Testing the Integrity of Cloth Wristbands

by Gene Bliley, Bliley Consulting LLC

For facilities that choose cloth wrist straps rather than commit to metal bands, the pinch test could be the deciding factor.

Cloth-style wristbands represent a serious reliability issue because the elastic band may lose its conductive properties over time. When this condition occurs, the operator is not grounded if the metal buckle loses contact with the wrist. A simple pinch test can detect this condition, and the defective band can be removed from service before the quality and reliability of electrostatic discharge-sensitive (ESDS) products are jeopardized.

I first became aware of this condition several years ago while serving as the ESD program manager at the Lucent Technologies manufacturing facility in Columbus, OH. At that time, cloth wristbands were optional in the ESD prevention program and a mixture of cloth and metal style bands existed.

Internal ESD audits revealed a large number of cloth wristbands that were not functional. ESD assessments conducted at equipment manufacturers' facilities revealed that the problem was widespread. In one case, 53% of the cloth wristbands sampled failed the cuff conductivity requirement. As a result, a decision was made to allow only metal, expansion type wristbands in the process.

Cloth Wristbands

To the casual observer, it may appear that the only purpose of the elastic band is to hold the metal buckle against the operator's wrist. The elastic band actually servers a dual role. The interior of the elastic band that contacts the wrist has conductive fibers knitted into the surface to assure complete circumferential contact. This construction technique can be seen in **Figure 1**.

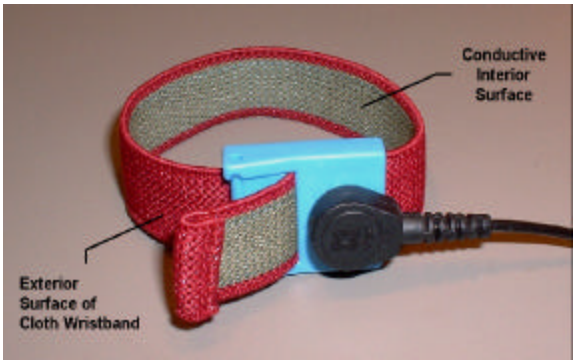

Figure 1. Typical Cloth Wristband Construction

The interior-cuff resistance limit is specified in ESD Association ESD-S1.1 Standard for Protection of Electrostatic Discharge Sensitive Items: Personnel Grounding Wrist Straps. The cuff resistance testing procedure is found in paragraph 5.2. Table 1 of the document, states that the interior cuff resistance must be ≤100 kΩ. This is a laboratory test for measuring the performance of new wristbands or for evaluating a new supplier's product.

It typically is not conducted as part of an ESD audit and I have never seen it used as part of the daily process check of the wristband system. It is for these reasons that many defective cloth wristbands are being used in ESD processes.

Analysis

As the cloth wristband is used repeatedly, two failure mechanisms occur:

1. The interior surface of the band becomes soiled.

2. The band loses its elasticity, and the interior surface becomes less conductive because the fibers breakdown due to stretching. It is difficult to estimate when this failure will occur. Some cloth bands seem to lose their conductivity faster than others because construction techniques, quality of materials, and properties of the conductive strip vary with manufacturers.

Eventually, the interior surface of the band becomes nonconductive, and the operator is grounded only while the metal buckle is contacting the wrist. The metal buckle can easily separate from the wrist when the operator pulls against the coiled wrist-strap grounding cord. During this time, the person is no longer grounded, and ESD damage becomes a possibility.

Figure 2 shows the voltage on an operator vs. time for grounded and ungrounded conditions. During the time that the operator is connected to ground, the body voltage is zero. When the connection loses ground, the voltage on the operator rapidly rises and falls to the approximate values shown in Figure 2. This potential represents a risk to ESDS devices and assemblies.

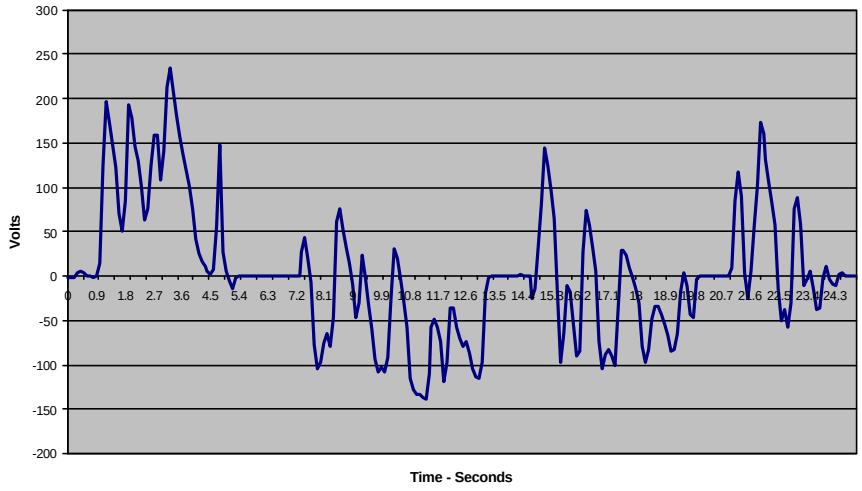

Figure 2. Graph of Body Voltage: Grounded vs. Ungrounded Operator

While the time intervals on the graph seem short, it is important to realize that they are extremely long with respect to an ESD event. A typical human body model (HBM) pulse has a rise time of less than 10ns and a decay time constant of 50ns to 300ns.

Pinch Test

The pinch test identifies defective cloth wristbands. It utilizes a typical wrist-strap tester and can be performed in a few seconds. It is also applicable to wristbands used in conjunction with continuous workstation monitors.

The following procedure is used to test the conductivity of the cloth wristband: The wrist strap assembly (wristband and coiled grounding cord) is plugged into the wrist-strap tester, as it normally would be to conduct a standard verification test. The wrist strap is not worn during this portion of the test. Instead, the operator pinches the band between the thumb and forefinger. One finger will be on the outside of the band and the other will be in contact with the interior or conductive surface of the band.

With the other hand, the operator activates the wrist-strap tester as usual. Do not touch the metal buckle or allow it to contact the hand holding the wristband. This procedure is shown in **Figure 3**.

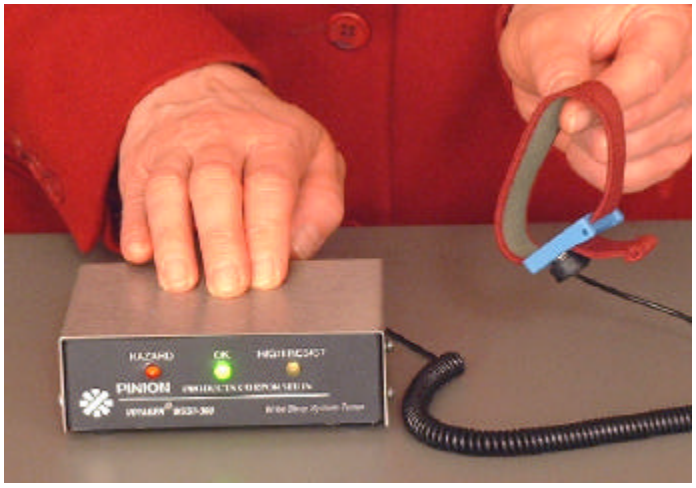

Figure 3. Procedure for Testing Cuff Conductivity

A passing condition on the wrist-strap tester indicates that the conductive portion of the band is functional. A failing condition means that either the band has lost its conductivity or the ground cord is defective.

Touching the metal buckle and repeating the test can easily validate the ground cord. If a passing condition is achieved but the pinch test failed, the band is defective and should be removed from service.

Conventional Testing

Once it has been determined that the band is functional, the wrist-strap assembly should be tested as recommended by the manufacturer or your company's specific instructions to ensure that a continuous path to ground is present. A high-resistance failure indicates a possible dry skin condition or a loose fitting wristband.

Lotion formulated for the electronic manufacturing environment should be applied to the skin beneath the wristband to improve conductivity. A wristband should fit snugly on the wearer's wrist and does not slip during normal use.

To complete the wrist-strap assembly test, the coiled ground cord must be lightly stressed by flexing the snap connector and the banana plug to verify that no intermittent condition exists.

Continuous Monitors

A defective band can produce momentary alarm conditions when normal activity at the station causes separation of the metal buckle and the operator's wrist. Continuous monitors that operate at a sample frequency may not detect this condition.

These monitors typically check for a properly grounded condition at 2-s to 3-s intervals. If ground is lost during the monitor's off period, the ungrounded condition can go undetected.

Continuous Monitors - *Single Wire*

The pinch test can be performed on cloth-style wristbands connected to continuous workstation monitors using the following procedure: The operator removes the wristband from his/her wrist. The band should still be connected to the grounding cord and constant monitor. The monitor will indicate an alarm condition because the person is no longer grounded.

The operator performing the test should pinch the band between the thumb and forefinger and hold for approximately 10 s. One finger will be on the outside of the band, and the other will be in contact with the interior surface. The monitor should then indicate a passing condition.

If the constant monitor continues to indicate a failing condition, the wristband has lost its conductivity and should be removed from service. This can be quickly verified by touching the metal buckle. If the monitor indicates a passing condition, the failure of the wristband has been confirmed.

Continuous Monitors - *Dual Wire*

For two-wire resistive and body-voltage sensing continuous monitoring systems, the testing procedure must be modified slightly. It is necessary to realize that the wristband consists of two halves, each connected to the constant monitor by a separate wire.

To evaluate these bands, make contact with both halves of the band simultaneously. This can be easily accomplished by having the operator performing the test pinch one half of the band with the thumb and forefinger of the left hand and the other half of the band with the thumb and forefinger of the right hand. This procedure is shown in **Figure 4**.

Figure 4. Testing Wristband Connected to a Continuous Monitor

Within approximately 10 s, the monitor should indicate a passing condition. If a passing condition cannot be obtained, the band has lost its conductivity. This can be quickly determined by touching both halves of the metal buckle. If the monitor indicates a passing condition, the failure of the wristband has been confirmed and the band should be removed from service.

Conclusion

If you use cloth-style wristbands in your ESD prevention program, collect data by incorporating the pinch test into your auditing practices to determine if a cuff-continuity problem exists. If a significant number of defective cloth wristbands are found, consider incorporating the cuff-conductivity test into the daily process check of the wristband system. By doing so, you can verify that the wristband is performing its intended function of safeguarding the quality and reliability of your products.

About the Author

Gene Bliley *is a member of the ESD Association and offers ESD engineering consultation, factory assessments, and training to the manufacturing community. Previously, he managed the ESD control program at the Lucent Technologies facility in Columbus, OH. While there, Mr. Bliley was a member of the Lucent Global Leadership Team Steering Committee; co-chairman of the corporate ESD Control Subcommittee, and a member of the Lucent ESD Task Group. Bliley Consulting, 614-939-0184, e-mail: ebliley@blileyconsulting.com.*