POLICY			
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1. Scope

Description of requirements and procedures for master meters to be used as verification standards.

2. Reference documents

Trade Metrology Act
SANS1698

3. Policy

3.1 Calibration/validation of master meters

General accuracy requirements for master meters and auxiliary equipment are given in clauses 3.5 and 3.7 of SANS 1698 as applicable

3.2 Using verification standard measures

3.2.1 Value of test measure graduations: Clause 3.1.8.3 of SANS 1698 dealing with the value of graduations on the test measure means that the value of graduations may not be larger than 10% of the tolerance on the trade use meter to be verified with the master meter.

Therefore: If the measure used to calibrate the master meter has a volume of 2 000 L and the tolerance on a trade use meter is 0,25% then the value of the graduation shall be at least 0,5 L.

0,25% of 2 000 L = 5 L
10% of 5 L = 0,5 L

3.2.2 Test measure volume: Clause 4.2.3.2 of SANS 1698 requires that the test measure shall have a capacity equal to at least the volume delivered in one minute at the highest flow rate that the master meter will be used to verify a trade use meter. This means that the test measure volume restricts the use of the master meter to verifying meters with a marked maximum flow rate per minute not greater than the test measure volume i.e. if the master meter is not calibrated with a volume equal to one minute at the maximum flow rate of the master meter, then it is restricted to verifying meters with a flow rate per minute equal to the test measure volume.

3.3 Using verification standard massmeters

When using a massmeter to calibrate/validate a master meter the applicable requirements of clause 4.2 of SANS 1698 apply.

3.4 Design requirements for master meters and auxiliary equipment

3.4.1 Master meters and instruments used for auxiliary measurements shall comply with the requirements of clauses 3.5 and 3.7 of SANS 1698.

3.4.2 Resolution of indication: Clause 3.5.1 of SANS 1698 dealing with resolution of indication requires the accuracy of reading to be at least 10% of permissible error on the meter being verified. This in effect dictates the test volume, which must be increased above one minutes' flow, at marked maximum flow rate per minute, if necessary to comply.

Example: If a master meter has a digital resolution of 1 L then 1 L must equal 0,025% of the throughput volume for the verification test. This will be 4 000 L at all flow rates with an error

allowance of 0,25%. For analogue registers interpolation to the nearest half scale interval is allowed so the throughput volume could be reduced to 2 000 L in the above example.

Certain mechanical master meters such as the Avery Hardoll have a special vernier scale for more accurate reading and this may be used if tested during the calibration of the master meter.

Irrespective of the resolution of the indicator on a master meter, all test volumes may not be less than volume delivered in one minute at the marked maximum flow rate of the meter being verified.

3.4.3 Affects of pressure and temperature on the accuracy of master meters: Clause 3.5.5 of SANS 1698 is applicable and proof must be supplied that the accuracy of measurement of the meter (i.e. increase/decrease in cyclic volume or hydraulic slippage) is not affected by more than 0,025% by variations in pressure and temperature within the stated working ranges of the meter, or corrections shall be made. Proof could be in the form of authentic test results published by the manufacturer or other documentation acceptable to the Director. If corrections for temperature or pressure must be made, proof of the accuracy (validation) of these corrections must also be supplied. Correction factors must be related to a standard reference temperature or pressure, as applicable, for which the meter is designed.

Verification test procedures shall state that the master meter may not be used outside its rated (marked) operating ranges for temperature and pressure. Thermometers and pressure gauges used to make corrections or ensure that the master meter remains within rated operating conditions shall comply with clause 3.7 of SANS 1698 and be fitted in the master meter pipe layout in close proximity to the meter.

3.4.4 Prevention of gas intake: To ensure that no gas is present in the system at least a sight glass shall be fitted in the pipe work downstream of the master meter. Pipe work before and after the meter shall be designed in such a way as to prevent air pockets from being trapped (e.g. unnecessary high points). During calibration of the master meter the supply line must contain a suitable gas eliminator or an automatic means to ensure that no gas is present in the test liquid supply.

3.4.5 Prevention of effect of flow disturbances: The inlet and outlet piping of the master meter test rig shall be of such design that any disturbance does not affect the accuracy of the master meter. It may be necessary to include a length of straight pipe before the meter to correct any flow profile disturbance caused by bends and swivel joints in the loading arm or other coupling of the meter under test.

3.4.6 Control of flow: There shall be a dedicated quick action valve, fitted in the master meter system downstream of the master meter, for starting and ending the flow and controlling flow rates. In cases where a master meter is fitted upstream of the meter being verified this valve shall be downstream of both meters. A staged shut off valve on the meter being verified is not acceptable and should be left fully open during calibration.

Strainer: A suitable strainer shall be fitted upstream of the master meter in such a manner that it does not affect the accuracy of the master meter. If a strainer is not fitted in the master meter inlet piping a strainer in the calibration liquid supply line or system being verified may be relied onto protect the master meter but in this case calibration procedures for the master meter and verification procedures for meters being verified shall require that such strainer must physically be examined before the respective testing to ensure that it is present, complete and suitable for protecting the master meter.

3.4.7 Markings: Besides for the flow rate range the rated temperature and pressure ranges must be marked on the meter. Any other markings decided on during the evaluation will be communicated to the submitter.

3.5 Calibration frequencies for master meters

Master meters shall be calibrated at frequencies that will ensure accuracy at all times of use (see SANS 1698 clauses 6.2 and 6.2.3.2). When first taken into service they shall be calibrated before each use to build up a calibration history (i.e. the ability to maintain accuracy and repeatability over a period of time) in order to determine a suitable calibration frequency. The period between calibrations may be increased up to a maximum period of twelve months, according to evidence of the ability of the master meter to maintain its accuracy over a period of use and subject to written acceptance by the Director. In cases of extended calibration periods the master meter shall be calibrated, as far as possible, at all the flow rates for which it is intended to be used. If at any time during in service checks or from discrepancies noted, the master meter is found to exceed permissible error limits the affect on previous verifications shall be ascertained and any necessary corrective actions taken.

B. APPROVAL REQUIREMENTS FOR MASTER METERS

Master meters do not require formal approval in terms of the Trade Metrology Act but must be evaluated against these requirements and SANS 1698 to ensure accuracy (see SANS 1698 clause 3.5.7).

The quality system calibration procedure and the procedure for use of the master meter as a verification standard (verification procedure), shall be submitted to the Director for evaluation and formal approval.

Evaluation will be done by calibrating the master meter using a verification standard (measure or massmeter) at minimum of two different facilities using different pipe layouts to determine any affect of differing flow profiles (e.g. bottom loading facility with loading arm and top loading facility with a drop/still pipe). Before submission the submitter shall conduct a full calibration according to his procedure and submit final test results. The evaluation of the verification procedure will be conducted on an actual trade use meter.

C. CALIBRATION OF MASTER METERS

3.6 Standards for calibrating master meters

These shall be calibrated according to the requirements of clauses 4.1.1 to 4.1.4 or 4.31 to 4.2.3.4 (as applicable), 6.1 to 6.1.3 (as applicable), 6.2 to 6.2.5 (as applicable) and 6.3 of SANS 1698. Maximum permissible errors for test measures are given in clause 3.3.5, for massmeters in clause 3.6 (as applicable) and for instruments for auxiliary measurements in clause 3.7 of SANS 1698.

3.7 Master Meters

The following are requirements that must be addressed in the documented test procedure or other relevant quality system documentation as applicable.

3.7.1 Competence of calibration officer: The calibration shall be done by a competent person. The competency of this person shall be addressed in the accredited laboratory's quality system and he or she shall be delegated the duty (see clause 6.1.2 of SANS 1698). After calibration the master meter shall be sealed with a dedicated seal design or number not used by verification officers for normal verification purposes (see clause 6.3 of SANS 1698).

3.7.2 Requirements to be addressed in test procedures

3.7.3 Calibration flow rates: If the master meter is not calibrated at the specific flow rates for which it will be used (i.e. master meter calibrated immediately before verifying a specific meter) then at least 6 flow rates shall be tested. These flow rates shall include 10% and 100% of the maximum flow rate of the master meter with the other four, or more, being evenly spread between. If during calibration it is not possible to attain the maximum flow rate of the master meter the use of the master for verification purposes will be restricted to a flow rate of 10% higher than that calibrated. A notice warning of this restriction shall be included on the calibration certificate and brought to the attention of verification officers.

3.7.4 Maximum permissible errors: Clause 3.5.2 requires that results of calibration tests, done at the same flow rate (repeatability), shall not vary by more than 10% of the tolerance on the instrument being verified. Clause 3.5.3 of SANS 1698 indicates that if errors at the various flow rates tested (linearity) are within 10% of the smallest error allowed on the trade meter to be verified then these errors need not be taken into account when verifying a trade use instrument. Clause 3.5.8 requires that if errors on the master meter exceed 10% of the tolerance allowed on the instrument being verified, at the flow rate being tested, they shall be taken into account when verifying a trade use instrument. All errors determined during calibration shall be recorded and retained for record purposes.

3.7.5 Control of flow during calibration: Flow shall be started and ended and the rate controlled by using a quick action valve positioned downstream of the master meter. This control valve should be situated as close as possible to the calibration standard to ensure the connecting pipe is kept full when the measure/receptacle is drained. Flow shall be started and stopped as quickly as practically possible but smoothly to prevent line shock or excessive expansion in any flexible hoses.

3.7.6 Product and supply: Calibration shall be undertaken with each of the products for which the master meter will be used. To prevent any possibility of gas in the system during calibration the supply line shall be fitted with a suitable gas eliminator or automatic gas prevention system. The gas eliminator or other system shall be visually inspected before calibration commences to check for possibility of malfunction. During the calibration run the sight glass at the master meter shall be observed for any signs of gas in the product.

3.7.7 Rated operating conditions: During calibration tests the master meter temperature and pressure must be monitored to see that it is operating within its marked operating conditions irrespective of whether or not the average pressure or temperature will be used in the calculation of error.

3.7.8 Determination of errors: Applicable minimum requirements for calibration tests are given in clause 4.2 of SANS 1698 and these shall be addressed in quality system procedures or an indication given as to why they are not applicable. The affect on the meter (body or operation) by temperature or pressure variations from the rated operating conditions (see 2.3 of the basic requirements in A above) shall also be considered.

In the case of electronic master meters, after entering all the meter factors (k factors) a further two tests at each flow rate shall be conducted as per SANS 1698 clause 4.2.1.1 and 4.2.1.2 to determine the final errors on the master meter before sealing.

D. PROCEDURES FOR USE OF MASTER METERS WHEN VERIFYING TRADE USE METERS

The normal tests for trade use meters shall be carried out and covered by the verification test procedures. The following requirements shall also be addressed in the verification test procedure.

1. When connecting the master meter to the meter being verified, precaution shall be taken to ensure that bends in pipe work or loading arm and any flow rate controller, including an orifice plate fitted after the meter being verified, is sufficiently far upstream of the master meter so that any flow profile disturbance does not affect the accuracy of the master meter.

2. Any hose between the meter being verified and the master meter shall be non-expandable (e.g. dry hose when in normal use). If not, replace with rigid pipe or non-expandable pipe with suitable couplings. A vacuum breaker shall be effectively sealed or removed to prevent air entering the piping between the two meters.

3. Ensure that any pressure loss over the master meter does not reduce the flow rate of the system being verified.

4. Ensure that the product return line after the master meter does not cause excessive pressures that will increase the normal operating pressure in the meter being verified or master meter or cause a reduced maximum flow rate. It will be preferable to discharge measured product into an intermediate tank rather than a bulk storage tank.

5. All valves between the meter being verified and the master meter shall remain fully open during the test. If applicable, test the action of automatic shut off mechanisms prior to the accuracy tests and then programme them with a volume greater than the test volume so that they remain fully open during accuracy tests.

6. Flow shall be started and ended and the flow rate controlled by using the dedicated quick action valve positioned downstream of the master meter. If the master meter is fitted upstream of the meter being verified then the control valve shall be downstream of the meter being verified. Do not use a staged shut of valve to end a delivery as the slow speed could affect the accuracy of results. Manipulation of pump pressure shall not be used to control the rate of flow unless the design of a meter system being verified requires this to be done.

7. During a test, flow shall be started and ended as quickly as practically possible but smoothly to prevent line shock or expansion of any flexible hoses. This action should be as consistent as possible between tests to ensure consistent conditions. When shutting down do not attempt to reach a whole number on an analogue indicator by bleeding the system as the slow flow may cause inaccuracies in the master meter and meter being verified.

8. Before testing commences visually inspect:

a) The required gas eliminator or gas prevention system on the meter system being verified. Ensure that it is complete, appears serviceable and that gas release valves are adequately vented. If there is any suspicion that the gas eliminator or gas prevention system is unserviceable, abort the verification.
b) In cases where the master meter is not protected by its own system strainer, open the strainer housing of the system being verified and ensure that it is complete and suitable for protecting the master meter. If there is any suspicion that the strainer is unserviceable or unsuitable, abort the verification.

9. A master meter shall not be used to verify meters on bulk delivery vehicles or portable tanks where a drain test of the gas eliminator or gas prevention system is required.

10. Before starting a verification test run pass a sufficient volume of product through the system and master meter to equalise pressures and temperature in the piping.

11. During a test run monitor the temperature and pressure at the master meter to ensure that the rated operating conditions are not exceeded. If the meter being verified is situated some distance from the master meter and there is a possibility that temperature of the product may differ between the meters then the affect on the volume of the product will need to be determined to comply with clause 3.5.6 of SANS 1698. It will also be necessary to determine the average temperature of the test run where a meter fitted with a temperature compensator is being verified. If the pressure in the master meter during the test is substantially different from the pressure during calibration it may be necessary to correct the reading for the compressibility of the liquid being measured if compressibility will affect on the volume of the product by more than 10 % of the smallest maximum permissible error of the meter being verified.

12. During each verification test run, monitor the sight glass at the master meter to ensure that there is no gas present in the product.

13. If the trade use meter being verified is fitted with a temperature compensator the indication on the master meter shall be converted to volume at 20 ºC using the normal test sheets and compared to the indication on the meter being verified. Under no circumstances shall a temperature compensator fitted to the master meter be used to determine the actual volume at 20 ºC. Before testing commences ensure that the correct density of the product at 20 ºC is entered in the meter being verified.

    Normal tests approved in the quality system procedure for verification by means of an open measure shall also be carried out on the temperature compensator (e.g. ice test).

    In cases where a meter with electronic calculator, indicator and conversion device also has a gross (uncompensated) indication, it will be acceptable to carry out the accuracy tests with the gross values and then verify the accuracy of temperature conversion to 20 ºC as a separate test. This will mean that the accuracy of conversion at all test temperatures (each flow rate) will not be verified during accuracy tests and the temperature sensor will need separate verification. Before testing commences ensure that the correct density of the product at 20 ºC is entered in the meter being verified.

    An acceptable method for verification of the temperature conversion function on electronic meter registers is as follows:

    a) Compulsory at all verifications:
    Remove the meter temperature sensor and verify it against a calibrated standard thermometer, with a resolution of not greater than 0,2 ºC, at a low temperature of below 5 ºC, at ambient water temperature and at a high temperature of above 40 ºC. Taking the error on the standard thermometer into consideration verify that any error on the meter temperature indication does not exceed 0,5 ºC.
    NOTE: Sufficient time must be allowed for the electronic temperature sensor to stabilise at the test temperature.

    b) For initial verification and when software is changed after initial verification, to ensure that correct conversion tables are entered:
    When the temperature sensor and standard thermometer are stabilised at the low temperature in a) reset the meter to zero and deliver at least 500 L of product. Using the temperature indicated by the standard thermometer and the applicable correction factor from IP Petroleum

Measurement Table B, convert the gross volume indicated by the meter to volume at 20 ºC. Verify that the calculated volume does not differ from the indicated net volume by more than 0,25%. A suitable test sheet is attached as annex A.
NOTE: Ensure that the density of the product at 20 ºC is correctly set on the meter.

14. The throughput volume during verification tests shall be at least the volume that will be delivered in one minute at the maximum flow rate marked on the meter being verified. This will need to be increased if the resolution of the indicator on the master meter is larger than 10% of the tolerance that is permitted on the meter being verified (see SANS 1698 clause 3.5.1). Example if the master meter with a digital indication has a resolution of 1 L and it is used to verify a meter having a maximum flow rate of 1 000 L/min than the throughput would normally be 1000 L and the tolerance on this volume will be 2,5 L. However, this means that the 1L resolution on the master meter is 40% of the tolerance and the test volume will need to be increased to 4 000 L for the 1 L resolution to equal 10%. In the case of a master meter with an analogue indication interpolation of 0,5 of a scale value is acceptable and in this case the test volume would need to be increased to 2 000 L.