

Combining Wrist Straps, Monitors, and Lotions

Here's how one aerospace firm integrated wrist straps, constant monitoring, and conductive lotions to achieve maximum grounder reliability.

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Wrist straps have limited life times due to flexing and abuse, causing them to wear out and require replacement. Regular timed replacements are wasteful because good wrist straps get scrapped along with bad ones. Also, because wrist straps can fail in a moment, and ESD damage can occur in nanoseconds, occasional checks of wrist aren't effective since failures and damage can occur in the periods between tests, however brief.

When a wrist strap fails in a periodic test, one must always ask: "How long ago did the failure take place, and have products been damaged since then?" In a facility with a rigorous ESD program, all hardware handled since the last successful test of a failed wrist strap would be re-tested, and some might even be scrapped to head off possible latent failures- a pretty costly way to assure quality.

Worse, the grounder's failure may be intermittent. Continuous monitoring is needed to find intermittent malfunctions promptly, or sometimes to find them at all since an intermittent strap may be "on its good behavior" during periodic tests.

How much of a problem is intermittence, and how frequently do wrist straps fail? To find out we checked the cords in a production area. One day, we might find all of them to be in order, but on the following day, one or more high-resistance cords (bad cords) might be found. Our survey's results are given in Table 1.

Table 1

Description	Operator-to-Ground Resistance		Cord Resistance		Bad Cords %
	< 7M Ω	> 7M Ω	1M Ω	> 10M Ω	
Eight Areas With 10% of Wrist Straps Checked Monthly for Three Years	Not Measured		163	28	15%
One Area: Unchecked for Several Years	27	23	43	7	14%
Same Area: One Day Later	29	23	52	0	0%
Same Area: Two Days Later	27	16	42	1	2%

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Of course, there was no way of knowing whether a high-resistance cord had been defective for only a few minutes or for the whole interval between tests. Nor could we tell if subtle ESD damage, the germ of a latent failure, had been done by the improperly grounded employee.

We had found in prior work that reasons for high resistance to ground included internally broken ground cords, oversized stainless-steel expansion bands, loose, stretched cloth bands, soiled cloth bands with high contact resistance to the skin, soiled bead chains with high resistance between links, and operator's dry skin.

Preventing Resistance to Ground

In Table 1, a large number of operators had high resistance to ground. Table 2 shows that loose straps and dry skin are significant causes of such high forms of resistance.

Table 2

Strap Type	Strap Tightness	Antistatic Lotion	MΩ to Ground
Stainless-Steel Expansion* (Five Straps)	Tight	No	0.9, 1.1, 1.1, 1.5, & 1.8
Stainless-Steel Expansion (One Strap)	Tight	No Yes	2.6 1.5
Conductive Polyolefin (One Strap)	Tight	No Yes	1.7 1.7 1.2
Stretch Cloth** (Two Straps)	Tight	No	4.0, 6.0,
Stretch Cloth (One Strap)	Tight	No Yes	3.0 1.2
Stretch Cloth (Three Straps)	Fairly Tight	No Yes	6.0, 21.0, 30.0, 1.3, 5.0 & 3.0
Stretch Cloth (One Strap)	Loose	No Yes	800 2.5

*In previous work, fifteen operators with straps of varying tightness and without lotion had resistances ranging from 1.0 to 30 MΩ.

** In previous work, four operators with straps of varying tightness and without lotion had resistances ranging from 1.5 to 55 MΩ. Six operators with bead chains and without lotion had readings of 1.5 to 40 MΩ.

Tight straps, particularly metal ones, gave satisfactory results (i.e., 6 MOhms or less), with readings that could be further improved with conductive lotion. However, a cloth strap that was only "fairly tight," giving a reading of 30 MOhms, was lowered to 3.0 MOhms with conductive lotion. One loose cloth strap that read 800 MOhms was reduced to 2.5 MOhms with lotion.

The lotion was obviously effective, and it is often needed to achieve our suggested resistance to ground of 10 MOhms. But without continuous monitoring, the operator cannot know when the lotion's effectiveness is running out and letting resistance drift too high. In such a case, a constant monitor might also serve as a lotion monitor. Remember that lotions are not suited to all applications since they can attract dirt and may possibly contaminate components.

These observations and considerations indicate that monitoring of wrist straps must be continuous, not occasional. Vigilance must be eternal because using a wrist strap without a

continuous monitor is like removing one's hands from the steering wheel of a fast-moving car—both auto accidents and ESD events can happen in a fraction of a second.

Given our experience, we elected to use dual-cord continuous monitoring, and our reasons were these:

- 1. For a continuous monitor with a dual cord, an intermittent failure in one conductor will normally be discovered while the other conductor remains sound, keeping the operator grounded and ESD sensitive parts safe.**
- 2. both the operator and ground connections are checked because resistance is measured through a loop including both commercial power ground and a dedicated static ground.**
- 3. Such monitors aren't fooled into reading "OK" when a high capacitance touches the cord or strap.**
- 4. Since resistance is measured through a loop that includes two skin-contact points, the actual resistance of the operator to ground is a fraction of the alarm level (10 MOhms), thus providing a safety factor.**
- 5. Such monitors do not have to be "tuned" to the capacitance(s) of individual operators, and a single annual calibration is sufficient for reliable operation.**

Since our original recommendation of these monitors, long-term trials of them in our manufacturing areas have shown them to be effective, and they now are required in some programs.

Three suppliers have certified monitors to our in-house specification, which includes features such as springs for plugging in the cord's banana plugs (so that the operator can pull free from any direction for maximum safety) and an internal switch that shuts off the audio alarm when both plugs are removed.

Despite our favorable experience, no product will please everyone. Some judge continuous wrist-strap monitors to be troublesome and their audible alarms to be annoying. Thus, any monitor should be tested in-plant before a purchase is made.

[For More Information](#)

For more information on wrist straps and testing, see the following sources:

J.M. Kolyer, W.E. Anderson, and D.E. Watson, "Hazards of Static Charges and Fields at the Workstation," 1984 EOS/ESD Symposium Proceedings, p. 7.

J.M. Kolyer and DE Watson, "Cost Effective Methods of Testing/Monitoring Wrist Straps," 1986 EOS/ESD Symposium Proceedings, p. 34.