



Standard Test Method for External Fixator Joints¹

This standard is issued under the fixed designation F 1747; 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.

1. Scope

1.1 This test method covers the procedures for determining the stiffness and strength of external fixator joints under axial loads and bending moments.

1.2 Depending on its design and its use in the overall construct, the joint of an external fixator needs to transmit one or more components of loading (tension, compression, torsion, or bending, or all of these) between the elements it grips (anchorage elements or bridge elements), without either itself or its gripping interface(s) undergoing either permanent deformation or excessive elastic deformation.

1.3 This test method also covers procedures for determining the range of adjustability in degrees of freedom for which the joint's configuration can be adjusted by the user, and procedures for determining the joint's range of motion in degrees of freedom for which motion is permitted if the fixator is unlocked.

1.4 *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:

- E 4 Practices for Load Verification of Testing Machines²
- F 1541 Terminology and Classification of External Skeletal Fixators³
- F 1745 Test Method for External Fixator Connectors³
- F xxx1 Test Method for External Fixator Performance and Testing³

3. Terminology

3.1 Definitions:

3.1.1 *hysteresis*—for cyclic loading, is defined as unity minus the ratio of energy recovered (during load release) to energy input (during load uptake).

3.1.2 *input loading axis*—the line of application in the case

of a force input, or the axis about which a moment is applied in the case of a moment input.

3.1.3 *input loading element*—that fixator element (for example, pins, rod) gripped by the joint, through which the applied force or moment loading is transmitted to the joint.

3.1.4 *joint*—an external fixator sub-assembly consisting of a connecting element and one or more bridge or anchorage elements gripped by that connector.

3.1.5 *output loading element*—that fixator element through which restraint to the applied load is provided, by means of attachment to the testing machine base.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *connector*—of the two (or more) elements comprising any joint or junction, the connector is that element to which the end-user applies an active gripping force or torque in order to engage the attachment.

3.2.2 *joints*—joints should be described in terms of the types of elements that they connect, and, where appropriate, in terms of their adjustment or unlocked degrees of freedom.

3.2.2.1 *Discussion*—Examples of joints are a pin/rod articulation, a pin-cluster/rod articulation, a ring/rod articulation, and a rod/rod articulation, in each case with the connector being considered as an integral part of the articulation.

3.2.2.2 *Discussion*—Joints whose configuration can be adjusted, or that can be selectively unlocked to permit specific types of motion, are said to possess adjustment degrees of freedom or unlocked degrees of freedom, respectively, in the corresponding linear or angular displacement directions.

4. Summary of Test Method

4.1 Connecting elements (clamps) are obtained, and if applicable, assembled using the techniques and equipment recommended by the manufacturer.

4.2 Unlike testing of the connecting element alone, testing a joint requires inclusion of the specific bridge or anchorage elements gripped by the connector, or both, that in principle may slip with respect to the connector during load uptake.

4.3 Axial loads or bending moments are applied to the joint through one of the gripped elements, and a graphical plot of load (or moment) versus displacement is used to determine the effective stiffness (and strength, if tested to failure) of the joint.

4.4 For range of adjustability/motion assessment, the joint is unlocked, and quasi-static linear or angular displacements are input until encountering a discontinuous increase in resisting

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² Annual Book of ASTM Standards, Vol 03.01.

³ Annual Book of ASTM Standards, Vol 13.01.

force or moment, indicative of the limit of adjustability or motion of the joint in the particular degree of freedom considered.

5. Significance and Use

5.1 These laboratory benchtop tests are used to determine values for the effective stiffness (or strength, or both) of an articulation, under force or moment loadings.

5.1.1 The deformations accruing under loading consist of elastic deformation in the clamp body itself, plus any deformation (especially, slip) occurring at the interface between the clamp and the gripped element(s).

5.1.2 Where appropriate, the joint's range of adjustability or its range of motion when "dynamized," or both, are also measured.

5.2 The results obtained in this test method are not intended to predict the clinical efficacy or safety of the tested elements. This test method is intended only to measure the uniformity of the elements tested, or to compare the mechanical performance of different joints.

5.3 This test method may not be appropriate for all types of external skeletal fixator applications. The user is cautioned to consider the appropriateness of the method in view of the materials and designs being tested and their potential application.

6. Apparatus

6.1 Force (or Moment, or Both) Application Fixture:

6.1.1 The loading configuration is shown schematically in Fig. 1. The loading input axis must pass through one of the bridge (or anchorage) elements gripped by the connector.

6.1.2 Gripping of the input loading element by the testing apparatus should be at a site as close as possible to the body of the connector, so as to minimize elastic flexure in the loading input element itself.

6.1.3 Restraint is provided either:

6.1.3.1 By rigidly affixing the body of the connector to the testing machine base, in which case the only (potential slip-page) interface included in the loading path is that between the loading input element and the connector body; or

6.1.3.2 By rigidly affixing another of the gripped elements, termed the loading output element, to the testing machine base (again, gripping as closely as possible to the connector). In this case, two potential slip interfaces are included in the loading path.

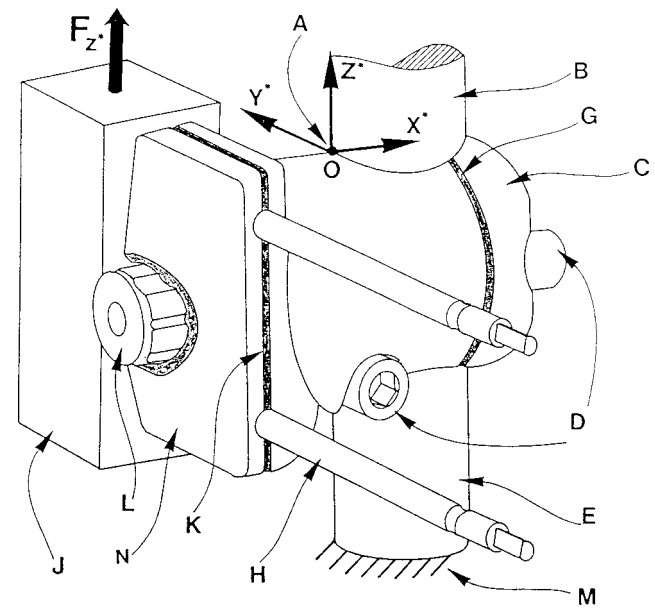
6.2 Load Frame—Machines used for testing shall conform to the requirements of Practice E 4. The loads used for the test shall be within the loading range of the test machine as defined in Practice E 4.

6.3 Data Acquisition Device—A suitable recorder to plot a graph of load versus load frame displacement on perpendicular axes.

7. Test Specimens

7.1 All tested elements should normally be representative of new clinical quality products.

7.2 If one or more of the elements to be tested has been previously used, appropriately describe the nature of such prior usage.



- A. Local coordinate system, defined with respect to landmark point O)
- B. Rod (as normally gripped by connector)
- C. Connector body
- D. Connector tightening mechanism(s)
- E. Output loading element (here, a rod gripped by the connector and rigidly affixed to the test machine base.)
- G. Rod grip interface
- H. Pins (as normally gripped by connector)
- J. Loading platen, clamped to pins (the input loading element) as closely as possible to the site of connector gripping)
- K. Pin clamping interface
- L. Pin grip/clamp tightening mechanism
- M. Testing machine base (fixed)
- N. Pin grip/clamp

NOTE 1—In this figure, the input loading is a force F_{z^*} in the Z^* direction, delivered through an input platen clamped to the input loading element (the pins).

FIG. 1 Schematic for Testing an External Fixator Joint (Example Generic for a Pin-Rod Joint)

7.3 Prepare the test specimens in the manner in which they would normally be used clinically. For example, if a particular joint would normally be sterilized in a particular manner prior to use, it should be similarly sterilized prior to mechanical testing.

7.4 If the elements to be tested are prototypes or are under development, or both, either include in the report the geometric and material information needed to fully characterize all such elements, or reference detailed descriptive information.

8. Procedure

8.1 Assembling the Joint to be Tested:

8.1.1 Clamp the input loading element (and, if appropriate, the output loading element) by the connecting element according to manufacturer instructions. In situations where this clamping force (or torque) is discretionary, measure and record the magnitude of the applied tightening force (or torque) since this may affect interface slip.

8.1.2 The input (and output) loadings elements serve as attachments for gripping by the testing apparatus. This test method is applicable only to those components of loading (force or moment, or both) that can be applied through such elements.