Specifications Guidelines

White Paper

Agilent Technologies has definitions for its Test & Measurement product specifications and how they are presented. The following material is extracted from these manufacturing recommendations. Some of the practices may not apply to (Agilent) products introduced before 1996, nor relate directly to those used in Agilent's worldwide service operations.

Product Specification Terminology

We begin by providing a basis for a common understanding of the language used at Agilent Technologies when discussing product specifications. Figure 1 depicts the hierarchy of terms.

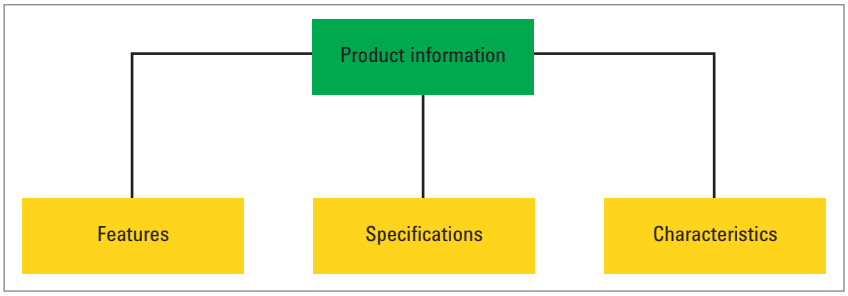

Figure 1. Hierarchy of terms

Product Specification Terminology (continued)

Product information is an overall term for any attribute used to describe a product and its capabilities. It is the most general term used for discussing the property of a product.

A **feature** is an attribute of product offered as a special attraction. Features describe, or enhance, the usefulness of the product to the customer. A feature is not necessarily measurable; however, it may have an associated measurable parameter. If a feature with a measurable parameter is of interest to the customer, a product specification describes its performance. For example, HP-IB I/O interface is a feature and it is not measurable but Narrow Resolution Bandwidth Filter is a feature with the measurable parameter bandwidth.

Specifications formally describe product performance. A specification is a numerical value, or range of values, that bounds the performance of a product parameter. The product warranty covers the performance of parameters described by specifications. Products meet all specifications when shipped from the factory, or from an Agilent Customer Service Center following calibration.

Environmental specifications bound the external conditions applied to a product for which the specifications are valid. Some specifications are only valid over a limited, or restricted, set of external conditions but in such cases the specification includes a description of these limited conditions. The environmental specifications also define the conditions that a product may be subjected to without permanently affecting product performance or causing physical damage. These can be climatic, electromagnetic (as related to electromagnetic susceptibility), mechanical, electrical (as related to the power requirements of a product), or preconditions of operation (e.g., warm-up time or calibration interval).

Characteristics describe product performance that is useful in the application of the product, but is not covered by the product warranty. They describe performance that is typical of the majority of a given product, but is not subject to the same rigor associated with specifications.

Characteristics are often referred to as *Supplemental Characteristics*, Typical or Nominal values but these terms are not formally defined. However, *supplemental characteristic* is a generic term generally referring to all non-warranted product performance. The terms *typical* and *nominal* generally indicate the expected performance of a given product.

Specifications

Specifications describe the performance of parameters covered by the product warranty. The specifications do not, however, imply that any specific statistical distribution describes the performance of a parameter. Rather, the specifications simply bound the quantity of a parameter. This section outlines the model used to verify that products meet the specifications. The model was presented by Sherry Read and Timothy Read in the *Hewlett-Packard Journal* of June 1988, in their article "Statistical Issues in Setting Product Specifications".

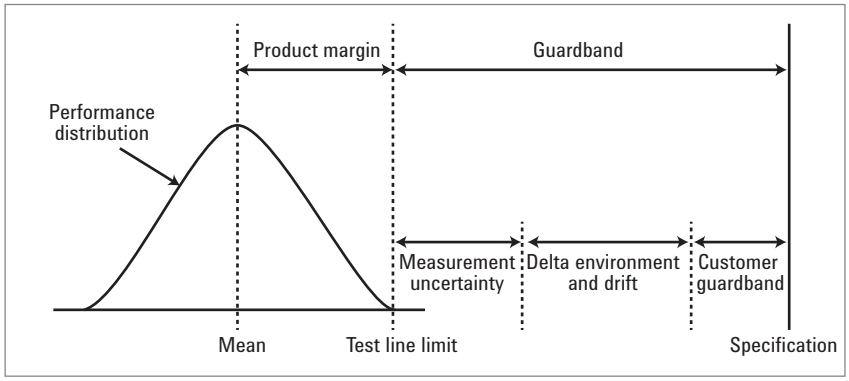

Figure 2. Statistical model for specifications

Figure 2 depicts the statistical model for the specifications. The model represents the relationship of a measured parameter and the specification. It shows a single-sided specification but a generalization of the model represents two-sided specifications that bound both sides of a parameter. Each element of the model is described.

Guardband is the difference between the test line limit and the value of the specification. The guardband accounts for measurement uncertainties, changes in performance due to external conditions, drift and any other mechanism that may affect performance. The application of guardband ensures, with a high level of confidence, that a product measured and found to be within the test line limit will meet the specification.

The **test line limit** is the pass-or-fail limit used by the manufacturing test procedures. The manufacturing test procedures perform measurements on products but not all parameters are actually measured. The performance parameter may be inferred through statistical correlation, sample testing, or other sound means. Products found to be outside the test line limit undergo repair and re-test.

The **performance distribution** represents the unit to unit variation of a parameter measured by a manufacturing test procedure. **Production margin** is a measure of the producability of the product. The proximity of the test line limit to the performance distribution determines the size of the production margin. A small production margin results in low yields from the manufacturing test procedures. A larger production margin results in higher yields but a potentially less competitive specification.

Specifications (continued)

Delta environmental represents the possible change in performance of a product over the range of external conditions applied to a product. Typically, the manufacturing test procedures execute under a limited set of external conditions; usually this is room temperature (25°C), 10-90% relative humidity and insignificant levels of electromagnetic interference, mechanical vibration and shock. Delta environmental guardband ensures that a product tested under a limited set of conditions meets the specifications for all conditions described by the environmental specifications.

Drift represents the possible change in performance of a characteristic over the calibration interval of a product.

Typically, delta environmental and drift is determined from empirical data gathered during the characterization phase of product development. In some cases, delta environmental and drift may be theoretically derived based on relevant data from components or materials used in a product.

Measurement uncertainty represents the possible errors associated with the equipment and the measurement techniques used during the testing of a product.

Customer guardband represents any additional guardband considered necessary to ensure that a product meets the specifications. In the majority of cases, the customer guardband is zero.

Characteristics and Supporting Specifications

Characteristics describe product performance that is useful in the application of the product, but is not covered by the product warranty. Characteristic information is representative of the product and in many cases, it may be supplemental to a specification. Characteristics are less structured than specifications. In most cases, they do not include the guardbands that are part of the specifications. Typically, determination of characteristics occurs during product development and they are not necessarily verified on all units produced.

They represent any one of the following:

- The average or median value of a parameter based on measurements from a significant number of units.
- A tolerance interval or proportion of a performance distribution derived from the measurement of a significant number of units. The proportion is typically greater than 80%.
- A parameter with a quantity that is not subject to variation (e.g., Marker Resolution). It may be either non-measurable, verifiable only through (non-traceable) functional pass-fail tests, or not be routinely measured. Nonetheless, if the feature associated with this characteristic is non-operational (and so yielding unexpected performance), the product warranty covers the repair of the failure.
- The quantity of a parameter that is not of significant importance to the customer (e.g., Product weight).
- The quantity of a parameter covered by a specification, but over a narrower range of conditions. For example, a specification describes the performance of a parameter over the 0 to 50 °C temperature range. A characteristic may describe the same parameter but over the 20 to 30 °C temperature range.

Supporting Specifications

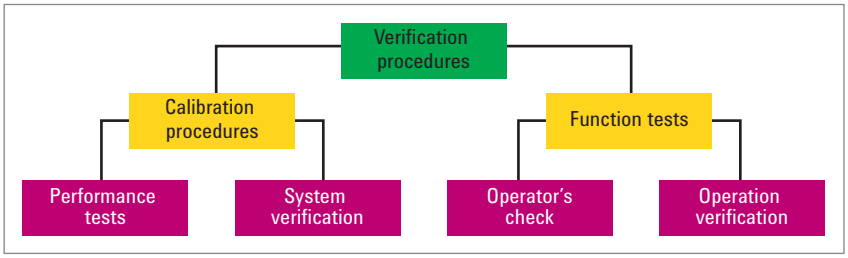

Figure 3. The testing hierarchy

Verification procedures are used to confirm the operation and performance of a product and include calibration procedures and function tests, as shown in Figure 3. Calibration procedures verify products meet specifications; function tests check them to be operational but do not necessarily verify products meet all specifications. The user documentation shipped with a product from the factory includes the verification procedures and clearly differentiate calibration procedures from function tests.

Function tests are quick tests designed to verify basic operation of a product. Function tests include operator's checks and operation verification procedures. An operator's check is normally a fast test used to verify basic operation of a product. An operation verification procedure verifies some, but not all, specifications, and often at a lower confidence level than a calibration procedure.

An **operator's check** performs a basic functional test of a product, use minimal test equipment and are run on a regular basis by the user of the product. Its purpose is to detect broken instruments; it does not verify performance to specifications. An operator's checks may be internal to a product; the procedure is executed by the product and may not require any external equipment or standards.

Operational verification (Op-Ver) tests are typically subsets of the performance tests. The purpose of operational verification tests is to verify instrument operation quickly with reasonable confidence. Operation verification procedures typically execute faster than calibration procedures because fewer points may be tested or a test system that is less accurate than the test system used for calibration procedures is used. They are usually performed after a repair or by customers as an incoming inspection. Normally, operation verification procedures test only the major parameters covered by specifications. Operation verification procedures do not verify that a product meets all specifications.

Calibration procedures verify that products or systems operate within the specifications. Calibration refers to the process of measuring parameters and referencing the measurement to a calibration standard, rather than the process of adjusting products for optimum performance. Parameters covered by specifications have a corresponding calibration procedure although some parameters may only be verified at the factory because special equipment is required. Calibration procedures include both performance tests and system verification procedures, are traceable to national standards and specify adequate calibration standards.

Supporting Specifications (continued)

Calibration procedures verify products meet the specifications by comparing measured parameters against a pass-fail limit which is the specification less any required guardband. The measurement uncertainty is not included as part of the guardband. Rather, the measurement uncertainty is reported along with the measured value on the test record card. Measured values that differ from the pass-fail limit by an amount less than the measurement uncertainty are specifically noted.

Calibration procedures also:

- Include instructions for the operation of the standards or accessory equipment
- Document the measurement uncertainty associated with each measured data point, or range of measured data points
- Specify the environmental conditions
- Provide a test record card
- Specify any required guardbands

Operating instructions

Calibration procedures include test method descriptions, a block diagram of the connections, and control settings for the unit-under-test and for the calibration standards. Specific setup instructions for the unit-under-test and for the standards are necessary for the operation of more complex instruments.

Environmental specifications

The external conditions applied during the performance of the calibration procedure are specified.

Test record card

A test record card is prepared as a result of performing a calibration procedure. This card provides:

- Reference to the test set-up
- A description of the measurement
- The pass-fail limits
- A space to record the actual reading
- The measurement uncertainty

Performance tests are the procedures used to verify that an instrument meets its specifications. **System verificatio**n procedures are the procedures to verify a system meets its system level specifications; however, system verification procedures do not verify the individual instruments of a system.

Measurement integrity

The technique developed to measure a particular parameter is designed to ensure that the results are traceable to standards that are external to the unit-under-test.

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Revised: October 11, 2012

Product specifications and descriptions in this document subject to change without notice.

This white paper was originally published in May 1996 and has been republished but not updated in 2012.

Published in USA, December 21, 2012
5991-1732EN

Agilent Technologies