilities. The linearization electronics of the measuring device must be protected from tampering and fraud utilizing a physical seal. No separate tests on parts of the measuring device are required.

- **2.1. Equipment Requirements.**

  This section needs to be reviewed by the work group developing criteria for electronics. When Tuthill tested their linearization board in Canada, they had problems because their Dual Channel Pulser "off" position of the pulse did not go close enough to zero volts. Tuthill furnished a dual channel pulser that goes down to within 0.2 volts in the "off" part of the pulse and then the Measurement Canada counters worked fine.

- **Section 2.5.1. and 2.5.3.**
  The word "devices" should be "EUT."

- **Section 2.6.2.1. and 2.6.2.3.**
  Do not limit "meter Factors" to 4 or 5 points. See proposed revisions to 2.6.2.5. below as a method to test all points for which the device is capable.

- **Section 2.6.2.5.**
  Delete runs number 2 through number 5 and replace with:

  2. Select frequencies that result in flow rates that lie between each pair of points programmed in Section 2.6.2.3. Test at each frequency.

  Change Run number 6 to number 3.

- **Factor Limit**
  The limit of 3 to 5 factors should be changed to cover any number of factors.

Discussion: Mr. Forkert explained that his company had introduced a meter into the market with a linearization board and was advised by the weights and measures authority that there were no regulations to address that component. He recommended including the feature as allowable in the register and to not require a separate evaluation of this component. He explained that the part could not be removed or modified without breaking a seal. He also requested that the e-linearization feature be considered as part of the meter just as the pulse output component is looked at as part of the meter.

Mr. Oppermann (Weights and Measures Consulting) commented that industry wants to be able to use e-linearization as a means to improve the performance of a meter and noted that this has been done for years with scales and load cells. Provided the performance is within acceptable levels, it should not matter how this is accomplished.

In discussing this issue, reference was made to NCWM Pub 14 Policy G. Range of Data Points, which addresses the use of "multi-point calibration." This policy specifies that "multi-point calibration" must be "blind and integral" which, according to the policy, is intended to mean it is programmed during the manufacture of the device and is not accessible in the field. The policy also prohibits multi-point calibration from being used as a means to establish the minimum turn down ratios of 5:1 or 10:1; however, it does allow the feature to be used to extend the measuring range beyond the minimum ratios. In discussing how this policy is to be applied in conjunction with Mr. Forkert's example, there were questions regarding the use of the term "blind and integral." Several members noted that a better definition of the term is needed in order to ensure consistent understanding of the term and its use in the application of requirements.

Mr. Forkert noted a distinction in his scenario is that they want the e-linearization feature to be considered a part of the meter, much as one would consider other components of the device. Understanding that the e-linearization feature is used to individually program each meter at the factory, some NTEP laboratory representatives expressed

concerns about the possibility of interchanging parts in the field and the impact on meter performance and questioned what means would be provided to deter field replacements. Some manufacturers noted that this should be viewed no differently than replacing other metrologically significant parts in the field; for example, meters are not shipped back to the factory for replacement of a rotor and replacement of the e-linearization board should be viewed in the same light. It is up to the user/installer to ensure continued compliance with accuracy and other requirements.

There were also questions during the discussion regarding whether or not the e-linearization feature should be listed as a feature on the CC. Some pointed out that other device types use metrologically significant components that can be replaced in the field when problems are encountered. Repairs, adjustments, or changes to these features are generally obvious or detectable. Mr. Patoray, (Consultants on Certification) gave several examples of weighing device applications such as load cells (which are not repairable in the field), junction boxes (which can be protected by a security seal), and electronic boards (which are completely replaced when they fail).

The Sector discussed developing language to clarify the application of Policy G., but was unable to reach a conclusion at the meeting. While they did not identify a specific alternative, there was general agreement that the electronic linearization that is programmed during the manufacture of a device should not be readily accessible in the field without breaking an approved seal. The NTEP Labs expressed concern regarding the unique nature of the programming and how interchange of the e-linearization board would be controlled in the field. The Sector agreed that this issue requires additional work that would best be accomplished by a small work group.

Decision: The Sector agreed that a small work group comprised of the following individuals be established to further develop this issue for the Sector's review.

Chairman:	Mr. Steve Patoray
Work Group Members:	Mr. Maurice Forkert
	Mr. Mike Frailer
	Mr. Mike Guidry
	Mr. Dmitri Karimov
	Mr. Rich Miller
	Mr. Ken Smith

The WG was tasked with the following:

1) Clarify Policy G. Range of Data Points by bouncing ideas off of Mike Frailer for:
   a. Defining what is meant by multi-point calibration shall be "blind and integral" to the measuring element.
   b. Clarifying what is meant by multi-point calibration shall be not "accessible" in the field.

2) Develop Language in Policy G. Range of Data Points to Allow for Uniform Interpretation and Application of the Criteria by the United States and Canadian Stakeholders by February 2010, including
   a. Where necessary to clarify the intent of the criteria:
      i. Modify Language
      ii. Define Terminology

3) Review and Discuss Modifications to Policy G. at the March 2010 NTEP Measuring Lab Meeting

7. Next Meeting

Source: NTETC Measuring Sector

Background/Discussion: The Sector was asked to develop a proposed date and location for the next meeting. The Sector agreed that holding the meeting in conjunction with the SWMA is still acceptable.

Decision: The Sector agreed to recommend to the NTEP Committee that the next Sector meeting be held in conjunction with the 2010 Southern Weights and Measure Association meeting, which is tentatively scheduled to be held in South Carolina. The NCWM is asked to communicate with the SWMA regarding its past difficulties booking lodgings for the Sector meetings and ask for assistance to prevent these difficulties in the future.

Additional Items as Time Allows:

The NCWM S&T Committee would appreciate input from the Measuring Sector on the following measuring-related issues on its agenda. If time permits, the Measuring Sector was asked for comments on these issues. In the interest of brevity, the narrative for each item was abbreviated. Full descriptions of the items can be found in the S&T Committee's 2009 Interim Report and 2010 Interim Agenda.

8. G-S.1. Marking (Software)

Source: NCWM S&T Committee

Purpose: This item is included on the Sector's agenda to allow for the Sector to review proposed changes to NIST Handbook 44 General Code paragraph G-S.1. Identification and provide comments to assist the NCWM S&T Committee in its deliberations on these proposals.

Background: The S&T Committee is considering changes to NIST Handbook 44 General Code paragraph G-S.1. Identification to better address software-based systems. The Committee has considered multiple proposals under this item.

Recommendation: A copy of the most recent proposal to modify G-S.1. was included in the 2009 Sector Agenda (see also the 2009 Final S&T Report). The Sector was asked to provide input to the S&T Committee on this issue.

Discussion: During the 2009 Sector meeting, Mr. Patoray, (Consultants on Certification) noted that an updated version of the proposal from the Software Sector is now available. In the more recent version, software-based devices must have a version number for both built-for-purpose and not-built-for purpose devices. The version number can be included in a "look-up" menu. A serial number could be required for a built-for-purpose device. Additional work is being done on definitions and the Sector is encountering a significant amount of opposition from the general weighing industry whose members hold a large number of CCs.

Mr. Wotthlie (MD) made comment that the previous version of the proposal (prior to the one with the most recent modifications) was reasonable. The latest changes by the Software Sector include requirements for hard marking which do not seem reasonable.

Decision: While the Sector briefly discussed this item, it did not have comments to offer the S&T Committee.

9. G-S.8.1. Access to Calibration and Configuration Adjustments, Proposed Changes to Language

Source: NCWM S&T Committee

Purpose: This item is included on the Sector's agenda to allow for the Sector to review proposed changes to NIST Handbook 44 General Code paragraph G-S.8. Sealing and associated paragraphs and provide comments to assist the NCWM S&T Committee in its deliberations on these proposals.

Background: The S&T Committee has considered multiple proposals to modify and expand NIST Handbook 44 General Code paragraph G-S.8. Provision for Sealing Electronic Adjustable Components and associated subparagraph G-S.8.1. Multiple Weighing or Measuring Elements that Share a Common Provision for Sealing. The Committee agreed that if a device designed for commercial applications is capable of being "sealed" while leaving

available either external or remote access to the calibration or configuration mode, it is clearly in violation of the current G-S.8. Provision for Sealing Electronic Adjustable Components and General Code paragraph G-S.2. Facilitation of Fraud and, therefore, no change to the existing language is needed. However, because of the ongoing disagreement on the interpretation of G-S.8. among the NTEP laboratories, the Committee agreed to make changes to the proposal based on the concerns raised during multiple open hearings.

Although multiple iterations of proposed language have been submitted, reviewed, and discussed, at the 2009 NCWM Interim Meeting, the Committee concluded that the item is not ready for a vote. However, the Committee decided to maintain the item on its agenda in anticipation that language would be developed by the 2010 Interim Meeting.

During the 2009 NCWM Annual Meeting, the S&T Committee received comments during the open hearing that no action may be needed and that the existing language in HB 44 is sufficient. Additional comments indicated that other proposals are overly complex. Oregon and Maryland believe that amended requirements for sealing are needed by the NTEP labs and field officials in order to consistently interpret and apply sealing requirements.

The Committee believes that all parties agree with the intent of the proposal. Both the WMD and SMA proposals include language that restates the existing language in G-S.8., but is essentially reformatted for clarification. Additionally, both proposals include new requirements for providing indications when a device is in adjustment mode. WMD proposed further language to address devices that may have more that one method of sealing.

Recommendation: Proposals considered by the Committee were included in the 2009 Sector agenda (and are also available as part of the S&T Committee's 2009 Interim and Final Reports). The Sector was asked for technical input on this issue that could be provided to the S&T Committee to help them in their assessment of the proposed changes.

Discussion: The Sector briefly discussed this issue, giving examples of how the requirements in paragraph G-S.8. have been applied to measuring devices. Mr. Patoray, (Consultants on Certification) noted that some weighing devices could be left in the calibration mode even though a physical security seal has been affixed and he further commented that the term "effective" has been questioned in discussions on this issue.

Most Sector members agreed that the Sector and NTEP measuring labs have consistently understood and applied the criteria in paragraph G-S.8. Mr. Wotthlie observed that, if the Sector sends a statement to the S&T Committee, it should say measuring devices either cannot function in the calibration or configuration mode or it should not be possible to seal the device while in that mode. Mr. Wotthlie gave the example of the mechanical temperature compensators that must be deactivated in order to reapply a security seal; this is considered an acceptable means of security and it complies with paragraph G-S.8. He also noted that the measuring laboratories have been consistently applying this requirement. Mr. Wotthlie noted that clarification is needed so the weighing labs are consistent in applying these requirements. Even though paragraph G-S.8. is relatively clear, he would suggest only changing a few words for clarification.

Decision: The Sector reviewed the proposed changes to General Code paragraph G-S.8.1. currently under consideration by the NCWM S&T Committee. The Sector agreed that measuring devices with NTEP CCs have been evaluated to either:

(1) not function in the calibration or configuration mode;
(2) not be sealed in the calibration or configuration mode; or
(3) clearly indicate the device is in the calibration or configuration mode.

The Sector agreed that these options reflect the intent of General Code paragraph G-S.8. and, because the intent of the paragraph is understood and appropriately applied by the measuring community, the Sector recommends that no changes be proposed to General Code paragraph G-S.8.

10. Temperature Compensation for Liquid Measuring Devices Code

Source: NCWM S&T Committee

Purpose: This item is included on the Sector's agenda to allow for the Sector to review proposed changes to the NIST Handbook 44 Liquid Measuring Devices Code to address temperature compensation for retail motor-fuel devices and to provide comments to assist the NCWM S&T Committee in its deliberations on these proposals.

Background: The NCWM S&T Committee is considering a proposal to modify Section 3.30. Liquid-Measuring Devices (LMD) Code by modifying paragraphs S.2.6., S.2.7.1., S.2.7.3., N.4.1.1.(a) and (b), N.5., UR.3.6.1.1., and UR.3.6.1.2., to add new paragraphs S.1.6.8., S.2.7.2., S.4.3., UR.3.6.1.3., and UR.3.6.4., and to renumber other existing paragraphs as appropriate to recognize temperature compensation for retail devices.

Based on comments heard from the floor at the 2009 NCWM Annual Meeting, the S&T Committee acknowledged that additional work may be needed to specific sections of the proposed changes to the code. Points raised and discussed by the Committee include the following:

- There was a question of whether to reference "15 °C" or "15.56 °C." The Committee agreed that industry practice has been to use "15 °C" and that this is the reference used internationally; consequently, they believe it should be kept as "15 °C." This is also supported by the L&R Committee's 2009 Interim Report which references a statement by the Meter Manufacturers' Association indicating that 15 °C is used internationally and industry would likely follow that convention should SI units be used.
- Clarification is needed for the differences between wholesale devices and systems. In question were paragraph S.1.6.8. Representations from Devices with Temperature Compensation and paragraph S.2.7.2. Display of Temperature.
- Clarification is needed for how S.2.7.2. applies to electronic registers that can only indicate in terms of compensated quantities when the compensator is activated; the compensator would need to be activated and an additional run completed in order to view an uncompensated reading.
- Review the use of the term "invoice" and consider if the term is well understood for retail transactions which have typically used terminology such as "printed receipt" or recorded representation.
- Review the language in the VTM code under Item 331-2 and consider where changes might be needed to ensure consistency for the conditions and period of use for this feature.

The Committee decided to keep the status of this item as an "Information" item and acknowledges that some jurisdictions are already facing the imminent possibility of temperature-compensated retail motor-fuel equipment in their jurisdictions. The Committee believes that these standards are necessary whether or not the issue of a model method sale regulation is adopted in NIST Handbook 130 since weights and measures jurisdictions may decide to permit this equipment based upon their individual State laws or regulations.

Recommendation: Proposed changes to the Liquid-Measuring Devices Code currently under consideration by the NCWM S&T Committee were included in the 2009 Sector agenda (and are also available as part of the S&T Committee's 2009 Interim and Final Reports). At its 2009 meeting, the Sector was asked for technical input on this issue that could be provided to the S&T Committee to help them in their assessment of the proposed changes.

Discussion: Mr. Karimov (Liquid Controls) noted that he questioned how paragraph S.2.7.3. would apply with regard to the simultaneous display of net and gross volumes, particularly for equipment that delivers multiple product types and product types under both compensated and uncompensated conditions. Other Sector members agreed that paragraph S.2.7.3. as modified would not require simultaneous display of net and gross volume. The Sector agreed that the gross and net volumes should not be required to be simultaneously displayed.

Mr. Wotthlie encouraged manufacturers to carefully review the proposed changes to ensure that the changes would not negatively affect their equipment. By identifying changes early in the process, this can avoid having to revisit the requirements after they have already been adopted in Handbook 44.

The Sector also had a great deal of discussion on proposed paragraph UR.3.6.1.1. Use of Automatic Temperature Compensation regarding temperature compensator and nontemperature compensated meters where the delivery is temperature compensated. Mr. Wotthlie (MD) suggested that a search needs to be done for the terms "retail" and "wholesale" to ensure that they have been inserted or deleted as appropriate to reflect the expanded application. A related question was raised by Mr. Oppermann (Weights and Measures Consulting) regarding how revised paragraph UR.3.6.1.3. Recorded Representations (Invoices, Receipts, and Bills of Lading) (formerly numbered UR.3.6.1.2.) was intended to apply in applications where the sale is to the end user.

Decision: The Sector discussed the proposed changes to the LMD Code to recognize temperature compensation for retail motor-fuel devices, particularly paragraph UR.3.6.1.1. Use of Automatic Temperature Compensation; however, it had no specific comments to forward to the S&T Committee.

11. T.2.1. Tolerances – Vehicle-Tank Meters (VTMs)

Source: NCWM S&T Committee

Purpose: This item is included on the Sector's agenda to allow for the Sector to review proposed changes to the tolerances in NIST Handbook 44 Vehicle Tank Meters Code paragraph T.2.1. Automatic Temperature-Compensating Systems devices and to provide comments to assist the NCWM S&T Committee in its deliberations on these proposals.

Background: The S&T Committee continues to consider the following proposed changes to decrease the ATC tolerances on VTMs.

> **T.2.1. Automatic Temperature-Compensating Systems.** The difference between the meter error (expressed as a percentage) for results determined with and without the automatic temperature-compensating system activated shall not exceed:
>
> (a) **~~0.4~~0.2 %** for mechanical automatic temperature-compensating systems; and
>
> (b) **~~0.2~~0.1 %** for electronic automatic temperature-compensating systems.
>
> The delivered quantities for each test shall be approximately the same size. The results of each test shall be within the applicable acceptance or maintenance tolerance.
>
> **(Amended 201X)**

The Committee requested data (in addition to that provided by the submitter) to be submitted in either support or opposition to the proposed changes. At the 2009 Annual Meeting, the Committee reported that it received additional VTM test data from the State of Maine. This data supports the proposed change to the tolerances; the change would not impact the compliance rate for the devices included in these tests. The Committee noted that to date it has received only data in support of the proposed change.

The Committee heard opposition from the Meter Manufacturers Association and received a letter from David Rajala (Veeder-Root) expressing similar concerns over the proposed change to the tolerances. Both expressed concerns over the test procedures and test equipment that might be used by some jurisdictions, noting that, should non-NIST traceable thermometers or improper test procedures be used, the proposed tolerances would be too small.

Recommendation: The Committee asks for additional input from the Measuring Sector regarding these proposed changes. Data in support or opposition of the changes would be appreciated.

Decision: Time did not permit the Sector to discuss these proposed changes. Consequently, the Sector took no position on this proposal.

12. Water Meters – Test Draft Sizes, Repeatability Tests, and Tolerance Values

Source: NCWM S&T Committee

Purpose: This item is included on the Sector's agenda to allow for the Sector to review proposed changes to the NIST Handbook 44 Water Meters Code for test draft sizes, repeatability test criteria, and tolerances values and to provide comments to assist the NCWM S&T Committee in its deliberations on these proposals.

Background: The S&T Committee has reviewed multiple proposals to modify the test procedures and tolerances associated with testing water meters under NIST Handbook 44 Section 3.36. Water Meters Code. These proposals were included on the Committee's 2009 agenda under Information Item 336-3 N.3. Test Drafts and N.4. Testing Procedures and Developing Item. The water meter manufacturers who submitted the proposed changes have expressed concerns that the test draft sizes for some tests are not adequate and may result in erroneous test results. These manufacturers are also proposing that the test procedures and draft sizes be aligned with the standards of the American Water Works Association (AWWA).

At the 2009 NCWM Annual Meeting, the S&T Committee reported receiving additional data from the water meter manufacturers; a comparison of current H44 requirements, AWWA standards, and the proposed changes; comments from NIST WMD; and excerpts from corresponding international standards.

The above information as well as correspondence between the water meter manufacturers and the S&T Committee is available upon request from the Sector technical advisor and S&T Committee technical advisor, Ms. Butcher.

The Committee recently received eight additional alternate proposals from five water meter manufacturers. These proposals are being discussed between the five manufacturers, the State of California Division of Measurement Standards (represented on the S&T Committee by Ms. Kristin Macey), and several California counties (including 2010 S&T Committee Chairman, Mr. Brett Saum, San Luis Obispo County, CA). The S&T Committee anticipates receiving an update of these eight revisions from the fall regional weights and measures associations.

Recommendation: The Sector was asked to provide any comments regarding this issue to the S&T Committee.

Decision: Time did not permit the Sector to discuss these proposed changes. Consequently, the Sector took no position on this proposal.

13. Draft Code Section 3.3X. Hydrogen Gas-Measuring Devices

Source: NCWM S&T Committee

Purpose: This item is included on the Sector's agenda to allow for the Sector to review a draft code being proposed for inclusion in NIST Handbook 44 to address commercial hydrogen gas-measuring devices and to provide comments to assist the NCWM S&T Committee in its deliberations on these proposals.

Background: The NCWM S&T Committee's Agenda added a new item to its Developing Item in 2008 to recognize work being done to develop a code for commercial hydrogen gas-measuring devices by the U.S. National Work Group (USNWG) for the Development of Commercial Hydrogen Measurement Standards. The WG, which presently includes weights and measures officials, manufacturers and users of hydrogen measuring devices, and federal agency representatives, continues to look for input and participation from the weights and measures community in the development of the code and associated test procedures. The most current version of the draft code can be found on NIST WMD's home page at http://ts.nist.gov/WeightsAndMeasures/Developing-Commercial-Hydrogen-Measurement-Standards.cfm. This web page is a resource for the U.S. weights and measures and hydrogen community regarding the latest information and status of ongoing work to develop uniform and appropriate legal metrology standards for commercial hydrogen measurements.

At its August 2009 meeting, the USNWG on Hydrogen agreed that the code is ready to propose for adoption as a tentative code, with the caveat that some additional verification needs to be completed over the coming months to validate the proposed tolerances and test notes.

Recommendation: This item was included on the Sector's agenda to make the Sector aware of the work and to encourage input and participation from Sector members. A copy of the most recent draft code was provided to the Sector for reference.

Decision: Time did not permit the Sector to discuss these proposed changes. Consequently, the Sector took no action on this item. This item was included on the Sector's agenda to make the Sector aware of the work and to encourage input and participation from Sector members.

Appendix A
NTETC Measuring Sector (MS)
Action List – October 2009

	Responsible Party	Task	Details	Deadline
1	Mike Keilty working with interested Sector members	Refine the example for a "separated technology" proposal and circulate it for review.	<Integrate the separated technology proposal with that presented at the 2009 Sector meeting. <Circulate the newly edited version among Measuring Sector members.	December 15, 2009, to complete a revised example of Policy C.
		Discuss revisions with interested Sector members.	<Discuss revision with members who are able to attend the January 2010 NCWM Interim Meeting. <Solicit additional comments via electronic communication	January 2010 Interim Meeting
		Make additional revisions and present draft to the Sector for review and approval.	<Make any additional revisions as needed. <Distribute revised version to Sector.	2010 Sector Meeting
3	Metrologically Significant Characteristics of Technologies Work Group (WG) Chair: Rodney Cooper Co-Chair: Rich Miller Work Group: Marc Buttler Paul Glowacki Mike Guidry Gordon Johnson Dmitri Karimov Henry Oppermann Steve Patoray Dan Reiswig	Form new MS Metrologically Significant Characteristics of Technologies Work Group to arrive at a uniform, appropriate, and clear approach for initial, subsequent, and additional tests for the performance of a device technology	<Create a Short List features/options affecting the metrological characteristics of each device technology <Provide a 1-page analysis that briefly documents and provides the rationale for including each metrological characteristic in the list <WG reviews First Draft List of significant constituents and condenses to only relevant characteristics[1] <WG prepares Final List for its January 2010 NCWM Meeting[2]	[1]December 15, 2009, to complete the First Draft List that is ready for the WG's Review [2]January 15, 2010, for the Final List for the WG's First Meeting
3	Mike Keilty Tina Butcher	Coordinate with NCWM to enable Metrologically Significant Characteristics of Technologies Work	<Contact NTEP Admin Director (Don Onwiler) for meeting approvals	October 15, 2009

Appendix A
NTETC Measuring Sector (MS)
Action List – October 2009

	Responsible Party	Task	Details	Deadline
		Group to meet briefly at the: (1) January 2010 NCWM Meeting and (2) July 2010 NCWM Meeting		
2	Tina Butcher	Forward HydroCarbon (HC) Vapor Meter Checklist developed by CADMS for consideration of the NTEP CMTE	<Add HC Vapor Meter Checklist to NCWM Pub 14 <NOTE Input is needed on HC Vapor Meter Checklist from HC Vapor Meter OEMs	November 1, 2009
4A	Test Criteria for an Electronic Indicator Submitted Separately from a Measuring Element for NTEP Evaluation Work Group: Rodney Cooper Maurice Forkert Dmitri Karimov Rich Miller Dave Rajala Ralph Richter	WG Provides Input on the Checklist developed by CADMS	<WG Provides Input to Dan Reiswig 1 month prior to March 2010 NTEP Lab Meeting	February 2010
4B	Checklist Developer: Dan Reiswig	Modify the Checklist for Discussion at the March 2010 NTEP Lab Meeting	<Dan Reiswig Modifies Draft Checklist based on Input of the WG	March 2010
4C	Checklist Developer: Dan Reiswig	MS Labs Discuss and Make Necessary Modification at the March 2010 NTEP Lab Meeting	<Dan Reiswig Modifies Draft Checklist based on Labs' Input from the March 2010 NTEP Lab Meeting	Late August 2010 Final Draft Checklist Distributed 1 month prior to the Fall 2010 MS Meeting
4D	Dan Reiswig/Tina Butcher	Finalize the Checklist for the 2011 NCWM Pub 14	<Dan Reiswig works with Technical Advisor to incorporate input from Fall 2010 Sector meeting. <If further Sector review is not required, Technical Advisor submits draft to the NTEP Committee to consider for 2011 Pub 14.	November 1, 2010, MS Submits Final Checklist for consideration of the NTEP CMTE to include in the 2011 NCWM Pub 14
6A	Maurice Forkert	Clarify Policy G. Range of	Bounce ideas off of	

Appendix A
NTETC Measuring Sector (MS)
Action List – October 2009

	Responsible Party	Task	Details	Deadline
	Mike Frailer Mike Guidry Dmitri Karimov Rich Miller Lead: Steve Patoray Ken Smith	Data Points	Mike Frailer for: (1) Defining what is meant by multi-point calibration shall be "blind and integral" to the measuring element (2) Clarifying what is meant by multi-point calibration shall be not "accessible" in the field	
6B	Maurice Forkert Mike Frailer Mike Guidry Dmitri Karimov Rich Miller Lead: Steve Patoray Ken Smith	Develop Language in Policy G. Range of Data Points to Allow for Uniform Interpretation and Application of the Criteria by the U.S. and Canadian Stakeholders	<In Policy G, where necessary to clarify the intent of the criteria: (1) Modify Language (2) Define Terminology <Review and Discuss Modifications to Policy G. at the March 2010 Lab Mtg	February 2010
9	Tina Butcher	Forward the MS Position on the Proposal to Modify HB44 General Code G-S.8 to the 2010 NCWM S&T CMTE	<Measuring Devices with CCs have been evaluated to either: (1) not function in the calibration or configuration mode (2) not be sealed in the calibration or configuration mode or (3) clearly indicate the device is in the calibration or configuration mode <MS recommends no changes to paragraph G-S.8 since the intent is understood and appropriately applied by MS members	November 1, 2009

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Appendix B

Proposed Revisions to Policy C – Product Family Table, prepared by Mike Keilty, Attachment to 2009 Agenda (Agenda Item 1)

C. Product Families for Meters

When submitting a meter for evaluation, the manufacturer must specify the product family and critical parameters for which the meter is being submitted.

The product family and the specific product subgroup covered by the Certificate are to be identified on Page 1 of the Certificate of Conformance. More detailed information, including the typical product types found in the subgroup, is to be included in the application section of the Certificate.

Table C.1. Tests to be Conducted
Test A – Products must be individually tested and noted on the Certificate of Conformance.
Test B - To obtain coverage for a range of products within a family: Test with one product having a low specific gravity; test with a second product having a high specific gravity. The Certificate of Conformance will cover all products in the product family within the specific gravity range tested.
Test C - To obtain coverage for a range of products within a family: Test with one product having a low viscosity; test with a second product having a high viscosity. The Certificate of Conformance will cover all products in the product family within the viscosity range tested.
Test D – To obtain coverage for a product family: Test with one product in the product family. The Certificate of Conformance will cover all products in the family.
Test E – To obtain coverage for a range of products within a family: Test with one product having a low kinematic viscosity; test with a second product having a high kinematic viscosity. The Certificate of Conformance will note coverage for all products in the family within the kinematic viscosity range tested.
Test F – To obtain coverage for a range of products within a family: Test with one product having a specified conductivity. The Certificate of Conformance will note coverage for all products in both of the families with conductivity equal to or above the conductivity of the tested liquid.

Table C.2. Product Family Test Table			
Mass Meter Product Family & Test Requirements	**Magnetic Flow Meter Product Family & Test Requirements**	**Positive Displacement Flow Meter Product Family & Test Requirements**	**Turbine Flow Meter Product Family & Test Requirements**
Test B Normal Liquids Includes the following for Mass Flow Meters: Fuels, Lubricants, Industrial and Food Grade Liquid Oils, Solvents General, Solvents Chlorinated, Pure Alcohols & Glycols, Water (De-mineralized &	**Test F** Fuels, Lubricants, Industrial and Food Grade Liquid Oils, Solvents General, Solvents Chlorinated, Pure Alcohols & Glycols, Water (De-mineralized & de-ionized), Heated Products (above 50 °C)*	**Test C** Fuels, Lubricants, Industrial and Food Grade Liquid Oils	**Test E** Fuels, Lubricants, Industrial and Food Grade Liquid Oils
		Test C Solvents General	**Test E** Solvents General
		Test C Solvents Chlorinated	**Test A** Solvents Chlorinated
		Test C Alcohols, Glycols, & Water Mixes Thereof	**Test E** Alcohols, Glycols, & Water Mixes Thereof

Table C.2. Product Family Test Table

Mass Meter Product Family & Test Requirements	Magnetic Flow Meter Product Family & Test Requirements	Positive Displacement Flow Meter Product Family & Test Requirements	Turbine Flow Meter Product Family & Test Requirements
de-ionized), Heated Products (above 50 °C)* Water (Tap, Potable & Nonpotable), Water Mixes of Alcohols & Glycols, Juices, Beverages, Clear Liquid and Suspensions Fertilizers, Crop Chemicals, Liquid Feeds, Chemicals	**Test D** Water (Tap, Potable & Nonpotable), Water Mixes of Alcohols & Glycols, Juices, Beverages, Clear Liquid and Suspensions Fertilizers, Crop Chemicals, Liquid Feeds, Chemicals		
		Test D Water	**Test D** Water
		Test C Clear Liquid Fertilizers	**Test A** Clear Liquid Fertilizers
		Test C Crop Chemicals *(Type A)*	**Test A** Crop Chemicals *(Type A)*
		Test C Crop Chemicals *(Type B)*	**Test A** Crop Chemicals *(Type B)*
		Test C Flowables	**Test A** Flowables
		Test C Crop Chemicals *(Type C)*	**Test A** Crop Chemicals *(Type C)*
		Test C Crop Chemicals *(Type D)*	**Test A** Crop Chemicals *(Type D)*
		Test C Suspension Fertilizers	**Test A** Suspension Fertilizers
		Test C Liquid Feeds	**Test A** Liquid Feeds
		Test C Chemicals	**Test A** Chemicals
Test B Heated Products (above 50 °C)	*See above	**Test C** Heated Products (above 50 °C)	**Test A** Heated Products (above 50 °C)
Test D Compressed Liquids	Not Applicable (conductivity too low)	**Test C** Fuels and Refrigerants	**Test E** Fuels and Refrigerants
		Test C NH_3	**Test A** NH_3
Test D Compressed Gases	*Note: CNG is only included in Section 3.37 Mass Flow Meters of Handbook 44*		*CNG*

Table C.2. Product Family Test Table			
Mass Meter Product Family & Test Requirements	**Magnetic Flow Meter Product Family & Test Requirements**	**Positive Displacement Flow Meter Product Family & Test Requirements**	**Turbine Flow Meter Product Family & Test Requirements**
Test D Cryogenic Liquids and Liquefied Natural Gas	Not Applicable (conductivity too low)	**Test A** Cryogenic Liquids and Liquefied Natural Gas –	**Test D** Cryogenic Liquids and Liquefied Natural Gas –

[1]*Note: The Typical Products listed in this table are not limiting or all-inclusive; there may be other products and product trade names, which fall into a product family. Water and a product such as stoddard solvent or mineral spirits may be used as test products in the fuels, lubricants, industrial, and food- grade liquid oils product family.*

[2] The specific gravity of a liquid is the ratio of its density to that of water at standard conditions, usually 4 °C (or 40 °F) and 1 atm. The density of water at standard conditions is approximately 1000 kg/m3 (or 998 kg/m3)

[3] Diesel fuel blends (biodiesel) with up to 20 % vegetable or animal fat/oil.

[4] Gasoline includes oxygenated fuel blends with up to 15 % oxygenate.

$$\text{Centistokes} = \frac{\text{Centipoise}}{\text{Specific Gravity}}$$

[5] Kinematic viscosity is measured in centistokes.

Source for some of the viscosity value information is in the Industry Canada - Measurement Canada "Liquid Products Group, Bulletin V-16-E (rev. 1), August 3, 1999."

Table C.3. Typical Product Family Characteristics			
Product Families	**Typical Products**	**Reference Viscosity* (60 °F) Centipoise (cP)**	**Reference Specific Gravity* (60 °F)**
Normal Liquids Fuels, Lubricants, Industrial and Food Grade Liquid Oils	Diesel Fuel	10	0.72
	Gasoline	0.28	0.72
	Fuel Oil (#1, #2, #3, #4)	8 to 88	0.9
	Kerosene	1.94	0.75
	Light Oil	13.47	0.86
	Spindle Oil		
	Lubricating Oils	20 to 1000	0.80 to 0.90
	SAE Grades	192 to 3626	0.9
	Bunker Oil	11,200	0.99
	6 Oil (#5, #6)	66-13,000	0.9
	Crude Oil	3-1783	0.79 to 0.97
	Asphalt	100 to 5000	
	Vegetable Oil	133	0.92
	Biodiesel above B20	10.12	0.86
	Avgas	1.5 to 6	
	Jet A	1.5 to 6	
	Jet A-1	1.36	0.76
	Jet B	1.5 to 6	
	JP4	1.02	0.76
	JP5	1.94	0.76
	JP7 JP8	1.82	0.76
	Cooking Oils	9.93	0.92
	Sunflower Oil	90.1	0.93
	Soy Oil	90.6	0.93
	Peanut Oil	11 to 110	0.9 to 1.0
	Olive Oil	116.8	0.92
	Corn Oil	4.0	0.91
Normal Liquids Solvents General	Acetates	0.44	0.93
	Acetone	0.34	0.8
	Ethylacetate	1.36	0.96
	Hexane	0.34	0.66
	MEK	0.45	0.81
	Toluene	0.62	0.87
	Xylene	0.86	0.89
Normal Liquids Solvents Chlorinated	Carbon Tetra-Chloride	0.99	1.6
	Methylene-Chloride	0.46	1.34
	Perchloro-Ethylene	1	1.6
	Trichloro-Ethylene	0.6	1.47
Normal Liquids Alcohols, Glycols & Water Mixes thereof	Ethanol	1.29	0.79
	Methanol	0.64	0.80
	Butanol	3.34	0.81
	Isopropyl	2.78	0.79
	Isobutyl	4.54	0.81
	Ethylene glycol	25.5	1.19
	Propylene glycol	54	1.04

Product Families	Typical Products	Reference Viscosity* (60 °F) Centipoise (cP)	Reference Specific Gravity* (60 °F)
Normal Liquids Water	Tap Water	1.0	1.0
	Deionized	1.0	1.0
	Demineralized	1.0	1.0
	Potable	1.0	1.0
	Nonpotable	1.0	1.0
	Juices	1.0	1.0
	Beverages	1.0	1.0
	Milk	1.0	1.0
Normal Liquids Fertilizers	Clear Liquid Fertilizers	31 to 110	1.17 to 1.44
	Nitrogen Solution	31 to 110	1.17 to 1.44
	28%, 30% or 32%	31 to 110	1.28 to 1.32
	20% Aqua-Ammonia	1.1 to 1.3	0.89
	Urea	1.0	1.89
	Ammonia Nitrate	11.22	1.16 to 1.37
	N-P-K solutions		1.2 to 1.4
	10-34-0	48	1.39
	9-18-9		1.32
Normal Liquids Crop Chemicals *(Type A)*	Herbicides	4 to 400	0.7 to 1.2
	Round-up		
	Touchdown		
	Banvel		
	Treflan		
	Paraquat		
	Prowl		
Normal Liquids Crop Chemicals *(Type B)*	Fungicides	0.7 to 100	0.7 to 1.2
	Insecticides		
	Adjuvants		
	Fumigants		
Normal Liquids Flowables	Dual	20 to 900	1 to 1.2
	Bicep		
	Marksman		
	Broadstrike		
	Doubleplay		
	Topnotch		
	Guardsman		
	Harness		
Normal Liquids Crop Chemicals *(Type C)*	Fungicides	20 to 900	1 to 1.2
Normal Liquids Crop Chemicals *(Type D)*	Micronutrients	20 to 1000	0.9 to 1.65
Normal Liquids Suspension Fertilizers	3-10-30	100 to 1000	0.9 to 1.65
	4-4-27	20 to 215	0.9 to 1.65
Normal Liquids Liquid Feeds	Liquid Molasses	8640	1.25
	Molasses plus Phos Acid and/or Urea (Treacle)	2882	1.1 to 1.3
Normal Liquids Chemicals	Sulfuric Acid	1.49	1.83
	Hydrochloric Acid	0.80 to 1. 0	1.1
	Phosphoric Acid	161	1.87

Product Families	**Typical Products**	**Reference Viscosity* (60 °F) Centipoise (cP)**	**Reference Specific Gravity* (60 °F)**
Heated Products	Bunker C	11,200	1.99
	Asphalt	100 to 5000	
Compressed Liquids Fuels and Refrigerants NH_3	LPG		
	Propane	0.098	0.504
	Butane	0.19	0.595
	Ethane		
	Freon 11	0.313	1.49
	Freon 12	0.359	1.33
	Freon 22	1.99	1.37
	Anhydrous Ammonia	0.188	0.61
Compressed Gases	Compressed Natural Gas (CNG)		0.6 to 0.8 (1=Air)
Cryogenic Liquids and Liquefied Natural Gas	Liquefied Oxygen	0.038	0.66
	Nitrogen	1.07	0.31
	Liquefied Natural Gas		

*Reference fluid properties are not all inclusive and are representative examples only.

Appendix C

Proposed Revisions to NCWM Publication 14, Policy C, Product Families for Meters – By Henry Oppermann and Mike Keilty Following October 2009 Sector Meeting

C. Product Families for Meters

When submitting a meter for evaluation, the manufacturer must specify the product family and critical parameters for which the meter is being submitted.

The product family and the specific product subgroup covered by the Certificate are to be identified on Page 1 of the Certificate of Conformance. More detailed information, including the typical product types found in the subgroup, is to be included in the application section of the Certificate.

Mass Meter Product Category & Test Requirements			**Magnetic Flow Meter Product Category & Test Requirements**		**Positive Displacement Flow Meter Product Category & Test Requirements**		**Turbine Flow Meter Product Category & Test Requirements**	
Test B: To cover a range of the following products, test with one product having a low specific gravity and test with a second product having a high specific gravity. The Certificate of Conformance will cover **all products in all product categories listed in the table** within the specific gravity range tested.			Test F – To cover a range of the following products, test with one product having a specified conductivity. The Certificate of Conformance will cover all products in both of the families with conductivity equal to or above the conductivity of the tested liquid.		Test C - To cover a range of products **within each product category**, test with one product having a low viscosity and test with a second product having a high viscosity **within each category**. The Certificate of Conformance will cover **all products in the product category** within the viscosity range tested.		Test E – To cover a range of products **within each product category**, test with one product having a low kinematic viscosity and test with a second product having a high kinematic viscosity **within each category**. The Certificate of Conformance will cover **all products in the product category** within the kinematic viscosity range tested.	
Typical Products	**Specific Gravity* (60 °F)**	**Product Category**	**Typical Products**	**Product Category**	**Product Category:** Fuels, Lubricants, Industrial and Food Grade Liquid Oils (FL&O)		**Product Category:** Fuels, Lubricants, Industrial and Food Grade Liquid Oils (FL&O)	
Asphalt		FL&O	Gasoline	FL&O	**Typical Products**	**Reference Viscosity* (60 F)**	**Typical Products**	**Reference Viscosity* (60 °F)**
Asphalt		Heated	JP4	FL&O		**Centipoise (cP)**		**Centipoise (cP)**
Avgas		FL&O	Jet A-1	FL&O	Gasoline	0.28	Gasoline	0.28
Jet A		FL&O	JP7 & JP8	FL&O	JP4	1.02	JP4	1.02
Jet B		FL&O	Kerosene	FL&O	Jet A-1	1.36	Jet A-1	1.36
Spindle Oil		FL&O	JP5	FL&O	JP7 & JP8	1.82	JP7 & JP8	1.82
Adjuvants	0.7 to 1.2	CC	Corn Oil	FL&O	Kerosene	1.94	Kerosene	1.94
Banvel	0.7 to 1.2	CC	Cooking Oils	FL&O	JP5	1.94	JP5	1.94

Mass Meter Product Category & Test Requirements			**Magnetic Flow Meter Product Category & Test Requirements**		**Positive Displacement Flow Meter Product Category & Test Requirements**		**Turbine Flow Meter Product Category & Test Requirements**	
Fumigants	0.7 to 1.2	CC	Diesel Fuel	FL&O	Corn Oil	4	Corn Oil	4
Fungicides	0.7 to 1.2	CC	Biodiesel above B20	FL&O	Cooking Oils	9.93	Cooking Oils	9.93
Herbicides	0.7 to 1.2	CC	Light Oil	FL&O	Diesel Fuel	10	Diesel Fuel	10
Insecticides	0.7 to 1.2	CC	Sunflower Oil	FL&O	Biodiesel above B20	10.12	Biodiesel above B20	10.12
Paraquat	0.7 to 1.2	CC	Soy Oil	FL&O	Light Oil	13.47	Light Oil	13.47
Prowl	0.7 to 1.2	CC	Olive Oil	FL&O	Sunflower Oil	90.1	Sunflower Oil	90.1
Round-up	0.7 to 1.2	CC	Vegetable Oil	FL&O	Soy Oil	90.6	Soy Oil	90.6
Touchdown	0.7 to 1.2	CC	Bunker Oil	FL&O	Olive Oil	116.8	Olive Oil	116.8
Treflan	0.7 to 1.2	CC	Avgas	FL&O	Vegetable Oil	133	Vegetable Oil	133
Ammonia Nitrate	1.16 to 1.37	Fert	Jet A	FL&O	Bunker Oil	11,200	Bunker Oil	11,200
Crude Oil	0.79 to 0.97	FL&O	Jet B	FL&O	Avgas	1.5 to 6	Avgas	1.5 to 6
Lubricating Oils	0.80 to 0.90	FL&O	Asphalt	FL&O	Jet A	1.5 to 6	Jet A	1.5 to 6
Peanut Oil	0.9 to 1.0	FL&O	Peanut Oil	FL&O	Jet B	1.5 to 6	Jet B	1.5 to 6
Hexane	0.66	Sol Gen	SAE Grades	FL&O	Asphalt	100 to 5000	Asphalt	100 to 5000
Diesel Fuel	0.72	FL&O	Lubricating Oils	FL&O	Peanut Oil	11 to 110	Peanut Oil	11 to 110
Gasoline	0.72	FL&O	Crude Oil	FL&O	SAE Grades	192 to 3626	SAE Grades	192 to 3626
Kerosene	0.75	FL&O	6 Oil (#5, #6)	FL&O	Lubricating Oils	20 to 1000	Lubricating Oils	20 to 1000
Jet A-1	0.76	FL&O	Fuel Oil (#1, #2, #3, #4)	FL&O	Crude Oil	3 to 1783	Crude Oil	3 to 1783
JP4	0.76	FL&O	Spindle Oil	FL&O	6 Oil (#5, #6)	66 to 13,000	6 Oil (#5, #6)	66 to 13,000
JP5	0.76	FL&O	Acetone	Sol Gen	Fuel Oil (#1, #2, #3, #4)	8 to 88	Fuel Oil (#1, #2, #3, #4)	8 to 88
JP7 JP8	0.76	FL&O	Hexane	Sol Gen	Spindle Oil		Spindle Oil	
Ethanol	0.79	Alc Gly	Acetates	Sol Gen	**Product Category:** Solvents General (Sol Gen)		**Product Category:** Solvents General (Sol Gen)	
Isopropyl	0.79	Alc Gly	MEK	Sol Gen	**Typical Products**	**Reference Viscosity* (60 °F)**	**Typical Products**	**Reference Viscosity* (60 °F)**
Acetone	0.8	Sol Gen	Toluene	Sol Gen		**Centipoise (cP)**		**Centipoise (cP)**
Methanol	0.80	Alc Gly	Xylene	Sol Gen	Acetone	0.34	Acetone	0.34
Butanol	0.81	Alc Gly	Ethylacetate	Sol Gen	Hexane	0.34	Hexane	0.34

Mass Meter Product Category & Test Requirements			**Magnetic Flow Meter Product Category & Test Requirements**		**Positive Displacement Flow Meter Product Category & Test Requirements**		**Turbine Flow Meter Product Category & Test Requirements**	
Isobutyl	0.81	Alc Gly	Methylene-Chloride	Sol Chl	Acetates	0.44	Acetates	0.44
MEK	0.81	Sol Gen	Trichloro-Ethylene	Sol Chl	MEK	0.45	MEK	0.45
Biodiesel above B20	0.86	FL&O	Carbon Tetra-Chloride	Sol Chl	Toluene	0.62	Toluene	0.62
Light Oil	0.86	FL&O	Perchloro-Ethylene	Sol Chl	Xylene	0.86	Xylene	0.86
Toluene	0.87	Sol Gen	Methanol	Alc Gly	Ethylacetate	1.36	Ethylacetate	1.36
20 % Aqua-Ammonia	0.89	Fert	Ethanol	Alc Gly	**Product Category:** Solvents Chlorinated (Sol Chl)		**Product Category:** Alcohols, Glycols & Water Mixes Thereof (Alc Gly)	
Xylene	0.89	Sol Gen	Isopropyl	Alc Gly	**Typical Products**	**Reference Viscosity* (60 F) Centipoise (cP)**	**Typical Products**	**Reference Viscosity* (60 F) Centipoise (cP)**
6 Oil (#5, #6)	0.9	FL&O	Butanol	Alc Gly				
Fuel Oil (#1, #2, #3, #4)	0.9	FL&O	Isobutyl	Alc Gly	Methylene-Chloride	0.46	Methanol	0.64
SAE Grades	0.9	FL&O	Ethylene glycol	Alc Gly	Trichloro-Ethylene	0.6	Ethanol	1.29
Corn Oil	0.91	FL&O	Propylene glycol	Alc Gly	Carbon Tetra-Chloride	0.99	Isopropyl	2.78
Cooking Oils	0.92	FL&O	Demineralized	Water	Perchloro-Ethylene	1	Butanol	3.34
Olive Oil	0.92	FL&O	Deionized	Water	**Product Category:** Alcohols, Glycols & Water Mixes Thereof (Alc Gly)		Isobutyl	4.54
Vegetable Oil	0.92	FL&O	Asphalt	Heated	**Typical Products**	**Reference Viscosity* (60 °F) Centipoise (cP)**	Ethylene glycol	25.5
Acetates	0.93	Sol Gen	Bunker C	Heated			Propylene glycol	54
Soy Oil	0.93	FL&O	Test D – To obtain coverage for a product category: Test with one product in the product category. The Certificate of Conformance will cover all products in the category.		Methanol	0.64	Compressed liquids: Fuels and Refrigerants, NH_3	
							Typical Products	**Reference Viscosity* (60 °F) Centipoise (cP)**
Sunflower Oil	0.93	FL&O			Ethanol	1.29	Propane	0.098
							Anhydrous Ammonia	0.188
Ethylacetate	0.96	Sol Gen			Isopropyl	2.78	Butane	0.19
Bunker Oil	0.99	FL&O			Butanol	3.34	Freon 11	0.313

Mass Meter Product Category & Test Requirements			**Magnetic Flow Meter Product Category & Test Requirements**		**Positive Displacement Flow Meter Product Category & Test Requirements**		**Turbine Flow Meter Product Category & Test Requirements**	
Beverages	1.0	Water	Tap water	Water	Isobutyl	4.54	Freon 12	0.359
Deionized	1.0	Water	Potable	Water	Ethylene glycol	25.5	Freon 22	1.99
Demineralized	1.0	Water	Nonpotable	Water	Propylene glycol	54	Ethane	
Juices	1.0	Water	Juices	Water	**Product Category:** Clear Liquid Fertilizers (Liq Fert)		Test A – The following products must be individually tested and noted on the Certificate of Conformance.	
Milk	1.0	Water	Beverages	Water	**Typical Products**	**Reference Viscosity* (60 °F)**		
Nonpotable	1.0	Water	Water mixes of alcohols & glycols	Alc Gly		**Centipoise (cP)**	**Typical Products**	**Product Category**
Potable	1.0	Water	Urea	Fert	Urea	1	Methylene-Chloride	Sol Chl
Tap Water	1.0	Water	Ammonia Nitrate	Fert	Ammonia Nitrate	11.22	Trichloro-Ethylene	Sol Chl
Propylene glycol	1.04	Alc Gly	10-34-0	Fert	10-34-0	48	Carbon Tetra-Chloride	Sol Chl
Hydrochloric Acid	1.1	Chem	20 % Aqua-Ammonia	Fert	20 % Aqua-Ammonia	1.1 to 1.3	Perchloro-Ethylene	Sol Chl
Ethylene glycol	1.19	Alc Gly	Chlear Liquid Fert	Fert	Chlear Liquid Fert	31 to 110	Urea	Liq Fert
Liquid Molasses	1.25	Liq Feed	Nitrogen Solution	Fert	Nitrogen Solution	31 to 110	Ammonia Nitrate	Liq Fert
9-18-9	1.32	Fert	28 %, 30 % or 32 %	Fert	28 %, 30 % or 32 %	31 to 110	10-34-0	Liq Fert
Methylene-Chloride	1.34	Sol Chl	N-P-K solutions	Fert	N-P-K solutions		20% Aqua-Ammonia	Liq Fert
10-34-0	1.39	Fert	9-18-0	Fert	9-18-0		Chlear Liquid Fert	Liq Fert
Trichloro-Ethylene	1.47	Sol Chl	4-4-27	Sus Fert	**Product Category:** Suspension Fertilizers (Sus Fert)		Nitrogen Solution	Liq Fert
Carbon Tetra-Chloride	1.6	Sol Chl	3-10-30	Sus Fert	**Typical Products**	**Reference Viscosity* (60 °F)**	28 %, 30 % or 32 %	Liq Fert
Perchloro-Ethylene	1.6	Sol Chl	Molasses plus Phos Acid and/or Urea (TreaChle)	Liq Feed		**Centipoise (cP)**	N-P-K solutions	Liq Fert
Sulfuric Acid	1.83	Chem	Liquid Molasses	Liq Feed	4-4-27	20 to 215	9-18-0	Liq Fert
Phosphoric	1.87	Chem	Sulfuric Acid	Chem	3-10-30	100 to 1000	4-4-27	Sus Fert

Mass Meter Product Category & Test Requirements			**Magnetic Flow Meter Product Category & Test Requirements**		**Positive Displacement Flow Meter Product Category & Test Requirements**		**Turbine Flow Meter Product Category & Test Requirements**	
Acid								
Urea	1.89	Fert	Phosphoric Acid	Chem	**Product Category:** Liquid Feeds (Liq Feed)		3-10-30	Sus Fert
Bunker C	1.99	Heated	Hydrochloric Acid	Chem	**Typical Products**	**Reference Viscosity* (60 °F)**	Molasses plus Phos Acid and/or Urea (TreaChle)	Liq Feed
Fungicides	1 to 1.2	CC	Herbicides	CC-A		**Centipoise (cP)**	Liquid Molasses	Liq Feed
Micronutrients	1 to 1.2	CC	Round-up	CC-A	Molasses plus Phos Acid and/or Urea (TreaChle)	2882	Asphalt	Heated
Molasses plus Phos Acid and/or Urea (TreaChle)	1.1 to 1.3	Liq Feed	Touchdown	CC-A	Liquid Molasses	8640	Bunker C	Heated
3-10-30	0.9 to 1.65	Liq Fert	Banvel	CC-A	**Product Category:** Heated Products (Heated)		Sulfuric Acid	Chem
4-4-27	0.9 to 1.65	Liq Fert	Treflan	CC-A	**Typical Products**	**Reference Viscosity* (60 °F)**	Phosphoric Acid	Chem
Micronutrients	0.9 to 1.65	Liq Fert	Paraquat	CC-A		**Centipoise (cP)**	Hydrochloric Acid	Chem
28%, 30% or 32%	1.28 to 1.32	Fert	Prowl	CC-A	Asphalt	100 to 5000	Herbicides	CC-A
N-P-K solutions	1.2 – 1.4	Fert	Herbicides	CC-A	Bunker C	11,200	Round-up	CC-A
Chlear Liquid Fert	1.17 to 1.44	Fert	Fungicides	CC-B	**Product Category:** Chemicals (Chem)		Touchdown	CC-A
Nitrogen Solution	1.17 to 1.44	Fert	Insecticides	CC-B	**Typical Products**	**Reference Viscosity* (60 °F)**	Treflan	CC-A
Test D – To obtain coverage for each of the following product categories, test with one product in **each** product category. The Certificate of Conformance will cover all of the products in **the** product category in which a product was tested.			Adjuvants	CC-B			Banvel	CC-A
			Fumigants	CC-B	Sulfuric Acid	1.49	Paraquat	CC-A
			Fungicides	CC-C	Phosphoric Acid	161	Prowl	CC-A
Product Category	**Typical Products**	**Specific Gravity***	Micronutrients	CC-D	Hydrochloric Acid	0.80 to 1. 0	Herbicides	CC-A

Mass Meter Product Category & Test Requirements			**Magnetic Flow Meter Product Category & Test Requirements**		**Positive Displacement Flow Meter Product Category & Test Requirements**		**Turbine Flow Meter Product Category & Test Requirements**	
		(60 F)						
Comp gas	Compressed Natural Gas (CNG)	0.6 to 0.8 (1=Air)			**Product Category:** Crop Chemicals (Type A) (CC-A)		Fungicides	CC-B
					Typical Products	**Reference Viscosity* (60 °F)**	Insecticides	CC-B
Comp liq	Anhydrous Ammonia	0.61				**Centipoise (cP)**	Adjuvants	CC-B
Comp liq	Butane	0.595			Herbicides	4 to 400	Fumigants	CC-B
Comp liq	Ethane				Round-up	4 to 400	Fungicides	CC-C
Comp liq	Freon 11	1.49			Touchdown	4 to 400	Micronutrients	CC-D
Comp liq	Freon 12	1.33			Banvel	4 to 400	Dual	Flow
Comp liq	Freon 22	1.37			Treflan	4 to 400	Bicep	Flow
					Paraquat	4 to 400	Marksman	Flow
Comp liq	Propane	0.504			Prowl	4 to 400	Broadstrike	Flow
					Product Category: Crop Chemicals (Type B) (CC-B)		Doubleplay	Flow
Cryo LNG	Liquefied Natural Gas				**Typical Products**	**Reference Viscosity* (60 °F)**	Topnotch	Flow
Cryo LNG	Liquefied Oxygen	0.66				**Centipoise (cP)**	Guardsman	Flow
Cryo LNG	Nitrogen	0.31			Fungicides	0.7 to 100	Harness	Flow
					Insecticides	0.7 to 100	NH_3	
					Adjuvants	0.7 to 100	Test D – To obtain coverage for a product category: Test with one product in the product category. The Certificate of Conformance will cover all products in the category.	
					Fumigants	0.7 to 100		
					Product Category: Crop Chemicals (Type C) (CC-C)			
					Typical Products	**Reference Viscosity* (60 °F)**	Tap Water	Water
						Centipoise (cP)	Deionized	Water
					Fungicides	20 to 900	Demineralized	Water
					Product Category: Crop Chemicals (Type D) (CC-D)		Potable	Water

Mass Meter Product Category & Test Requirements			**Magnetic Flow Meter Product Category & Test Requirements**		**Positive Displacement Flow Meter Product Category & Test Requirements**		**Turbine Flow Meter Product Category & Test Requirements**	
					Typical Products	**Reference Viscosity* (60 °F)**	Nonpotable	Water
						Centipoise (cP)	Juices	Water
					Micronutrients	20 to 1000	Beverages	Water
					Product Category: Flowables (Flow)		Milk	Water
					Typical Products	**Reference Viscosity* (60 °F)**	Liquefied Oxygen	Cryo LNG
						Centipoise (cP)	Nitrogen	Cryo LNG
					Dual	20 to 900	Liquefied Natural Gas	Cryo LNG
					Bicep	20 to 900		
					Marksman	20 to 900		
					Broadstrike	20 to 900		
					Doubleplay	20 to 900		
					Topnotch	20 to 900		
					Guardsman	20 to 900		
					Harness	20 to 900		
					Product Category: Compressed Liquids: Fuels and Refrigerants (Comp liq)			
					Typical Products	**Reference Viscosity* (60 °F)**		
						Centipoise (cP)		
					Propane	0.098		
					Anhydrous Ammonia	0.188		
					Butane	0.19		
					Freon 11	0.313		
					Freon 12	0.359		
					Freon 22	1.99		
					Ethane			

Mass Meter Product Category & Test Requirements			Magnetic Flow Meter Product Category & Test Requirements		Positive Displacement Flow Meter Product Category & Test Requirements		Turbine Flow Meter Product Category & Test Requirements	
					Test D – To obtain coverage for a product category: Test with one product in the product category. The Certificate of Conformance will cover all products in the category.			
					Product Category: All Water (Water)			
					Typical Products	**Reference Viscosity* (60 °F)**		
						Centipoise (cP)		
					Tap Water	1.0		
					Deionized	1.0		
					Demineralized	1.0		
					Potable	1.0		
					Nonpotable	1.0		
					Juices	1.0		
					Beverages	1.0		
					Milk	1.0		
					Test A – The following products must be individually tested and noted on the Certificate of Conformance.			
					Product Category: Cryogenic Liquids and Liquefied Natural Gas (Cryo LNG)			
					Typical Products	**Reference Viscosity* (60 °F)**		
						Centipoise (cP)		
					Liquefied Oxygen	0.038		
					Nitrogen	1.07		
					Liquefied Natural Gas			

Product Family Table – Category Abbreviations	
Abbreviation	**Product Categories**
FL&O	Fuels, Lubricants, Industrial and Food Grade Liquid Oils
Solv Gen	Solvents General
Solv Cl	Solvents Chlorinated
Alc Gly	Alcohols, Glycols & Water Mixes thereof
Water	Water
Fert	Fertilizers
CC-A	Crop Chemicals *(Type A)*
CC-B	Crop Chemicals *(Type B)*
CC-C	Crop Chemicals *(Type C)*
CC-D	Crop Chemicals *(Type D)*
Flow	Flowables
Sus Fert	Suspension Fertilizers
Liq Feed	Liquid Feeds
Chem	Chemicals
Heated	Heated Products
Comp liq	Compressed Liquids: Fuels and Refrigerants NH_3
Comp gas	Compressed Gases
Cryo LNG	Cryogenic Liquids and Liquefied Natural Gas

[1]*Note: The Typical Products listed in this table are not limiting or all-inclusive; there may be other products and product trade names, which fall into a product family. Water and a product such as stoddard solvent or mineral spirits may be used as test products in the fuels, lubricants, industrial, and food- grade liquid oils product family.*

[2] The specific gravity of a liquid is the ratio of its density to that of water at standard conditions, usually 4 °C (or 40 °F) and 1 atm. The density of water at standard conditions is approximately 1000 kg/m^3 (or 998 kg/m^3)

[3] Diesel fuel blends (biodiesel) with up to 20 % vegetable or animal fat/oil.

[4] Gasoline includes oxygenated fuel blends with up to 15 % oxygenate.

$$\text{Centistokes} = \frac{\text{Centipoise}}{\text{Specific Gravity}}$$

[5] Kinematic viscosity is measured in centistokes.

Source for some of the viscosity value information is in the Industry Canada - Measurement Canada "Liquid Products Group, Bulletin V-16-E (rev. 1), August 3, 1999."

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Appendix D

Draft Hydrocarbon Gas Vapor-Measuring Devices Checklist

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Measuring Devices

Hydrocarbon Gas-Vapor Measuring Devices

Technical Policy • Checklists • Test Procedures

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Hydrocarbon Gas-Vapor Measuring Devices 2009

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Hydrocarbon Gas-Vapor Measuring Devices

Hydrocarbon Gas-Vapor Measuring Devices Checklist and Test Procedures

Introduction

The checklist is designed so that the user can determine and record in a logical sequence the conformance of the device with the elements of the checklist. The user should make copies of the checklist to serve as worksheets and preserve the original for reference. Unless specifically requested to do so, the applicant is not required to submit a completed checklist to NTEP prior to the evaluation; however, the applicant is urged to carefully review the checklist prior to submission to ensure that the device meets the requirements of the checklist. In most cases, the results of evaluation for each element can be recorded by checking the appropriate response. In some cases, the user is required to record values, results, or comments. In those cases, space is provided; examples are:

1. **Yes** ☐ **No** ☐ **N/A** ☐

2. ☐ EXTERNAL ☐ INTERNAL ☐ N/A

3. Comments:

This checklist is a guide for conducting prototype examinations to determine compliance with the requirements of NIST Handbook 44. These criteria shall apply only to type evaluation examinations, not on a retroactive basis to devices that are currently in service. The General Code requirements apply to all classes of devices. The specific code requirements supersede General Code requirements in all cases of conflict.

I. General

Code Reference: G-S.1. Identification

Virtually all weighing and measuring equipment must be clearly and permanently marked with the manufacturer's name or trademark, model designation, and serial number. Dispensers, consoles, cash registers interfaced with dispensers, retrofit computing registers, and customer card-activated terminals must all have these markings. As a practical matter, some equipment does not need a serial number. "Satellite" modules in a modular system (e.g., keyboard module and cash drawer) need not have serial numbers because they do not have any "intelligence."
A serial number is required in the following circumstances:

Separate Device: A device is capable of operating as a weighing or measuring device without being interfaced with or connected to other components.

Separate Main Element: Primary indicating elements must be marked. The device is a major element in the weighing or measuring system. That is, it is metrologically significant to the operation and/or performance of the system and interfaces with different compatible main elements. Examples: Indicating elements, weighing elements, meter registers, meter measuring elements (vehicle tank meters and loading rack meters).

Component: The device is a component in a system, may be used in different models of devices, and is sufficiently complex to warrant a separate evaluation and a separate CC (e.g., load cells and vapor recovery nozzles). Such a device may or may not be placed into an enclosure with other components of the system. When installed in an enclosure, the complete device must be marked with a serial number, and the one serial number will suffice for the entire collection of components. If it is not placed in an enclosure with other components, the component must be marked with a serial number.

Equipment must be marked on a surface that is an integral part of the device, and the marking must be visible after installation. If the required information is not positioned in a visible location after installation, a duplicate, permanent identification badge must be located in a visible location. A removable cover is an acceptable location for the required information only if a permanent ID badge is located elsewhere on the device.

The information may be on a metal or plastic plate that is attached with pop rivets, adhesive, or other means, but may not be fastened by removable bolts or screws. A foil or vinyl badge may be used provided that the badge can survive wear and tear, remains legible, and is difficult to remove. The printing on a foil badge must be easily readable and not easily obliterated by rubbing with a relatively soft object (e.g., the wood of a pencil)

Location of the information:

1. Identification

All equipment shall be clearly and permanently marked on an exterior visible surface after installation. It must contain the following information (prefix lettering may be initial capitals, all capitals, or all lower case):

Code Reference: G-S.1.

1.1. Name, initials, or trademark of the manufacturer. Yes☐ No ☐ N/A ☐

1.2. A model designation that positively identifies the pattern or design. The Model designation shall be prefaced by the word "Model", "Type", or "Pattern". These terms may be followed by the term "Number" or an abbreviation of that word. The abbreviation for the word "Number" shall, at a minimum, begin with the letter "N" (e.g., No or No.) The abbreviation for the word "Model" shall be "Mod" or "Mod.". Yes☐ No ☐ N/A ☐

1.3. Except for not built-for-purpose, software-based devices, a nonrepetitive serial number. The serial number shall be prefaced by words, an abbreviation, or a symbol, that clearly identifies the number as the required serial number. Abbreviations for the word "Serial" shall, as a minimum, begin with the letter "S," and abbreviations for the word "Number" shall, as a minimum, begin with the letter "N" (e.g., S/N, SN, Ser. No, and S No.). Yes☐ No ☐ N/A ☐

1.4. For not built-for-purpose, software-based devices the current software version or revison designation. The version or revision identifier shall be prefaced by the word "Version" or "Revision" as appropriate and either word may be followed by the word "Number." The abbreviations for the word “Version” shall, as a minimum, begin with the letter "V". The abbreviation for the word “Number” shall, as a minimum, begin with the letter "N" (e.g., No or No.). Yes☐ No ☐ N/A ☐

Code Reference: G-S.1. (e).

1.5. The NTEP Certificate of Conformance (CC) Number or a corresponding CC addendum number for devices that have a CC. The number shall be prefaced by the terms "NTEP CC", "CC", or "Approval". These terms may be followed by the word "Number" or an abbreviation for the Word "Number". The abbreviation shall as a minimum begin with the letter "N" (e.g., No or No.). Yes☐ No ☐ N/A ☐

The device must have an area, either on the identification plate or on the device itself, suitable for the application of the Certificate of Conformance Number. If the area for the CC Number is not part of an identification plate, then note its intended location below and how it will be applied.

Location of CC Number if not located with the identification:

Code Reference: G-S.1.1. Location of Marking Information for Not Built-for-Purpose Devices, Software-Based

1.6. For not built-for-purpose, software-based devices the following shall apply:

1.6.1. The required information in G-S.1 Identification. (a), (b), (d), and (e) shall be permanently marked or continuously displayed on the device; or Yes☐ No ☐ N/A ☐

1.6.2. The Certificate of Conformance (CC) Number shall be: Yes☐ No ☐ N/A ☐

- permanently marked on the device; or
- continuously displayed; or
- accessible through an easily recognized menu and, if necessary, a submenu. Examples of menu and submenu identification include, but are not limited to "Help," "System Identification," "G-S.1. Identification," or "Weights and Measures Identification."

Note: For (1.6.2.), clear instructions for accessing the information required in G-S.1. (a), (b), and (d) shall be listed on the CC, including information necessary to identify that the software in the device is the same type that was evaluated.

1.7. The identification badge must be visible after installation. Yes☐ No ☐ N/A ☐

1.8. The identification badge must be permanent. Yes☐ No ☐ N/A ☐

Code Reference: S.4.1. Marking Requirements – Limitation of Use

1.9 If a device is intended to measure accurately only products having particular properties, or to measure accurately only under specific installation or operating conditions, or to measure accurately when used in conjunction with specific accessory equipment, these limitations shall be clearly and permanently marked on the device. Yes☐ No ☐ N/A ☐

Code Reference: S.4.2. Marking Requirements -Discharge Rate

1.10. A volume-measuring device shall be marked to show it's rated gas capacity in cubic meters or cubic feet per hour. Yes☐ No ☐ N/A ☐

Code Reference: S.4.3. Temperature Compensation

1.11. If a device is equipped with a temperature compensator, this shall be marked on the badge or immediately adjacent to the badge and on the register. Yes☐ No ☐ N/A ☐

Code Reference: S.4.4. Badge

1.12. A badge affixed in a prominent position on the front of the device shall show the manufacturer's name, serial number and model number of the device, and capacity rate of the device for the particular products that it was designed to meter as recommended by the manufacturer. Yes☐ No ☐ N/A ☐

Code Reference: G-S.2. Facilitation of Fraud

This applies to all metering systems, including dispensers controlled from a remote location and vehicle tank meters. An exception is permitted if the unit price can be changed at a dispenser only through the use of a key to gain access to the unit price mechanism, e.g., mechanical computing registers. Such action would be obvious to a consumer and would inhibit changing the unit price during a delivery.

1.13. All equipment and all mechanisms, software, and devices attached to or used in conjunction therewith shall be so designed, constructed, assembled, and installed for use such that they do not facilitate the perpetration of fraud. Yes☐ No ☐ N/A ☐

Code Reference: G-S.3. Permanence

Equipment shall be of such materials, design, and construction that, under normal service conditions:

1.14. Accuracy will be maintained. Yes☐ No ☐ N/A ☐

1.15. Operating parts will continue to function as intended, Yes☐ No ☐ N/A ☐

1.16. Adjustments will remain reasonably permanent. Yes☐ No ☐ N/A ☐

Code Reference: G-S.4. Interchange or Reversal of Parts

If a metering system has parts that may be interchanged or reversed in normal field assembly, the system shall either be constructed so that reversal will not affect the accuracy of the system or the parts must be marked to indicate their proper position. For most metering devices, this applies only to the reversal of connectors of cables to peripheral devices.

If a metering system has any parts that may be interchanged or reversed in normal field assembly, the parts must either be:

1.17. Constructed so that reversal will not affect performance, Yes☐ No ☐ N/A ☐

1.18. Marked or keyed to indicate the proper position. Yes☐ No ☐ N/A ☐

2. Graduations, Indications, and Recorded Representations

Several general requirements facilitate the reading and interpretation of displayed and recorded values. Each display for quantity must be appropriate in design and have sufficient capacity for particular applications to be suitable for the application. Metering devices must be capable of indicating the maximum quantity that can normally be expected in a particular application.

Code Reference: S.1.1. Primary Elements

2.1. **General.** -A device shall be equipped with a primary indicating element and may also be equipped with a primary recording element. Yes☐ No ☐ N/A ☐

2.2. **Units.** - A volume-measuring device shall indicate, and record if equipped to record, its deliveries in terms of cubic meters or cubic feet, or multiple or decimal subdivisions of cubic meters or cubic feet. Yes☐ No ☐ N/A ☐

Code Reference: S.1.1.3. Value of the Smallest Unit – Volume Measuring Devices

2.3. The value of the smallest unit of indicated delivery, and recorded delivery if the device is equipped to record, shall not exceed:

2.3.1. (a) 1 m^3 (1 000 dm^3) (100 ft^3) when the maximum rated gas capacity is less than 100 m^3/h (10 000 ft^3/h); Yes☐ No ☐ N/A ☐

2.3.2. (b) 10 m^3 (1 000 ft^3) when the maximum rated gas capacity is 280 m^3/h (10 000 ft^3/h) up to but not including 1 700 m^3/h (60 000 ft^3/h); Yes☐ No ☐ N/A ☐

2.3.3. (c) 100 m^3 (10 000 ft^3) when the maximum rated gas capacity is 1 700 m^3/h (60 000 ft^3/h) or more. Yes☐ No ☐ N/A ☐

Code Reference: S.1.1.4.

2.4. Primary indicating and recording elements shall advance digitally or continuously and be susceptible to advancement only by the mechanical operation of the device. Yes☐ No ☐ N/A ☐

Code Reference: S.1.1.5. Proving Indicator

2.5. Devices rated less than 280 m^3/h (10 000 ft^3/h) gas capacity shall be equipped with a proving indicator measuring 0.025, 0.05, 0.1, 0.2, or 0.25 m^3 per revolution (1, 2, 5, or 10 ft^3 per revolution) for testing the meter. Devices with larger capacities shall be equipped as follows: Yes☐ No ☐ N/A ☐

2.5.1. (a) Devices rated 280 m^3 (10 000 ft^3) up to but not including 1 700 m^3/h (60 000 ft^3/h) gas capacity shall be equipped with a proving indicator measuring not greater than 1 m^3 (100 ft^3) per revolution. Yes☐ No ☐ N/A ☐

2.5.2. (b) Devices rated 1 700 m^3/h (60 000 ft^3/h) gas capacity or more shall be equipped with a proving indicator measuring not more than 10 m^3 (1 000 ft^3) per revolution. Yes☐ No ☐ N/A ☐

2.5.3. The test circle of the proving indicator shall be divided into 10 equal parts. Additional subdivisions of one or more of such equal parts may be made. Yes☐ No ☐ N/A ☐

Code Reference: S.1.2. Graduations

2.6. **Length.** - Graduations shall be so varied in length that they may be conveniently read. Yes☐ No ☐ N/A ☐

2.7. **Width.** - In any series of graduations, the width of a graduation shall in no case be greater than the width of the minimum clear interval between graduations, and in no case should it exceed 1.0 mm (0.04 in) for indicating elements and 0.5 mm (0.02 in) for proving circles. Yes☐ No ☐ N/A ☐

Code Reference: S.1.2.3. Clear Interval Between Graduations

2.8. The clear interval shall be not less than 1.0 mm (0.04 in). If the graduations are not parallel, the measurement shall be made: Yes☐ No ☐ N/A ☐

2.8.1. (a) along the line of relative movement between the graduations at the end of the indicator, **Yes☐ No ☐ N/A ☐**

or

2.8.2. (b) if the indicator is continuous, at the point of widest separation of the graduations. **Yes☐ No ☐ N/A ☐**

Code Reference S.1.3. Indicators

2.9. **Symmetry.** - The index of an indicator shall be symmetrical with respect to the graduations, at least throughout that portion of its length associated with the graduations. Yes☐ No ☐ N/A ☐

2.10. **Length.** - The index of an indicator shall reach to the finest graduations with which it is used. Yes☐ No ☐ N/A ☐

Code Reference: S.1.3.3. Indicator Width

2.11. The width of the index of an indicator in relation to the series of graduations with which it is used shall be not greater than:

2.11.1. (a) the width of the widest graduation, and Yes☐ No ☐ N/A ☐

2.11.2. (b) the width of the minimum clear interval between graduations. Yes☐ No ☐ N/A ☐

2.11.3. When the index of an indicator extends along the entire length of a graduation, that portion of the index of the indicator that may be brought into coincidence with the graduation shall be of the same width throughout the length of the index that coincides with the graduation Yes☐ No ☐ N/A ☐

2.12 **Clearance.** - The clearance between the index of an indicator and the graduations shall in no case be more than 1.5 mm (0.06 in). Yes☐ No ☐ N/A ☐

2.13. **Parallax.** - Parallax effects shall be reduced to the practicable minimum. Yes☐ No ☐ N/A ☐

3. Code Reference: S.2. Design of Measuring Elements

Code Reference: S.2.1. Pressure Regulation

3.1. Except when measured as a retail motor fuel, the vapor should be measured at a normal gauge pressure (psig) of:

3.1.1. (a) 2 740 Pa ± 685 Pa [11 in of water column (0.40 psig) ± 2.75 in of water column (0.10 psig)] for liquefied petroleum gas vapor; or Yes☐ No ☐ N/A ☐

3.1.2. (b) 1 744 Pa ± 436 Pa [7 in of water column (0.25 psig) ± 1.75 in of water column (0.06 psig)] for natural and manufactured gas. Yes☐ No ☐ N/A ☐

When vapor is measured at a pressure other than what is specified above for the specific product, a volume multiplier shall be applied within the meter or to the billing invoice based on the following equation:
Where

VPM = Volume pressure multiplier
AAP = Assumed atmospheric pressure in psia
GP = Gauge pressure in pascal or psig
NGP = Normal gauge pressure in pascal or psig

The assumed atmospheric pressure is to be taken from HB 44 Sec 3.33. Tables 2 and 2M .

3.1.3. When liquefied petroleum gas vapor is measured at a pressure of 6 900 Pa (1 psig) or more, the delivery pressure shall be maintained within ± 1 725 Pa (± 0.25 psig). Yes☐ No ☐ N/A ☐

3.1.4. Pressure variations due to regulator lock off shall not increase the operating pressure by more than 25%. Yes☐ No ☐ N/A ☐

3.2. **Provision for Sealing.** - Adequate provision shall be made for applying security seals in such a manner that no adjustment may be made of any measurement element. Yes☐ No ☐ N/A ☐

3.3. **Maintenance of Vapor State.** - A device shall be so designed and installed that the product being measured will remain in a vapor state during passage through the meter. Yes☐ No ☐ N/A ☐

3.4. **Automatic Temperature Compensation.** - A device may be equipped with an adjustable automatic means for adjusting the indication and registration of the measured volume of vapor to the volume at 15 °C (60 °F). Yes☐ No ☐ N/A ☐

4. Design of Discharge Lines

Code Reference S.3.

4.1 **Diversion of Measured Vapor.** - No means shall be provided by which any measured vapor can be diverted from the measuring chamber of the meter or the discharge line therefrom. Yes☐ No ☐ N/A ☐

5. Repeatability of Indications

Code Reference: G-S.5.4.

The quantity measured by a device shall be repeatable within tolerance for the same indication. One condition that may create a problem is that the value of the quantity division may be large relative to the tolerance. A delivery must be within tolerance wherever the delivery is stopped within the nominal indication of the test draft. Meters that may be at the tolerance limit may be out of tolerance at an extreme limit of the nominal quantity indication.

5.1. When a digital indicator is tested, the delivered quantity shall be within tolerance at any point within the quantity-value division for the test draft. Yes☐ No ☐ N/A ☐

The following philosophy and list of sealable parameters applies to provision for sealing all liquid/vapor-measuring devices.

An electronic data audit trail is a means of allowing a weights and measures inspector to review how many times any electronic adjustment, which affects the accuracy of a weight, or volume measurement has been changed. The information contained in the audit trail shall consist of a cumulative and non-destructible number (even if a power failure occurs) which increments each time any of the adjustments required to be sealed have been changed. The electronic data audit trail information shall be capable of being recalled by the official on the main display of the device.

As a minimum, devices which use an audit trail to provide security for sealable parameters shall satisfy the following criteria and shall use the format set forth in Appendix A of the checklist for Liquid-Measuring Devices.

Philosophy for Sealing
Typical Features to be Sealed

Principles for Determining Features to be Sealed

The need to seal some features depends upon:

- The ease with which the feature or the selection of the feature can be used to facilitate fraud; and
- The likelihood that the use of the feature will result in fraud not being detected.

Features or functions which the operator routinely uses as part of device operation, such as setting the unit prices on dispensers and maintaining unit prices in price look-up codes stored in memory, are not sealable parameters and shall not be sealed.

If a parameter (or set of parameters) selection would result in performance that would be obviously in error, such as the selection of parameters for different countries, then it is not necessary to seal the selection of these features.

If individual device characteristics are selectable from a "menu" or a series of programming steps, then access to the "programming mode" must be sealable. (Note: If an audit trail is the only means of security, then the audit trail shall update only after at least one sealable parameter has been changed; simply accessing the sealable parameters via a menu shall not update the audit trail.)

If a physical act, such as cutting a wire is required to change a parameter setting and physically repairing the cut is required to reactivate the parameter, then this physical repair process would be considered an acceptable way to select parameters without requiring a physical seal or an audit trail.

Typical Features and Parameters to be Sealed

The following provides examples of configuration and calibration parameters that are to be sealed. The examples are provided for guidance and are not intended to cover all possible parameters.

Calibration Parameters: Calibration parameters are those parameters whose values are expected to change as a result of accuracy adjustments. Examples include the following.

1. Measuring element adjustments where linearity corrections are used, e.g., flow rate 1 and meter factor 1, flow rate 2 and meter factor 2, etc.
2. Mass flow meter adjustments for zero adjustments (not simply setting the display to zero) and span settings.

Configuration Parameters: Configuration parameters are those parameters whose values are expected to be entered only once and not changed after all initial installation settings are made. Examples include the following.

1. Octane or other blend setting ratios (optional in Canada at this time)
2. Temperature, pressure, density, and other sensor settings for zero, span, and offset values
3. Measurement units (in Canada, only if not displayed or printed on the primary register)
4. Temperature compensation table, liquid coefficient of expansion, or compressibility factors or tables
5. Liquid density setting (in Canada, only if not displayed or printed on the primary register) and allowable liquid density input range
6. Vapor pressures of liquids if used in calculations to establish the quantity
7. Meter or sensor temperature compensation factors
8. False or missing pulse limits for dual pulse systems (Canada only)
9. On/off status of automatic temperature, pressure, or density correction
10. Automatic or manual data input for sensors
11. Dual pulse checking feature status on or off
12. Flow control settings (optional in Canada)
13. Filtering constants

Hydrocarbon Gas-Vapor Measuring Device Features and Parameters	
Typical Features or Parameters to be Sealed	**Typical Features or Parameters Not Required to be Sealed**
Measuring element adjustment (both mechanical and electronic)	Analog-to-digital converters
Linearity correction values	Quantity division value (display resolution)
Measurement units (e.g., cubic feet to cubic meters)	Double pulse counting
~~Octane blend setting for retail motor-fuel dispensers~~	Communications
Any tables or settings accessed by the software or manually entered to establish the quantity (e.g., specific gravity, pressure, etc.)	
Density ranges	
Pulsers	
Signal pick-up (magnetic or reluctance)	
Temperature probes and temperature offsets in software	
Pressure and density sensors and transducers	
Flow control settings, e.g., flow rates for slow-flow start, quantity for slow-flow start and stop	
Temperature compensating systems (on/off)	
Differential pressure valves	
As a point of clarification, the flow control settings referenced above are those controls typically incorporated into the installations of large-capacity meters (wholesale meters). The reference does not include the point at which retail motor-fuel dispensers slow product flow during a prepaid transaction to enable the dispenser to stop at the preset amount.	

Note: The above examples of adjustments, parameters, and features to be sealed are to be considered "typical" or "normal." This list may not be all inclusive. Some parameters other than those listed, which affect the metrological performance of the device, must be sealed. If listed parameters or other parameters, which may affect the metrological function of the device, are not sealed, the manufacturer must demonstrate that all settings comply with the most stringent requirements for the application of the device (i.e., the parameter does not affect compliance with Handbook 44).

(Section 3.33. of Handbook 44, Code for Hydrocarbon Gas Vapor-Measuring Devices, does not include specific design criteria for electronic audit trails. Based upon G-A.3., Special and Unclassified Equipment, and G-S.8., Provisions for Sealing Electronic Adjustable Components, Table S.2.2.of the Liquid-Measuring Devices Code, Categories of Device and Methods of Sealing, will be applied to the type evaluation of cryogenic devices until specific design criteria are added to Section 3.33. of Handbook 44 for the design of audit trails installed in Hydrocarbon Gas Vapor-measuring devices.)

Category 1 Devices (Devices with No Remote Configuration Capability):

- The device is sealed with a physical seal or it has an audit trail with two event counters (one for calibration, the second for configuration). Yes☐ No☐ N/A☐
- A physical seal must be applied without exposing electronics. Yes☐ No☐ N/A☐
- Event counters are non-resettable and have a capacity of at least 000 to 999. Yes☐ No☐ N/A☐
- Event counters increment appropriately. Yes☐ No☐ N/A☐
- The audit trail information must be capable of being retained in memory for at least 30 days while the device is without power. Yes☐ No☐ N/A☐
- Accessing the audit trail information for review shall be separate from the calibration mode. Yes☐ No☐ N/A☐
- Accessing the audit trail information must not affect the normal operation of the device. Yes☐ No☐ N/A☐
- Accessing the audit trail information shall not require removal of any additional parts other than normal requirements to inspect the integrity of a physical security seal. (e.g., a key to open a locked panel may be required). Yes☐ No☐ N/A☐

Category 2 Devices (Devices with Remote Configuration Capability but Controlled by Hardware):

- The physical hardware enabling access for remote communication must be on- site. Yes☐ No☐ N/A☐
- The physical hardware must be sealable with a security seal or Yes☐ No☐ N/A☐
- The device must be equipped with at least two event counters: one for calibration, the second for configuration parameters Yes☐ No☐ N/A☐
  - calibration parameters event counter
  - configuration parameters event counter
- Adequate provision must be made to apply a physical seal without exposing electronics. Yes☐ No☐ N/A☐
- Event counters are non-resettable and have a capacity of at least 000 to 999. Yes☐ No☐ N/A☐
- Event counters increment appropriately. Yes☐ No☐ N/A☐
- Event counters may be located either: Yes☐ No☐ N/A☐
  - at the individual measuring device or
  - at the system controller
- If the counters are located at the system controller rather than at the individual device, means must be provided to generate a hard copy of the information through an on-site device. Yes☐ No☐ N/A☐
- An adequate number (see table below) of event counters must be available to monitor the calibration and configuration parameters of each individual device. Yes☐ No☐ N/A☐
- The device must either: Yes☐ No☐ N/A☐
  -clearly indicate when it is in the remote configuration mode or
  -the device shall not operate while in the remote configuration mode.
- If capable of printing in the calibration mode, it must print a message that it is in the calibration mode. Yes☐ No☐ N/A☐
- The audit trail information must be capable of being retained in memory for at least 30 days while the device is without power. Yes☐ No☐ N/A☐
- The audit trail information must be readily accessible and easily read. Yes☐ No☐ N/A☐

Minimum Number of Counters Required		
	Minimum Counters Required for Devices Equipped with Event Counters	**Minimum Event Counter(s) at System Controller**
Only one type of parameter accessible (calibration or configuration)	One (1) event counter	One (1) event counter for each separately controlled device, or one (1) event counter, if changes are made simultaneously.
Both calibration and configuration parameters accessible	Two (2) event counters	Two (2) event counters for each separately controlled device, or two (2) or more event counters if changes are made to all controlled devices simultaneously.

Category 3 Devices (Devices with Unlimited Remote Configuration Capability):

Category 3 devices have virtually unlimited access to sealable parameters or access is controlled though a password.

- For devices manufactured after January 1, 2001, the device must either: Yes☐ No☐ N/A☐
  - Clearly indicate when it is in the remote configuration mode, or
  - The device shall not operate while in the remote configuration mode
- The device is equipped with an event logger Yes☐ No☐ N/A☐
- The event logger automatically retains the identification of the parameter changed, the date and time of the change, and the new value of the parameter. Yes☐ No☐ N/A☐
- Event counters are nonresettable and have a capacity of at least 000 to 999. Yes☐ No☐ N/A☐
- The system is designed to attach a printer, which can print the contents of the audit trail. Yes☐ No☐ N/A☐
- The audit trail information must be capable of being retained in memory for at least 30 days while the device is without power. Yes☐ No☐ N/A☐
- The event logger must have a capacity to retain records equal to ten times the number of sealable parameters in the device, but not more than 1000 records are required. Yes☐ No☐ N/A☐
- The event logger drops the oldest event when the memory capacity is full and a new entry is saved. Yes☐ No☐ N/A☐
- Describe the method used to seal the device or access the audit trail information.

Code Reference: G-UR.1.1. Suitability of Equipment

A device must be properly designed and have sufficient capacity to be suitable to use in a particular application. A device must measure the appropriate characteristics of a commodity to accurately determine the quantity, have the necessary components (e.g. vapor eliminator) to eliminate factors that may cause measurement errors during normal use, have sufficient capacity to indicate the quantity measured and the associated total price if it is a computing device. The meter must have the proper flow rate capacity to operate over the actual flow rates for the application, and the device must have a quantity division appropriate for the application. Some specific requirements for device characteristics are given in the specific codes for particular devices.

2.25. The equipment is suitable for its intended application. Yes☐ No ☐ N/A ☐

Code Reference: G-UR.1.2. Environment

2.26. Equipment shall be suitable for use in the environment in which it will be used. Suitability with respect to environment includes the effects of wind, weather, temperature variations, and radio frequency interference. A device must work and remain accurate under its actual conditions of use. Yes☐ No ☐ N/A ☐

Code Reference: G-UR.3.3. Position of Equipment

Paragraph G-UR.3.3. requires that the primary indicating element be visible from a reasonable customer position. Many electronic vehicle-mounted metering/controlling systems on which transaction information is displayed are mounted inside the cab of the delivery vehicle. This location is not considered visible from a reasonable customer position. Some systems provide a remote customer display as a standard feature and some do not. The application section of any Certificate of Conformance issued to a vehicle-mounted metering/controlling system must limit the system to installations where a customer indicator is provided and located in a reasonable customer position (e.g., at the meter on the rear of the vehicle).

A. Field Evaluation and Permanence Test for Hydrocarbon Gas Vapor Meters

The following tests are to be run on vapor meter as part of the permanence test:

1. Three tests at the maximum discharge rate.

2. Three slow-flow tests. (Refer to slow-flow tests below)

3. One low-flame test. (Refer to low-flame test below)

Only one meter will be required for the initial test, after which the meter must have air or product passed through it as part of the permanence test. The amount of air or product shall be at least the maximum flow rate times 1000. California weights and measures performs this test in approximately 60 days. Although it is longer than the usual 30-day test, this is considered appropriate because these meters are usually tested only every ten years.

Following the period of use, the tests listed above are to be repeated. All results within the range of flow rates to be included on the certificate of conformance must be within the applicable tolerances. Extended flow range testing performed at the manufacturer's discretion may be included on the certificate of conformance provided the results are within the acceptable tolerances.

B. Test Medium – The device shall be tested with air or the product to be measured.

C. Temperature and Volume Change - Care should be exercised to reduce to a minimum any volume changes. The temperature of the air, bell-prover oil, and the meters under test should be within 1 °C (2 °F) of one another. The devices should remain in the proving room for at least 16 hours before starting any proving operations to allow the device temperature to approximate the temperature of the proving device.

D. Test Drafts - Except for low-flame tests, test drafts shall be at least equal to one complete revolution of the largest capacity proving indicator, and shall in no case be less than 0.05 m^3 or 2 ft^3. All flow rates shall be controlled by suitable outlet orifices.

E. Test Procedures - If a device is equipped with an automatic temperature compensator, the proving device reading shall be corrected to 15 °C (60 °F), using an approved table.

F. Normal Tests - The normal test of a device shall be made at a rate not to exceed the capacity rate given on the badge of the meter.

G. Automatic Temperature Compensation - If a device is equipped with an automatic temperature compensator, the quantity of the test draft indication of the standard shall be corrected to 15°C (60 °F).

H. Repeatability Tests – Tests for repeatability should include a minimum of three consecutive test drafts of approximately the same size and be conducted under controlled conditions where variations in factors, such as temperature pressure, and flow rate are reduced to the extent that they will not affect the results obtained.

I. Special Tests - "Special" tests shall be made to develop the operating characteristics of a device, and any special elements and accessories attached to or associated with the device. Any test except as set forth in N.4.1. shall be considered a special test.

J. Slow Test. - The device shall be tested at a rate not less than 20 percent of the marked capacity rate, or (at the check rate) not less than the minimum flow rate if marked on the device, whichever is less.

K. Low-Flame Test. - The device shall be tested at an extremely low-flow rate as given in HB 44 Sec 3.33.Table 1. The test shall consist of passing air at a pressure of 375 Pa (1.5 in water column) through the meter for not less than 60 minutes. The meter shall continue to advance at the conclusion of the test period.

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Appendix E

Checklist for Testing Electronic Digital Indicators with Simulated Pulses

This checklist is used for Technical Policy **U. Evaluating electronic digital indicators submitted separate from a measuring element.**

Code Reference: G-S.1. Identification

All equipment shall be clearly and permanently marked on an exterior visible surface after installation. It must contain the following information (prefix lettering may be initial capitals, all capitals, or all lower case):

1.1. Name, initials, or trademark of the manufacturer. **Yes ☐ No ☐ N/A ☐**

1.2. A model designation that positively identifies the pattern or design. The Model designation shall be prefaced by the word "Model", "Type", or "Pattern". These terms may be followed by the term "Number" or an abbreviation of that word. The abbreviation for the word "Number" shall, at a minimum, begin with the letter "N" (e.g., No or No.) The abbreviation for the word "Model" shall be "Mod" or "Mod.". **Yes ☐ No ☐ N/A ☐**

1.3. Except for not built-for-purpose, software-based devices, a nonrepetitive serial number. The serial number shall be prefaced by words, an abbreviation, or a symbol, that clearly identifies the number as the required serial number. Abbreviations for the word "Serial" shall, as a minimum, begin with the letter "S," and abbreviations for the word "Number" shall, as a minimum, begin with the letter "N" (e.g., S/N, SN, Ser. No, and S No.). **Yes ☐ No ☐ N/A ☐**

1.4. For not built-for-purpose, software-based devices the current software version or revision designation. The version or revision identifier shall be prefaced by the word "Version" or "Revision" as appropriate and either word may be followed by the word "Number." The abbreviations for the word “Version” shall, as a minimum, begin with the letter "V". The abbreviation for the word “Number” shall, as a minimum, begin with the letter "N" (e.g., No or No.). **Yes ☐ No ☐ N/A ☐**

Code Reference G-S.1. (e).

1.5. The NTEP Certificate of Conformance (CC) Number or a corresponding CC addendum number for devices that have a CC. The number shall be prefaced by the terms "NTEP CC", "CC", or "Approval". These terms may be followed by the word "Number" or an abbreviation for the Word "Number". The abbreviation shall as a minimum begin with the letter "N" (e.g., No or No.). **Yes ☐ No ☐ N/A ☐**

The device must have an area, either on the identification plate or on the device itself, suitable for the application of the Certificate of Conformance Number. If the area for the CC Number is not part of an identification plate, then note its intended location below and how it will be applied.

Location of CC Number if not located with the identification:

_____

_____

Code Reference: G-S.1.1. Location of Marking Information for Not Built-for-Purpose, Software-Based Devices Not Built-for-Purpose Devices, Software-Based

1.6. For not built-for-purpose, software-based devices the following shall apply:

1.6.1. The required information in G-S.1 Identification. (a), (b), (d), and (e) shall be permanently marked or continuously displayed on the device; or

1.6.2. The Certificate of Conformance (CC) Number shall be:

- permanently marked on the device; or
- continuously displayed; or
- accessible through an easily recognized menu and, if necessary, a submenu. Examples of menu and submenu identification include, but are not limited to "Help," "System Identification," "G-S.1. Identification," or "Weights and Measures Identification."

Note: For (1.6.2.), clear instructions for accessing the information required in G-S.1. (a), (b), and (d) shall be listed on the CC, including information necessary to identify that the software in the device is the same type that was evaluated.

1.7. The identification badge must be visible after installation. **Yes ☐ No ☐ N/A ☐**

1.8. The identification badge must be permanent. **Yes ☐ No ☐ N/A ☐**

Code Reference: G-S.2. Facilitation of Fraud

This applies to all metering system indicators installed at a fixed location or vehicle tank meter applications and controlled remotely or within the device itself.
This requirement addresses the process of changing the unit price or unit prices set in a metering system.

1.9. The system shall prevent a change of unit price during a delivery. **Yes ☐ No ☐ N/A ☐**

Code Reference: G-S.3. Permanence

Equipment shall be of such materials, design, and construction that, under normal service conditions:

1.10. Accuracy will be maintained. **Yes ☐ No ☐ N/A ☐**

1.11. Operating parts will continue to function as intended, **Yes ☐ No ☐ N/A ☐**

1.12. Adjustments will remain reasonably permanent. **Yes ☐ No ☐ N/A ☐**

Code Reference: G-S.4. Interchange or Reversal of Parts

If a metering system has parts that may be interchanged or reversed in normal field assembly, the system shall either be constructed so that reversal will not affect the accuracy of the system or the parts must be marked to indicate their proper position. For most metering devices, this applies only to the reversal of connectors of cables to peripheral devices.

If a metering system has any parts that may be interchanged or reversed in normal field assembly, the parts must either be:

1.13. Constructed so that reversal will not affect performance, **Yes ☐ No ☐ N/A ☐**

1.14. Marked or keyed to indicate their proper positions. **Yes ☐ No ☐ N/A ☐**

2. Indications, and Recorded Representations

Code Reference: G-S.5.1. Indicating and Recording Elements

Several general requirements facilitate the reading and interpretation of displayed values. Each display for quantity or total price must be appropriate in design and have sufficient capacity for particular applications to be suitable for the application. Metering devices must be capable of indicating the maximum quantity and money values that can normally be expected in a particular application.

2.1. **Minimum quantity value indications.**

2.1.1. Display is capable of 1.0 **Yes ☐ No ☐ N/A ☐**

2.1.2. Display is capable of 01 **Yes ☐ No ☐ N/A ☐**

2.1.3. Display is capable of 0.01 **Yes ☐ No ☐ N/A ☐**

2.1.4. Display is capable of 0.001 **Yes ☐ No ☐ N/A ☐**

2.1.5. Display is capable of other (fill in blank): **Yes ☐ No ☐ N/A ☐**

2.2. **Money value display**

	2.2.1.	Money value is properly displayed	**Yes ☐ No ☐ N/A ☐**
3.2.	**The indications must be clear, definite, and accurate.**		
	2.2.1.	Values must be clear, definite, and accurate	**Yes ☐ No ☐ N/A ☐**
	2.2.2.	Unit of measure is programmable Gallon, Liter, Pound	**Yes ☐ No ☐ N/A ☐**
	2.2.2.	Unit of measure is applied by permanent marking on indicator housing	**Yes ☐ No ☐ N/A ☐**
2.3.	The indications must be easily read under normal operating conditions.		**Yes ☐ No ☐ N/A ☐**
2.4.	Symbols for decimal points shall clearly identify the decimal position. (Generally acceptable symbols are dots, small commas, or x.)		**Yes ☐ No ☐ N/A ☐**
2.5.	**The zero indication must consist of at least the following minimum indications as appropriate:**		
	2.5.1.	One digit to the left and all digits to the right of a decimal point.	**Yes ☐ No ☐ N/A ☐**
	2.5.2.	If a decimal point is not used, at least one active decade must be displayed.	**Yes ☐ No ☐ N/A ☐**
2.6.	Totalizer values must be accurate to the nearest minimum interval with decimal points displayed or subordinate digits adequately differentiated from others, if applicable.		**Yes ☐ No ☐ N/A ☐**

Code Reference: G-S.5.2.2. Digital Indication and Representation

Basic operating requirements for devices:

2.7.	All digital values of like value in a system shall agree with one another.	**Yes ☐ No ☐ N/A ☐**
2.8.	A digital value coincides with its associated analog value to the nearest minimum graduation.	**Yes ☐ No ☐ N/A ☐**
2.9.	Digital values shall round off to the nearest minimum unit that can be indicated or recorded.	**Yes ☐ No ☐ N/A ☐**
2.10.	When a digital zero display is provided, the zero indication shall consist of at least one digit to the left and all digits to the right of the decimal point.	**Yes ☐ No ☐ N/A ☐**

Agreement of indications shall be checked for several deliveries. The totalizer shall be checked for accuracy and agreement with individual deliveries and with other totalizers in the system.

2.11.	All digital values of like value in a system agree with one another.	**Yes ☐ No ☐ N/A ☐**
2.12.	Digital values coincide with associated analog values to the nearest minimum graduation. We do not request to test a digital indicator with an analog register. This sounds like a field enforcement test?	**Yes ☐ No ☐ N/A ☐**
2.13.	Digital values "round off" to the nearest minimum unit that can be indicated or recorded.	**Yes ☐ No ☐ N/A ☐**
2.14.	The device totalizer shall agree with the total of the individual deliveries and with other totalizers in the system.	**Yes ☐ No ☐ N/A ☐**

Code Reference: G-S.5.2.3. Size and Character

Digits used for comparable values must be uniform in size and character, but subordinate values may be displayed in different and less prominent digits than more significant values. The latter more likely occurs on analog devices. In digital indications, the digits are usually of uniform size throughout a particular display. The size of digits may differ for different quantities, for example, the quantity and unit price digits may be smaller than the total price digits.

2.15.		**Yes ☐ No ☐ N/A ☐**
2.16.	Indications and recorded representations shall be appropriately portrayed or designated.	**Yes ☐ No ☐ N/A ☐**

Code Reference: G-S.5.2.4. Values Defined

2.17. Values shall be adequately defined by a sufficient number of figures, words, symbols, or combinations, which are uniformly placed so that they do not interfere with the accuracy of the reading. **Yes ☐ No ☐ N/A ☐**

Code Reference: G-S.5.2.5. Permanence

2.18. Indications, or recorded representations and their defining figures, words, and symbols shall be of such character that they will not tend to easily become obliterated or illegible. **Yes ☐ No ☐ N/A ☐**

Code Reference: G-S.5.3., G-S.5.3.1. Values of Graduated Intervals or Increments

2.19. Digital indications and recorded representations shall be uniform in size, character, and value throughout any series. Quantity values shall be defined by the specific unit of measure in use. **Yes ☐ No ☐ N/A ☐**

2.20. Indications shall be uniform throughout any series. **Yes ☐ No ☐ N/A ☐**

2.21. Quantity values shall be identified by the unit of measure. **Yes ☐ No ☐ N/A ☐**

Code Reference: G-S.5.4. Repeatability of Indications

The quantity measured by a device shall be repeatable within tolerance for the same indication. One condition that may create a problem is that the value of the quantity division may be large relative to the tolerance. A delivery must be within tolerance wherever the delivery is stopped within the nominal indication of the test draft. Meters that may be at the tolerance limit may be out of tolerance at an extreme limit of the nominal quantity indication.

2.22. When a digital indicator is tested, the delivered quantity shall be within tolerance at any point within the quantity-value division for the test draft. **Yes ☐ No ☐ N/A ☐**

Code Reference: G-S.5.6. Recorded Representations

2.23. All recorded values shall be digital. (See also G-UR.3.3.) **Yes ☐ No ☐ N/A ☐**

Code Reference: G-S.5.7. Magnified ~~Graduations and~~ Indications

2.24. Magnified indications shall conform to all requirements for ~~graduations and~~ indications. **Yes ☐ No ☐ N/A ☐**

Code Reference: G-S.6. Marking, Operational Controls, Indications, and Features

All operational controls, indications, and features shall be clearly and definitely identified. Nonfunctional keys and annunciators shall not be marked because their marking implies that the key or annunciator is functional and should be inspected or tested by the enforcement official. Keys and operator controls that are visible to a customer in a direct sale transaction shall be marked with words or symbols to the extent that they can be understood by the customer and aid in understanding the transaction. Keys that are visible only to the console operator need to be marked only to the extent that a trained operator can understand the function of each key.

2.25. All operational controls, indications, and features including switches, lights, displays, and push buttons shall be clearly and definitely identified. **Yes ☐ No ☐ N/A ☐**

2.26. All dual function (multi-function) keys or controls shall be marked to clearly identify all functions. **Yes ☐ No ☐ N/A ☐**

2.27. Non-functional controls and annunciators shall not be marked. **Yes ☐ No ☐ N/A ☐**

Code Reference: G-S.7. Lettering, Readability

2.28. Required markings and instructions shall be permanent and easily read. **Yes ☐ No ☐ N/A ☐**

Code Reference: G-S.8. Sealing Electronic Adjustable Components, and Provision for Sealing of Adjustable Components or Audit Trial

2.29. Electronic adjustable components that affect the performance of a device shall provide for an approved means of security (e.g. data change audit trail) or for physically applying a security seal. These components include the following: (1) mechanical adjustment mechanism for meters, (2) the electronic calibration factor and automatic temperature compensator for electronic meter registers, (3) selection of pressure for density correction capability and correction values, and (4) pulser setting and gallon/liter conversion switches when they may accidentally or intentionally be used to perpetrate fraud. **Yes □ No □ N/A □**

The following philosophy and list of sealable parameters applies to provision for sealing all liquid-measuring devices.

An electronic data audit trail is a means of allowing a weights and measures inspector to review how many times any electronic adjustment, which affects the accuracy of a volume measurement has been changed. The information contained in the audit trail shall consist of a cumulative and non-destructible number (even if a power failure occurs) which increments each time any of the adjustments required to be sealed have been changed. The electronic data audit trail information shall be capable of being recalled by the official on the main display of the device.

As a minimum, devices which use an audit trail to provide security for sealable parameters shall satisfy the following criteria and shall use the format set forth in Appendix A of the checklist for Liquid-Measuring Devices.

Philosophy for Sealing

Typical Features to be Sealed

Principles for Determining Features to be Sealed

The need to seal some features depends upon:

- The ease with which the feature or the selection of the feature can be used to facilitate fraud; and
- The likelihood that the use of the feature will result in fraud not being detected.

Features or functions which the operator routinely uses as part of device operation, such as setting the unit prices on dispensers and maintaining unit prices in price look-up codes stored in memory, are not sealable parameters and shall not be sealed.

If a parameter (or set of parameters) selection would result in performance that would be obviously in error, such as the selection of parameters for different countries, then it is not necessary to seal the selection of these features.

If individual device characteristics are selectable from a "menu" or a series of programming steps, then access to the "programming mode" must be sealable. (Note: If an audit trail is the only means of security, then the audit trail shall update only after at least one sealable parameter has been changed; simply accessing the sealable parameters via a menu shall not update the audit trail.)

If a physical act, such as cutting a wire is required to change a parameter setting and physically repairing the cut is required to reactivate the parameter, then this physical repair process would be considered an acceptable way to select parameters without requiring a physical seal or an audit trail.

Typical Features and Parameters to be Sealed

The following provides examples of configuration and calibration parameters that are to be sealed. The examples are provided for guidance and are not intended to cover all possible parameters.

Calibration Parameters: Calibration parameters are those parameters whose values are expected to change as a result of accuracy adjustments. Examples include the following.

1. Measuring element adjustments where linearity corrections are used, e.g., flow rate 1 and meter factor 1, flow rate 2 and meter factor 2, etc.
2. Mass flow meter adjustments for zero adjustments (not simply setting the display to zero) and span settings.

Configuration Parameters: Configuration parameters are those parameters whose values are expected to be entered only once and not changed after all initial installation settings are made. Examples include the following.

1. Octane or other blend setting ratios (optional in Canada at this time)
2. Temperature, pressure, density, and other sensor settings for zero, span, and offset values
3. Measurement units (in Canada, only if not displayed or printed on the primary register)
4. Temperature compensation table, liquid coefficient of expansion, or compressibility factors or tables
5. Liquid density setting (in Canada, only if not displayed or printed on the primary register) and allowable liquid density input range
6. Vapor pressures of liquids if used in calculations to establish the quantity
7. Meter or sensor temperature compensation factors
8. False or missing pulse limits for dual pulse systems (Canada only)
9. On/off status of automatic temperature, pressure, or density correction
10. Automatic or manual data input for sensors
11. Dual pulse checking feature status on or off
12. Flow control settings (optional in Canada)
13. Filtering constants

Liquid-Measuring Device Features and Parameters	
Typical Features or Parameters to be Sealed	**Typical Features or Parameters Not Required to be Sealed**
Measuring element adjustment (both mechanical and electronic)	Analog-to-digital converters
Linearity correction values	Quantity division value (display resolution)
Measurement units (e.g., gallons to liters)	Double pulse counting
Octane blend setting for retail motor-fuel dispensers	Communications
Any tables or settings accessed by the software or manually entered to establish the quantity (e.g., specific gravity, pressure, etc.)	
Density ranges	
Pulsers	
Signal pick-up (magnetic or reluctance)	
Temperature probes and temperature offsets in software	
Pressure and density sensors and transducers	
Flow control settings, e.g., flow rates for slow-flow start, quantity for slow-flow start and stop	
Temperature compensating systems (on/off)	
Differential pressure valves	
As a point of clarification, the flow control settings referenced above are those controls typically incorporated into the installations of large-capacity meters (wholesale meters). The reference does not include the point at which retail motor-fuel dispensers slow product flow during a prepaid transaction to enable the dispenser to stop at the preset amount.	

Note: The above examples of adjustments, parameters, and features to be sealed are to be considered "typical" or "normal." This list may not be all inclusive. Some parameters other than those listed, which affect the metrological performance of the device, must be sealed. If listed parameters or other parameters, which may affect the metrological function of the device, are not sealed, the manufacturer must demonstrate that all settings comply with the most stringent requirements for the application of the device (i.e., the parameter does not affect compliance with Handbook 44).

Category 1 Devices (Devices with No Remote Configuration Capability):

- The device is sealed with a physical seal or it has an audit trail with two event counters (one for calibration, the second for configuration). **Yes ☐ No ☐ N/A ☐**
- A physical seal must be applied without exposing electronics. **Yes ☐ No ☐ N/A ☐**
- Event counters are non-resettable and have a capacity of at least 000 to 999. **Yes ☐ No ☐ N/A ☐**
- Event counters increment appropriately. **Yes ☐ No ☐ N/A ☐**

- The audit trail information must be capable of being retained in memory for at least 30 days while the device is without power. **Yes ☐ No ☐ N/A ☐**
- Accessing the audit trail information for review shall be separate from the calibration mode. **Yes ☐ No ☐ N/A ☐**
- Accessing the audit trail information must not affect the normal operation of the device. **Yes ☐ No ☐ N/A ☐**
- Accessing the audit trail information shall not require removal of any additional parts other than normal requirements to inspect the integrity of a physical security seal. (e.g., a key to open a locked panel may be required). **Yes ☐ No ☐ N/A ☐**

Category 2 Devices (Devices with Remote Configuration Capability but Controlled by Hardware):

- The physical hardware enabling access for remote communication must be on-site. **Yes ☐ No ☐ N/A ☐**
- The physical hardware must be sealable with a security seal or **Yes ☐ No ☐ N/A ☐**
- The device must be equipped with at least two event counters: one for calibration, the second for configuration parameters
  - calibration parameters event counter
  - configuration parameters event counter

  Yes ☐ No ☐ N/A ☐
- Adequate provision must be made to apply a physical seal without exposing electronics. **Yes ☐ No ☐ N/A ☐**
- Event counters are non-resettable and have a capacity of at least 000 to 999. **Yes ☐ No ☐ N/A ☐**
- Event counters increment appropriately. **Yes ☐ No ☐ N/A ☐**
- Event counters may be located either:
  - at the individual measuring device or
  - at the system controller

  Yes ☐ No ☐ N/A ☐
- If the counters are located at the system controller rather than at the individual device, means must be provided to generate a hard copy of the information through an on-site device. **Yes ☐ No ☐ N/A ☐**
- An adequate number (see table below) of event counters must be available to monitor the calibration and configuration parameters of each individual device. **Yes ☐ No ☐ N/A ☐**
- The device must either:
  -clearly indicate when it is in the remote configuration mode or
  -the device shall not operate while in the remote configuration mode.

  Yes ☐ No ☐ N/A ☐
- If capable of printing in the calibration mode, it must print a message that it is in the calibration mode. **Yes ☐ No ☐ N/A ☐**
- The audit trail information must be capable of being retained in memory for at least 30 days while the device is without power. **Yes ☐ No ☐ N/A ☐**
- The audit trail information must be readily accessible and easily read. **Yes ☐ No ☐ N/A ☐**

Minimum Number of Counters Required		
	Minimum Counters Required for Devices Equipped with Event Counters	**Minimum Event Counter(s) at System Controller**
Only one type of parameter accessible (calibration or configuration)	One (1) event counter	One (1) event counter for each separately controlled device, or one (1) event counter, if changes are made simultaneously.

Minimum Number of Counters Required		
	Minimum Counters Required for Devices Equipped with Event Counters	**Minimum Event Counter(s) at System Controller**
Both calibration and configuration parameters accessible	Two (2) event counters	Two (2) event counters for each separately controlled device, or two (2) or more event counters if changes are made to all controlled devices simultaneously.

Category 3 Devices (Devices with Unlimited Remote Configuration Capability):

Category 3 devices have virtually unlimited access to sealable parameters or access is controlled though a password.

- For devices manufactured after January 1, 2001, the device must either: **Yes ☐ No ☐ N/A ☐**
  - Clearly indicate when it is in the remote configuration mode, or
  - The device shall not operate while in the remote configuration mode
- The device is equipped with an event logger **Yes ☐ No ☐ N/A ☐**
- The event logger automatically retains the identification of the parameter changed, the date and time of the change, and the new value of the parameter. **Yes ☐ No ☐ N/A ☐**
- Event counters are nonresettable and have a capacity of at least 000 to 999. **Yes ☐ No ☐ N/A ☐**
- The system is designed to attach a printer, which can print the contents of the audit trail. **Yes ☐ No ☐ N/A ☐**
- The audit trail information must be capable of being retained in memory for at least 30 days while the device is without power. **Yes ☐ No ☐ N/A ☐**
- The event logger must have a capacity to retain records equal to ten times the number of sealable parameters in the device, but not more than 1000 records are required. **Yes ☐ No ☐ N/A ☐**
- The event logger drops the oldest event when the memory capacity is full and a new entry is saved. **Yes ☐ No ☐ N/A ☐**
- Describe the method used to seal the device or access the audit trail information.

_____

_____

Code Reference: G-UR.1.1. Suitability of Equipment

A device must be properly designed and have sufficient capacity to be suitable to use in a particular application. A device must measure the appropriate characteristics of a commodity to accurately determine the quantity, have the necessary components (e.g. vapor eliminator) to eliminate factors that may cause measurement errors during normal use, have sufficient capacity to indicate the quantity measured and the associated total price if it is a computing device. The meter must have the proper flow rate capacity to operate over the actual flow rates for the application, and the device must have a quantity division appropriate for the application. Some specific requirements for device characteristics are given in the specific codes for particular devices.

2.24. The equipment is suitable for its intended application. **Yes ☐ No ☐ N/A ☐**

2.25. Equipment shall be suitable for use in the environment in which it will be used. Suitability with respect to environment includes the effects of wind, weather, temperature variations, and radio frequency interference. A device must work and remain accurate under its actual conditions of use. **Yes ☐ No ☐ N/A ☐**

2.26. **Simulator tests: All tests shall have a minimum of 10,000 pulses applied to the device for each test. Test with a minimum of two API/Density settings.**

Product:		**Meter Factor:**	**K Factor:**	
1	Test at a temperature between 55 – 65 degrees F at the manufactures rated maximum frequency/pulse rate.	API Gravity: Temperature:		**Yes ☐ No ☐ N/A ☐**
2	Test at a temperature between 55 – 65 degrees F at manufactures rated minimum frequency/pulse rate.	API Gravity: Temperature:		**Yes ☐ No ☐ N/A ☐**
3	Test at a temperature below 35 degrees F at manufactures rated maximum frequency/pulse rate.	API Gravity: Temperature:		**Yes ☐ No ☐ N/A ☐**
4	Test at a temperature below 35 degrees F at manufactures rated minimum frequency/pulse rate.	API Gravity: Temperature:		**Yes ☐ No ☐ N/A ☐**
5	Test at a temperature above 100 degrees F at manufactures rated maximum frequency/pulse rate.	API Gravity: Temperature:		**Yes ☐ No ☐ N/A ☐**
6	Test at a temperature above 100 degrees F at manufactures rated minimum frequency/pulse rate.	API Gravity: Temperature:		**Yes ☐ No ☐ N/A ☐**
7	Test at a temperature between 55 – 65 degrees F at the manufactures rated maximum frequency/pulse rate.	API Gravity/Density: Temperature:		**Yes ☐ No ☐ N/A ☐**
8	Test at a temperature between 55 – 65 degrees F at manufactures rated minimum frequency/pulse rate.	API Gravity/Density: Temperature:		**Yes ☐ No ☐ N/A ☐**
9	Test at a temperature below 35 degrees F at manufactures rated maximum frequency/pulse rate.	API Gravity/Density: Temperature:		**Yes ☐ No ☐ N/A ☐**
10	Test at a temperature below 35 degrees F at manufactures rated minimum frequency/pulse rate.	API Gravity/Density: Temperature:		**Yes ☐ No ☐ N/A ☐**
11	Test at a temperature above 100 degrees F at manufactures rated maximum frequency/pulse rate.	API Gravity/Density: Temperature:		**Yes ☐ No ☐ N/A ☐**
12	Test at a temperature above 100 degrees F at manufactures rated minimum frequency/pulse rate.	API Gravity/Density: Temperature:		**Yes ☐ No ☐ N/A ☐**
13		API Gravity/Density: Temperature:		**Yes ☐ No ☐ N/A ☐**
14		API Gravity/Density: Temperature:		**Yes ☐ No ☐ N/A ☐**

Appendix F

Proposed Criteria for Electronic Linearization

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August 27, 2009

Mrs. Tina Butcher
NIST, Weights & Measures Div
100 Bureau Drive, MS 2600
Gaithersburg, MD 20899

Subject: Agenda Item

I used the Canadian Document VO-AP-037, Version 00.02 on Linearization Functions Incorporated in Measuring Instruments as the basis for this item. I did not find any copyright so I hope this is legal. If not, please delete.

I added a paragraph to the Scope. This paragraph would bring electronic output PD meters, turbine meters, etc that do not have a shaft output on equal requirements as other meters that currently incorporate electronics in the measuring device.

1.2 Scope

This procedure applies to pulse processing electronic devices incorporating the linearization of the pulse per unit volume versus pulse frequency. This includes all flow computers, electronic registers, correction devices and supporting software external to the measuring device. The tests verify the proper functioning and accuracy of the linearization schemes.

For pulse processing electronic devices incorporating the linearization of the pulse per unit that is within the measuring device, the results of the device accuracy and endurance tests will verify the complete measuring device capabilities. The linearization electronics of the measuring device must be protected from tampering and fraud utilizing a physical seal. No separate tests on parts of the measuring device are required.

2.1 Equipment Requirements

This needs to be reviewed by the electronic group. When we tested our linearization board in Canada, we had problems because their Duel Channel Pulser off position of the pulse did not go close enough to zero volts. We furnished them a duel channel pulser that goes down to within 0.2 volts in the off part of the pulse and then their counters worked fine.

2.5.1 and 2.5.3

The word "devices" should be "EUT"

2.6.2.1 and 2.6.2.3

Do not limit "meter Factors" to 4 or 5 points. See revised 2.6.2.5 as a method to test all points the device is capable of.

2.6.2.5

Delete Runs #2 through #5 and replace with:

2. Select frequencies that results in flow rates that lie between each pair of points programmed in 2.6.2.3. Test at each frequency.

Change Run number 6 to number 3.

One other area that I would support a change is the limit of 3 to 5 factors. The regulation should be written to cover any number of factors.

Maurice Forkert
Compliance and
Design Engineer

Measurement Canada / Mesurer Canada	Approval and Calibration Services Laboratory Technical Manual

APPROVAL PROCEDURE

FOR

LINEARIZATION FUNCTIONS INCORPORATED IN MEASURING INSTRUMENTS

DOCUMENT NUMBER
VO-AP-037

VERSION: 00.02

Filename: VO-AP-037-V00.02 - Linearization functions in Measuring Instruments.wpd

Document Title: LINEARIZATION FUNCTIONS INCORPORATED IN MEASURING INSTRUMENTS Document number: VO-AP-037	Version No.: 00.02	Page 3 of 19

RECORD OF CHANGE

Version	Date	Description
00.01	2005.11.30	Original Release
00.02	2005.12.08	Correct errors, make small improvements to document Add section for Step type linearization scheme.

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1.0 INTRODUCTION

1.1 Purpose

This approval procedure (AP) describes the process to evaluate the linearization functions incorporated in electronic measuring devices in order to determine compliance with applicable requirements, as provided in the *Weights and Measures Act and Regulations.*

1.2 Scope

This procedure applies to pulse processing electronic devices incorporating the linearization of the pulse per unit volume factor versus pulse frequency. This includes all flow computers, electronic registers, correction devices and supporting software external to the device. The tests verify the proper functioning and accuracy of the linearization schemes .

SEE ADDED PARAGRAPH

1.3 Applicable Documents

Document Number	Document Title
	Weights and Measures Act and Regulations Sections SVM-1
GN-LP-003	Vocabulary of Technical and Metrological Terms

1.4 Abbreviations and Symbols

N/A	

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 must be greater than the maximum input frequency of the electronic device under test. Variable output voltage of 5V with a frequency output of ±0.1% or better.
Universal Counter	The maximum frequency must be greater than the maximum rated input frequency of the electronic device under test.
Dual Channel Pulser	Dual channel, variable phase shift (0°, 90°, 120°, 180°), variable output voltage (5V, 12V, 24V)

2.2 Software Requirements

Software Name	Description / Performance Requirements
Microsoft Excel ASL_Linearization.xls	Accepts 4 or 5 values for the meter factor (MF) or the K factor versus flow rates, as provided by the manufacturer. During test runs, the correct factor is calculated by interpolating in between flow rates and used to measure the device's accuracy.

2.3 Environmental Requirements

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

2.4 Safety Requirements

Kindly refer to the applicable Measurement Canada Health and Safety documentation.

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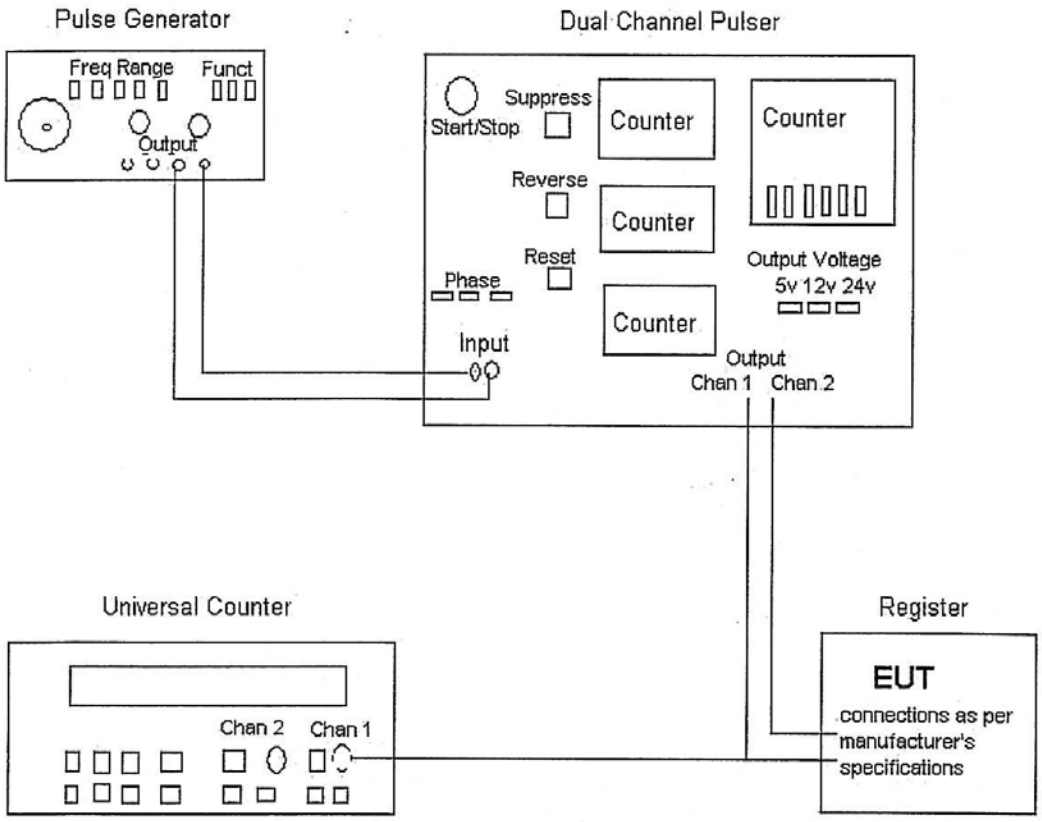
2.5 Set-up

Kindly refer to the block diagram below for details of equipment setup and connections.

Linearization test Set-up



2.5.1 Connect the Output of the Pulse Generator to the Input of the Dual Channel Pulser, making sure to connect the positive terminals together and the negative (ground) terminals together. Select a "square wave" function and a frequency in between the maximum and minimum range of the device. ? EUT

2.5.2 On the Dual Channel Pulser select the appropriate phase shift (90°, 120° or 180°) and voltage output for the device (5V, 12V or 24V). Connect the Output of Channel 1 of the Pulser to both the Input Channel 1 of the Universal Counter and to the Input of the device as specified by the manufacturer. EUT

2.5.3 Connect the Output of Channel 2 of the Dual Channel Pulser to the Input of the device, as specified by the manufacturer. EUT

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2.6 Instructions

2.6.1 Familiarize yourself with the device's measurement adjustment scheme. Applying codes supplied by the manufacturer, program various meter factors or K factors to determine functionality of the adjustment feature. Use Appendix A, section 3.1 to determine the type of linearization applied and to verify that the adjustment complies with established regulations.

2.6.2 Devices using step type linearization scheme

2.6.2.1 In a step type adjustment scheme, a single correction factor is applied over each specific range of flow rates. For this simple and common approach, the correction factors (up to 5) and the corresponding range of flow rates are programmed to the device, as specified by the manufacturer. The calculated corrected meter factor (MF) or corrected K factor remains constant over the specified range of flow rates and only steps to a new value when the flow rate lies within a different range.

2.6.2.2 Determine the minimum and maximum input frequencies, and the maximum flow rate (Q_{max}) for the device under test. These values are required to establish test points across the full operating range of the linearization feature.

2.6.2.3 Confirm the number of meter factors allowed, as specified by the manufacturer (usually 4 or 5). Divide the maximum flow rate by the number of meter factors permitted and program the values below into the device. Take care to program the values in ascending order of flow rates, starting from the minimum value, unless otherwise specified by the manufacturer.

Note: Depending on the design of the device either the error factors, the meter factors or the K factors may be specified and programmed. Select the appropriate column from the tables below to program the device accordingly.

a) If 4 meter factors are permitted:

Test points	(% Qmax) (%)	Error factor (%)	Meter factor	K factor (Pulses/L)
1	25	0.05	0.99950	0.99950 x Base K
2	50	0.24	0.99760	0.99760 x Base K
3	75	0.00	1.00000	1.00000 x Base K
4	100	-0.24	1.00240	1.00240 x Base K

b) If 5 meter factors are permitted:

Test points	(% Qmax) (%)	Error factor (%)	Meter factor	K factor (Pulses/L)
1	20	0.05	0.99950	0.99950 x Base K
2	40	0.24	0.99760	0.99760 x Base K
3	60	0.00	1.00000	1.00000 x Base K

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4	80	-0.24	1.00240	1.00240 x Base K
5	100	0.00	1.00000	1.00000 x Base K

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2.6.2.4 The minimum number of pulses required to achieve an error resolution of 0.01% is 10,000. All test runs performed must include at least this number of pulses.

2.6.2.5 Using the test sheet in Appendix B, perform test runs on the device at the recommended flow rates below, ensuring to input at least the minimum number of pulses at each different rate. Select frequencies that will result in flow rates that fall in between the set points for the meter factors entered in section 2.6.2.3. As a minimum, run tests as follows:

Run	Comments
1	Select a frequency that results in a flow rate below the first point programmed in 2.6.2.3
2	Select a frequency that results in a flow rate that lies between the first and second points programmed in 2.6.2.3
3	Select a frequency that results in a flow rate that lies between the second and third points programmed in 2.6.2.3
4	Select a frequency that results in a flow rate that lies between the third and forth points programmed in 2.6.2.3 (if a minimum of 4 factors are used)
5	Select a frequency that results in a flow rate that lies between the forth and fifth points programmed in 2.6.2.3 (if a minimum of 5 factors are used)
6	Select a frequency that results in a flow rate that lies above the last point programmed in 2.6.2.3

2.6.3 Devices using linear interpolation linearization scheme

2.6.3.1 In this scheme, referred to as "linear interpolation" (sometimes also referred to as "point-to-point linearization"), separate and discreet straight lines of the form $Y = mX + b$ are drawn between adjacent predetermined calibration values. The"Y" values (either corrected meter factors (MF) or corrected K factors) are calculated relative to the pulse frequency rate "X". These values are used to correct the raw meter pulse signal and provide an estimate of the true value of flow.

2.6.3.2 Same as 2.6.2.2.

2.6.3.3 Same as 2.6.2.3.

2.6.3.4 Same as 2.6.2.4

2.6.3.5 Same as 2.6.2.5

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2.6.4 Devices using curve fitting of the form $Y = a + b(1/X) + cX + d(X^2) + e(X^3)$

2.6.4.1 The third method employs the reduction of calibration data, (meter factor or K factor "Y" vs flow rate "X"), using a preselected modelling equation. One model commonly chosen is a 4th order equation in the form of $Y = a + b(1/X) + c(X) + d(X^2) + e(X^3)$. The data manipulation is usually performed using software external to the flow computer or correction device, and results in a series of coefficients (a, b, c, d, e, etc.) and an estimate of the uncertainty of the curve fit. The equation coefficients are then programmed into the correction device or flow computer. The calculated corrections are then used by the flow computer or correction device to correct the "raw meter pulse signal" and provide an estimate of the true value of flow.

2.6.4.2 Assuming that the model is a 4th order equation, program the following coefficients into the correction device for evaluation purposes:

Coefficient	Value
a	6.5072493
b	-62.267514
c	-0.13650801
d	0.00085092719
e	-5.105311×10^{-7}

2.6.4.3 Using the test sheet in Appendix B, perform test runs on the device at the recommended flow rates below, ensuring to input at least the minimum number of pulses at each different rate. Select frequencies that will result in flow rates that span the full range of the device's capabilities.. As a minimum, run tests as follows:

Run	% Q_{max}	Comments
1	10	Select a frequency that results in a flow rate that lies between 0% and 20% of the maximum.
2	30	Select a frequency that results in a flow rate that lies between 20% and 40%. maximum.
3	50	Select a frequency that results in a flow rate that lies between 40% and 60% maximum.
4	70	Select a frequency that results in a flow rate that lies between 60% and 80% maximum.
5	90	Select a frequency that results in a flow rate that lies between 80% and 100% maximum.
6	110	Select a frequency that results in a flow rate that lies above 100% of the specified maximum.

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2.7 Calculations

2.7.1 Calculations of K factor or Meter Factor (MF) for a step type linearization method

2.7.1.1 To calculate the K factor or MF during test runs, record the flow rate. From the step graph of the K factor (Y) versus flow rate (X) programmed to the device, move along the X axis to the recorded flow rate. Read the corresponding K factor (Y value)

2.7.1.2 Sample calculation for step type linearization method

Assume that a device can accept 4 K factors that are programmed as per the table presented in section 2.6.2.3(a). Then for any flow rates in between 25% Q_{max} and 50% Q_{max} the K factor is 0.99950 x Base K factor. Also for any flow rates above 100% Qmax the K factor is 1.00240 x Base K factor.

2.7.2 Calculations of K factor or Meter Factor (MF) for the linear interpolation linearization method

2.7.2.1 With this type of linearization scheme, the error factors are calculated by interpolating in between two set data points. To calculate the K factor or MF during test runs, record the flow rate. From the linear graph of the K factor (Y) versus flow rate (X) programmed to the device, move along the X axis to the recorded flow rate. Read the corresponding K factor (Y value), which can be calculated as follows:

$$Y = Y_1 + \frac{(X - X_1)}{(X_2 - X_1)} \times (Y_2 - Y_1)$$

where Y_2 = K factor of next highest set point
X_2 = Flow rate of next highest set point
Y_1 = K factor of next lowest set point
X_1 = Flow rate of next lowest set point
Y = K factor to be calculated
X = Flow rate of current test

2.7.2.2 Sample calculation for linear interpolation type linearization method

Assume that a device can accept 5 MFs that are programmed as per the table presented in section 2.6.2.3(b). Then for a flow rate of 30% Q_{max} the MF is 0.99855, calculated as follows:

$$Y = 0.9995 + \frac{(30 - 20)}{(40 - 20)} \times (0.9976 - 0.9995) = 0.99855$$

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2.7.3 Calculations of K factor or Meter Factor (MF) for the curve fitting linearization method

2.7.3.1 With the curve fitting scheme, the error factors are calculated using coefficients for a polynomial specified by the manufacturer, usually of the form of $Y = a + b(1/X) + c(X) + d(X^2) + e(X^3)$. To calculate the K factor or MF during test runs, record the flow rate. From the polynomial graph of the K factor (Y) versus flow rate (X) programmed to the device, move along the X axis to the recorded flow rate. Read the corresponding K factor (Y value), which can also be calculated by substituting the flow rate (X value) into the specified curve.

2.7.3.2 Sample calculation for curve fitting type linearization method

If the coefficients in section 2.6.4.2 above are programmed into the device, then the expected theoretical values for the correction factor and the volume at the flow rates below are:

Test points	Flow rate (L/min)	Expected Meter factor	Expected K factor (Pulses/L)	Expected Volume (L)
1	20	1.00000	1.00000 x Base K	Pulse count ÷ (1.00000 x Base K)
2	50	0.50000	0.50000 x Base K	Pulse count ÷ (0.50000 x Base K)
3	90	0.05000	0.05000 x Base K	Pulse count ÷ (0.05000 x Base K)
4	130	1.54126	1.54126 x Base K	Pulse count ÷ (1.54126 x Base K)
5	180	6.18250	6.18250 x Base K	Pulse count ÷ (6.18250 x Base K)
6	110	13.64210	13.6421 x Base K	Pulse count ÷ (13.6421 x Base K)

Note: For other flow rates calculate the expected correction factor using the recommended coefficients in section 2.6.4.2.

2.7.4 Linearization Error Calculations

2.7.4.1 Regardless of the correction scheme used to determine a true volume, the linearization error is a function of the volume indicated by the device ($V_{indicated}$) and the expected theoretical volume ($V_{expected}$) calculated as follows.

$$\text{Linearization Error (\%)} = \frac{V_{indicated} - V_{expected}}{V_{expected}} \times 100$$

where

$$V_{expected} = \frac{\text{Pulse count}}{\text{Calculated Linearizing K factor}}$$ if the K factor is programmed

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or

$$V_{expected} = \frac{\text{Pulse count x Calculated Linearizing Mf}}{\text{Base K factor}}$$ if Meter Factor is programmed

2.8 Pass/Fail Criteria

Description	Criteria	Reference	Pass–Fail
General Requirements	Kindly refer to Appendix 3.1 "General Requirements Checklist - Linearization function".	SVM-1	
Linearization Error	Must not exceed ±0.02%	???	

Note: The Linearization spreadsheet **ASL_Linearization.xls** is available to help interpolate meter factors and calculate the percentage errors automatically. Kindly use the spreadsheet in conjunction with the test sheet presented in Appendix B to assist you in the evaluation.

3.0 APPENDICES, WORK SHEETS AND TABLES

3.1 Appendix A: General Requirements Checklist - Linearization function

			Comments
1)	Linearization function characteristics: a) Type of function: G Step G Linear G Function Desc:_____ G Other Decs:_____ b) Number of programmable points:____ Resolution:_____ c) Adjustment variable: G K factor or G Meter factor d) Sampling frequency:_____		
2)	Is the means of adjustment used for processing pulses in order to vary measurement results sealable and located so as to be inaccessible without the removal of a portion of the exterior housing? SVM1-8	G N/A G NC G C	
3)	If the means of adjustment is accessible without the removal of the exterior housing, then:		
	a) Is the adjustment range less than ± 2% of the volume of liquid delivered? SVM1-9(a)	G N/A G NC G C	
	b) Is the adjustment range sealable? SVM1-9(b)	G N/A G NC G C	
	c) Is the means of adjustment adjustable while the device is operating? SVM1-9(c)	G N/A G NC G C	

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General Requirements Checklist - Linearization function (continued)

			Comments
4)	If the means of adjustment automatically selects a predetermined correction factor that corresponds to the flow rate in order to linearize the meter accuracy curve, then:		
a)	Is the adjustment range less than ± 0.25% between adjacent factors? SVM1-10(a)	G N/A G NC G C	
b)	Are the correction factors readily verifiable either by means of display or printing of the factors, or by other means? SVM1-10(b)	G N/A G NC G C	

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3.2 Appendix B

Linearization function test sheet

	A	B	C	D	E	F	G
Run	Pulses	Frequency (Pulses/Sec)	Expected Flow rate [(60 * B) / D] (L/min)	Expected K Factor [Interpolated] (Pulses/L)	Expected Volume [A / D] (L)	Indicated Volume [Device] (L)	% Error [((F-E) / E) * 100)] (%)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

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Appendix G

National Conference on Weights and Measures / National Type Evaluation Program

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