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Designation: ~~D8019 – 15~~ D8019 – 23

Standard Test Methods for Determining the Full Section Flexural Modulus and Bending Strength of Fiber Reinforced Polymer Crossarms Assembled with Center Mount Brackets[1]

This standard is issued under the fixed designation D8019; 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~~ Scope*

1.1 These test methods cover the determination of the flexural modulus and bending strength of both the tangent and deadend ~~arms bent about their~~ Fiber Reinforced Polymer (FRP) composite crossarms loaded perpendicular to the plane of minor and major axes. One method covers testing of assembled tangent crossarms including the tangent bracket and relative hardware. The other method covers testing of assembled deadend crossarms with a deadend bracket and relative phase loading hardware. The failure modes and associated stresses can be used for predicting the phase load capacities of pultruded crossarms specific to certain conductor loading ~~scenarios.~~scenarios exerted by conductors.

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1.2 The test ~~methods~~data described in this standard can be used for predicting the vertical and horizontal component loads of deadend and tangent arms. Both deadend and tangent crossarms shall be tested in the two configurations described in Figures 1 and ~~2.~~ 2, respectively. This will permit the ~~manufactures~~manufacturers to publish both vertical and horizontal design capacities for deadend crossarm configurations so that two way bending stresses, caused by catenary effects, can be considered when developing the capacity of the deadend crossarms by utility design engineers and manufacturers.

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

1.4 This standard will not address all factors that affect the phase loading capacity.

1.5 This standard does not address the use of core materials that are added to increase the structural capacity of the crossarms. ~~Core material~~ Contribution of core materials shall not be considered ~~in~~within the calculations provided in this standard. Use of core material properties in design computations to identify improvement in design strengths of crossarms is the sole responsibility of the designee in-charge of the project.

1.6 Torsional effects occurring during standard in service usage are not considered within this standard.

1.7 *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~~safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

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[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.18 on Reinforced Thermosetting Plastics.

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***A Summary of Changes section appears at the end of this standard**

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NOTE 1—There is no known ISO equivalent to this standard.

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D883 Terminology Relating to Plastics
D4968 Practice for Annual Review of Test Methods and Specifications for Plastics
E4 Practices for Force Calibration and Verification of Testing Machines
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E456 Terminology Relating to Quality and Statistics
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E2935 Practice for Evaluating Equivalence of Two Testing Processes

3. Terminology

3.1 Terms used in this standard are defined in accordance with Terminology D883, unless otherwise specified. For terms relating to precision and bias and associated issues, the terms used in this standard are defined in accordance with Terminology E456.

3.2 Definitions of variables used in the calculations as shown in Section 11 are as follows:

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a = distance from phase hardware to the center mount bolt through the crossarm, in. (m),
A_w = area of the webs in shear in.^{2} [m^2],
E = flexural modulus, psi (Pa),
I = moment of inertia about the neutral axis of the crossarm, in.^{4} [m^4],
L = support span, in. [m],
M = moment at failure, lbf-in [N•m],
P = ultimate or failure load acting through a single center mount bolt, lbf [N],
S_x = section modulus about the neutral axis of the crossarm, in.^{3} [m^3],
V = in-plane shear force, lbf [N],
σ = bending stress at failure, psi [Pa],
δ = deflection relative to the applied load, in. [m],
τ_{max} = maximum transverse shear stress, psi [Pa],
Q = static moment of area in.^{3} [m^3],
t = thickness of region or regions under consideration in. [m].

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4. Summary of Test Methods Including Deadend and Tangent Crossarm Configurations with Commercial Hardware Attached

4.1 *Deadend Crossarms:*

4.1.1 The assembled deadend crossarm, including two phase single sided position hardware and a center mount bracket fabricated to the specifications as detailed by the manufacturer, is positioned in a ~~three point~~ bend apparatus and loaded until failure occurs.

4.1.2 A center mount bracket or a fabricated test bracket, matching the bolt size and dimensional specifications of the ~~manufacturers~~manufacturer's commercial bracket, is attached to the arm as detailed by the manufacturer.

~~4.1.3 A three point bend load is then induced into the cross arm assembly until a structural failure of the hardware or crossarm occurs.~~

4.1.3 The bracket is to be loaded or constrained, depending on the load apparatus, such that no eccentric loading occurs.

[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.

4.1.4 Load is induced into the crossarm assembly until a structural failure of the hardware or crossarm occurs.

4.1.5 Load and deflection data are to be recorded at set intervals or continuously until failure occurs.

4.2 *Tangent Crossarms:*

4.2.1 The assembled tangent crossarm, including ~~two phase single sided deadend position hardware and~~ a center mount tangent bracket fabricated to the specifications as detailed by the manufacturer, is positioned in a ~~three point~~ bend apparatus and loaded until failure occurs.

4.2.2 A tangent bracket, matching the ~~specifications,~~specifications of the ~~manufacturers~~manufacturer's commercial bracket, is attached to the arm as detailed by the ~~manufacturer.~~manufacturer, and schematically shown in Figs. 3 and 4.

~~4.2.3 A three point bend load is then induced into the crossarm assembly such that the bracket and phase hardware is loaded until failure.~~

4.2.3 The bracket is to be loaded or constrained, depending on the load apparatus, such that the load produces eccentric loading into the bracket and arm mimicking the tangent connection to a wood, fiberglass, steel or concrete pole.

4.2.4 A load is induced into the crossarm assembly such that the bracket and phase hardware is loaded until failure.

4.2.5 Load and deflection data are to be recorded at set intervals or continuously until failure occurs.

5. Significance and Use

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5.1 Determination of the flexural modulus, beam bending strength and full assembly strength, by this test method is especially useful for product validation, design and specification purposes.

5.2 Calculated values for flexural modulus, bending strength and full assembly strength will vary with specimen depth, span length, hole configurations, loading rate, and ambient test temperature. A minimum span to depth ratio of 16:1 is required for establishing the flexural ~~modulus.~~ modulus, wherein shear deformation effects are neglected.

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5.3 *Validity*—Stress at failure, σ, is only valid for crossarm failures due to local compression buckling. Other controlling modes of failure will dictate the ultimate phase loading capacities. For example, in-plane shear, fastener pin bearing, position hardware, center mount failures and fastener pull out will dictate the failure mode and ~~ultimately~~ the crossarm capacity.

6. Apparatus

6.1 *Testing Machine*—A properly installed and operated load actuator, ideally one which can be operated at constant rates of load or deflection, used in combination with a properly calibrated load cell. Error in the load measuring system shall not exceed ±1 % of the maximum load expected to be measured. The test setup shall also be equipped with deflection measuring devices. The stiffness of the testing apparatus shall be such that the total elastic deformation of the load frame does not exceed 1 % of the total deflection of the test specimen during testing, or appropriate corrections shall be made. The accuracy of the testing machine shall be calibrated and verified in accordance with Practices E4.

6.2 *Loading Noses and Supports*—The crossarms shall be either loaded through the center mount, or through the phase hardware. The test fixture shall allow for various lengths of crossarms to be evaluated. The crossarm length range shall be dictated by typical industry requirements. Spreader bars used throughout the testing shall be doubly symmetric steel sections. The spreader bar shall be oriented to induce bending about the major axis. Additionally, the spreader bar shall be designed to allow for in-plane movement parallel to its minor axis.

6.3 ~~*Loading Noses and Supports:*~~ *Deadend Crossarm Loaded Through the Center Mount:*

6.3.1 *2-Conductor Locations*—~~The manufacturer's deadend crossarm shall be either loaded through the center mount, or through the phase hardware. In the event of~~ When loading through the center mount, the manufacturer's deadend crossarm shall be assembled with a production center mount bracket or fabricated replica. Load shall be applied through the back of the center mount bracket. The deadend crossarm shall be fully fabricated, representing the finished product, with the phase position deadend hardware attached. The crossarm test fixture supports shall connect directly to the phase position hardware. Load is applied through the center mount bracket, into the arm and resisted by the phase loading eye nut hardware representing a two phase single sided deadend crossarm fabrication. The loading configuration described is shown in Fig. 1.

6.3.2 *4-Conductor Locations*—For ~~deadend crossarm testing loaded through the phase hardware, and for tangent crossarm testing, the manufacturer's center mount shall be mounted to a rigid structure that represents a pole structure in the proper orientation. The crossarm shall be loaded by pulling on the phase hardware in an appropriate direction for the test method. For tangent crossarm testing, this would be in an apparent vertical direction. For deadend crossarm testing, this would be in an apparent horizontal direction.~~ designs with four or more phase hardware positions, a spreader bar shall be used to connect the two outermost phase hardware positions on each side. The point centered between the two position attachments is then attached to the support. This configuration is used to determine assembly, strength capacity only, not modulus calculations. The loading configuration described is shown in Fig. 2.

~~6.3 *Deadend Crossarm Test Set Up*—The test fixture shall allow for various lengths of crossarms to be tested. The crossarm length range shall be dictated by typical industry offerings. The fixture shall permit the loading of the arm in one of two ways: such that the load is applied through the center mount bracket, into the arm and resisted by the phase loading eyenut hardware representing a two phase single sided deadend crossarm fabrication, or such that the load is applied through the phase loading eye nut hardware representing two phase single sided deadend crossarm fabrication, into the arm, and resisted by the secured center mount bracket. The loading configuration described is shown in Fig. 1.~~

~~6.4 *Tangent Crossarm Test Set Up*—The test fixture shall allow for various lengths of tangent crossarms to be tested. The crossarm length range shall be dictated by typical industry requirements. The fixture shall permit the tangent bracket to be solidly mounted to a structural member that represents a pole.~~

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6.4 ~~In absence of specific insulator hardware requirements for application, the tangent crossarm shall be loaded by applying an apparent vertical force through two eyenuts, hoist rings, or other securing hardware connected to the load apparatus using a threaded rod or bolt at the appropriate conductor location, in a configuration which represents typical tangent arm usage. The load path shall propagate from the eyenut or other securing hardware, through the threaded rod or bolt, to washers which span the entire width of the crossarm. The load shall then be distributed from the washer, through the crossarm, where it is then distributed to the tangent bracket and into the mount. It is critical that the mount used in the commercial sale of the tangent arm be used in the test, as the arm strength will be influenced by the hardware or center mount. The loading configuration described is shown in Fig. 2.~~*Crossarms Loaded Through Phase Hardware:*

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6.4.1 *2-Locations*—For deadend crossarm tests loaded through the phase hardware, and for tangent crossarm testing, the manufacturer's center mount shall be mounted to a rigid structure that represents a pole structure in the proper orientation. The crossarm shall be loaded by pulling on the phase hardware in an appropriate direction for the crossarm configuration. For tangent crossarm testing, this would be in an apparent vertical direction. For deadend crossarm testing, this would be in an apparent horizontal direction. The load shall be applied through the two outermost phase hardware positions on each side of the center mount bracket and into the arm, resisted by the secured center mount bracket. In absence of specific insulator hardware requirements for application, the crossarm shall be loaded by applying force through two eye nuts, hoist rings, or other securing hardware connected to the load apparatus using a threaded rod or bolt at the appropriate conductor location. The load path shall

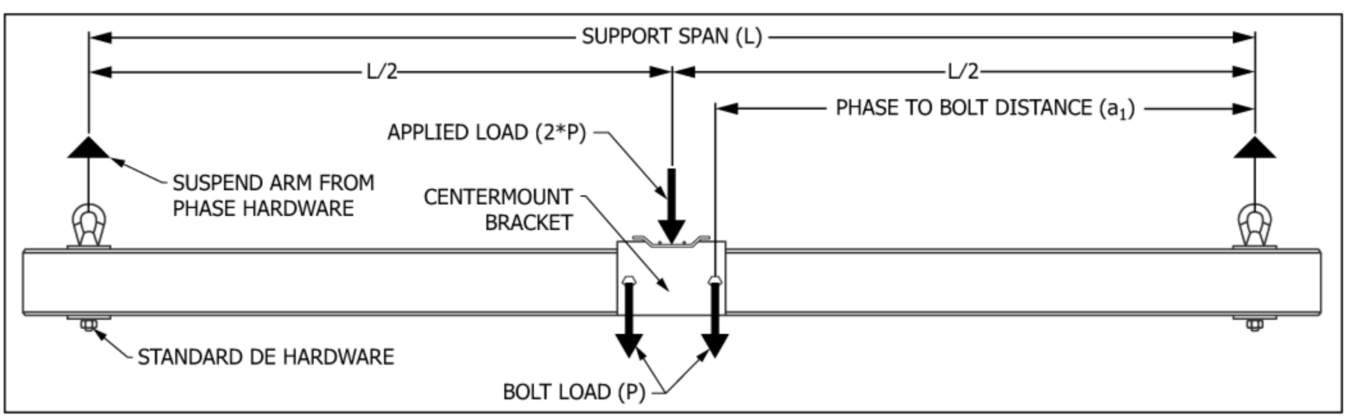

FIG. 1 ~~Three-Point Bend Dead End Crossarm Test Set Up~~Test Set Up—2 Phase Deadend Loaded Through the Center Mount

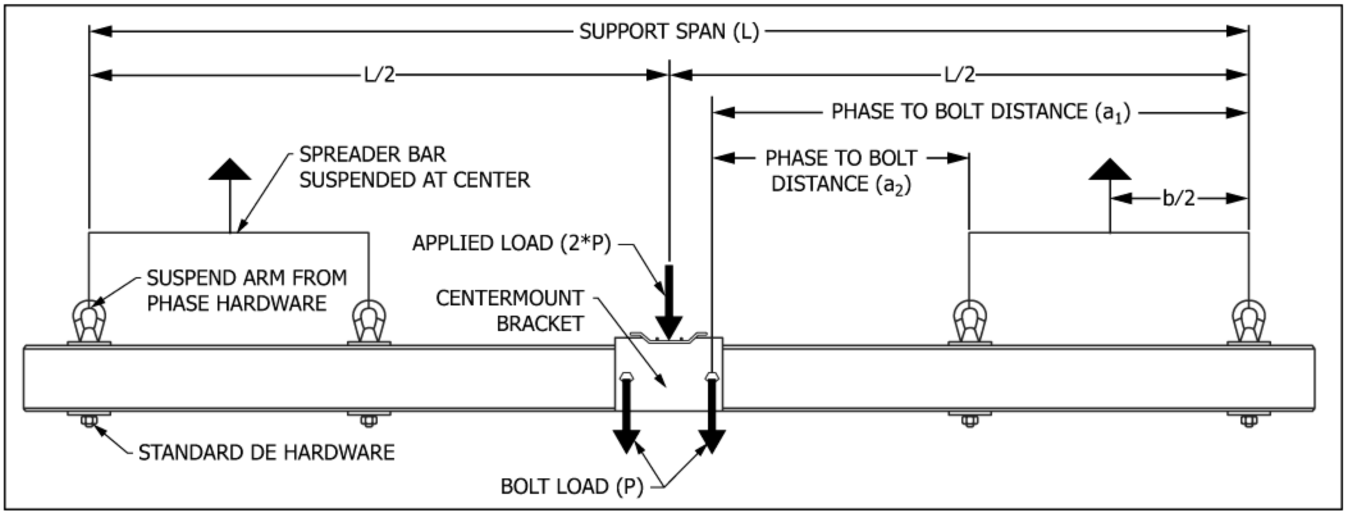

FIG. 2 ~~Three-Point Bend Tangent Crossarm Test~~Test Set Up—4 Phase Deadend Loaded Through the Center Mount

propagate from the eye nut or other securing hardware, through the threaded rod or bolt, to washers which span the entire width of the crossarm. The load shall be distributed from the washer, through the crossarm, where it is then distributed to the center bracket and into the support fixture. It is critical that the mount used in the commercial sale of the crossarm be used in the test, as the arm strength will be influenced by the hardware or center mount. The loading configuration described is shown in Fig. 3.

NOTE 2—This configuration can also be used for non-primary loading direction tests, vertical for deadends and horizontal for tangents. The secondary attachment through-hole shall be perpendicular to the primary direction.

6.4.2 *4-Locations*—For designs with four or more phase hardware positions, load shall be applied to the position hardware either by a spreader bar connecting the two outermost locations, or by using independent load-controlled actuators at each location. This configuration is used to determine assembly strength capacity only, not modulus calculations. The loading configuration described is shown in Fig. 4.

6.5 *Deflection Measuring Device*—A properly calibrated device to measure the deflection of the crossarms shall be used. The device shall automatically and continuously record the deflection during the test. In the absence of an automated data acquisition system, a properly calibrated deflection dial gauge shall be used. A minimum of ten manual recordings shall be taken at approximately the same load increments throughout the duration of the test. The deflection dial gauge shall ~~be accurate to~~ have a resolution of ±0.001 in. [±0.0254 mm].

7. Sampling and Test Specimens

7.1 *Sampling*—A minimum of five specimens, per each test method described in 4.1 and 4.2, shall be tested for each arm length that displays a different failure mode. Alternatively, the minimum quantity as required by the agency or the appropriate codes and standards.

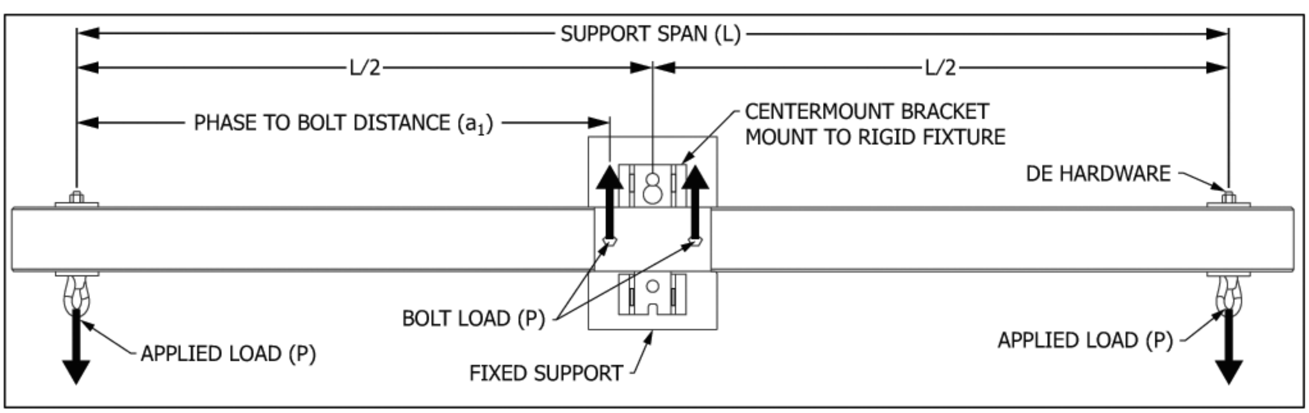

FIG. 3 Test Set Up—2 Phase Crossarm Loaded Through the Phase Hardware

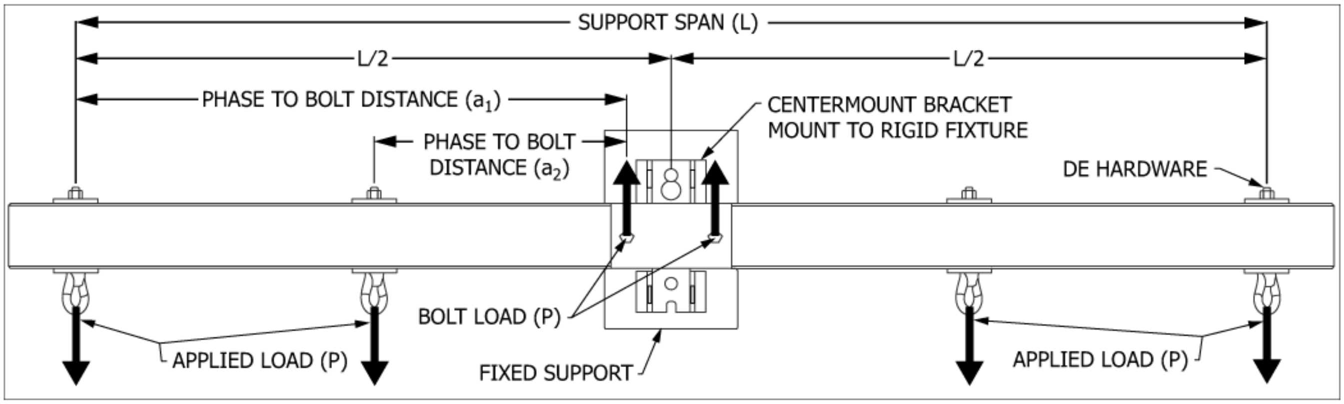

FIG. 4 Test Set Up—4 Phase Crossarm Loaded Through the Phase Hardware

7.2 *Specimens*—Specimens shall be full-scale samples, fabricated in accordance with the manufacturer's specifications and outfitted with standard deadend or tangent crossarm hardware and tested at the desired span length.

7.3 *Specimen Preparation*—Specimens shall be of the same material composition, geometric characteristics, and manufactured by the same process as those described in the manufacturer's specifications and as available commercially.

7.4 *Labeling*—Label the test specimens (date, batch number, line number) so that they will be distinct from each other and traceable back to the specimen of origin, and will neither influence the test nor be affected by it.

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NOTE 3—Non-load bearing accessories such as identification (I.D.) tags, end caps and commercial markings are not required for test specimens.

8. Calibration and Standardization

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

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9. Conditioning

9.1 If the test requestor does not explicitly specify a pre-test conditioning environment, conditioning is not required, and the ~~test~~ specimens shall be tested at normal room temperature (20-25°C or 68-77°F).

9.2 If no explicit conditioning process is performed the specimen conditioning process shall be reported as "unconditioned."

10. Procedure and Test Setup

10.1 If needed, condition test specimens as required. Store the test specimens in the conditioned environment until test time if the test environment is different than the conditioning environment.

10.2 Before testing, measure and record the cross-sectional shape and dimensions as necessary. Record the dimensions to three significant figures.

10.3 Measure and record the length of the unsupported span.

10.4 *Rate of Testing*—Set the loading nose displacement to be continuous and at a rate as calculated by Eq 1:

$$R = (Z \times L^2)/(6 \times h) \quad (1)$$

where:

R = loading nose displacement rate, mm/min (in./min),