



Designation: ~~C297/C297M – 04 (Reapproved 2010)~~ C297/C297M – 15

Standard Test Method for Flatwise Tensile Strength of Sandwich Constructions¹

This standard is issued under the fixed designation C297/C297M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method determines the flatwise tensile strength of the core, the core-to-facing bond, or the facing of an assembled sandwich panel. Permissible core material forms include those with continuous bonding surfaces (such as balsa wood and foams) as well as those with discontinuous bonding surfaces (such as honeycomb).

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. ~~Within the text the inch-pound units are shown in brackets.~~ The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.2.1 Within the text the inch-pound units are shown in brackets.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*²

[C271/C271M Test Method for Density of Sandwich Core Materials](#)

[C274 Terminology of Structural Sandwich Constructions](#)

[D792 Test Methods for Density and Specific Gravity \(Relative Density\) of Plastics by Displacement](#)

[D883 Terminology Relating to Plastics](#)

[D2584 Test Method for Ignition Loss of Cured Reinforced Resins](#)

[D2734 Test Methods for Void Content of Reinforced Plastics](#)

[D3039/D3039M Test Method for Tensile Properties of Polymer Matrix Composite Materials](#)

[D3171 Test Methods for Constituent Content of Composite Materials](#)

[D3878 Terminology for Composite Materials](#)

[D5229/D5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials](#)

[E4 Practices for Force Verification of Testing Machines](#)

[E6 Terminology Relating to Methods of Mechanical Testing](#)

[E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process](#)

[E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods](#)

[E456 Terminology Relating to Quality and Statistics](#)

[E1309 Guide for Identification of Fiber-Reinforced Polymer-Matrix Composite Materials in Databases](#)

[E1434 Guide for Recording Mechanical Test Data of Fiber-Reinforced Composite Materials in Databases](#)

[E1471 Guide for Identification of Fibers, Fillers, and Core Materials in Computerized Material Property Databases](#)

3. Terminology

3.1 *Definitions*—Terminology [D3878](#) defines terms relating to high-modulus fibers and their composites. Terminology [C274](#) defines terms relating to structural sandwich constructions. Terminology [D883](#) defines terms relating to plastics. Terminology [E6](#)

¹ This test method is under the jurisdiction of ASTM Committee [D30](#) on Composite Materials and is the direct responsibility of Subcommittee [D30.09](#) on Sandwich Construction.

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² For referenced ASTM standards, visit the ASTM website, [www.astm.org](#), or contact ASTM Customer Service at [service@astm.org](#). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

defines terms relating to mechanical testing. Terminology **E456** and Practice **E177** define terms relating to statistics. In the event of a conflict between terms, Terminology **D3878** shall have precedence over the other terminologies.

3.2 ~~Symbols:~~

~~A —cross-sectional area of a test specimen~~

~~CV —coefficient of variation statistic of a sample population for a given property (in percent)~~

~~F_z^{fu} —ultimate flatwise tensile strength~~

~~P_{max} —maximum force carried by test specimen before failure~~

~~S_{n-1} —standard deviation statistic of a sample population for a given property~~

~~x_1 —test result for an individual specimen from the sample population for a given property~~

~~\bar{x} —mean or average (estimate of mean) of a sample population for a given property~~

3.2 Symbols:

3.2.1 A —cross-sectional area of a test specimen

3.2.2 CV —coefficient of variation statistic of a sample population for a given property (in percent)

3.2.3 e —edge tolerance between specimen and loading blocks

3.2.4 F_z^{fu} —ultimate flatwise tensile strength

3.2.5 P_{max} —maximum force carried by test specimen before failure

3.2.6 S_{n-1} —standard deviation statistic of a sample population for a given property

3.2.7 x_1 —test result for an individual specimen from the sample population for a given property

3.2.8 \bar{x} —mean or average (estimate of mean) of a sample population for a given property

4. Summary of Test Method

4.1 This test method consists of subjecting a sandwich construction to a uniaxial tensile force normal to the plane of the sandwich. The force is transmitted to the sandwich through thick loading blocks, which are bonded to the sandwich facings or directly to the core.

4.2 The only acceptable failure modes for flatwise tensile strength are those which are internal to the sandwich construction. Failure of the loading block-to-sandwich bond is not an acceptable failure mode.

5. Significance and Use

5.1 In a sandwich panel, core-to-facing bond integrity is necessary to maintain facing stability and permit load transfer between the facings and core. This test method can be used to provide information on the strength and quality of core-to-facing bonds. It can also be used to produce flatwise tensile strength data for the core material. While it is primarily used as a quality control test for bonded sandwich panels, it can also be used to produce flatwise tensile strength data for structural design properties, material specifications, and research and development applications.

5.2 Factors that influence the flatwise tensile strength and shall therefore be reported include the following: facing material, core material, adhesive material, methods of material fabrication, facing stacking sequence and overall thickness, core geometry (cell size), size, cell wall thickness), core density, adhesive thickness, specimen geometry, specimen preparation, specimen conditioning, environment of testing, specimen alignment, loading procedure, speed of testing, facing void content, adhesive void content, and facing volume percent reinforcement. Properties that may be derived from this test method include flatwise tensile strength.

6. Interferences

6.1 *Material and Specimen Preparation*—Poor material fabrication practices, lack of control of fiber alignment, and damage induced by improper specimen machining are known causes of high data scatter in composites in general. Specific material factors that affect sandwich composites include variability in core density and degree of cure of resin in both facing matrix material and core bonding adhesive. Important aspects of sandwich panel specimen preparation that contribute to data scatter are incomplete or nonuniform core bonding to facings, misalignment of core and facing elements, the existence of joints, voids or other core and facing discontinuities, out-of-plane curvature, facing thickness variation, and surface roughness.

6.2 *System Alignment*—Excessive bending will cause premature failure. Every effort should be made to eliminate excess bending from the test system. Bending may occur as a result of misaligned grips, poor specimen preparation, or poor alignment of the bonding/loading blocks and loading fixture. If there is any doubt as to the alignment inherent in a given test machine, then the alignment should be checked as discussed in Test Method **D3039/D3039M**.

6.3 *Geometry*—Specific geometric factors that affect sandwich flatwise tensile strength include core cell geometry, core thickness, specimen shape (square or circular), adhesive thickness, facing thickness, and facing per-ply thickness.

6.4 *Environment*—Results are affected by the environmental conditions under which the tests are conducted. Specimens tested in various environments can exhibit significant differences in both strength behavior and failure mode. Critical environments must be assessed independently for each facing, adhesive and core material tested.

6.5 *Conditioning*—As it is inappropriate to bond a moisture-conditioned specimen to the bonding/loading blocks, it is necessary to perform the bonding operation prior to such conditioning. The presence of the bonding/loading blocks will affect the degree of moisture intake into the specimen, in comparison to a non-bonded sample.

7. Apparatus

7.1 *Micrometers—Micrometers and Calipers*—~~The micrometer(s) shall use a 4- to 5-mm [0.16- to 0.20-in.] nominal diameter ball-interface on irregular surfaces such as or a flat anvil interface shall be used to measure the specimen thickness. A ball interface is recommended for thickness measurements when facings are bonded to the core and at least one surface is irregular (e.g. the bag-side of a facing laminate, and thin facing laminate that is neither smooth nor flat). A micrometer or caliper with a flat anvil interface is recommended for thickness measurements when facings are bonded to the core and both surfaces are smooth (e.g. tooled surfaces). A micrometer or caliper with a flat anvil interface on machined edges or very smooth tooled surfaces. The shall be used for measuring length and width, as well as the specimen thickness when no facings are present. The use of alternative measurement devices is permitted if specified (or agreed to) by the test requestor and reported by the testing laboratory. The accuracy of the instrument(s) instruments shall be suitable for reading to within ~~±1%-1%~~ 1% of the sample length, width and thickness dimensions. For typical specimen geometries, an instrument with an accuracy of $\pm 25 \pm 0.025$ mm [± 0.001 in.] is desirable for thickness, length and width measurement. adequate for the length, width, and thickness measurements.~~

7.2 *Loading Fixtures*—The loading fixtures shall be self-aligning and shall not apply eccentric loads. A satisfactory type of apparatus is shown in Fig. 1. A dual-pin connection or universal joint shall be attached to each loading block to minimize any moments imparted to the test specimen. The loading blocks shall be sufficiently stiff to keep the bonded core or facings essentially

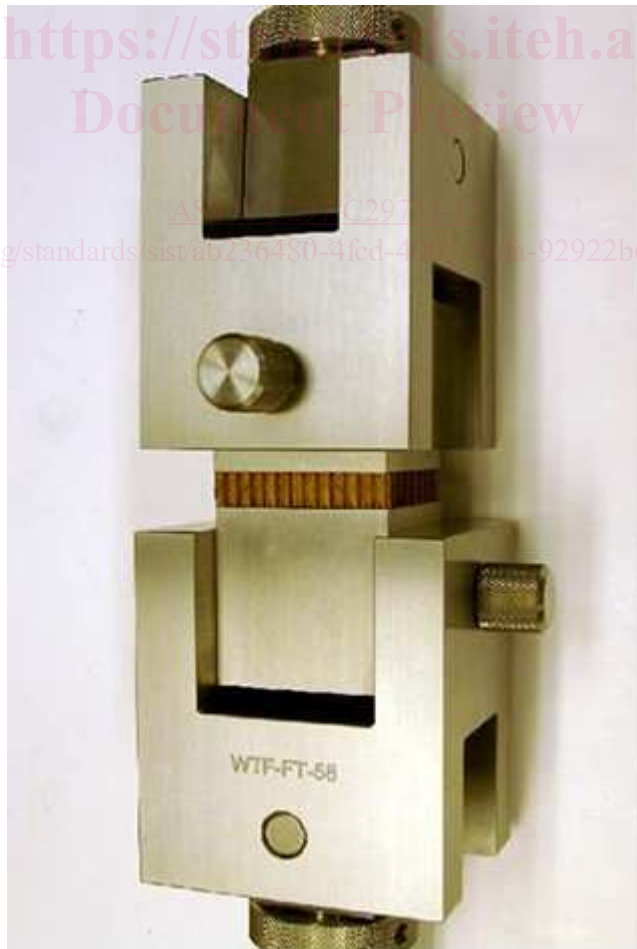


FIG. 1 Flatwise Tension Test Setup

flat under load. Loading blocks 40 to 50 mm [1.5 to 2.0 in.] thick have been found to perform satisfactorily. Permissible Recommended dimensions and tolerances for the loading blocks (along with alignment requirements) are provided in Fig. 2.

7.3 *Testing Machine*—The testing machine shall be in accordance with Practices E4 and shall satisfy the following requirements:

7.3.1 *Testing Machine Configuration*—The testing machine shall have both an essentially stationary head and a movable head.

7.3.2 *Drive Mechanism*—The testing machine drive mechanism shall be capable of imparting to the movable head a controlled velocity with respect to the stationary head. The velocity of the movable head shall be capable of being regulated in accordance with 11.6.

7.3.3 *Load Force Indicator*—The testing machine ~~load-sensing~~force-sensing device shall be capable of indicating the total force being carried by the test specimen. This device shall be essentially free from inertia lag at the specified rate of testing and shall indicate the force with an accuracy over the force range(s) of interest of within $\pm 1\%$ of the indicated value.

7.4 *Conditioning Chamber*—When conditioning materials at non-laboratory environments, a temperature/vapor-level controlled environmental conditioning chamber is required that shall be capable of maintaining the required temperature to within $\pm 3^\circ\text{C}$ [$\pm 5^\circ\text{F}$] $\pm 3^\circ\text{C}$ [$\pm 5^\circ\text{F}$] and the required relative humidity level to within $\pm 3\%$. Chamber conditions shall be monitored either on an automated continuous basis or on a manual basis at regular intervals.

7.5 *Environmental Test Chamber*—An environmental test chamber is required for test environments other than ambient testing laboratory conditions. This chamber shall be capable of maintaining the gage section of the test specimen at the required test environment during the mechanical test.

8. Sampling and Test Specimens

8.1 *Sampling*—Test at least five specimens per test condition unless valid results can be gained through the use of fewer specimens, as in the case of a designed experiment. For statistically significant data, consult the procedures outlined in Practice E122. Report the method of sampling.

8.2 *Geometry*—Test specimens shall have a square or circular cross-section, cross section, and shall be equal in thickness to the sandwich panel thickness. Recommended dimensions and tolerances for the core specimens are provided in Fig. 3. Minimum specimen facing areas for various types of core materials are as follows:

8.2.1 *Continuous Bonding Surfaces (for example, balsa wood, foams)*—The minimum facing area of the specimen shall be 625 mm² [1.0 in.²], and the minimum width or diameter of the loading blocks shall be 25 mm [1.0 in.]. Recommended tolerances for the core specimens are provided in Fig. 3.

8.2.2 *Discontinuous Cellular Bonding Surfaces (for example, honeycomb)*—The required facing area of the specimen is dependent upon the cell size, to ensure a minimum number of cells are tested. Minimum facing areas and specimen dimensions are recommended in Table 1 for the more common cell sizes. These are intended to provide approximately 60 cells minimum in

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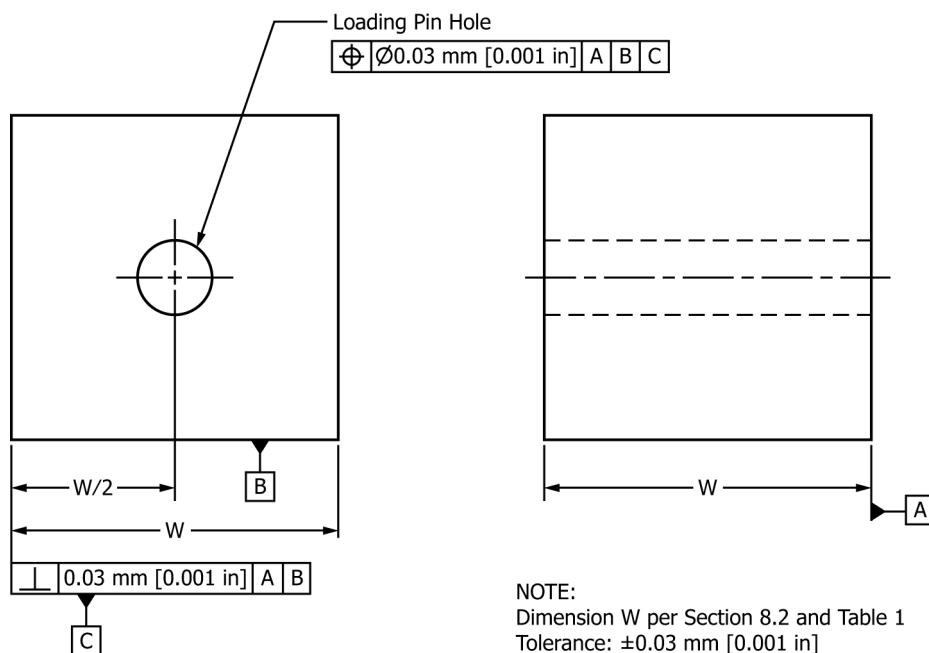
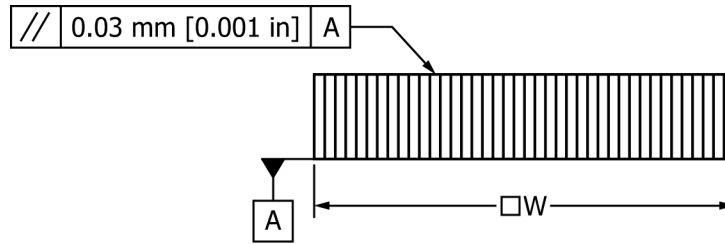


FIG. 2 Loading Block Dimensions and Tolerances



NOTES:

1. Dimension W per Section 8.2 and Table 1
2. Tolerance:
 - a) Cores with continuous bonding surfaces: $\pm 0.03 \text{ mm [0.001 in]}$
 - b) Cores with discontinuous bonding surfaces: $\text{Minimum } \{(\text{cell size})/2; \pm 3 \text{ mm } [\pm 0.1 \text{ in}]\}$

FIG. 3 Core Specimen Dimensions and Tolerances

TABLE 1 Recommended Minimum Specimen Facing Area

Minimum Cell Size (mm [in.])	Maximum Cell Size (mm [in.])	Minimum Facing Area (mm ² [in. ²])
-	3.0 [0.125]	625 [1.0]
3.0 [0.125]	6.0 [0.250]	2500 [4.0]
6.0 [0.250]	9.0 [0.375]	5625 [9.0]

TABLE 1 Recommended Minimum Specimen Facing Area and Loading Block Dimensions

Minimum Cell Size (mm [in.])	Maximum Cell Size (mm [in.])	Minimum Loading Block Dimension W (mm [in.])	Minimum Facing Area (mm ² [in. ²])
-	3.0 [0.125]	25 [1.0]	625 [1.0]
3.0 [0.125]	6.0 [0.250]	50 [2.0]	2500 [4.0]
6.0 [0.250]	9.0 [0.375]	75 [3.0]	5625 [9.0]

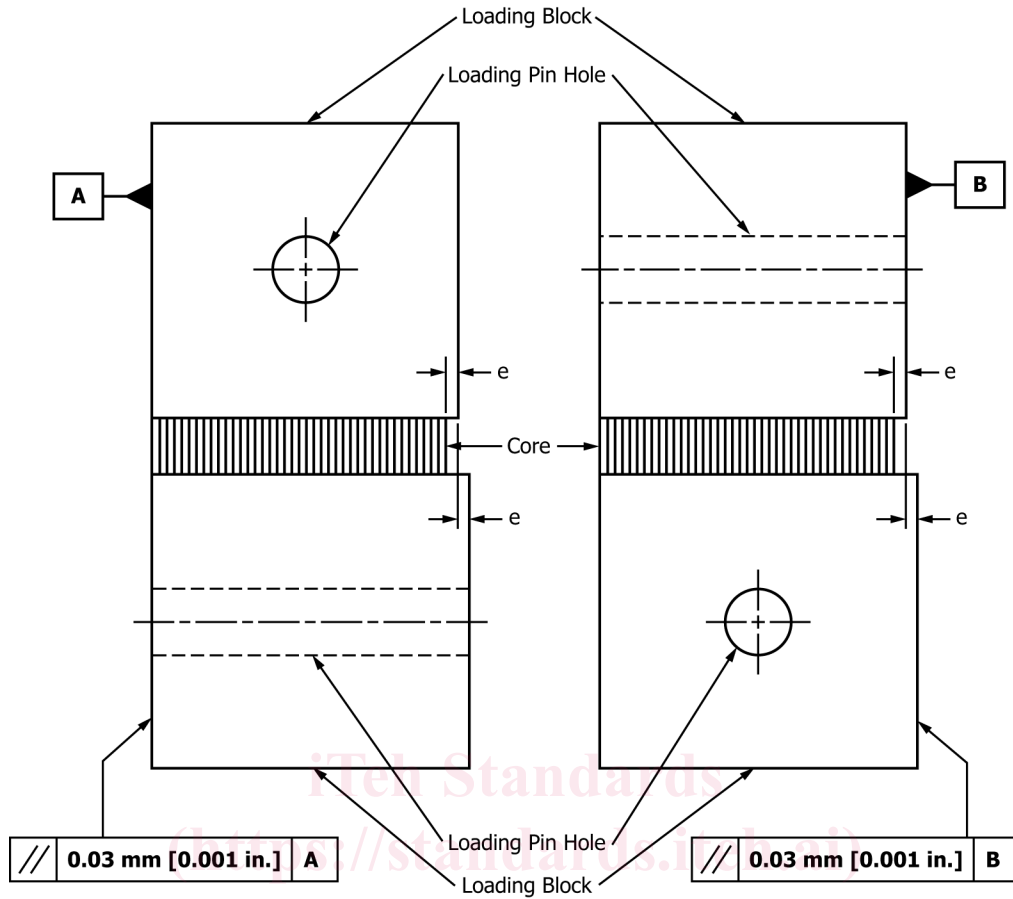
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the test specimen. The largest facing area listed in the table (5625 mm² [9.0 in.²]) is a practical maximum for this test method. Cores with cell sizes larger than 9 mm [0.375 in.] may require a smaller number of cells to be tested in the specimen.

8.3 Specimen Preparation and Machining—Specimen preparation is extremely important for this test method. Take precautions when cutting specimens from large panels to avoid notches, undercuts, rough or uneven surfaces, or delaminations due to inappropriate machining methods. Obtain final dimensions by water-lubricated precision sawing, milling, or grinding. The use of diamond tooling has been found to be extremely effective for many material systems. Edges should be flat and parallel within the specified tolerances. Record and report the specimen cutting preparation method.

8.4 Labeling—Label the test specimens so that they will be distinct from each other and traceable back to the panel of origin, and will neither influence the test nor be affected by it.

8.5 Loading Fixture Bonding—The loading blocks shall be bonded to the core or facings of the test specimen using a suitable adhesive. To minimize thermal exposure effects upon the existing core-to-facing bonds, it is recommended that the assembly bonding temperature be at room temperature, or at least 28°C [50°F] 28 °C [50 °F] lower than that at which the sandwich was originally bonded. Similarly, the assembly bonding pressure shall not be greater than the original facing-to-core bonding pressure. It is recommended to bond the specimens to the loading blocks using a suitable bonding fixture (e.g. one with a deep 90° v-shaped notch and a corner undercut) that provides support and alignment to the assembly during the entire bonding process. Take care to ensure that the specimen and blocks do not move during the bonding process. Permissible tolerances for the bonded assembly (along with alignment requirements) are provided in Fig. 24. Edge tolerances (e) between the specimen and loading block edges, as well as those between loading block edges, shall meet the requirements of Fig. 4 along each side of the specimen. Loading block edge parallelism requirements in Fig. 4 may be satisfied through the use of a bonding fixture which meets the parallelism requirements throughout the supporting surfaces.



NOTE:
 Edge Tolerance, e:
 a) Cores with continuous bonding surfaces: ± 0.03 mm [0.001 in]
 b) Cores with discontinuous bonding surfaces: Minimum $\{(cell\ size)/2\}; \pm 3$ mm [± 0.1 in]

FIG. 24 Permissible Bonded Assembly Dimensions and Tolerances

9. Calibration

9.1 The accuracy of all measuring equipment shall have certified calibrations that are current at the time of use of the equipment.

10. Conditioning

10.1 The recommended pre-test condition is effective moisture equilibrium at a specific relative humidity as established by Test Method D5229/D5229M; however, if the test requestor does not explicitly specify a pre-test conditioning environment, no conditioning is required and the test specimens may be tested as prepared.

10.2 *Standard Conditioning Procedure*—Unless a different environment is specified as part of the experiment, condition the test specimens in accordance with Procedure C. The pre-test specimen conditioning process, to include specified environmental exposure levels and resulting moisture content, shall be reported with the test data.

NOTE 1—The term “moisture,” as used in Test Method D5229/D5229M, includes not only the vapor of a liquid and its condensate, but the liquid itself in large quantities, as for immersion of Test Method D5229/D5229M, and store and test at standard laboratory atmosphere ($23 \pm 3^\circ\text{C}$ [$73 \pm 5^\circ\text{F}$] and $50 \pm 5\%$ relative humidity).

10.3 If no explicit conditioning process is performed, the specimen conditioning process shall be reported as “unconditioned” and the moisture content as “unknown.”

11. Procedure

11.1 *Parameters to Be Specified Before Test:*

- 11.1.1 The specimen sampling method, specimen geometry, and conditioning travelers (if required).
- 11.1.2 The properties and data reporting format desired.