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# Pattern Approval Specifications for Brake Force Measuring Instruments for Legal Use

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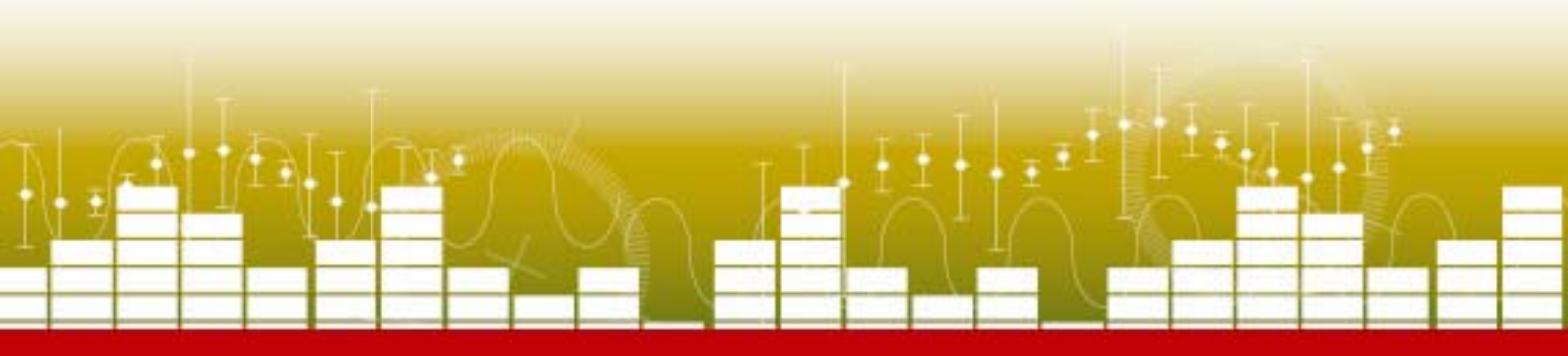
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## TERMINOLOGY

The following terminology includes terms applicable to those instruments covered by this recommendation and some general terms included in the *International Vocabulary of Basic and General Terms in Metrology* (VIM, 1984 edition).

## GENERAL TERMS

### T.1 Brake Force Measuring Instrument

A measuring instrument which determines and indicates the force between the road and the wheels of a vehicle due to the application of its brakes. The instrument includes components such as a force measurement transducer (or transducers) which measures quantity related to the force of the brakes, a processor and an indicator.

### T.2 Component

A part of an instrument that is usually manufactured as a separate unit and is capable of being independently tested.

### T.3 Force Measurement Transducer

A device which measures a quantity related to the brake force and which provides a signal to the processor from which the force is derived.

### T.4 Processor

A device which contains all the necessary information and receives all the necessary signals from the transducers to enable it to calculate the brake force as well as other quantities. It may also store information, provide checking facilities for the information and communicate with auxiliary devices.

### T.5 Indicator

A device which displays the force calculated by the processor and other quantities. It may or may not be associated with the processor.

### T.6 Auxiliary Devices

Devices that repeat the indication, ticket printers, card readers, data input terminals etc.

## MEASUREMENT TERMS

### T.7 Brake Force

The force between the road and the wheels of a vehicle due to the application of the vehicle brakes.

### T.8 Brake Balance

The difference between the brake forces of the two wheels (or two pairs of wheels) on one axle.

### T.9 Minimum Error

The relative maximum permissible error which equals the minimum absolute error quantity.

### T.10 Maximum Quantity

The maximum measurable quantity as specified by the manufacturer of the force measurement transducer (for testing of components) or of the measuring instrument.

### T.11 Zero Quantity

The quantity equivalent to the force measured with the wheels rotating but without the brakes applied.

## ELECTRONIC TERMS

### T.12 Electronic Brake Force Measuring Instrument

A brake force measuring instrument equipped with electronic devices.

### T.13 Electronic Device

A device employing electronic sub-assemblies and performing a specific function. An electronic device is usually manufactured as a separate unit and is capable of being independently tested.

Note: An electronic device as defined above, may be a complete measuring instrument or part of a measuring instrument.

**T.14 Electronic Sub-assembly**

Part of an electronic device employing electronic components and having a recognisable function of its own.

**T.15 Electronic Component**

The smallest physical entity which uses electron or hole conduction in semi-conductors, gases or in a vacuum.

**PERFORMANCE TERMS****T.16 Error of Indication**

The indication of a measuring instrument minus the (conventional) true value of the measurand (VIM 5.24).

**T.17 Intrinsic Error**

The error of a measuring instrument used under reference conditions (VIM 5.27).

**T.18 Initial Intrinsic Error**

The intrinsic error of a measuring instrument as determined prior to performance tests.

**T.19 Maximum Permissible Error**

The extreme values (positive and negative) of the error of indication permitted by regulation. The absolute value of the maximum permissible error is the same value without sign.

**T.20 Repeatability**

The closeness of the agreement between the results of successive measurements of the same measurand carried out under the same conditions (VIM 3.06).

**T.21 Fault**

The difference between the error of indication and the intrinsic error of a measuring instrument.

Note: Principally a fault is the result of an undesired change of data contained in, or flowing through, an electronic measuring instrument.

**T.22 Significant Fault**

A fault greater than the absolute value of the minimum error.

The following faults are not considered to be significant, even when they exceed the value defined above:

- (a) faults arising from simultaneous and mutually independent causes in the measuring instrument itself or in its checking facilities;
- (b) faults implying the impossibility to perform any measurement;
- (c) transitory faults being momentary variations in the indication, which cannot be interpreted, memorised or transmitted as a measurement result; and
- (d) faults giving rise to variations in the measurement result so serious that they are bound to be noticed by all those interested in the result of the measurement.

**T.23 Influence Quantity**

A quantity which is not the subject of the measurement but which influences the value of the measurand or the indication of the measuring instrument (VIM 2.10).

**T.23.1 Influence Factor**

An influence quantity having a value within the rated operating conditions of the measuring instrument, specified in this recommendation.

**T.23.2 Disturbance**

An influence quantity having a value within the limits specified in this recommendation, but outside the specified rated operating conditions of the measuring instrument.

Note: An influence quantity is a disturbance if for that influence quantity the rated operating conditions are not specified.

#### **T.24 Rated Operating Conditions**

Conditions of use giving the range of values of influence quantities for which the metrological characteristics are intended to lie within the specified maximum permissible errors.

#### **T.25 Reference Conditions**

A set of specified values of influence factors fixed to ensure valid intercomparison of results of measurements (adapted from VIM 5.07).

#### **T.26 Performance**

The ability of the measuring instrument to accomplish its intended functions.

### **CHECKING TERMS**

#### **T.27 Checking Facility**

A facility incorporated in a measuring instrument which enables significant faults to be detected and acted upon.

Note: Acted upon is any adequate response made by the measuring instrument, e.g. a luminous or acoustic signal, blocking of the process.

#### **T.28.1 Automatic Checking Facility**

A checking facility operating without the intervention of an operator.

##### **T.28.1.1 Permanent Automatic Checking Facility (Type P)**

An automatic checking facility operating at each measurement cycle.

##### **T.28.1.2 Intermittent Automatic Checking Facility (Type I)**

An automatic checking facility operating at certain time intervals or over a fixed number of measurement cycles.

##### **T.28.2 Non-automatic Checking Facility (Type N)**

A checking facility which requires the intervention of an operator.

### **TESTING TERMS**

#### **T.29 Test**

A series of operations intended to verify the compliance of the equipment under test (EUT) with certain requirements.

##### **T.29.1 Test Procedure**

A detailed description of the tests.

##### **T.29.2 Test Program**

A description of a series of tests for certain type of equipment.

##### **T.29.3 Performance Test**

A test intended to verify whether the equipment under test (EUT) is able to accomplish its intended functions.

## SECTION I — GENERAL REQUIREMENTS

### 1. SCOPE

This document specifies the metrological and technical requirements for the pattern approval of instruments used to measure the force between the road and the wheels of a vehicle due to the application of its brakes. The document also includes pattern approval procedures, verification procedures and test methods.

### 2. APPLICATION

These rules apply to instruments which have two sets of rollers on which the road wheels (single or dual) of one axle of a vehicle are placed. The rollers are driven by their own motor (e.g. mechanical, hydraulic, electric) and the force caused on each wheel by the application of the vehicle brakes is measured. The difference between each wheel is also measured.

The instrument may be located in a fixed position or may be mobile.

## SECTION II — METROLOGICAL REQUIREMENTS

### 3. UNITS OF MEASUREMENT

The following units of measurement and their symbols shall be used.

Quantity	Name of unit	Unit symbol
Force	newton	N
	kilonewton	kN
Speed	kilometre per hour	km/h
Load	kilogram	kg
	tonne	t

## 4. MAXIMUM PERMISSIBLE ERRORS

### 4.1 Value of Maximum Permissible Errors

The maximum permissible error applicable to the measurement of force by the instrument for verification and reverification is  $\pm 10\%$  of the quantity measured or  $\pm 3\%$  of the maximum quantity, whichever is the greater.

### 4.2 Value of Maximum Permissible Errors for Laboratory Simulation Tests

Subject to agreement between the manufacturer and NMI on the form of the simulation, the instrument shall be tested under laboratory-simulated conditions for pattern evaluation.

The maximum permissible errors for laboratory-simulated tests are  $\pm 5\%$  of the quantity measured or  $\pm 1.5\%$  of the maximum quantity, whichever is the greater.

### 4.3 Repeatability

The difference between the results of several measurements of the same force applied to the same rollers or applied to both sets of rollers for one axle, shall not be greater than half of the absolute value of the applicable maximum permissible error specified in clauses 4.1 and 4.2.

### 4.4 Maximum Permissible Variation Between Indicators

The difference between the indications of the same quantity on different digital indicators shall not exceed one scale interval.

### 4.5 Rules for the Determination of Errors

The rules for the determination of errors are as follows:

- (a) The reference standards used for the determination of the maximum permissible errors shall have a combined uncertainty (95% probability)



of not greater than one-third of the maximum permissible error specified.

- (b) The maximum permissible errors apply to all instruments irrespective of their principles of operation.
- (c) The maximum permissible errors are applicable for increasing and decreasing quantities.
- (d) For simulation tests the instrument shall be tested in as complete a form as possible; however components may also be tested. The components which make up an instrument generally comprise the following:
  - one or more transducers which measure a quantity from which the force is derived; and
  - a processor and indicator.
- (e) The initial intrinsic error is found at reference conditions of  $20 \pm 5^\circ\text{C}$ , atmospheric pressure, nominal voltage and  $50 \pm 15\%$  relative humidity.
- (f) The initial intrinsic error is referenced to a straight line which passes through zero and maximum output
- (g) The maximum permissible errors for laboratory simulation tests are applicable for the influence factors, disturbances and humidity effects given in section 5.
- (h) The maximum permissible error shall be rounded to the nearest scale interval.
- (i) If load cells are used to measure the force, they shall comply with the metrological requirements of *OIML R 60. Metrological Regulations for Load Cells* with an appropriate class and number of verification scale intervals to achieve the required simulation test maximum permissible errors.
- (j) If components are tested separately, then reduced maximum permissible errors may be applied to each component such that  $p_1^2 + p_2^2 + p_3^2 + \dots \leq 1$ , where  $p_1$  etc are component fractions of the maximum permissible

error for simulation tests of the instrument. The fractions are subject to agreement between the manufacturer and NMI.

## 5. INFLUENCE FACTORS, DISTURBANCES AND HUMIDITY

### 5.1 Rated Operating Conditions for Influences Factors

Instruments shall be designed and manufactured so that they do not exceed the maximum permissible errors when tested over the following ranges of influence factors:

- (a) mains power voltage variations:  $-15$  to  $+10\%$  of nominal voltage; and
- (b) air temperature variations:  $-10$  to  $+40^\circ\text{C}$ .

A battery operated electronic instrument shall either continue to function correctly or not indicate any quantity when the voltage is below the manufacturer's specified nominal voltage.

### 5.2 Disturbances

Electronic instruments shall be designed and manufactured so that when subjected to disturbances, either a significant fault does not occur or the fault is detected and a visible or audible indication is provided in conjunction with the indication of the measurement. Such disturbances include:

- (a) short time power reduction;
- (b) electrical bursts;
- (c) electrostatic discharge; and
- (d) electromagnetic susceptibility.

The fault indication shall continue until the user takes action or the fault is corrected. This requirement may apply separately to each individual cause of significant fault and/or each part of the instrument.

The severity levels of the disturbances are given in Annex A.3.

Note: The choice of which of the above alternatives is used is left to the manufacturer.

### 5.3 Humidity

Electronic measuring instruments which consist of components with hollow, sealed spaces and normally used in outdoor applications shall have these devices subjected to the damp heat cyclic test described in Annex A.2.3.

The difference in indication at reference conditions (see clause 4.5(e)) for the same input before and after the test shall not differ by more than the absolute value of the minimum error.

In addition all electronic measuring instruments shall be subjected to the damp heat steady state test described in Annex A.2.2.

The indication for the same input shall remain within the maximum permissible errors when applied at reference conditions before and after the test (see clause 4.5(e)) and when applied at the test conditions specified in Annex A.2.2 after two days at these conditions.

### 5.4 Tests

A pattern of an instrument is presumed to comply with the requirements of clauses 5.1 to 5.3 if it has passed the examination and tests specified in Annex A.

The maximum permissible errors referred to in clauses 5.1 to 5.3 are those applicable for laboratory simulation tests. The errors are specified in clause 4.2.

## SECTION III — TECHNICAL REQUIREMENTS

The following technical requirements will ensure that the instrument is constructed so that it complies with the metrological requirements and will be suitable for legal use.

## 6. OPERATIONAL REQUIREMENTS

### 6.1 Fraudulent Use

Instruments shall not facilitate fraudulent use.

### 6.2 Suitability of Construction

Instruments shall be constructed so that all controls, indicators etc are suitable for service under normal conditions of use.

### 6.3 Suitability for Verification

Instruments shall be constructed so that the performance requirements of this document can be applied. In particular, provision shall be made for checking the force measurement transducers *in situ* by applying an input from a reference standard.

### 6.4 Zero Adjustment

Instruments shall be provided with facilities to set the instrument to be correct when the brake force is at zero.

### 6.5 Rollers

The rollers shall be designed so that there is minimal slip between the tyres and the rollers and excessive wear on the tyres is prevented.

## 7. INDICATORS AND PRINTING DEVICES

An instrument shall be provided with at least one indicator showing simultaneously the force values measured for each wheel or pair of wheels on one axle. In addition the balance between the two wheels shall be shown. Provision may also be made for indicating the speed and the load of each wheel. Other indicators and printers may be fitted and all shall comply with the following.

### 7.1 Clarity of Indications

Indications and printing shall be clear and unambiguous and printing shall be indelible.

Digital indications shall be stable at the changeover point. All digits shall be oriented in the normal viewing position and shall permit reading by simple juxtaposition.

## 7.2 Units of Measurement

All indicators shall include the name or symbol of the unit of measurement. On tickets, the name or symbol may be printed by the printer or preprinted on the ticket.

## 7.3 Value of the Scale Interval

The value of all scale intervals shall be in the form 1, 2 or  $5 \times 10^n$  where  $n$  is a positive or negative whole number or zero.

The value of the force scale interval shall not be greater than 1% of maximum quantity. All indicators and printers showing the force shall have the same value of the scale interval.

The value of the balance scale interval shall not be greater than 1%.

## 7.4 Decimal Numbers

If the indication is expressed in a decimal form, there shall be at least one zero preceding the decimal mark for values less than unity.

The decimal mark on tickets shall be printed with the measured value by the printer.

One or more fixed zeros may be used to the right of the variable numbers for values greater than unity.

## 7.5 Printed Information

Any printed ticket shall include sufficient information to identify the transaction, for example:

- owner identification;
- vehicle identification;
- force measurement for both wheels;
- balance measurement;
- date of transaction; and
- transaction serial number.

## 7.6 Multi-segment Indicators

When the quantity is displayed by means of multi-segment indicators, provision shall be made for automatic testing of the indicators by displaying all segments both on and off.

## 8. MARKINGS

Instruments shall be clearly and permanently marked on a permanently attached nameplate in the vicinity of the indicating device with the following information:

- manufacturer's name or mark;
- instrument designation (model identification);
- serial numbers of components of instrument and year of manufacture;
- pattern approval mark;
- maximum capacity (*max*);
- scale interval (*d*);
- any other special notice relating to the instrument or its indicators.

## 9. VERIFICATION MARK AND SEALING

### 9.1 Verification Mark

Provision shall be made for the application of a verification mark either on a stamping plug or on an adhesive label. The following requirements apply:

- (a) the mark shall be easily affixed without affecting the metrological properties of the instrument;
- (b) the mark shall be visible without moving or dismantling the instrument when in use;
- (c) the part on which the mark is located shall not be removable from the instrument without damaging the mark; and
- (d) the size of the space shall be sufficient to contain the marks applied by the verifying or certifying authority.

### 9.2 Sealing

Provision shall be made for sealing those devices with parameters that determine the measurement result.

## **10. CONSTRUCTION REQUIREMENTS FOR ELECTRONIC MEASURING INSTRUMENTS**

### **10.1 General**

Electronic measuring instruments shall be constructed so that they comply with the following metrological and technical requirements:

- influence factors specified in clause 5.1 and corresponding test procedures specified in Annex A; and
- disturbances specified in clause 5.2 and corresponding test procedures specified in Annex A.

### **10.2 Checking Facilities**

The following general requirements apply to checking facilities if they are included in the instrument to detect disturbances as specified in clause 5.2. The methods used for checking are the responsibility of the manufacturer. Facilities other than those referred to in this section may be required to maintain the metrological performance.

#### **10.2.1 Type**

The checking facility may be either permanent automatic (type P), intermittent automatic (type I) or non-automatic (type N) as appropriate.

#### **10.2.2 Evaluation of Facilities**

It shall be possible during the pattern approval examination to determine the presence and correct functioning of these facilities.

#### **10.2.3 Detection Indication**

If a significant fault is detected either the instrument is made inoperative or a visual or audible indication shall automatically occur and shall continue until the user takes action or the fault or error is corrected.

#### **10.2.4 Simulated Measuring Operation**

Means shall be provided to perform or simulate a measuring process typical of the electronic instrument:

- (a) when switched on, or in the case of an electronic instrument permanently connected to a mains power supply, on switching on the indication;
- (b) automatically at a selected period; or
- (c) at the discretion of the operator.

Such means could be, for example, a mechanical or electrical reference signal simulating and giving a measurement result.

#### **10.2.5 Transducer Check**

The presence of the transducer that it is working correctly within expected ranges and the correctness of the data transmission shall be checked during each measurement cycle.

#### **10.2.6 Processor Check**

All data storage components shall be checked at least when switching on the instrument or its indication to ensure that the values of all permanently memorised instructions and data are correct.

All relevant measurement data shall be checked for correct values whenever it is transferred or stored internally or transmitted to peripheral equipment through an interface.

#### **10.2.7 Indication Check**

When switching on the instrument or its indicator, a special procedure shall be performed which shows all relevant elements of the indicator display, in both active and non-active states, for sufficient time to allow the operator to check them.

#### **10.2.8 Auxiliary Devices Check**

The presence of the auxiliary device and the correctness of the data transmission shall be checked.

## SECTION IV — METROLOGICAL CONTROLS

### 11. GENERAL

The metrological control of measuring instruments consists of pattern approval, initial verification and subsequent verification.

#### 11.1 Pattern Approval

##### 11.1.1 Documentation

Submission of an instrument to NMI for pattern approval shall be accompanied by sufficient technical information including drawings, specifications, photographs and descriptions to ensure complete understanding of the construction and method of operation of the instrument.

Details of the measurement data contained in the memory, calculation methods and details of checking facilities shall also be provided.

For electronic measuring instruments the documentation shall include a list of electronic sub-assemblies with their essential characteristics, and a description of the electronic devices with drawings, diagrams and general software information explaining their construction and operation.

##### 11.1.2 Sample Instruments

Examination shall be carried out on at least one sample instrument submitted for laboratory-simulated tests.

The laboratory tests may be carried out on the components of the instrument instead of the instrument.

##### 11.1.3 Laboratory Examination

The instrument shall be examined in conjunction with the submitted documentation to ensure that it complies with the technical requirements of Section III.

##### 11.1.4 Laboratory-simulated Tests

Instruments or components of instruments tested under laboratory-simulated conditions

shall comply with the maximum permissible errors for laboratory-simulated tests (clause 4.2), influence factors, disturbances and humidity effects (clause 5) and performance tests (Annex A).

The tests may be carried out using an appropriate reference standard which applies a simulated quantity to the instrument representing the total quantity range likely to be met in practice.

For motor driven rollers the reference standard may consist of a lever attached to the motor and weights suspended on a weights hanger from a knife-edge located on the lever at a known distance from the centre line of the motor, roller assembly. By measuring the roller radius ( $r$ ), the lever length ( $l$ ) and knowing the value of the weights applied, the equivalent force in newtons at the circumference of the rollers is:

$$F(N) = W(\text{kg}) \times l(\text{mm}) \times 9.81 (\text{m/s}^2) / r (\text{mm})$$

The indicated force shall equal this value within the maximum permissible errors.

While carrying out the tests, the rollers shall be driven at the speed (or speeds) at which the instrument is used.

Before tests commence, the lever shall be balanced to give zero reading on the indicator with the rollers rotating and no load on the weights hanger.

#### 11.2 Initial Verification

Instruments tested for initial verification shall comply with the certificate of approval and the maximum permissible errors for initial and subsequent verification (clause 4.1). The reference standard and method of use specified in clause 11.1.4 may be used.

#### 11.3 Subsequent Verification

Subsequent verification shall be carried out to the same conditions as for initial verification.

**ANNEX A.**  
**PERFORMANCE TESTS AND EXAMINATIONS UNDER LABORATORY-  
SIMULATED CONDITIONS**

**A.1 GENERAL**

Performance tests carried out under the influence factors, disturbances and humidity effects specified in clauses 5.1, 5.2 and 5.3 respectively, ensure that electronic measuring instruments perform over a range of environmental conditions likely to be met in normal use.

The instrument shall be switched on for a period of time equal to, or greater than, the warmup time specified by the manufacturer. Power is to be 'on' for the duration of each test.

The reference standard providing the input during the tests shall be kept at reference conditions as specified in clause 4.5(e).

**A.1.1 Tests for Influence Factors**

At least three tests at five equally spaced, increasing and decreasing simulated quantities shall be carried out between minimum and maximum quantities, inclusive. The tests should first be carried out under reference conditions (clause 4.5(e)) and then at each of the extreme conditions of the influence factors specified in clause 5.1.

When the effect of one influence factor is being evaluated, all other factors shall be held relatively constant at a value close to the reference conditions specified in clause 4.5(e). The indication shall be adjusted to zero at zero quantity at reference conditions and shall not be adjusted again during the tests. Any deviation of zero indication due to the test condition shall be recorded and indications at any test quantity shall be corrected accordingly to obtain the measurement result.

The mean of the three test results at each quantity and each condition shall be calculated and compared with the maximum permissible errors. The three test results at each quantity shall be compared

with the permissible difference for repeatability. If applicable the variation between indicators shall also be checked against the permissible difference.

**A.1.2 Tests for Disturbances**

Tests for disturbances shall be carried out on all instruments, whether or not they are fitted with checking facilities.

At least three tests at one simulated quantity shall be carried out, firstly at reference conditions (see clause 4.5(e)) and no disturbances, and then with the applications of each disturbance specified in clause 5.2. Only one disturbance at a time shall be applied. The difference between the mean of the three tests with and without the disturbance shall be calculated and compared with the significant fault. All indicators shall be checked.

**A.1.3 Tests for Humidity Effects**

For the damp heat, steady state test, at least three tests at five equally spaced, increasing and decreasing simulated quantities shall be carried out at the reference conditions (clause 4.5(e)) before and after the application of the damp heat and at the specified damp heat.

The indication shall be adjusted to zero at zero quantity at reference conditions and shall not be adjusted again during the tests. Any deviation of zero indication due to the test condition shall be recorded and indications at any test quantity shall be corrected accordingly to obtain the measurement result.

The mean of the three test results at each quantity and at each condition shall be calculated and compared with the maximum permissible errors. The repeatability of three test results shall be compared with the permissible difference.

For damp heat, cyclic tests at least three tests at one simulated quantity shall be carried out at reference conditions (see clause 4.5(e)) before and after the application of the damp heat. The mean of the three test results shall be calculated and the difference between the two tests compared with the permissible change. Any deviation in zero indication shall be treated the same as for damp heat, steady state tests.

## **A.2 TEST PROCEDURES FOR INFLUENCE FACTORS**

Additional information for carrying out the test procedures for influence factors are given below. The instrument being tested is referred to as the equipment under test (EUT).

### **A.2.1 Static Temperatures Test**

The test procedure in brief consists of exposure of the EUT to constant temperatures within the range specified in clause 5.1, under 'free air' conditions for 2 h after the temperature of the EUT has stabilised. The EUT shall be tested as specified in Annex A.1.1 in the following order:

- (a) at a temperature of 20°C following conditioning;
- (b) at the specified high temperature of 40°C;
- (c) at the specified low temperature of -10°C; and
- (d) again at 20°C following conditioning.

The rate of change of temperature during the transition period between test temperatures shall not exceed 1°C/min and the humidity of the test environment shall not exceed 20 g/m<sup>3</sup>.

#### **Maximum Allowable Variations**

All functions shall operate as designed. The test results shall comply with the maximum permissible error for laboratory simulation tests specified in clause 4.2.

#### **References**

IEC 60068-2-1 (1990), IEC 60068-2-2 (1974) and IEC 60068-3-1 (1974).

### **A.2.2 Damp Heat Steady State Test**

The test procedure in brief consist of exposure to a temperature of 40°C and a relative humidity of 85% for a period of two days. The handling of the EUT shall be so that no condensation of water occurs on the EUT.

The EUT shall be tested as specified in Annex A.1.4.

#### **Maximum Allowable Variations**

All functions shall operate as designed. The test results shall comply with the requirements specified in clause 5.3.

#### **References**

IEC 60068-2-3 (1969), IEC 60068-3-4 (2001) and IEC 60068-2-56 (1988).

### **A.2.3 Damp Heat, Cyclic (Condensing) Test**

The test procedure in brief consists of exposure of the EUT to cyclic temperature variation between 25 and 40°C. The relative humidity shall be maintained above 95% during the temperature change and low temperature phases, and at 93% at the upper temperature phases. Condensation should occur on the EUT during the temperature rise.

The 24 h cycle consists of:

- (a) temperature rise during 3 h;
- (b) temperature maintained at upper value until 12 h from the start of the cycle;
- (c) temperature lowered to lower value within 3 to 6 h, the rate of fall during the first 90 min being such that the lower value would be reached in 3 h; and
- (d) temperature maintained at lower value until the 24 h cycle is completed.

The stabilising period before, and recovery after, the cyclic exposure shall be such that

all parts of the EUT are within 3°C of their final temperature. Two cycles shall be carried out.

The EUT shall be tested as specified in Annex A.1.4.

#### Maximum Allowable Variations

All functions shall operate as designed. The test results shall comply with the requirements specified in clause 5.3.

#### References

IEC 60068-2-30 (1980) and  
IEC 60068-3-4 (2001).

#### **A.2.4 AC Power Variation Test**

The test procedure in brief consists of subjecting the EUT to AC mains power variations specified in clause 5.1 under constant environmental conditions. The EUT shall be tested as specified in Annex A.1.1 in the following order:

- (a) at nominal voltage;
- (b) at an upper limit of 110% of nominal voltage; and
- (c) at a lower limit of 85% of nominal voltage.

The nominal values being those marked on the instrument.

#### Maximum Allowable Variations

All functions shall operate as designed. The test results shall comply with the maximum permissible error for laboratory simulation tests specified in clause 4.2.

#### **A.2.5 Battery Voltage Variation Test**

The test procedure in brief consists of subjecting the EUT to DC power supply variations specified in clause 5.1 under constant environmental conditions. The EUT shall be tested as specified in Annex A.1.1 in the following order:

- (a) at nominal battery voltage; and
- (b) at various reduced voltage below nominal battery voltage.

The nominal value being that specified by the battery manufacturer and marked on the battery.

#### Maximum Allowable Variations

All functions shall operate as designed. The test results shall comply with the maximum permissible errors for laboratory simulation tests specified in clause 4.2 or alternatively the indication shall blank.

### **A.3 TEST PROCEDURES FOR DISTURBANCES**

#### **A.3.1 Short Time Power Reduction Test**

The test procedure in brief consists of subjecting the EUT to short time power reductions by reducing the AC mains voltage. The test shall be conducted under constant environmental conditions.

A test generator suitable for reducing the amplitude of the AC mains voltage shall be used. The test generator shall be adjusted before connecting the EUT.

Each test shall be repeated ten times with an interval of at least 10 s. The EUT shall be tested as specified in Annex A.1.2 with the following reductions:

- (a) 100% reduction in 8 to 10 ms; and
- (b) 50% reduction in 16 to 20 ms.

#### Maximum Allowable Variations

If the instrument does not detect and react to a significant fault occurring as a consequence of the short time power reduction, then the fault shall not exceed the value defined in clause 5.2.

#### **A.3.2 Electrical Bursts Test**

The test procedure in brief consists of subjecting the EUT to electrical bursts of voltage spikes. The test shall be conducted under constant environmental conditions.

The transient generator shall have an output impedance of 50 Ω and shall be adjusted before connecting the EUT. At least ten positive and ten negative randomly phased



bursts of voltage spikes with a double exponential waveform shall be applied. Each spike shall have a rise time of 5 ns and a half amplitude duration of 50 ns. The burst length shall be 15 ms, the burst period (repetition time interval) shall be 300 ms.

The EUT shall be tested as specified in Annex A.1.2 at the following amplitudes (peak values):

- (a) 1 kV for power supply lines; and
- (b) 0.5 kV for input/output control circuit and communication lines;

with a repetition frequency of the impulses of  $5 \text{ kHz} \pm 20\%$ .

#### Maximum Allowable Variations

If the instrument does not detect and react to a significant fault occurring as a consequence of the electrical bursts, then the fault shall not exceed the value defined in clause 5.2.

#### Reference

IEC 61000-4-4 (1995).

### A.3.3 Electrostatic Discharge Test

The test procedure in brief consists of subjecting the EUT to electrostatic discharges under constant environmental conditions.

A capacitor of 150 pF shall be charged using a suitable DC voltage source. The capacitor shall then be discharged through the EUT by connecting one terminal to the ground (chassis) and the other via  $330 \Omega$  to surfaces which are normally accessible to the operator. At least ten discharges shall be applied. The time interval between successive discharges shall be at least 10 s. EUT not equipped with a ground terminal shall be placed on a grounded plate which projects beyond the EUT by at least 0.1 m on all sides. The ground connection to the capacitor shall be as short as possible.

In the contact discharge mode, to be carried out on conductive surfaces, the electrode shall be in contact with the EUT and the

discharge shall be actuated by the discharge switch of the generator.

In the air discharge mode, on insulating surfaces, the electrode shall be brought up to the EUT and the discharge occurs by spark.

The EUT shall be tested as specified in Annex A.1.2 at a test voltage of 6 kV for the contact mode and 8 kV for the air mode.

#### Maximum Allowable Variations

If the instrument does not detect and react to a significant fault occurring as a consequence of the electrostatic discharge, then the fault shall not exceed the value defined in clause 5.2.

#### Reference

IEC 61000-4-2 (2001).

### A.3.4 Electromagnetic Susceptibility Test

The test procedure in brief consists of exposing the EUT to electromagnetic radiation under constant environmental conditions. The field strength can be generated using the following methods:

- (a) the strip line is used at low frequencies (below 30 MHz or in some cases below 150 MHz) for small EUT;
- (b) the long wire is used at low frequencies (below 30 MHz) for larger EUTs; or
- (c) dipole antennas or antennas with circular polarisation placed 1 m from the EUT for high frequencies.

The specified field strength shall be established prior to the actual testing without the EUT in the field. The field shall be generated in two orthogonal polarisations and the frequency range shall be scanned slowly. If antennas with circular polarisation, i.e. log spiral or helical, are used to generate the electromagnetic field a change in the position of the antennas is not required.

When the test is carried out in a shielded enclosure to comply with international laws prohibiting interference to radio communications, the effect of reflected radiation from the shield shall be negated by such means as anechoic shielding.

The EUT shall be tested as specified in Annex A.1.2 at a field strength of 3 V/m, 80% AM, 1 kHz sine wave over a frequency range of 26 to 1 000 MHz.

#### Maximum Allowable Variations

If the instrument does not detect and react to a significant fault occurring as a consequence of the electromagnetic susceptibility of the instrument, then the fault shall not exceed the value defined in clause 5.2.

#### Reference

IEC 61000-4-3 (2002).

### BIBLIOGRAPHY

References are given below to publications of the International Electrotechnical Commission (IEC) of which mention is made in some of the tests in Annex A. Where available, reference is also made to the corresponding Australian standards.

IEC 60068-2-1 (1990) Basic Environmental Testing Procedures. Part 2: Tests. Test A: Cold. Section 3 — Test Ad: Cold for Heat-dissipating Specimen with Gradual Change of Temperature.

Also refer to amendments IEC 60068-2-1-am1 (1993) and IEC 60068-2-1-am2 (1994).

IEC 60068-2-2 (1974) Basic Environmental Testing Procedures. Part 2: Tests. Test B: Dry Heat. Section 4 — Test Bd: Dry Heat for Heat-dissipating Specimen with Gradual Change of Temperature.

Also refer to amendments IEC 60068-2-2-am1 (1993) and IEC 60068-2-2-am2 (1994).

IEC 60068-2-3 (1969) Basic Environmental Testing Procedures. Part 2: Tests. Test Ca: Damp Heat, Steady State.

The equivalent Australian standard is AS 1099.2.3–1990.

IEC 60068-2-30 (1980) Basic Environmental Testing Procedures. Part 2: Tests. Guidance for Damp Heat Tests. Test Dd and Guidance: Damp Heat, Cyclic (12 + 12-hour Cycle).

Also refer to amendment IEC 60068-2-30-am1 (1985).

IEC 60068-2-56 (1988) Basic Environmental Testing Procedures. Part 2: Tests. Test Cb: Damp Heat, Steady State, Primarily for Equipment.

IEC 60068-3-1 (1974) Basic Environmental Testing Procedures. Part 3: Background Information. Section 1 — Cold and Dry Heat Tests.

Also refer to first supplement IEC 60068-3-1A (1978).

IEC 60068-3-4 (2001) Environmental Testing — Part 3 –4: Supporting Documentation and Guidance — Damp Heat Tests.

IEC 61000-4-2 (2001) Electromagnetic Compatibility (EMC). Part 4: Testing and Measurement Techniques. Section 2 — Electrostatic Discharge Immunity Test.

IEC 61000-4-3 (2002) Electromagnetic Compatibility (EMC). Part 4: Testing and Measurement Techniques. Section 3 — Radiated, Radio-frequency, Electromagnetic Field Immunity Test.

IEC 61000-4-4 (1995) Electromagnetic Compatibility (EMC). Part 4: Testing and Measurement Techniques. Section 4 — Electrical Fast Transient/Burst Immunity Test. Also refer to amendments IEC 61000-4-4-am1 (2000) and IEC 61000-4-4-am2 (2001).