

ENGINEERING PRACTICE STUDY

PROJECT NUMBER: 5961-2024-021

TITLE:

MIL-STD-750-4, TEST METHOD 4023:
"SCOPE DISPLAY"

PROPOSAL TO DEVELOP A DRAFT TO ADDRESS
AUTOMATIC TEST EQUIPMENT, UPDATE FIGURES
AND REQUIREMENTS FOR CLARITY AND CONSISTENCY

29 FEBRUARY 2024

FINAL REPORT

STUDY CONDUCTED BY

DLA LAND AND MARITIME
Document Standardization Division (VA)
Active Device Branch (VAC)

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Attachments: 2

I. OBJECTIVES: The objective of this Engineering Practice (EP) Study was to obtain input from the military services, device manufacturers, laboratories, and user community concerning a proposed revision to test method 4023 of MIL-STD-750-4.

II. BACKGROUND: The preparing activity for MIL-STD-750 (DLA-VAC) received a request from the laboratory suitability authority for MIL-STD-750 (DLA-VQE) to address the use of automatic test equipment (ATE) being used to perform Scope Display verification testing of devices to MIL-PRF-19500 in lieu of the human evaluation of curve tracer output. DLA-VAC prepared and coordinated an initial draft of a proposed 4023.3 that addressed the use of ATE. The proposed revision also contained both editorial and technical changes that proposed adding a new figure, modifying current figures, correcting editorial issues and reorganizing the test method format for clarity and consistency.

III. RESULTS: All comments received from the initial draft regarding the proposed changes in content and format were accepted and have been incorporated into the drafts for the final report. Additional comments regarding existing content that was not changed in the initial draft will be held for a future revision.

Both a clean reader draft (see attachment 1) and mark-up source draft (see attachment 2, which contains both additions and deletions) have been included for comparison and reviewing. A Key that identifies the changes that were made in the initial draft and final report draft has been included at the top of the first page of each attachment.

IV. CONCLUSIONS: The highlighted changes to the test method (see attachment 1) should be proposed for incorporation into the next standardization document change action to MIL-STD-750-4.

V. RECOMMENDATIONS: Prepare an initial draft of MIL-STD-750-4 using the results of this study for the draft of test method 4023.3.

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KEY to changes: Text that was added to the Initial Draft are highlighted in yellow.

Text that was added for the Final Report as a result of comments to the Initial Draft are highlighted in green.

Text that was proposed to be deleted in the Initial Draft and Final Report are not shown in this attachment, but can be viewed in attachment 2.

ATTACHMENT 1 to FINAL REPORT for Project 5961-2024-021
MIL-STD-750-4

METHOD 4023.3

SCOPE DISPLAY

1. **Purpose.** The purpose of this test method is to define criteria for inspection of the dynamic reverse characteristics of rectifiers, switching, and Zener diodes (hereafter referred to as 'device') when viewed on a curve tracer. This inspection criteria may not be applicable to specific rectifier designs where the device is not intended to be driven into avalanche breakdown, or where the applicable specification sheet has not provided for this inspection.

2. **Scope.** This test applies to all devices requiring stable or sharp and stable breakdown characteristics. The breakdown characteristic traces on all figures are shown in the first quadrant. The depictions on figures 4023-3 through 4023-13 have been compiled to describe commonly observed faults.

2.1 **Test conditions.** The inspections shall be classified by the following breakdown characteristics:

- a. Condition A – stable (only) types. The curve traces on figures 4023-4, 4023-9, 4023-11, and 4023-12 shall apply for condition A.
- b. Condition B – sharp and stable types. The curve traces on figures 4023-3 through 4023-13 shall apply for condition B.

NOTE: Since low voltage Zener devices do not inherently have, and some other devices may not have a sharp breakdown, specific exceptions in requirements are also provided herein.

3. **Definitions.**

3.1 **Symbols.**

- a. I_{BR} Safe maximum operating current
- b. I_Z Regulator current (for Zener devices)
- x. I_{ZT} Regulator current at specified test point (for Zener devices)
- c. R Series load resistance
- d. $V_{(BR)}$ Device breakdown voltage
- e. V_{CT} Peak open circuit supply voltage of the curve tracer)
- f. V_Z Regulator voltage (for Zener devices)

3.2 **Terms.**

3.2.1 **Ideal sharp and stable reverse trace** (see figure 4023-1). The ideal sharp and stable reverse trace is one which exhibits a single horizontal line up to the point of breakdown, then transitions vertically at the knee to form a 90 degree angle while maintaining the single line.

3.2.2 **Knee area.** The knee area is the area in which the trace transitions from the horizontal to the vertical, see figure 4023-1.

3.2.2.1 **Hard knee.** For a trace of a hard knee, see figure 4023-2.

3.2.2.2 **Soft knee.** For a trace of a soft knee, see figures 4023-2 and 4023-3.

3.2.3 Drift. For a trace of the drift condition, see [figure 4023-4](#).

3.3 Equations. The $V_{(BR)}$ (or V_Z) utilized in the following equations should be the minimum expected so as to always maximize the R value selected.

3.3.1 Equation 4023-1. The safe maximum operating current (device breakdown current) may be determined by:

$$I_{BR} = (V_{CT} - V_{(BR)}) / R \text{ or for Zener devices: } I_Z = (V_{CT} - V_Z) / R$$

3.3.1 Equation 4023-2. The open circuit voltage may be determined by:

$$V_{CT} = (I_{BR} * R) + V_{(BR)} \text{ or for Zener devices: } V_{CT} = (I_Z * R) + V_Z$$

3.3.3 Equation 4023-3. The resistance R may be determined by:

$$R = (V_{CT} - V_{(BR)}) / I_{BR} \text{ or for Zener devices: } R = (V_{CT} - V_Z) / I_Z$$

4. General requirements.

4.1 Apparatus. The apparatus used to determine the reverse current leakage shall be capable of applying the specified reverse voltage to the DUT and measuring the resulting parameters.

4.1.1 ATE. When used, ATE test instrumentation shall be capable of establishing the required testing conditions for measuring and recording the required electrical parameters to verify the acceptance criteria.

4.1.2 Curve tracer. When used, the curve tracer shall be a Tektronix Type 370, 371 or better.

4.1.3 Series load resistor. A series load resistor shall be used to limit the device reverse current and prevent device damage.

5. Detailed requirements.

5.1 Procedures.

5.1.1 Inspections using a curve tracer. When using a curve tracer to perform the inspection, the following details shall apply:

- The curve tracer presentation shall be configured so that the horizontal axis shall be calibrated in volts per division and the vertical axis shall be calibrated in amperes per division (or fractions thereof). The **horizontal and** vertical axis of the curve tracer presentation will be graduated into eight or ten divisions, each representing a pre-calibrated increment of current or voltage.
- A series load resistor shall be used to limit the device reverse current and prevent device damage. This typical resistance should be approximately one quarter or more of the device resistance at the breakdown specification, when the curve tracer set-up permits.

Example: A device to be observed at I_{BR} of 100 μA which is specified to be 400 volts minimum, would have a series resistance chosen according to the following:

$$R \geq 0.25 (400 / 0.0001), \text{ therefore: } R \geq 1 \text{ M}\Omega$$

The curve tracer V_{CT} may also require limitation, particularly if the series load resistance described cannot be achieved. See [figure 4023-1](#) and [5.1.1.e](#) for typical load line relationships to assure safe reverse current monitoring.

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Unless otherwise specified, the breakdown current shall be the current used for the breakdown voltage test.

- c. The trace should occur in the first and third quadrant of the display and be slowly adjusted from zero volts to attain the specified current with the maximum amount of resolution for determination of trace characteristics.
- d. The DUT shall be held under breakdown conditions for at least two second to ensure freedom from intermittent instability for breakdown drift.
- e. The vertical and horizontal sensitivity shall be adjusted on the curve tracer to provide a rendition of the complete trace to the specified current. Horizontal and vertical sensitivity shall be adjusted to provide a trace occupying no less than 50 percent of the available screen.
- f. The curve tracer voltage shall not be simply set at a predetermined value and snapped on instantaneously. This may be done only if the device to be tested is known to have a sufficiently narrow V_{BR} range with a predetermined series (load line) resistor setting (see 5.1.2.b.) and described below, to assure that the device will not be overpowered. This is typically the case for zener diodes prescreened on V_Z (or V_{BR}). The V_{CT} may then be adjusted such that the V_{CT} setting can provide no more current (I_{BR} or I_Z) than that required for avalanche breakdown, taking into account the series load resistance R on figure 4023-1. Unless otherwise specified, these relationships may be calculated by using equations 4023-1, 4023-2 and 4023-3.

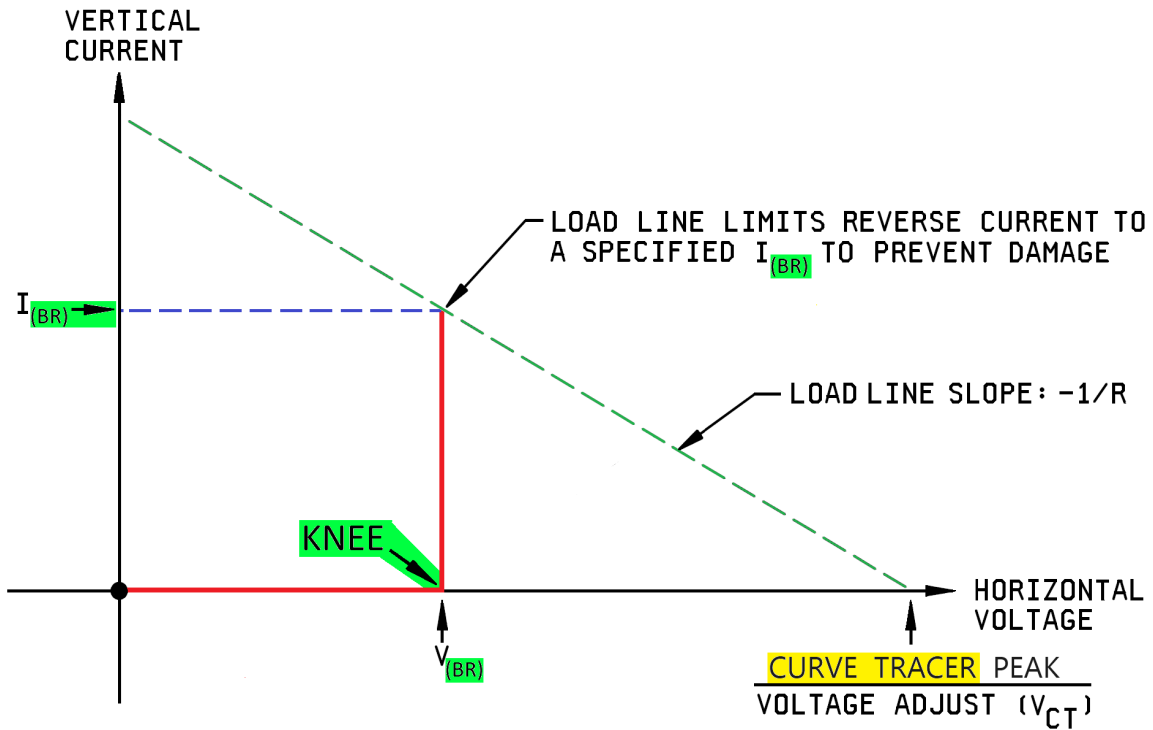
5.1.2 Inspections using ATE. The implementation of ATE in lieu of human evaluation shall be contingent of approval by the qualifying activity before it is used in acceptance of compliant devices. The test facility shall establish by correlation that the output of the ATE method is equal-to or better-than the results capable by using the default discrete equipment-human evaluation method of 5.1.1.

5.2 Acceptance criteria. Allowance for deviation from the desired characteristics described in this method or applicable specification sheet shall be granted by the qualifying activity. If a particular rejectable trace described herein is expected in a manufacturer's normal process, it shall be identified and explained during device conformance/qualification. Devices exhibiting the exceptional trace characteristic shall be present in the conformance/qualification lot to establish reliability. The criteria for acceptance or rejection of devices shall be as follows:

- a. Any device that is stable and conforms to the applicable illustrated scope conditions shall be accepted.
- b. Deviations from the ideal scope condition, which are not specifically allowed in this method or applicable specification sheet shall be cause for rejection of the DUT. Tolerances from acceptable devices have been assigned when applicable.
- c. Any device that exceeds the conditions in the applicable illustrated scope conditions shall be rejected.
- d. Any device that is acceptable but is continuing to move, drift or otherwise change shall be observed for another 2 seconds. This cycle of 2 second intervals will continue until the device stabilizes and is either acceptable by maintaining compliance with the acceptance criteria or shall be rejected by exceeding the acceptance criteria.
- e. Any device that is still drifting after a total of 10 seconds shall be rejected as being chronically unstable.

6. Summary. The following shall be specified in the applicable performance specification sheet or acquisition document:

- a. Test condition to be used (A or B see 2.1).
- b. The requirements for drift for devices that operate over 1,500 volts (see figure 4023-4).
- c. The requirements for slope for low voltage Zener devices below 5.5 volts.



NOTES:

1. This ideal reverse trace exhibits none of the undesirable characteristics described on figures 4023-4 through 4023-13.
2. Also, illustrated are the basic curve tracer adjustments and relation for a safe maximum operating current ($I_{(BR)}$) with the series load resistor (R) versus peak open circuit voltage (V_{CT}) and device breakdown voltage ($V_{(BR)}$).

FIGURE 4023-1. Ideal reverse trace.

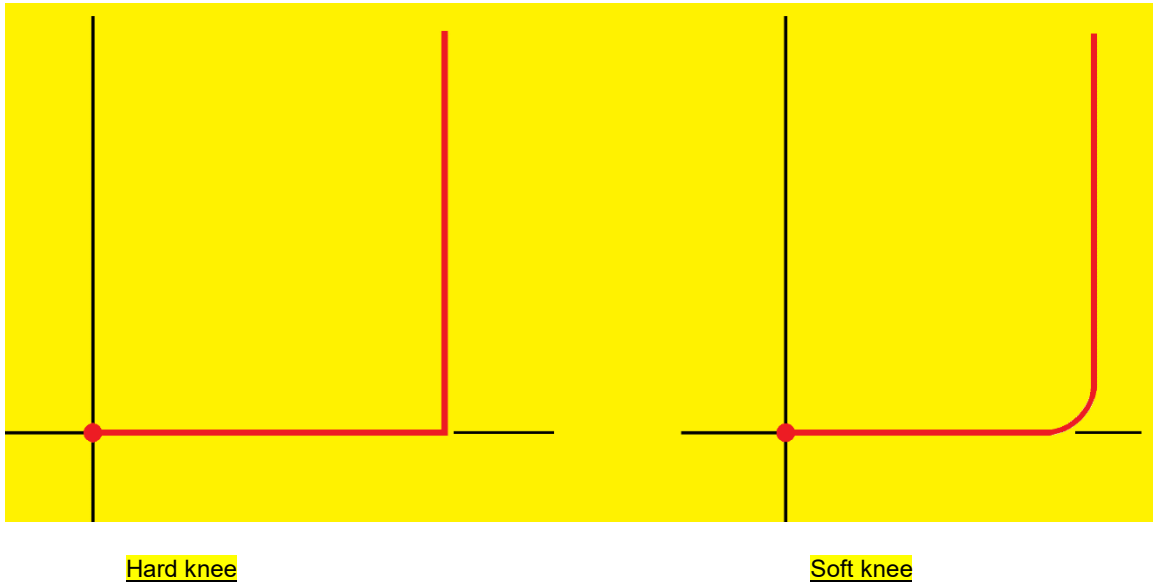
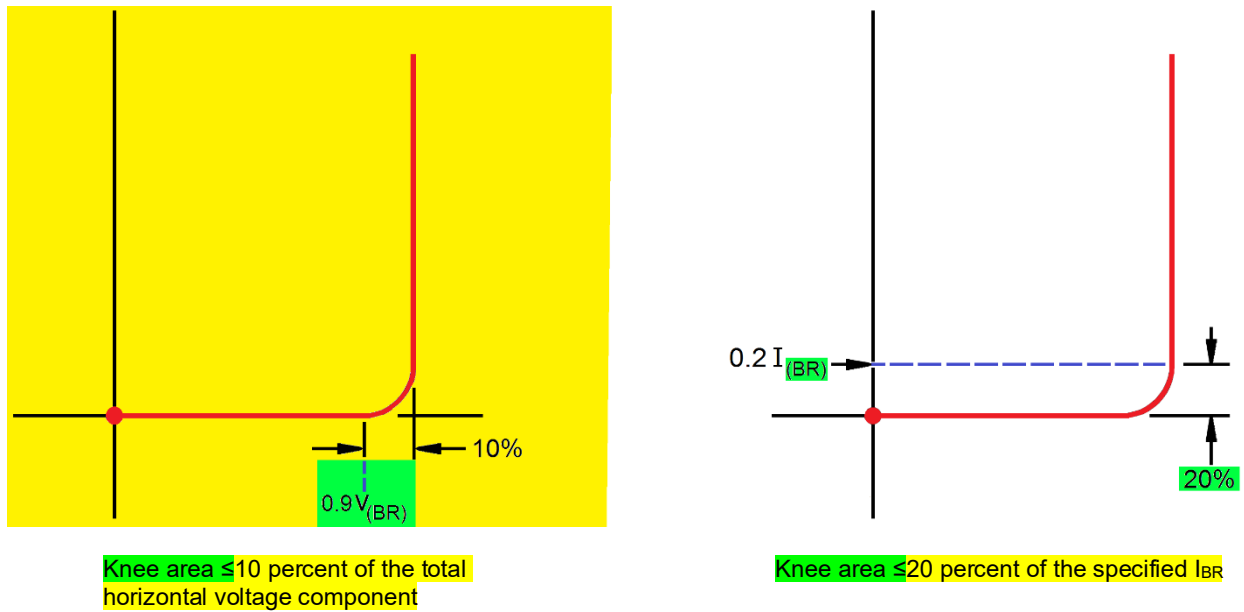


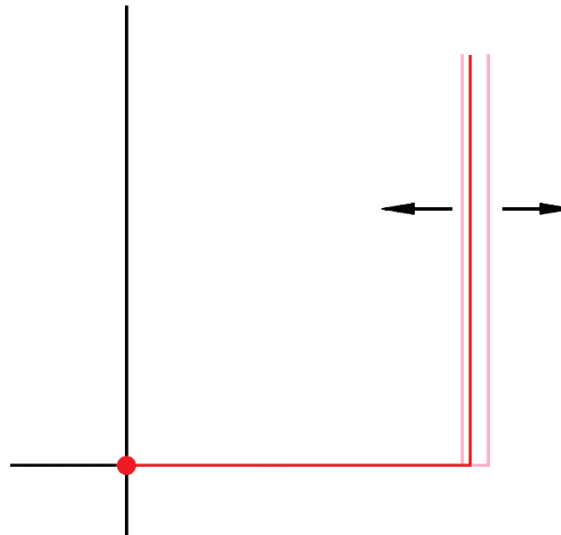
FIGURE 4023-2. Knee area descriptions.



NOTES:

1. Unless otherwise specified, this acceptable knee area should not require more than 10 percent of the total horizontal voltage component being viewed, or more than 20 percent of the specified I_{BR} .
2. Not applicable to signal diodes, fast, ultrafast, and Schottky rectifiers or low voltage Zener devices ≤ 10 volts.

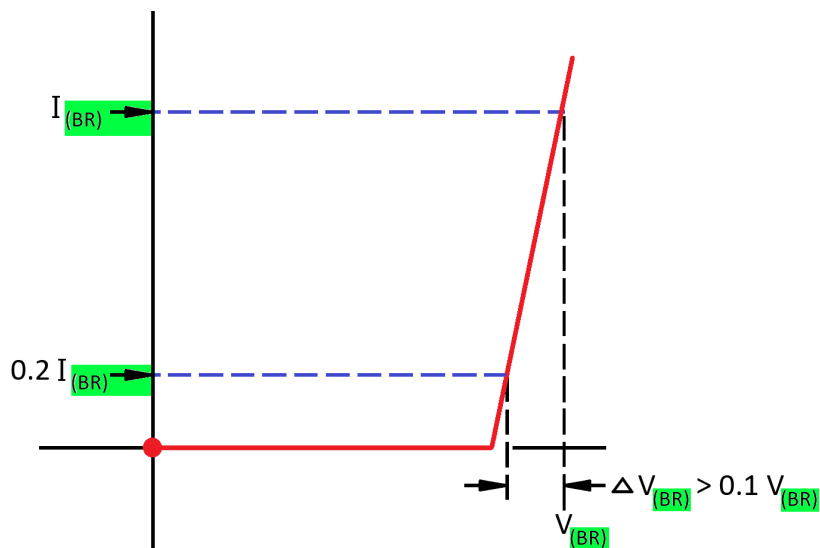
FIGURE 4023-3. Conditions for acceptable soft knee areas.



NOTES:

1. The vertical component of the trace should remain stable in the horizontal axis.
2. An undesirable drift is defined as greater than a 10 percent increase or 2 percent decrease in actual breakdown voltage up to 1,500 volts.
3. If over 1,500 volts, the allowable drift should be separately specified.

FIGURE 4023-4. Drift.

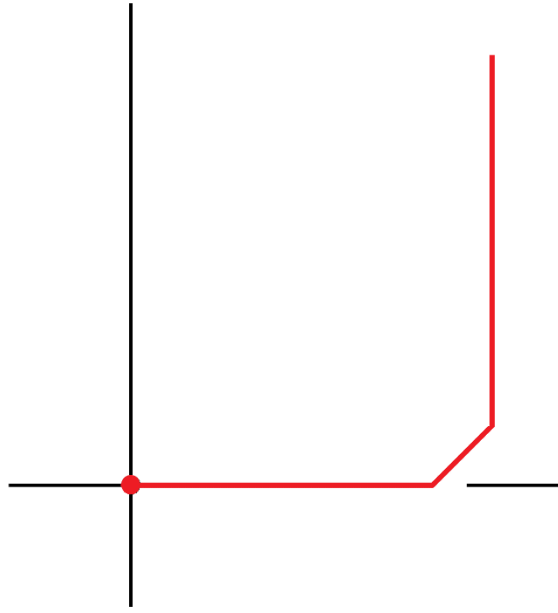


NOTES:

1. The slope shall be less than 10 percent of V_{BR} when viewed between 20 percent to 100 percent of the specified I_{BR} or I_Z .
2. Low voltage Zener devices below 5.5 volts are in exception to this requirement also, or other devices, as may be specified.

FIGURE 4023-5. Slope.

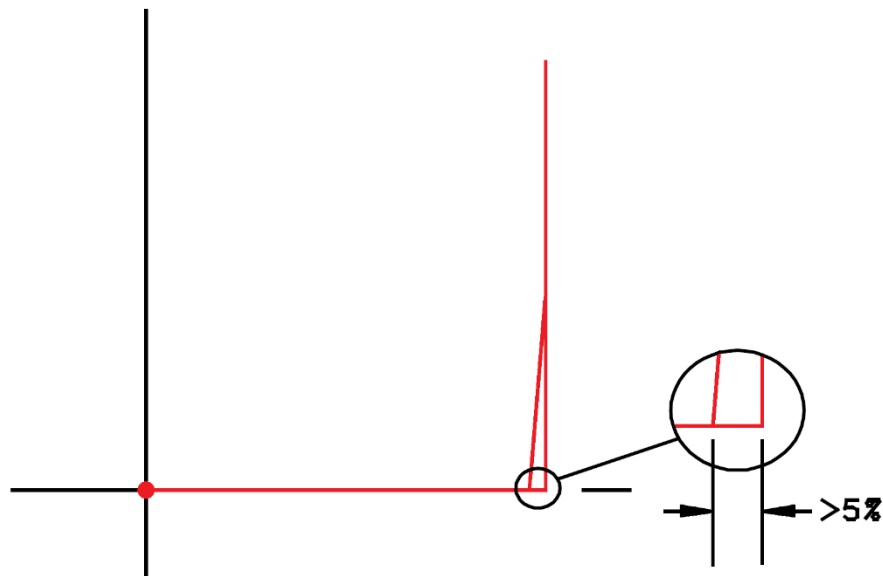
METHOD 4023.3



NOTES:

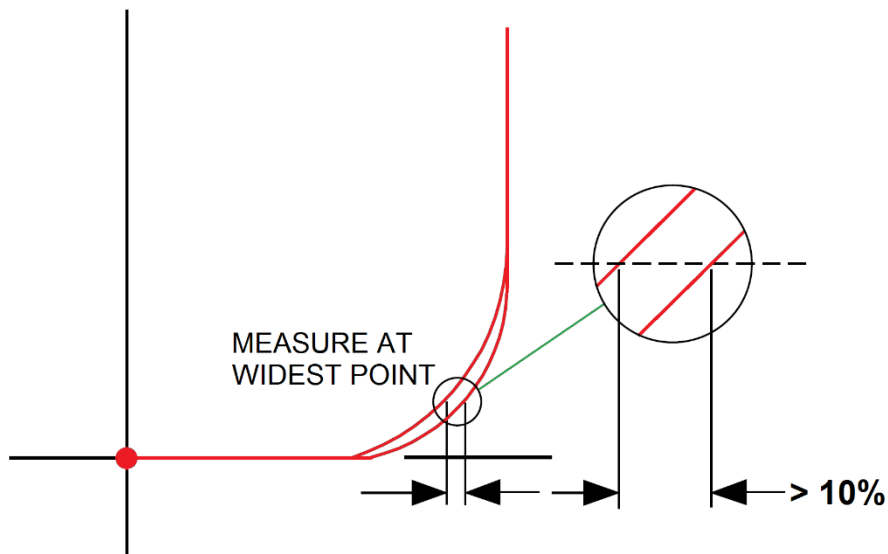
1. The double break is the area in which the trace transitions from the horizontal to the vertical.
2. Unless otherwise specified, this area should not occupy more than 10 percent of the total horizontal voltage component being viewed, or more than 20 percent of the specified I_{BR} or I_{ZT} .
3. This requirement is not applicable to ultrafast or Schottky rectifiers, and low voltage Zener devices ≤ 10 volts.

FIGURE 4023-6. Double break (reject criteria for sharp knee devices).



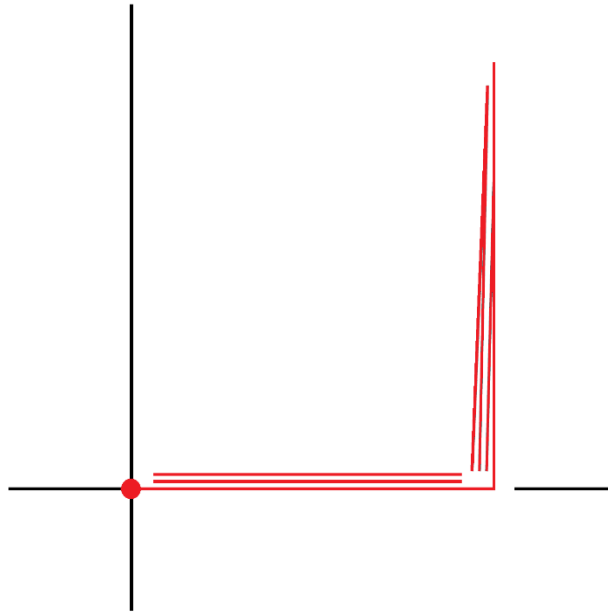
For standard rectifiers and Zener devices, the region at the knee may display a secondary trace no more than 5 percent of the total voltage of the DUT (see detail).

FIGURE 4023-7. Double trace, hard knee.



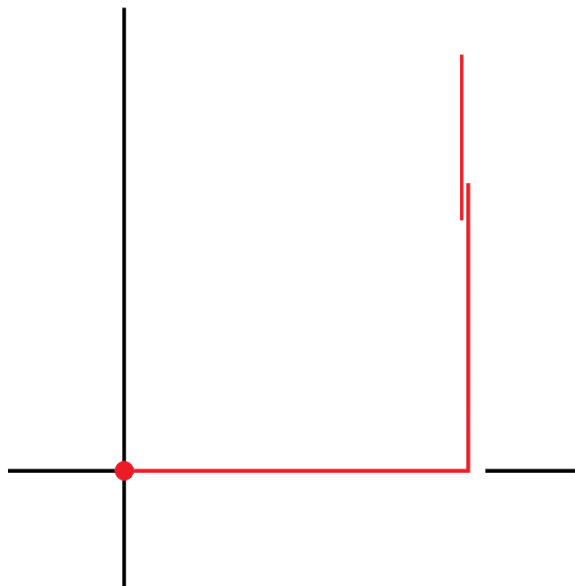
For soft knee diodes including signal diodes, low voltage Zener devices, and altered junction fast, superfast and ultrafast rectifiers, the region at the knee may display a secondary trace no more than 10 percent of the total voltage of the DUT (see detail).

FIGURE 4023-8. Double trace, soft knee.



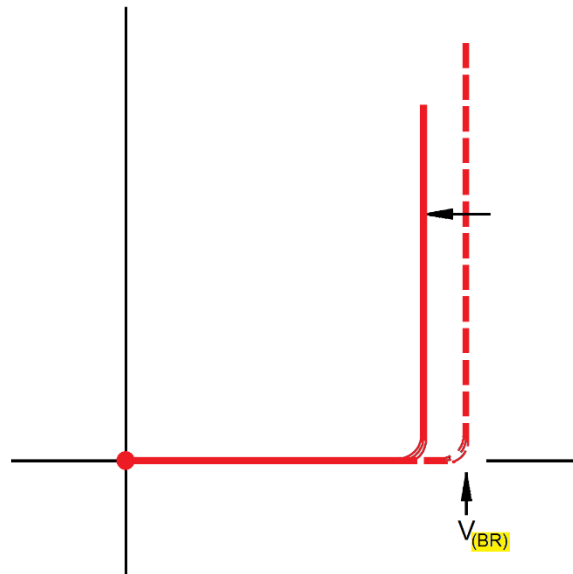
Any jittery movement of the trace in any direction, not caused by power line voltage fluctuations, shall not be acceptable.

FIGURE 4023-9. Unstable (jitter).



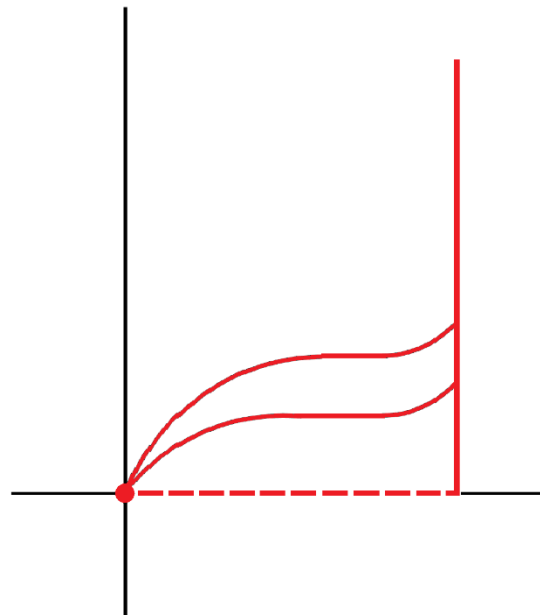
The vertical component shall not depart from a single vertical line, except for allowable double trace as shown on figures 4023-7 and 4023-8.

FIGURE 4023-10. Discontinuity.



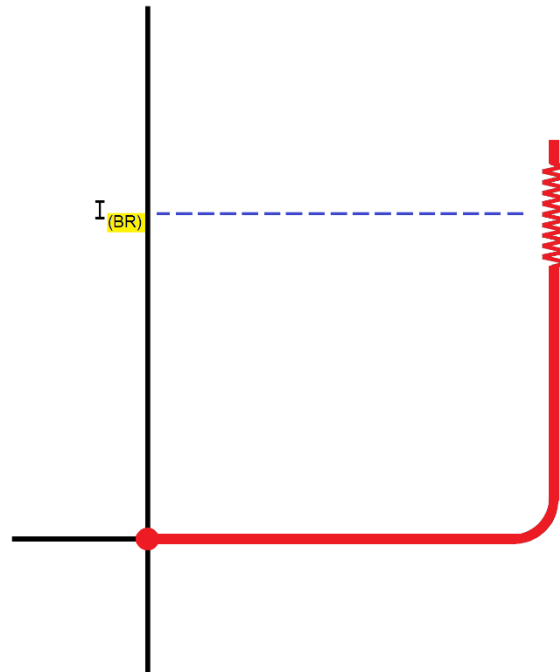
The vertical component shall not decrease its value abruptly by 2 percent or more of $V_{(BR)}$.

FIGURE 4023-11. Snap back - collapsing $V_{(BR)}$.



Leakage current (vertical) shall not degrade from an initial value.

FIGURE 4023-12. Floater.



NOTES:

1. Instability (arcing) appearing at or near the specified $I_{(BR)}$ region on the vertical trace (such as may be coincident with visible sparking activity within the device die region) shall not be present.
2. Noise at or near the knee is permissible, such as typically observed on avalanche-Zener devices.

FIGURE 4023-13. Arcing.

KEY to changes: Text that was added to the Initial Draft (ID) are highlighted in yellow.
Text that was proposed to be deleted in the ID are highlighted in red with strike-through.
Text that was added for the Final Report as a result of comments to the ID are highlighted in green.
Text to be deleted in the Final Report as a result of comments to the ID are highlighted in magenta with strike-through.

ATTACHMENT 2 to FINAL REPORT for Project 5961-2024-021
MIL-STD-750-4

METHOD 4023.2 3

SCOPE DISPLAY

1. **Purpose.** The purpose of this test method is to define criteria for inspection of the dynamic reverse characteristics of rectifiers, switching, and Zener diodes (hereafter referred to as 'device') when viewed on a curve tracer. This inspection criteria may not be applicable to specific rectifier designs where the semiconductor device is not intended to be driven into avalanche breakdown, or where the applicable specification sheet has not provided for this inspection.

2. **Scope.** This test applies to all devices requiring stable or sharp and stable breakdown characteristics. The breakdown characteristic traces on all figures 4023-1 through 4023-12 are shown in the first quadrant. The depictions on figures 4023-2 4023-3 through 4023-12 4023-13 have been compiled to describe commonly observed faults.

2.1 **Test conditions.** The inspections shall be classified as follows by the following breakdown characteristics:

- a. Condition A – stable (only) types. The curve traces on figures 4023-3, 4023-8, 4023-10, and 4023-14 4023-4, 4023-9, 4023-11, and 4023-12 shall apply for condition A.
- b. Condition B – sharp and stable types. The curve traces on figures 4023-2 4023-3 through 4023-12 4023-13 shall apply for condition B. The ideal sharp and stable trace is one which exhibits a single horizontal line up to the point of breakdown, then transitions vertically to form a 90 degree angle while maintaining the single line (see figure 4023-1). Deviations from this ideal, which are not specifically allowed in this method or applicable specification sheet shall be cause for rejection of the DUT. Tolerances from acceptable devices have been assigned when applicable.

NOTE: Since low voltage Zener devices do not inherently have, and some other devices may not have a sharp breakdown, specific exceptions in requirements are also provided herein. For ideal reverse trace see figure 4023-1. For soft knee see figure 4023-2. For drift see figure 4023-3.

3. **Definitions.**

3.1 **Symbols.**

- a. I_{BR} Safe maximum operating current
- b. I_Z Regulator current (for Zener devices)
- x. I_{ZT} Regulator current at specified test point (for Zener devices)
- c. R Series load resistance
- d. $V_{(BR)}$ Device breakdown voltage
- e. V_{CT} Peak open circuit supply voltage of the curve tracer)
- f. V_Z Regulator voltage (for Zener devices)

3.2 **Terms.**

3.2.1 **Ideal sharp and stable reverse trace** (see figure 4023-1). The ideal sharp and stable reverse trace is one which exhibits a single horizontal line up to the point of breakdown, then transitions vertically at the knee to form a 90 degree angle while maintaining the single line.

3.2.2 Knee area. The knee area is the area in which the trace transitions from the horizontal to the vertical, see figure 4023-1.

3.2.2.1 Hard knee. For a trace of a hard knee, see figure 4023-2.

3.2.2.2 Soft knee. For a trace of a soft knee, see figures 4023-2 and 4023-3.

3.2.3 Drift. For a trace of the drift condition, see figure 4023-4.

3.3 Equations. The $V_{(BR)}$ (or V_z) utilized in the following equations should be the minimum expected so as to always maximize the R value selected.

3.3.1 Equation 4023-1. The safe maximum operating current (device breakdown current) may be determined by:

$$I_{BR} = (V_{CT} - V_{(BR)}) / R \text{ or for Zener devices: } I_z = (V_{CT} - V_z) / R$$

3.3.1 Equation 4023-2. The open circuit voltage may be determined by:

$$V_{CT} = (I_{BR} * R) + V_{(BR)} \text{ or for Zener devices: } V_{CT} = (I_z * R) + V_z$$

3.3.3 Equation 4023-3. The resistance R may be determined by:

$$R = (V_{CT} - V_{(BR)}) / I_{BR} \text{ or for Zener devices: } R = (V_{CT} - V_z) / I_z$$

4. General requirements.

4.1 Apparatus. The apparatus used to determine the reverse current leakage shall be capable of applying the specified reverse voltage to the DUT and measuring the resulting parameters.

4.1.1 ATE. When used, ATE test instrumentation shall be capable of establishing the required testing conditions for measuring and recording the required electrical parameters to verify the acceptance criteria.

4.1.2 Curve tracer. When used, the curve tracer shall be a Tektronix Type 370, 371 or better.

4.1.3 Series load resistor. A series load resistor shall be used to limit the device reverse current and prevent device damage.

5. Detailed requirements.

5.1 Procedures.

5.1.1 Inspections using a curve tracer. When using a curve tracer to perform the inspection, the following details shall apply:

- The curve tracer presentation shall be configured so that the horizontal axis shall be calibrated in volts per division and the vertical axis shall be calibrated in amperes per division (or fractions thereof). The horizontal and vertical axis of the curve tracer presentation will be graduated into eight or ten divisions, each representing a pre-calibrated increment of current or voltage.
- A series load resistor shall be used to limit the device reverse current and prevent device damage. This typical resistance should be approximately one quarter or more of the device resistance at the breakdown specification, when the curve tracer set-up permits.

Example: A device to be observed at I_{BR} of 100 μA which is specified to be 400 volts minimum, would have a series resistance chosen according to the following:

$$R \geq 0.25 (400 / 0.0001), \text{ therefore: } R \geq 1 \text{ M}\Omega$$

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The curve tracer **peak voltage** (V_{CT}) may also require limitation, particularly if the series load resistance described cannot be achieved. See [figure 4023-1](#) and [3.e 5.1.1.e](#) for typical load line relationships to assure safe reverse current monitoring.

Unless otherwise specified, the breakdown current shall be the current used for the breakdown voltage test.

- c. The trace should occur in the first and third quadrant of the display and be slowly adjusted from zero volts to attain the specified current with the maximum amount of resolution for determination of trace characteristics.
- d. The DUT shall be held under breakdown conditions for at least two second to ensure freedom from intermittent instability for breakdown drift.
- e. The vertical and horizontal sensitivity shall be adjusted on the curve tracer to provide a rendition of the complete trace to the specified current. Horizontal and vertical sensitivity shall be adjusted to provide a trace occupying no less than 50 percent of the available screen.
- f. The curve tracer **voltage** shall not be simply set at a predetermined value and snapped on instantaneously. This may be done only if the **product device** to be tested is known to have a sufficiently narrow **breakdown voltage** (V_{BR}) range with a predetermined series (load line) resistor setting (see [5.1.2.b.](#)) and described below, to assure that the device will not be overpowered. This is typically the case for zener diodes prescreened on V_Z (or $V_{(BR)}$). The **peak open circuit supply voltage of the curve tracer** (V_{CT}) may then be adjusted such that the V_{CT} setting can provide no more current (I_{BR} or I_Z) than that required for avalanche breakdown, taking into account the series load resistance R on [figure 4023-1](#). Unless otherwise specified, these relationships may be calculated by [using equations 4023-1, 4023-2 and 4023-3](#).

$$I_{BR} = \frac{V_{CT} - V_{BR}}{R}, \text{ and } V_{CT} = I_{BR}R + V_{BR}$$

The resistance R may be determined by:

$$R = \frac{V_{CT} - V_{BR}}{I_{BR}}$$

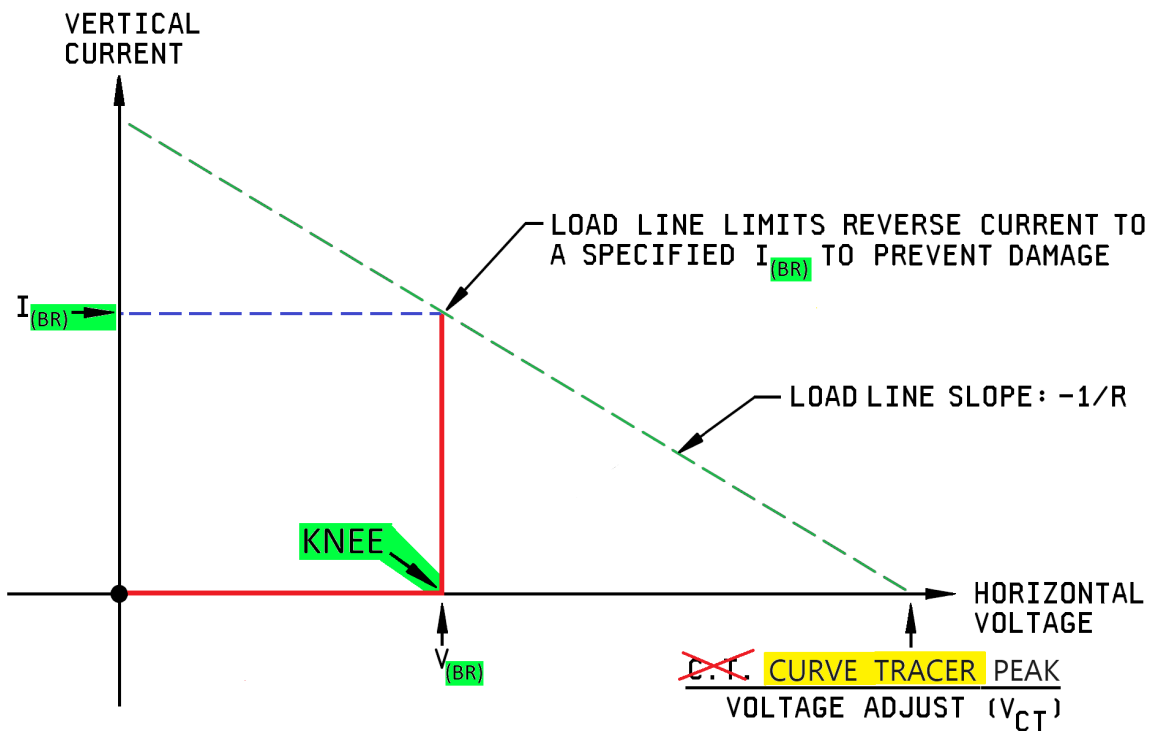
The V_{BR} (or V_Z) utilized in this equation should be the minimum expected so as to always maximize the R value selected.

5.1.2 Inspections using ATE. The implementation of ATE in lieu of human evaluation shall be contingent of approval by the qualifying activity before it is used in acceptance of compliant devices. The test facility shall establish by correlation that the output of the ATE method is equal-to or better-than the results capable by using the default discrete equipment-human evaluation method of [5.1.1](#).

5.2 Acceptance criteria. [g.](#) Allowance for deviation from the desired characteristics described in this method or applicable specification sheet shall be granted by the qualifying activity. If a particular rejectable trace described [herein](#) is expected in a manufacturer's normal process, it shall be identified and explained during device conformance/qualification. Devices exhibiting the exceptional trace characteristic shall be present in the conformance/qualification lot to establish reliability. [The criteria for acceptance or rejection of devices shall be as follows:](#)

- a. **h.** Any device that is stable and **passes** [conforms to](#) the applicable illustrated scope conditions shall be **passed** [accepted](#).
- b. Deviations from the ideal scope condition, which are not specifically allowed in this method or applicable specification sheet shall be cause for rejection of the DUT. Tolerances from acceptable devices have been assigned when applicable.

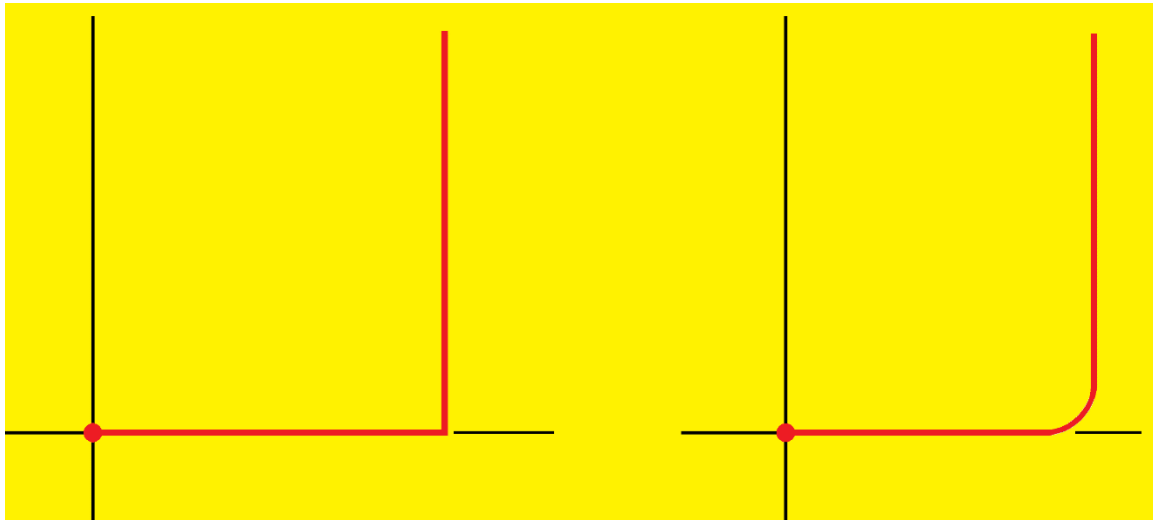
- c. Any device that exceeds the conditions in the applicable illustrated scope conditions will shall be failed rejected.
 - d. Any device that passes is acceptable but is continuing to move, drift or otherwise change shall be observed for another 2 seconds. This cycle of 2 second intervals will continue until the part device stabilizes and passes by still meeting is either acceptable by maintaining compliance with the pass acceptance criteria or fails shall be rejected by exceeding the pass acceptance criteria.
 - e. Any device that is still drifting after a total of 10 seconds shall be failed rejected as being chronically unstable.
6. 4- Summary. The following shall be specified in the applicable performance specification sheet or acquisition document:
- a. Test condition to be used (A or B see 2.1).
 - b. The requirements for drift for devices that operate over 1,500 volts (see figure 4023-4).
 - c. The requirements for slope for low voltage Zener devices below 5.5 volts.



NOTES:

1. This ideal reverse trace exhibits none of the undesirable characteristics described on the figures below.
2. Also, illustrated are the basic curve tracer adjustments and relation for a safe maximum operating current (I_{BR}) with the series load resistor (R) versus peak open circuit voltage (V_{CT}) and device breakdown voltage (V_{BR}).

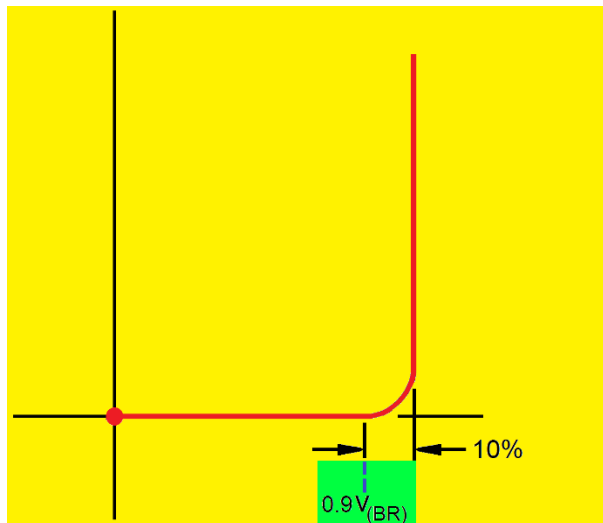
FIGURE 4023-1. Ideal reverse trace.



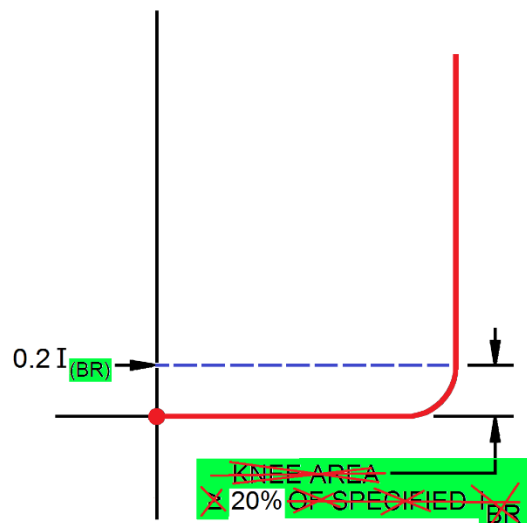
Hard knee

Soft knee

FIGURE 4023-2. Soft Knee area descriptions.



Knee area ≤ 10 percent of the total horizontal voltage component

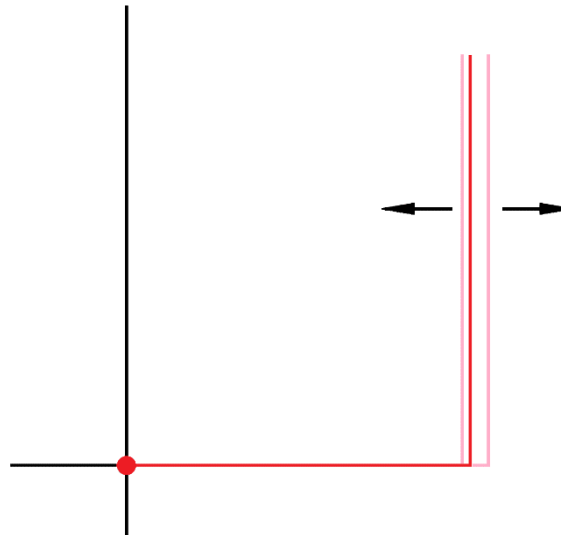


Knee area ≤ 20 percent of the specified I_{BR}

NOTES:

1. The knee area is the area in which the trace transitions from the horizontal to the vertical. Unless otherwise specified, this acceptable knee area should not require more than 10 percent of the total horizontal voltage component being viewed, or more than 20 percent of the specified I_{BR} .
2. Not applicable to signal diodes, low voltage zeners, fast, ultrafast, and Schottky rectifiers or low voltage Zener devices ≤ 10 volts.

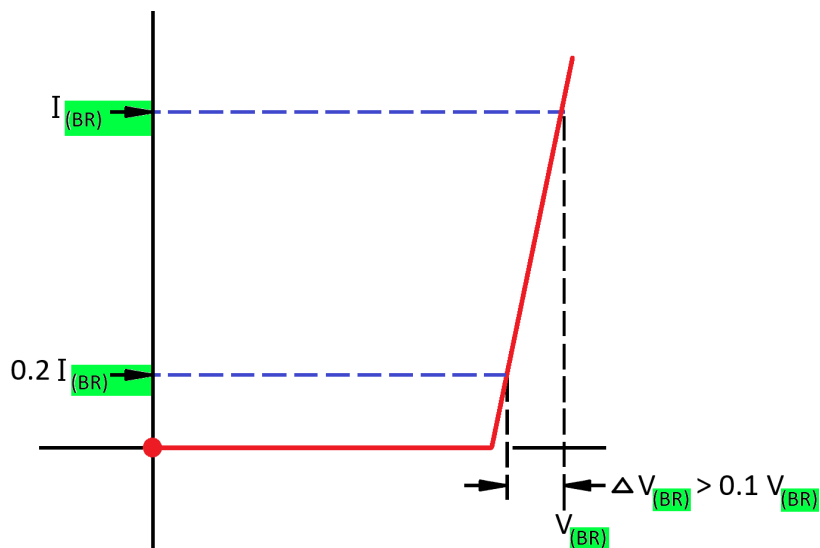
FIGURE 4023-2 3. Soft knee. Conditions for acceptable soft knee areas.



NOTES:

1. The vertical component of the trace should remain stable in the horizontal axis.
2. An undesirable drift is defined as greater than a 10 percent increase or 2 percent decrease in actual breakdown voltage up to 1,500 volts.
3. If over 1,500 volts, the allowable drift should be separately specified.

FIGURE 4023-4.3 4. Drift.

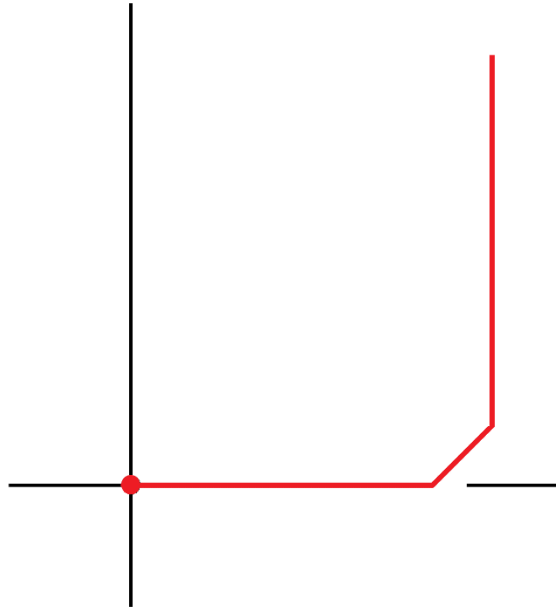


NOTES:

1. The slope shall be less than 10 percent of V_{BR} when viewed between 20 percent to 100 percent of the specified I_{BR} or I_Z .
2. Low voltage Zener devices below 5.5 volts are in exception to this requirement also, or other devices, as may be specified.

FIGURE 4023-4.4 5. Slope.

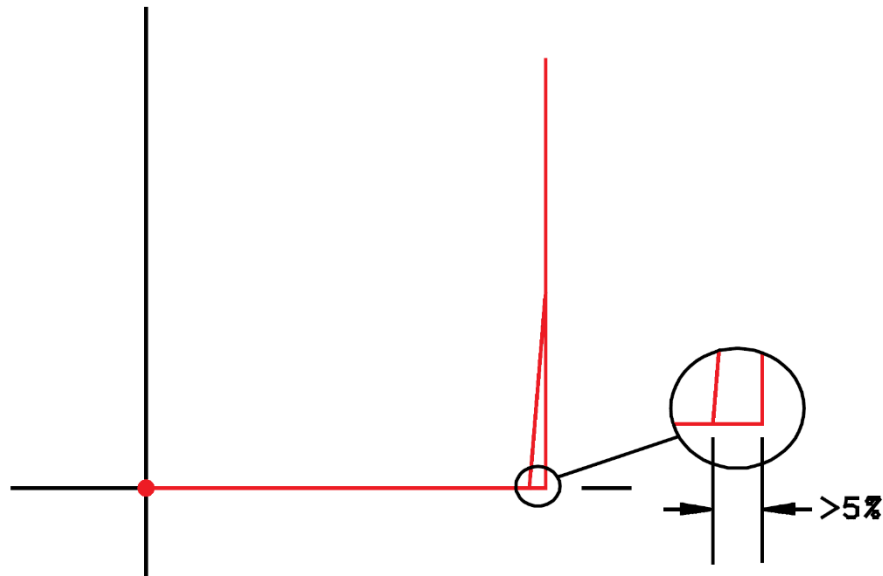
METHOD 4023.2 3



NOTES:

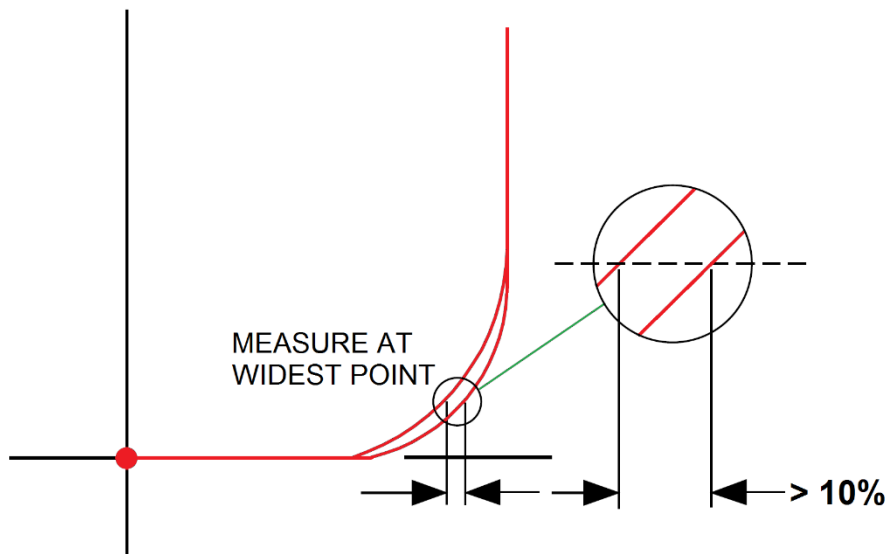
1. The double break is the area in which the trace transitions from the horizontal to the vertical.
2. Unless otherwise specified, this area should not occupy more than 10 percent of the total horizontal voltage component being viewed, or more than 20 percent of the specified I_{BR} or I_{ZT} .
3. This requirement is not applicable to ultrafast or Schottky rectifiers, and low voltage Zeners devices ≤ 10 volts.

FIGURE 4023-5 6. Double break (reject criteria for sharp knee devices).



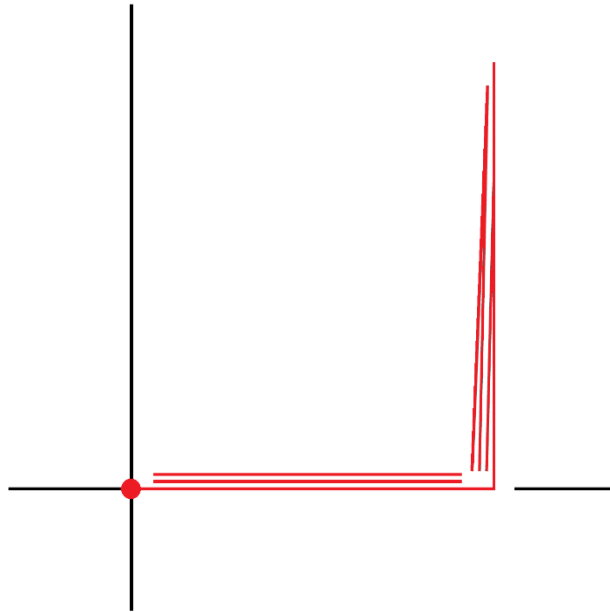
For standard rectifiers and Zener **s devices**, the region at the knee may display a secondary trace no more than 5 percent of the total voltage of the DUT (see detail).

FIGURE 4023-**6 7**. Double trace, **hard knee**.



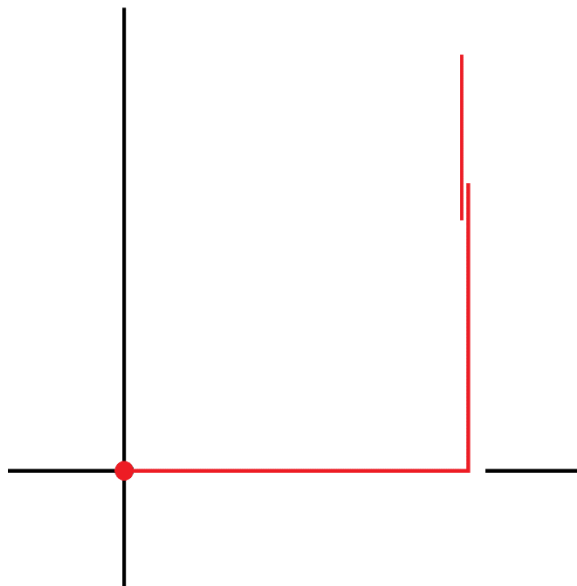
For soft knee diodes including signal diodes, low voltage Zener **s devices**, and altered junction fast, superfast and ultrafast rectifiers, the region at the knee may display a secondary trace no more than 10 percent of the total voltage of the DUT (see detail).

FIGURE 4023-**7 8**. Double trace, **soft knee**.



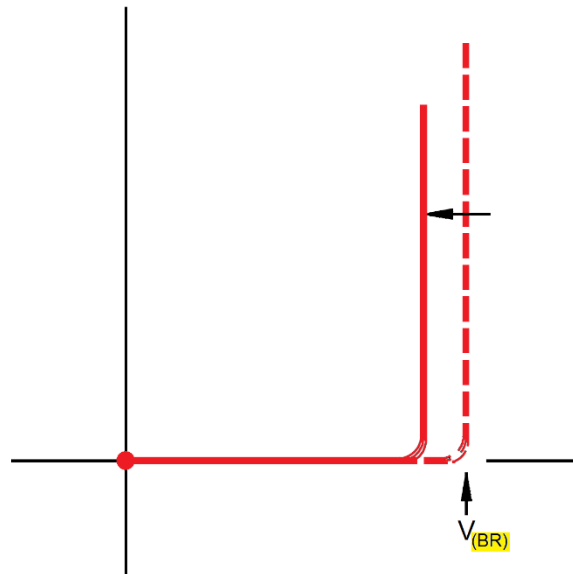
Any jittery movement of the trace in any direction, not caused by power line voltage fluctuations, shall not occur be acceptable.

FIGURE 4023-8 9. Unstable (jitter).



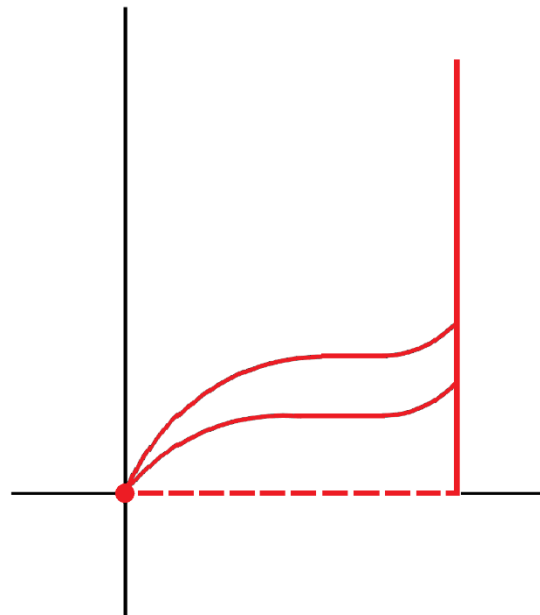
The vertical component shall not depart from a single vertical line, except as allowed for allowable double trace as shown on figures 4023-6 and 4023-7 and 4023-8.

FIGURE 4023-9 10. Discontinuity.



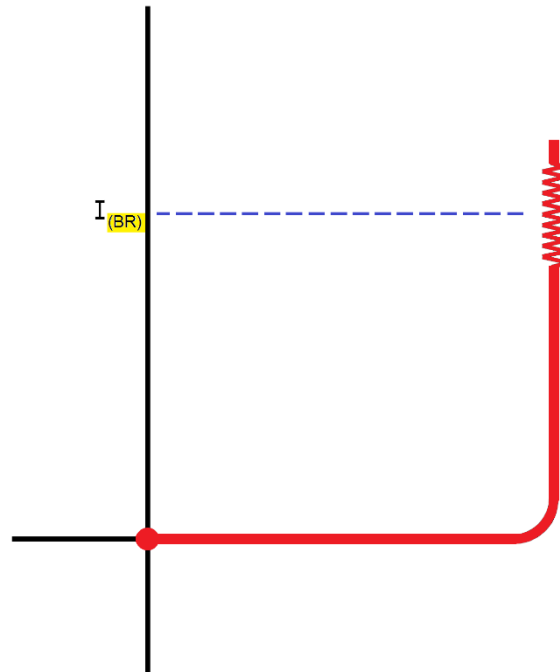
The vertical component shall not decrease its value abruptly by 2 percent or more of $V_{(BR)}$.

FIGURE 4023-10 11. Snap back – collapsing $V_{(BR)}$.



Leakage current (vertical) shall not degrade from an initial value.

FIGURE 4023-11 12. Floater.



NOTES:

1. Instability (arcing) appearing at or near the specified $I_{(BR)}$ region on the vertical trace (such as may be coincident with visible sparking activity within the device die region) shall not be present.
2. Noise at or near the knee is permissible, such as typically observed on avalanche-Zener devices.

FIGURE 4023-12 13. Arcing.