Understanding the Strain Relief Tests

The "Understanding the Product Safety Tests" Series

The *Strain Relief Test* is conducted on products that have an electrical cord or cable permanently attached to the product. This includes power cords, output cords, jumper cables, daisy chain cables, etc. These tests involve applying forces between the cord and the product to verify the cord is securely attached to the product.

Test Objective: The objective of these tests is to verify that any electrical cord or cable remains reliably and securely attached to the product.

Test Purpose: The purpose of the test is to confirm that normal stresses applied to cords or cables is not transmitted to the internal electrical connections. If stresses are applied to the electrical connections, they could become detached leading to a fault condition that results in a shock or fire hazard. Strain relief for cords and cables helps protect against forces such as someone:

a) Tripping over the cord,
b) Pulling the product by its cord,
c) Carrying or lifting the product by its cord,
d) Trying to move a product that is still plugged in or is connected to another product by an electrical cable.

Test Method: Each of the strain relief tests requires that the product be securely positioned and held in place so that the forces applied to the cord are focused on the cord strain relief mechanism = the product should not move when the forces are applied. The goal of course is to test the strain relief method.

1) Pull Force Test: The most common strain relief test is the pull force test. It involves pulling on the cord with a specified force for a specified duration of time.
    a) Multiple Pulls: Some standards specify frequent, quick pulls that equate to "jerking" the cord repeatedly. For example, some standards specify 25 pulls for 1 second each. The pull force for this test usually depends on the product weight, with test forces of 30, 60, & 100N being commonly used.
    b) Single Pull: Some standards specify a single, heavier, longer pull. For example, a 35lbf pull test for 1 minute is found in many standards.
2) Push-Back Test: When a product has an internal strain relief device, cord push-back can be a problem. The standard prohibits being able to push the cord and/or its leads back into the enclosure where they can reduce electrical spacings, contact higher voltage parts, contact parts that are hot, or become entangled in mechanical components.
3) Rotational Torque Test: Many standards also require a rotational torque be applied to the cord to insure that the cord does not rotate in its strain relief device. It also insures that the strain relief device does not rotate in its mounting hole – which is why certified strain relief devices mounted in a "D" or "Double D" shaped hole or otherwise keyed to prevent rotation.
4) Force Application Methods: A calibrated force gauge with a thick hook attachment is the preferred equipment for the "multiple pull force" test. A calibrated weight is often used for the heavier single pull force test. Some advanced force gauges have torque attachment options for performing the rotational torque tests – note that the torque levels are fairly low necessitating equipment rated for that low range. The push-back test is performed by hand.

Pass/Fail Criteria: Most standards indicate the following pass fail criteria:

A) Cord Slippage: Mark the cord before testing so you can measure slippage through the strain relief means – some standards have tight limits on slippage (i.e. maximum 2 mm).
B) Stress to Internal Connections: No forces may be transmitted to the electrical connections.

Other Considerations:

a) Grounding Conductor: The standards indicate that it is especially important not to transmit any forces on the power cord to the grounding (earthing) conductor. To accomplish this, prepare your power cord with a longer grounding lead and/or, move the grounding terminal closer to the strain relief device than the mains terminations. The goal is to insure that during any failure, the grounding conductor is the last lead to be pulled-out of its connection.
    - This is a safety critical design consideration. If the cord on a product gets pulled by a force large enough to pull the cord out of the product (way above the specifications in the standard), and the leads get pulled from their terminations, you want the ground to remain intact so any loose mains wiring will contact "ground" = tripping the circuit breaker, shutting off power, and removing shock and fire hazards.
b) Insulating Bushing/Cord Guard: For products with a metal enclosure, the point where the cord or cable enters the product enclosure is required to a have an insulating bushing to prevent the cord from being worn or cut by the enclosure and to protect the cord against excessive bending where it enters the enclosure. Do not use metal strain relief devices unless they have an integral plastic or rubber bushing.
c) A Knot in the Cord? Do not tie a knot in the cord as the strain relief means, even if your product safety standard does not prohibit this practice. There are other alternative methods to provide lower cost strain relief means including an internal plastic clamp and/or weaving or wrapping the cable through a series of internal posts.
d) Detachable Cables: The best way to avoid this test and the potential hazards presented by permanently attached cords and cables is to use detachable connectors – connectors that allow detaching the cable at the product enclosure. It is very common for a product to have a detachable power cord - which also allows the manufacturer or user to easily change the cord for an alternative plug configuration (i.e. international applications).
e) Cord Attached Connector Bodies: If the cord is detachable, the cord to connector attachment needs to meet the same strain relief requirements. Pulling the cord out of the plug/connector is especially a concern if the cord remains "live" when pulled from the connector.
f) Assumed Replacement: Some standards such as 61010-1 assume that any permanently connected power cord will need to be replaced at least once during the life of the product due to damage to the cord. Therefore, the power cord terminating connections must be "rewireable" = not require special tools and/or replacement of a connector that requires special tools to attach. The best way to comply is to connect the power cord leads to an internal terminal block. You must also use a strain relief device that is re-usable.

Conclusion: As you can see, we don't simply perform the tests because they are in the standard. Each test in the standard has a set of objectives that relate to the 6 Hazards of Product Safety. The Strain Relief Test is performed as part of the review for Shock & Fire hazards. Although the Strain Relief Test is a simple test, product cords are a major source of shocks, injuries, and fires in the home and office. It is therefore an extremely important test – another test that directly saves lives.