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**National
Measurement
Institute**

NITP 17.1

National Instrument Test Procedures for Density Hydrometers

Part 1: Brix Hydrometers for Cane Juice

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NITP 17.1

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Amendments

Item no.	Date	Page	Location	Details of change
1	February 2016	ii	Publication History	Minor editorial correction to remove words "final draft".

Preface

NMI's Chief Metrologist has determined that NITP 17.1 contains the test procedures for the verification of density hydrometers. Part 1 specifically addresses Brix hydrometers used to estimate sucrose concentration in a test sample on the basis of its density.

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Explanation of Terms

For explanations of terms see [General Information for Test Procedures](#). For other terms relating to hydrometers, refer to NMI [General Certificate of Approval \(CoA\) NMI 17/1/0](#).

Correction

Compensation for an estimated systematic effect, e.g. the temperature of a sample affects its density and therefore the observed brix value.

Observed brix reading; observed brix

The value read from a brix hydrometer at the recorded ambient temperature.

Observed temperature

The value read from a liquid-in-glass thermometer or the value indicated by a digital device.

Temperature; scaled-corrected temperature

The true temperature, i.e. the observed temperature with the appropriate scale correction applied.

Temperature-corrected brix

The observed brix reading corrected to 20.0 °C.

True brix; scale and temperature-corrected brix

The temperature-corrected brix value with the appropriate scale correction applied.

Abbreviations

BSES Bureau of Sugar Experimental Stations

CoA Certificate of Approval

°Bx Degrees Brix

MPE Maximum Permissible Error

MC Meniscus correction

NATA National Association of Testing Authorities

1. Scope

NITP 17.1 describes the test procedures for the verification and in-service inspection of density hydrometers to assess that they measure within the maximum permissible errors (MPEs) and that they comply with the [General Certificate of Approval \(CoA\) NMI 17/1/0](#).

The MPE for measurements using a Brix hydrometer is stated in Variant 1 of CoA NMI 17/1/0. The tests in NITP 17.1 Part 1 are specific to Brix hydrometers that are used to estimate the sucrose concentration in a test sample on the basis of its density.

The safety and environmental hazards associated with carrying out the test procedure will depend on the location and selected materials. As the precautionary measures included in this document may not be sufficient for every situation, it is expected that an on-site risk assessment and control plan will be carried out before commencing work.

All instruments must also comply with the *National Measurement Act 1960* (Cth), the *National Measurement Regulations 1999* (Cth) and the *National Trade Measurement Regulations 2009* (Cth).

2. Equipment

Refer to Appendix B for additional guidance on selected equipment.

1. Test Report (see Appendix A for example).
2. General CoA NMI 17/1/0
3. For each hydrometer submitted for verification using method 1:
A NATA-endorsed calibration report from a [NMI-appointed Verifying Authority](#) indicating the corrections for at least three points over the hydrometer scale.

The following items apply to *method 2* and *method 3* only:

4. Reference standard hydrometer that meets the following requirements:
 - (a) Valid Regulation 13 (Reg 13) certificate from a NMI-appointed Verifying Authority.
 - (b) Not used in routine measurements.
 - (c) Same scale range as the hydrometer under test.
 - (d) Same or smaller scale graduation interval as the hydrometer under test.
 - (e) Calibration report with scale corrections for at least six points.
For reference Brix hydrometers, 0.02 °Bx is the maximum measurement uncertainty.
 - (f) Stored in protective environments to prevent noticeable damage (e.g. scratches, etching, scale slippage, deposits on the glass and discolouration) that will require re-calibration of the reference hydrometer.
5. Thermometer that meets the following requirements:
 - (a) Scale range suitable for measuring the ambient and test liquid temperature.
 - (b) Valid Reg 13 certificate or a NATA calibration report (uncertainty ≤ 0.2 °C).
Refer to clause B.1 regarding instances where the reported thermometer scales corrections are taken as negligible.
 - (c) Scale interval for liquid-in-glass or digital device ≤ 0.1 °C.
6. Comparator jar that meets the following requirements:
 - (a) Any markings on the jar shall not interfere with obtaining accurate readings.

- (b) Sufficient depth so that the hydrometers can float freely at least 25 mm above the bottom.
- (c) The other dimensions shall be large enough to contain at least two hydrometers while maintaining at least 12.5 mm between the inner wall of the jar and any immersed hydrometer, and at least 12.5 mm between hydrometers.

Note: The in-house procedure shall state the maximum number of hydrometers of a particular size that can fit in the comparator jar.

7. Equipment for preparing test liquids of varying concentrations and densities: laboratory balance, volumetric flasks, graduated cylinders, pipettes.
8. Appropriate test liquids that are clear, colourless and have high surface tension (75 mN/m), which is similar to the value at which the reference hydrometer is calibrated. The brix values shall correspond with the test points on the submitted hydrometer.
 - For *method 2*: Aqueous sucrose solutions
 - For *method 3*: Aqueous solutions based on another substance described in Table 1. Refer to clause 4.3 for restrictions on the use of these substances.
9. Stirrer, i.e. an annular ring of glass or metal with a handle of sufficient length so that it can be conveniently moved up and down when stirring the liquid.
10. Background screen which is a screen slightly wider than the width of the comparator jar (black upper half and white lower half) and can assist in keeping the correct line of sight.
11. Cleaning equipment, i.e. soapy water, absolute alcohol (99%), lint-free cloth or tissue paper.

Table 1. Maximum brix level attainable with test liquids at 20 °C

Aqueous solution	Solute conc. (wt %)	Density (kg/m ³)	Approx brix (°Bx)
No solute (pure distilled water)	0	998.203	0
Sucrose (e.g. pure or refined sugar)	67*	1328.81	67
Sodium chloride, NaCl (e.g. pickling salt – min I, K, Ca)	26*	1197.2	43.9
Potassium iodide, KI (solid from lab supplier)	40	1395.9	77.5
Potassium iodide, KI (solid from lab supplier)	59*	~1720	>90 (off scale)
Sulfuric acid, H ₂ SO ₄ (conc. solution from lab supplier)	54	1435.0	83.4

* Approaching maximum solubility in aqueous solution.

3. Visual Inspection

Visually inspect the hydrometer for required data and characteristics. Record details on a test report.

3.1 Required Data

1. Test report reference number.
2. Date of test.
3. Type of test: verification or in-service inspection (for in-service inspection or reverification ensure that the verification mark is in place).
4. Verifier's name.
5. Name of owner/user.
6. Address of owner/user.

7. Name of contact person on premises.
8. Address of instrument location.
9. Description of instrument.
10. Manufacturer.
11. Model.
12. Serial number.
13. Scale range
14. Smallest scale graduation.

3.2 Characteristics of the Instrument

Where applicable the hydrometer and its use shall comply with the following clauses:

1. The instrument shall comply with the [General CoA NMI 17/1/0](#) Variant 1.

Note: Dimensions for metric hydrometers are specified in AS 2026:2003 clause 9.

Brix hydrometers typically used in sugar mills are most similar to the L50 series instruments in AS 2026:2003 regarding the total length, number of scale divisions, range and accuracy.

ASTM standard E126 – 05a on hydrometer testing requires a dimensional check. However, no dimensional specifications are present in the General CoA NMI 17/1/0 in regards to Variant 1.

2. The instrument shall be used in an appropriate manner (i.e. to test sugar mill products).
3. All mandatory descriptive markings shall be clearly and permanently marked on the hydrometer.
4. The instrument shall be clean.
5. The hydrometer is free from cracks, fissures, deep scratches, rough areas or any other damage to the glass.
6. Internally, the hydrometer is free from any loose pieces of ballast or other foreign material.
7. The paper scale within the instrument stem is straight and without twist.
8. The scale slippage indicator is present, correctly positioned and free from damage.
9. The instrument shall have a protective case for storage or transport (and for application of a verification mark).

4. Test Procedures

The following procedures determine if the performance of a hydrometer meets the requirements for use in trade. Select one method from the three possible methods, and perform all the listed steps on the hydrometer under test. Record results on a test report.

To improve continuity across the steps, selected details been extracted and moved to Appendix B and Appendix C. Familiarity with these mandatory Appendices is required.

The test procedures are described to apply to one hydrometer only. A sequence for testing is provided in clause 5 that also suggests how multiple hydrometers can be tested to maximise utilisation of the test liquid and reduce the overall testing time.

4.1 Method 1: Verification of a hydrometer calibrated by a Verifying Authority

Brix hydrometers with a NATA-endorsed calibration report from a [Verifying Authority](#) may be verified as fit for use in trade.

1. Ensure that calibration report has not expired and the serial number on the report corresponds with the submitted hydrometer.
2. Ensure that at least three points on the hydrometer has been tested and the corrections are expressed in °Bx units.
3. Assess the magnitude of the reported corrections to ensure they are all within the MPE. The MPE at any point of the scale of a brix hydrometer is 0.1 °Bx.
4. Determine whether the submitted hydrometer has passed or failed.

4.2 Method 2: Comparison against a reference standard in sucrose Solution

The hydrometer under test is compared to a reference standard at three points over its scale range: one point in the upper 25%, one point near the middle and one point in the lower 25%. Three readings will be recorded at each test point.

4.2.1 Preparation

Refer to Appendix B for guidance on selected equipment and Appendix C for standard techniques.

1. If the reported corrections for the thermometer and/or reference standard hydrometer are limited to a few points within the required scale range, interpolate the correction at other points. Include a table of interpolated corrections and/or the corrected values with the test report.
2. If possible, select a workspace where the ambient temperature is between 15 °C and 25 °C.
3. Ensure sufficient reagent is available to produce sucrose solutions with appropriate brix values.
4. Ensure that the hydrometers, comparator jar and necessary aids are clean. Allow these to equilibrate with the ambient temperature over a few minutes.
5. Pour one sucrose solution slowly down the inside of the jar to avoid formation of air bubbles. Introduce enough solution into the jar so that the hydrometer will float at least 25 mm above the bottom when it is immersed.
6. Position the thermometer in the jar for regular observation of the test liquid temperature. Ensure that the test liquid is at thermal equilibrium with the ambient conditions before proceeding.

4.2.2 Taking readings at a test point

1. Stir the liquid, avoiding the formation of air bubbles. Hold the hydrometer under test above the scale as described in clause C.1. Introduce it into the comparator jar, releasing it when it is approximately in its “equilibrium position”.

Note: Equilibrium position is the level of immersion, where the weight of the displaced liquid is equal to the net buoyant force so the hydrometer eventually floats still (resting).
2. When the hydrometer under test reaches its equilibrium position, raise the hydrometer a few centimetres from rest to allow the stem to drain. Clean the stem with the lint-free cloth as described in clause C.3. Gently lower the hydrometer back to its former resting position.
3. Pay attention to the appearance of the liquid surface. If the meniscus crinkles or is pulled out of shape, repeat step 2 as the stem is likely to be contaminated. If necessary, remove the hydrometer for cleaning. If the stem and the surface of the liquid are clean, it will not change as the hydrometer rises and falls.
4. Record the temperature observed for the test liquid as described in clause C.5.
5. When the hydrometer has settled to its equilibrium position once again, follow the observation instructions in clause C.8 to take the reading. Record the observed brix value in the test report.

6. Repeat step 1 to introduce the reference standard hydrometer into the jar. Take care to maintain adequate separation between hydrometers. Refer to clause 2 point 6(c) for the optimal space around each bulb.
7. Repeat steps 2 – 5 to take a reading on the reference hydrometer.
8. Repeat steps 2 – 5 **four times**, alternating between the hydrometer under test and the reference hydrometer, to obtain two more readings from each instrument. In case of any interruption, stir the liquid before returning to step 2 and proceeding with the remaining steps to obtain a reading.

4.2.3 Data correction and validation

1. Ensure a total of three readings have been recorded for each hydrometer, in addition to six observations of the test liquid temperature.
2. As described in clause B.1, apply the necessary scale correction to the observed temperature readings. Then in accordance with clauses B.2 and C.6, apply the appropriate temperature corrections from 0 to every reading taken from the two hydrometers. Record the corrected values in the test report.
3. Check that temperature-corrected values on each hydrometer do not vary by more than 0.05 °Bx as this indicates a testing anomaly (e.g. insufficient stirring) or a faulty instrument.
4. If the difference between the results of a hydrometer vary by more than 0.05 °Bx, repeat clause 4.2.2 steps 1 – 7 once, twice or three times to replace the discarded data. Replace the sucrose solution if contamination is suspected. Reject the instrument if it fails to produce repeatable measurements.

4.2.4 Taking readings at the other test points

1. Empty the jar and conduct a final rinse with some of the next sucrose solution to be used. Alternatively, use another clean comparator jar.
2. Repeat clause 4.2.1 steps 4 – 6 using the appropriate sucrose solution for the next test point on the brix scale, followed by all steps in clauses 4.2.2 and 4.2.3. Repeat this all again using the solution for the third test point.

4.2.5 Examination of results

1. Calculate the true brix values (i.e. the scale and temperature-corrected values) as described in clause B.2 for the reference standard hydrometer.
2. For each test point of the hydrometer under test, calculate the difference in the paired results, to give three values for the error at the test point. Refer to Table 2 for the pairing of corrected values for comparison at a test point.

Table 2: Results for comparison at a test point

Test point	Pair	Hydrometer under test (temperature-corrected brix)	Reference hydrometer (true brix)	Difference (error)
1	1	1st value	1st value	
1	2	2nd value	2nd value	
1	3	3rd value	3rd value	

3. Assess the magnitude of the errors at all three test points to ensure they are all within the MPE. The MPE at any point of the scale of a brix hydrometer is 0.1 °Bx.
4. Determine if the hydrometer under test has passed or failed.

4.3 Method 3: Comparison against a reference standard in another test liquid

The hydrometer under test is compared to the reference hydrometer using the as in clause 4.2 except the comparator jar is filled with another substance listed in Appendix E instead of aqueous sucrose.

If using sulfuric acid solution as the test liquid, servicing licensees need to be aware of the safety requirements associated with handling sulfuric acid solutions. For instance, water can be added to sucrose, sodium chloride (NaCl) and potassium iodide (KI) without issue, however specific techniques are required to safely dilute concentrated sulfuric acid.

The general guidelines in clause B.4 also cover the preparation of alternative solutions.

Additional requirements for verifiers that apply *method 3*:

1. Consider worksite safety and environmental requirements when disposing of test liquids.
2. If the test liquid is sulfuric acid, do not wipe the stem of immersed hydrometers as described in clause 4.2.2 step 2. Remove the hydrometer from the comparator jar for cleaning.

5. Suggested sequence for testing

5.1 General

1. Check the Certificate of Approval for any additional tests required. Make provision for including these tests in the testing sequence.
2. Visually inspect the hydrometer and record the required details on the test report.
3. Examine the performance by one of the tests: method 1 (clause 4.1), method 2 (clause 4.2) or method 3 (clause 4.3).
4. Determine whether the hydrometer has passed or failed.
5. In a similar fashion, test any other submitted hydrometers in sequence.
6. Carry out anything else you need to do to complete the procedure. See [General Information for Test Procedures](#) for more information. This may include:
 - obliterating any pre-existing verification mark hydrometer case;
 - applying a verification mark on the hydrometer case;
 - completing the test report for each submitted hydrometer; and
 - completing an NMI notice of verification form. The instrument owner may also request to have a copy for their records.

5.2 Multiple hydrometers tested simultaneously

Method 2 and *method 3* may be adapted to test multiple submitted hydrometers simultaneously.

1. Check the [General CoA NMI 17/1/0](#) and Variant 1 for any additional tests required.
2. Visually inspect the hydrometers submitted for testing and record the required details.
3. Prepare all the required test solutions, or prepare the test solution with the higher density first and dilute in turn as suggested in clause B.4.

Note: If the most dense (highest brix) test solution is prepared at the start with the intention of gradual dilution, the hydrometers will be tested in order of decreasing brix, i.e. the first point tested will be the highest brix, and the point with lowest brix will be tested last.

4. Examine the performance of the hydrometers under test according to clause 4.2 or clause 4.3.

- (a) If there are multiple submitted hydrometers with identical scale range, group the instruments according to the range.
- (b) If necessary, sub-divide the groups so the number of instruments in each group is one less than the maximum number accommodated by the comparator jar (see clause 2 point 6(c)).
- (c) For each group with the same scale range, first immerse all the hydrometers including the reference standard.
- (d) Raise, drain, wipe and re-immerses and read each resting hydrometer in sequence.
- (e) Stir the liquid, then perform repeat immersions and obtain additional readings at the test point using the same sequence.

Note: Ensure the test liquid temperature is constant throughout all readings (see clauses C.4 and C.5). Otherwise, record the observed temperature prior to each reading.

- (f) For each test point of the hydrometers under test, calculate the difference in the paired results to give three values for the error at the test point.
Refer to Table 3 for the pairing of temperature-corrected brix and the corresponding true brix values, in an example where two hydrometers are simultaneously compared to a reference standard hydrometer.

Table 3: Results for comparison at a test point (two submitted hydrometers)

Test point	Pair	Hydrometers under test (temperature corrected brix)	Reference hydrometer (true brix)	Difference (error)
1	1	Hydrometer #1: 1st value	1st value	
1	3	Hydrometer #1: 2nd value	2nd value	
1	5	Hydrometer #1: 3rd value	3rd value	
1	2	Hydrometer #2: 1st value	1st value	
1	4	Hydrometer #2: 2nd value	2nd value	
1	6	Hydrometer #2: 3rd value	3rd value	

- 5. Determine whether the hydrometer has passed or failed.
- 6. Carry out anything else you need to do to complete the procedure, e.g. removal of a pre-existing verification mark on a hydrometer case, application of a new mark, etc.

Appendix A: Test Report (Mandatory)

Appendix A contains a test report on which to record the results.

Although the format of the test report may vary according to the individual needs and requirements of trade measurement inspectors and servicing licensees, the following test report contains the minimum amount of information that must be recorded.

If the Certificate of Approval requires additional tests, attach pages that record the results of these tests.

Number each page of the test report in the style shown at the top of each of the following pages.

Test Report 1 for Hydrometer Under Test

Test Report for Brix Hydrometers

Required Data (clause 3.1)

Test report reference number Date of test

Type of test (tick one) Verification Reverification In-service inspection

For in-service inspection or reverification, record the verification mark:.....

Name of owner/user

Address of owner/user

Name of contact person on premises

Address of instrument location.....

Description of instrument

Manufacturer Model.....

Serial number..... Certificate of approval number

Scale range Smallest scale graduation

General Characteristics (clause 3.2)	Yes, no or N/A
Does the hydrometer comply with its Certificate of Approval?	
Is the instrument being used in an appropriate manner (i.e.to test sugar mill products)?	
Are all mandatory descriptive markings clearly and permanently marked?	
Is the instrument clean?	
Is the hydrometer is free from cracks, fissures, deep scratches, rough areas or any other damage to the glass?	
Internally, is the hydrometer is free from any loose pieces of ballast or other foreign material?	
Is the paper scale within the instrument stem is straight and without twist?	
Is the scale slippage indicator is present, correctly positioned and free from damage?	
Does the instrument have a protective case for storage or transport (and for application of a verification mark)?	

Test Report 1 for Hydrometer Under Test

Method 1: Verification of a hydrometer calibrated by a Verifying Authority (clause 4.1)

NMI lab or [Verifying Authority](#) name

NATA report reference number Calibration expiry date

Number of test points on calibration report

Did the hydrometer pass the visual inspection? Yes No

Were all the corrections on the calibration certificate within the MPE? Yes No

Was the hydrometer verified? Yes No

Verifier's name Identification number

Signature

Comments

.....
.....

Method 2 or Method 3: Comparison against a reference standard (clauses 4.2 and 4.3)

If *method 3* is applied, state the test liquid used

Test point 1

Observed temperature	True temperature	Hydrometer serial # or designation	Tick if ref std	Observed brix reading	Temperature-corrected brix value (°Bx)
			<input type="checkbox"/>		
			<input type="checkbox"/>		
			<input type="checkbox"/>		
			<input type="checkbox"/>		
			<input type="checkbox"/>		
			<input type="checkbox"/>		

Add extra rows for multiple hydrometers under test

Data at test point 1 validated Yes No

Test point 2

Observed temperature	True temperature	Hydrometer serial # or designation	Tick if ref std	Observed brix reading	Temperature-corrected brix value (°Bx)
			<input type="checkbox"/>		
			<input type="checkbox"/>		
			<input type="checkbox"/>		
			<input type="checkbox"/>		
			<input type="checkbox"/>		
			<input type="checkbox"/>		

Add extra rows for multiple hydrometers under test

Data at test point 2 validated Yes No

Test Report 1 for Hydrometer Under Test

Test point 3

Observed temperature	True temperature	Hydrometer serial # or designation	Tick if ref std	Observed brix reading	Temperature-corrected brix value (°Bx)
			<input type="checkbox"/>		
			<input type="checkbox"/>		
			<input type="checkbox"/>		
			<input type="checkbox"/>		
			<input type="checkbox"/>		
			<input type="checkbox"/>		

Add extra rows for multiple hydrometers under test

Data at test point 3 validated

Yes No

Examination of results

Test point number	Reference standard hydrometer: [Scale and temperature-corrected] True brix value (°Bx)	Hydrometer under test: Temperature-corrected brix value (°Bx)	Difference/error (°Bx)
1			
1			
1			
2			
2			
2			
3			
3			
3			

Add extra columns for multiple hydrometers under test

Did the hydrometer pass the visual inspection?

Yes No

Were all the errors against the reference standard at all test points within the MPE?

Yes No

Was the hydrometer verified?

Yes No

Verifier's name Identification number

Signature

Comments

.....

.....

Test Report 2 for the Standards of Measurement

Details of the Reference Standards of Measurement (clause 2)

Reference Standard Hydrometer			
Make			
Model			
Smallest scale graduation (°Bx)		Serial number	
Scale range (°Bx) Minimum		Maximum	
Regulation 13 certificate number		Certificate expiry date	
Expanded measurement uncertainty associated with corrections (k=2)			
Regulation 13 or NATA-certified Thermometer			
Make			
Model			
Smallest scale graduation (°C)		Serial number	
Regulation 13 certificate number		Certificate expiry date	
Expanded measurement uncertainty associated with corrections (k=2)			

Test Report 2 for the Standards of Measurement

Table of Interpolated Corrections and Scale Corrected Reference Standard Hydrometer Values (clauses 2 and B.2)

Temp-corrected reading (°Bx)	Scale correction (°Bx)		True brix (°Bx)	Temp-corrected reading (°Bx)	Scale correction (°Bx)		True brix (°Bx)
	Calibration report	Interpolated			Calibration report	Interpolated	

Test Report 2 for the Standards of Measurement

Temperature Correction Table to Convert Observed Temperature to True Temperature for the Thermometer (clauses 2 and B.1)

Observed temp (°C)	Correction (°C)		True temp (°C)	Observed temp (°C)	Correction (°C)		True temp (°C)	Observed temp (°C)	Correction (°C)		True temp (°C)
	Certified	Interpolated			Certified	Interpolated			Certified	Interpolated	
14.0				19.7				25.4			
14.1				19.8				25.5			
14.2				19.9				25.6			
14.3				20.0				25.7			
14.4				20.1				25.8			
14.5				20.2				25.9			
14.6				20.3				26.0			
14.7				20.4				26.1			
14.8				20.5				26.2			
14.9				20.6				26.3			
15.0				20.7				26.4			
15.1				20.8				26.5			
15.2				20.9				26.6			
15.3				21.0				26.7			
15.4				21.1				26.8			
15.5				21.2				26.9			
15.6				21.3				27.0			
15.7				21.4				27.1			
15.8				21.5				27.2			
15.9				21.6				27.3			
16.0				21.7				27.4			
16.1				21.8				27.5			
16.2				21.9				27.6			
16.3				22.0				27.7			
16.4				22.1				27.8			
16.5				22.2				27.9			
16.6				22.3				28.0			
16.7				22.4				28.1			
16.8				22.5				28.2			
16.9				22.6				28.3			
17.0				22.7				28.4			
17.1				22.8				28.5			
17.2				22.9				28.6			
17.3				23.0				28.7			
17.4				23.1				28.8			
17.5				23.2				28.9			
17.6				23.3				29.0			
17.7				23.4				29.1			
17.8				23.5				29.2			
17.9				23.6				29.3			
18.0				23.7				29.4			
18.1				23.8				29.5			
18.2				23.9				29.6			
18.3				24.0				29.7			
18.4				24.1				29.8			
18.5				24.2				29.9			
18.6				24.3				30.0			
18.7				24.4				30.1			
18.8				24.5				30.2			
18.9				24.6				30.3			
19.0				24.7				30.4			
19.1				24.8				30.5			
19.2				24.9				30.6			
19.3				25.0				30.7			
19.4				25.1				30.8			
19.5				25.2				30.9			
19.6				25.3				31.0			

Appendix B: Additional guidance for some equipment (Mandatory)

B.1 Corrections for the thermometer

The scale corrections stated on the certificate of the thermometer shall be applied to the observed temperatures if any the absolute value of any correction exceeds 0.2 °C. If scale corrections are not stated for the entire range, calculate the correction for each 0.1 °C increment by interpolation (e.g. linear) in between adjacent calibration test points.

If all the scale corrections are within ± 0.2 °C, the observed temperature can be used as the true temperature.

Ensure the thermometer is recalibrated according to the calibration schedule. New thermometers are prone to drift due to continued annealing of the glass. Conduct periodic ice-point checks to ensure that any drift is either insignificant or added to the certified scale corrections.

Ensure that the liquid-in-glass thermometer is used according on the method stated in the calibration certificate. Do not fully immerse a thermometer calibrated as partial-immersion device or only partially immerse a thermometer calibrated as full-immersion device.

B.2 Temperature and scale corrections for the reference hydrometer

The scale corrections stated on the certificate of the reference hydrometer are valid when the instrument and test liquid is at the temperature stated on the calibration certificate. This is usually 20.0 °C, the reference temperature at which the unit °Bx is defined.

Refer to steps 1 – 4 to obtain the appropriate scale correction for a reference hydrometer:

1. Observe the thermometer with each reading on the reference hydrometer
2. If a reading is not performed at 20.0 °C, determine the appropriate temperature correction from Appendix D. Calculate and record the temperature-corrected reading.
3. For each temperature-corrected reading, determine the appropriate scale correction from the Reg 13 certificate or the accompanying calibration certificate. If scale corrections are not stated for the entire range, calculate the correction at each point by interpolation in between adjacent calibration test points.

The measurement uncertainty of the interpolated correction can be approximated as equivalent to the uncertainty of the corrections in the calibration report provided that the reference hydrometer is verified at a **minimum of six test points** (per 10 °Bx range). The reference hydrometer should be verified at a number of points that do not correspond with the “manufacturer calibration points”. Typically, the manufacturer marks three points (minimum, maximum and centre of the scale) based on a three-point calibration and marks the two intervals in between with equal scale divisions.

4. Calculate and record the “scale and temperature-corrected” brix value (i.e. “true” brix value).

B.3 Number and amount of test liquids

The performance of a submitted hydrometer shall be tested at three points: one point in the upper 25% of the scale, one point near the middle and one point in the lower 25% of the scale. Three test liquids with different brix values are required to perform a complete test.

The minimum required amount of test liquid is the volume of the comparator jar. Ensure sufficient reagent is available to prepare twice the minimum amount in case the test liquid is contaminated and needs a new surface (by overflowing with more liquid of the same brix) or needs to be replaced.

B.4 Test liquid preparation

It is not necessary to determine the exact densities, concentrations or brix values of the test liquids. However, approximate values from concentration and density tables (refer to Appendix E) can streamline the solution preparation or dilution process.

Prepare several test liquids up to several hours in advance with brix values corresponding with the range encompassed by the submitted hydrometer. Cover the containers to prevent contamination while not in use. Shake or stir well before use.

Alternatively, prepare the solution with the highest brix first. Dilute the solution with sufficient water to ensure that the brix is within the range required for the comparison at the second test point. Repeat to obtain a test liquid with a lower brix corresponding with the third test point.

Note: Reusing the same test liquid on several hydrometers increases likelihood of surface contamination, particularly if sucrose solutions are used. If the presence of surface impurities is suspected, generate a new surface by overflowing with extra test liquid of the same brix before performing dilutions.

Appendix C: Standard procedures (Mandatory)

C.1 Cleanliness of the hydrometer

For uniform and reproducible readings, the hydrometers shall be clean and dry before immersion.

- Prepare the hydrometers, comparator jar and necessary aids by washing with soap and water. Dry, then wipe with a cloth moistened with alcohol to remove any residual soap film. If there are hard to reach surfaces, rinse with alcohol and then air dry.
- Other similar methods of cleaning may be employed. Take care not to damage the hydrometer.
- Do not touch the hydrometer at the bulb or on the stem portion containing the scale after cleaning. Hold the hydrometer above the scale between thumb and index finger.
- Reject the hydrometer if stubborn residue remains resulting in a faulty meniscus.

C.2 Cleaning of the stem in the 'double immersion' method

One way to reduce the time required to perform repeat readings is to allow hydrometer to remain in the jar after each reading. The stem is cleaned prior to the next reading, i.e. the liquid is wiped away from the stem before the second immersion.

Warning: Do not wipe the stem of an immersed hydrometer when the test liquid is sulfuric acid.

- Lift a resting hydrometer a few centimetres and wipe the stem with a lint-free cloth. Focus on the parts of the stem close to the intersection with the liquid surface. Carefully lower the hydrometer to the resting position and proceed with the remaining steps to obtain a reading.
- Ideally, the stem of the hydrometer shall not be wet more than two graduations above the surface, so that the liquid will rise uniformly around the stem and merge into an imperceptible film on the stem.

C.3 Equilibration of the hydrometer temperature with ambient

For uniform and reproducible readings, the hydrometer must be at the temperature of the liquid (which is same as ambient temperature) before immersion.

To reduce the equilibration period required before immersion, reduce the following:

- Difference in temperature of the cleaning agents (e.g. running water) and ambient.
- Duration that the hydrometer is immersed or in contact with cleaning agents
- Duration that the hydrometer is handled

C.4 Minimising variations in the ambient and liquid temperature

- Minimise changes in the ambient temperature by performing the test in a draught-free location away from direct sunlight. Controlled laboratory conditions are recommended.
- Allow sufficient time for the temperature of the test liquid to reach thermal equilibrium with ambient temperature. Any measured difference in the temperature should not exceed 0.2 °C.
- Minimise thermal or concentration gradients in the test liquid by mixing thoroughly prior to immersing the hydrometer. Periodically stir the test liquid in between a series of double immersions or if the testing is interrupted.

C.5 Monitoring the liquid temperature

A preliminary study is recommended to ascertain the magnitude of spatial temperature gradients in the comparator jar under test conditions:

- If negligible, the thermometer observations can be taken from the same location in the jar
- If not negligible, apply one or more of the recommendations in clause C.4.

- Monitor the temperature of the test liquid using the thermometer throughout the tests. Record the observed temperature to the nearest 0.1 °C for each hydrometer reading.

C.6 Temperature corrections for the hydrometer under test

The Brix scale is defined at 20.0 °C. When brix readings are taken at any other temperature, the corrections in Appendix D shall be applied.

Refer to the followings steps to obtain the appropriate temperature correction:

5. Take note of the temperature with each reading on the hydrometer
6. If a reading is not performed at 20.0 °C, determine the appropriate temperature correction from Appendix D. Calculate and record the temperature-corrected reading.

C.7 Maintaining constant surface tension

Corrections for the influence of surface tension are unnecessary as the test liquids are in the same surface tension category as the substance (cane juice) routinely measured for trade.

Compared to mineral oils and strong alcoholic mixtures which readily adhere to the hydrometer stem, weak aqueous solutions of sugar, salts and acids are more prone to unpredictable changes in surface tension caused by surface films of impurities.

- Reduce the risk of contamination by performing the test in an area that is relatively free of dust and air-borne particles. Ensure the residual soap film is removed from the hydrometers, comparator jar, stirrer and thermometer. Note that the risk of contamination increases where the test is prolonged or the test liquid is reused (e.g. multiple hydrometers of the same scale range are verified in the same test liquid).
- If contamination of the test liquid surface is suspected, purify the surface of the test liquid by causing an overflow of the liquid before observing a reading. If required, replace entire container of test liquid.
- In case the hydrometer is immersed too deep or an abnormal meniscus is observed, clean the stem (see clause C.1) or remove the hydrometer from the jar and thoroughly clean before restarting the measurement (see clause C.2).

C.8 Observation method (reading the scale at the base of the meniscus)

Brix hydrometers with scales adjusted for reading at the top of the meniscus are unconventional and rarely available. Laboratory methods at sugar mills require application of a meniscus correction (MC) when conventional hydrometers are used for measurements in opaque liquids such as cane juice (refer to Appendix G for details). To avoid conflict with laboratory methods, only brix hydrometers manufactured in the conventional manner shall be submitted for verification.

- Take all readings from where the base of the meniscus intersects the hydrometer stem.
- When taking the reading, view the scale from below and raise the line of sight until it is as close as possible to the plane of the liquid surface. Estimate to one-tenth of a scale division.
- This may be facilitated by the use of the background screen positioned about 100 mm from the hydrometer stem. Adjust the screen so that the line separating the black and white halves is 20 – 25 mm below the plane of the liquid surface.
- In the absence of a background screen, a white card held behind the comparator jar just below the liquid surface will also improve the readability.
- The meniscus will appear as a white ellipse against a black background and as the eye is raised, the ellipse flattens out until it becomes a fine white line against a dark background. Take the reading with reference to this line.

Appendix D: Corrections for brix hydrometer readings outside the reference temperature (Mandatory)

D.1 Temperature corrections to readings of brix hydrometers (calibrated at 20.0 °C)

Temperature °C	Observed per cent of sugar																		
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
	Subtract from observed per cent.																		
0	0.30	0.49	0.65	0.77	0.89	0.99	1.08	1.16	1.24	1.31	1.37	1.41	1.44	1.47	1.49	1.50	1.50	1.51	1.51
5	0.36	0.47	0.56	0.65	0.73	0.80	0.86	0.91	0.97	1.01	1.05	1.08	1.10	1.12	1.14	1.16	1.17	1.18	1.19
10	0.32	0.38	0.43	0.48	0.52	0.57	0.60	0.64	0.67	0.70	0.72	0.74	0.75	0.76	0.77	0.78	0.79	0.80	0.81
11	0.31	0.35	0.40	0.44	0.48	0.51	0.55	0.58	0.60	0.63	0.65	0.66	0.68	0.69	0.70	0.71	0.72	0.73	0.74
12	0.29	0.32	0.36	0.40	0.43	0.46	0.50	0.52	0.54	0.56	0.58	0.59	0.60	0.61	0.62	0.63	0.64	0.64	0.65
13	0.26	0.29	0.32	0.35	0.38	0.41	0.44	0.46	0.48	0.49	0.51	0.52	0.53	0.54	0.55	0.56	0.56	0.57	0.57
14	0.24	0.26	0.29	0.31	0.34	0.36	0.38	0.40	0.41	0.42	0.44	0.45	0.46	0.46	0.47	0.47	0.48	0.48	0.48
15	0.20	0.22	0.24	0.26	0.28	0.30	0.32	0.33	0.34	0.36	0.36	0.37	0.38	0.38	0.39	0.39	0.40	0.40	0.41
16	0.17	0.18	0.20	0.22	0.23	0.25	0.26	0.27	0.28	0.28	0.29	0.30	0.31	0.31	0.32	0.32	0.33	0.33	0.34
17	0.13	0.14	0.15	0.16	0.18	0.19	0.20	0.20	0.21	0.21	0.22	0.23	0.23	0.24	0.24	0.25	0.25	0.25	0.26
18	0.09	0.10	0.10	0.11	0.12	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15	0.16	0.16	0.16	0.16	0.17	0.17
19	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09
20	Add to observed per cent.																		
21	0.04	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09
22	0.10	0.10	0.11	0.12	0.12	0.13	0.14	0.14	0.14	0.15	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17	0.17
23	0.16	0.16	0.17	0.17	0.19	0.20	0.21	0.21	0.22	0.23	0.24	0.24	0.24	0.24	0.25	0.25	0.25	0.25	0.25
24	0.21	0.22	0.23	0.24	0.26	0.27	0.28	0.29	0.30	0.31	0.32	0.32	0.32	0.32	0.33	0.33	0.33	0.33	0.33
25	0.27	0.28	0.30	0.31	0.32	0.34	0.35	0.36	0.38	0.38	0.39	0.39	0.40	0.40	0.39	0.39	0.39	0.38	0.38
26	0.33	0.34	0.36	0.37	0.40	0.40	0.42	0.44	0.46	0.47	0.47	0.48	0.48	0.48	0.48	0.49	0.49	0.48	0.48
27	0.40	0.41	0.42	0.44	0.46	0.48	0.50	0.52	0.54	0.54	0.55	0.56	0.56	0.56	0.57	0.57	0.56	0.56	0.56
28	0.46	0.47	0.49	0.51	0.54	0.56	0.58	0.60	0.61	0.62	0.63	0.64	0.64	0.64	0.64	0.65	0.65	0.64	0.64
29	0.54	0.55	0.56	0.59	0.61	0.63	0.66	0.68	0.70	0.70	0.71	0.72	0.72	0.72	0.72	0.73	0.73	0.72	0.72
30	0.61	0.62	0.63	0.66	0.68	0.70	0.73	0.76	0.78	0.78	0.79	0.80	0.80	0.80	0.81	0.81	0.81	0.81	0.81
31	0.69	0.70	0.71	0.74	0.76	0.79	0.82	0.84	0.86	0.87	0.88	0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.89
32	0.76	0.78	0.79	0.82	0.85	0.87	0.90	0.93	0.95	0.95	0.96	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
33	0.84	0.85	0.87	0.90	0.93	0.96	0.99	1.01	1.03	1.04	1.05	1.05	1.06	1.06	1.06	1.06	1.06	1.06	1.05
34	0.91	0.93	0.95	0.98	1.02	1.04	1.07	1.10	1.12	1.12	1.13	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.13
35	0.99	1.01	1.02	1.06	1.10	1.13	1.16	1.18	1.20	1.21	1.22	1.22	1.23	1.23	1.22	1.22	1.22	1.22	1.21

This table is calculated using data on thermal expansion of sugar solutions by Plato assuming the instrument to be Jena 16 glass. The table should be used with caution and only for approximate results when the temperature differs much from the standard temperature or from the temperature of surrounding air. Reference: BSES Laboratory Manual for Sugar Mills, Vol. 2, Table 1, Page 1 of 2.

Appendix E: Tables of mass % solute and density at 20° C for aqueous test liquids (Informative)

Estimate the brix of a test liquid of known concentration by matching up its density (indicated in clauses E.1, E.2 and E.3) with the closest value in the sucrose table (see clause E.4).

For example, if a 20 % NaCl solution is prepared, the density should be 1.1478 g/cm³. This value is closest to 1147.877 kg/m³ - which is equivalent to 34.4 °Bx in the table for sucrose.

E.1 Sodium chloride (NaCl)

Mass %	Density (g/cm ³)	Mass %	Density (g/cm ³)
0.5	1.0018	10.0	1.0707
1.0	1.0053	12.0	1.0857
2.0	1.0125	14.0	1.1008
3.0	1.0196	16.0	1.1162
4.0	1.0268	18.0	1.1319
5.0	1.0340	20.0	1.1478
6.0	1.0413	22.0	1.1640
7.0	1.0486	24.0	1.1804
8.0	1.0559	26.0	1.1972
9.0	1.0633		

E.2 Potassium Iodide (KI)

Mass %	Density (g/cm ³)	Mass %	Density (g/cm ³)
0.5	1.0019	16.0	1.1284
1.0	1.0059	18.0	1.1469
2.0	1.0131	20.0	1.1659
3.0	1.0206	22.0	1.1856
4.0	1.0282	24.0	1.2060
5.0	1.0360	26.0	1.2270
6.0	1.0438	28.0	1.2487
7.0	1.0517	30.0	1.2712
8.0	1.0598	32.0	1.2944
9.0	1.0679	34.0	1.3185
10.0	1.0762	36.0	1.3434
12.0	1.0931	38.0	1.3692
14.0	1.1105	40.0	1.3959

E.3 Sulfuric acid (H₂SO₄)

Mass %	Density (g/cm ³)	Mass %	Density (g/cm ³)
0.5	1.0016	34.0	1.2518
1.0	1.0049	36.0	1.2685
2.0	1.0116	38.0	1.2855
3.0	1.0183	40.0	1.3028
4.0	1.0250	42.0	1.3205
5.0	1.0318	44.0	1.3386
6.0	1.0385	46.0	1.3570
7.0	1.0453	48.0	1.3759
8.0	1.0522	50.0	1.3952
9.0	1.0591	52.0	1.4149
10.0	1.0661	54.0	1.4351
12.0	1.0802	56.0	1.4558
14.0	1.0947	58.0	1.4770
16.0	1.1094	60.0	1.4987
18.0	1.1245	70.0	1.6105
20.0	1.1398	80.0	1.7272
22.0	1.1554	90.0	1.8144
24.0	1.1714	92.0	1.8240
26.0	1.1872	94.0	1.8312
28.0	1.2031	96.0	1.8355
30.0	1.2191	98.0	1.8361
32.0	1.2353	100.0	1.8305

E.4 Sucrose

ICUMSA Specification and Standard SPS-4 (1998); Densimetry and tables: sucrose – official; glucose, fructose and invert sugar – official.

Refer to the [General Certificate of Approval 17/0/1](#) Appendix B for a copy of the relevant table.

E.5 Reference

D.R. Lide (ed); CRC handbook of chemistry and physics, 87th ed., Taylor and Francis Group, 2006, Section 8 – Analytical Chemistry, Table 8-53 Concentrative properties of aqueous solutions.

Appendix F: Meniscus correction (Informative)

F.1 General

Brix hydrometers are conventionally designed to be read from the base of meniscus. Such hydrometers may be used in opaque liquids. In this case, the reading is taken where the top of the meniscus appears to meet the stem of the hydrometer. This reading requires adjustment.

When instruments designed to be read from the base of the meniscus are read from the top of the meniscus, an empirical scale adjustment equation by Langberg is used to calculate the necessary meniscus correction (MC). This equation is published in AS 2026:2003 which is referenced in [General CoA NMI 17/1/0](#).

F.2 Meniscus correction (MC) for hydrometer readings in cane juice

The appropriate MC required can be 0.8 – 1.0 kg/m³ in liquids with the same surface tension class and density as sugar solutions. In cane juice solutions which are typically under 30 °Bx, 0.1 °Bx is equivalent to 0.42 – 0.47 kg/m³.

The MC of 0.2 °Bx, stated in BSES Method 3 (2001) that is used across sugar mills is consistent with the metric density MC values in AS 2026:2003 Appendix 5.