



How Tough Are Your Batteries?

We Put the Most Popular Batteries to the Test
See How Each Brand Measures Up

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Motorola “Proven Tough” batteries are just that

There’s nothing more frustrating, and potentially dangerous, than when a battery fails in the field. You’re cut off from communicating with the people you need to get through to. That’s why you want to make sure the batteries you buy stand up to your demanding work environment and provide reliable power that your people count on. And when you know you can rely on your batteries, it makes your job a little easier.

Tested for the real world

We’ve tested hundreds of batteries to see how each stands up to real-world work environments. Because batteries that can’t withstand the rigors of your work aren’t much of a bargain over the long term if you have to replace batteries frequently because they quickly lose their ability to hold a charge or just don’t hold up. This white paper and the Proven Tough Web site will show the differences in quality and durability among some of the best-known batteries on the market, so you can make the right purchase decision on which batteries will serve your needs for the long term. You’ll see that Motorola batteries are a superior value for your business because they’re tested to stand up to just about any thing your work can throw at them.

Tested tough – proven tough

To measure how well Motorola batteries compare to the competition, Motorola hired an independent, outside service to select competitor batteries that could be tested against comparable Motorola batteries. There were 30 samples of each battery type that were compatible with Motorola’s most popular two-way radios, including batteries from Battery Zone, Honeywell, Power Products and Multiplier.

Motorola chose to conduct three tests that represent real-world situations that occur most often during normal battery use:

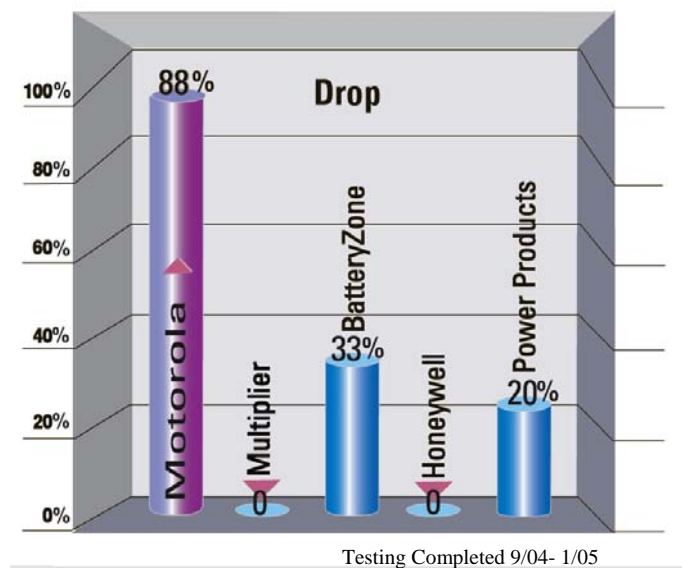
- Being dropped on a hard surface – Drop Test
- Being subjected to long periods of vibration – Vibration Test
- Being shocked by static electricity – Electrostatic Discharge (ESD) Test

Drop Test

Impacts and drops are some of the most frequently occurring incidences and stresses that two-way radios and batteries must endure. This drop test was set up according to the same U.S. military specifications the government uses for its own equipment (MIL810F Method 516.4). Technicians attached each battery to the appropriate Motorola radio and dropped it four feet onto a smooth metal sheet. Each individual battery went through seven cycles of six drops on each surface for a total of 42 impacts.

Batteries were inspected for damage, such as:

- Cracking or splitting open
- Damage to the connection with the radio
- Inability to charge
- Inability to discharge



Typical failures included the battery housing splitting, broken latches, being dislodged from the radio or failure to charge.

Results:

- 88% of the Motorola batteries passed.
- Multiplier: None of the Multiplier batteries survived – half of them failed in the first cycle.
- Battery Zone: Only 33% passed.
- Honeywell: None of the Honeywell batteries passed.
- Power Products: Only 20% passed – all 10 samples of two of the Power Products battery types failed.

Vibration Test

Portable two-way wireless radios regularly endure jostling, bouncing, shaking and vibration. These conditions can be a common source of battery failure. The vibration test also followed military specifications (MIL810F Method 514.5, Procedure 1, Category 24, figure 514C-18 and figure 514C-17) to test sine vibration (follows a regular, repeating pattern) and random vibration (no predictable shaking pattern). Each radio went through a total of 12 hours of vibration.

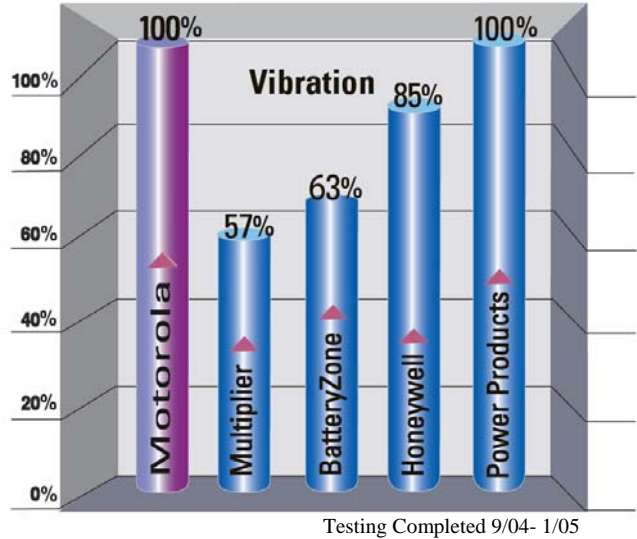
The batteries were inspected once after each axis of vibration, for a total of six inspections to determine:

- Cracking or splitting open
- Damage to the connection with the radio
- Inability to charge
- Inability to discharge

Broken latches and failure to provide power were the major causes of failure.

Results:

- 100% of the Motorola batteries passed.
- Multiplier: Only 57% passed – all 10 samples of one Multiplier battery type failed.
- Battery Zone: Only 63% passed.
- Honeywell: Only 85% passed.
- Power Products: All the Power Products batteries passed.



ESD Test

Static electricity and other electrical shocks can disable a two-way wireless radio battery. The Electrostatic Discharge (ESD) test followed standards set by the International Electrotechnical Commission and was conducted in two parts:

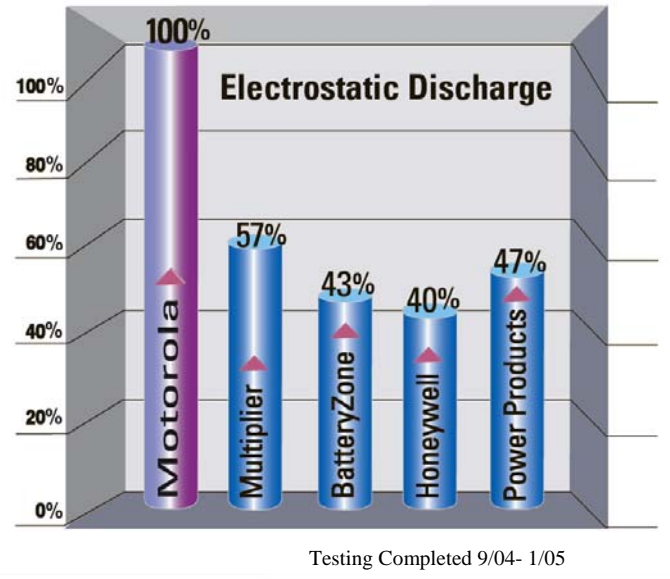
1. An air discharge test, where the probe is close to the battery but not touching, and tested at positive 4KV, 8KV, 10KV, 12KV, and 15KV, and at negative 4KV, 8KV, 10KV, 12KV, and 15KV.
2. A contact discharge test, where the probe touches the battery, and tested at positive 4KV, 6KV, and 8KV, and at negative 4KV, 6KV, and 8KV.

Every battery went through each combination of contact, power level and polarity 10 times, for a total of 200 air discharges and 60 contact discharges per battery. After each set of 10 discharges, technicians inspected the batteries for their ability to charge and discharge.

Typical failures included inability to charge, thermistor problems and flashing LEDs.

Results:

- 100% of the Motorola sample batteries passed.
- Multiplier: Only 57% passed – nine out of 10 samples of one Multiplier battery type failed.
- Battery Zone: Only 43% passed – all 10 of one Battery Zone battery type failed.
- Honeywell: Only 40% passed – all 10 of one Honeywell battery type and nine out of 10 of another type failed.
- Power Products: Only 47% passed – nine out of 10 of one Power Products battery type failed.

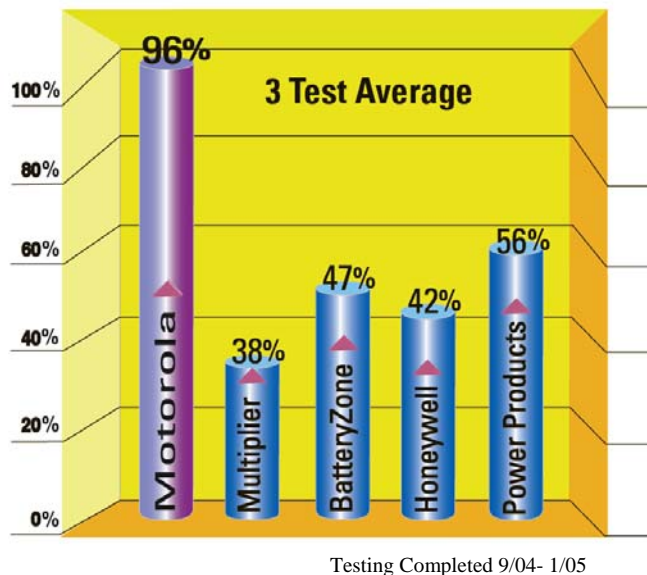


Motorola's Superior Performance

The results of the Drop, Vibration and ESD tests show that Motorola batteries dramatically outperform competing batteries from Battery Zone, Honeywell, Power Products and Multiplier. The average for all three tests demonstrates Motorola batteries are tougher than the competition:

- Motorola: 96%
- Multiplier: 38%
- Battery Zone: 47%
- Honeywell: 42%
- Power Products: 56%

Each Motorola battery is designed, engineered and thoroughly tested to provide optimum performance and



matched to guarantee the same high standards of quality that you enjoy with your Motorola two-way radios and accessories. Motorola stands behind its batteries with industry-leading warranties, so you can be confident that its batteries will meet your toughest requirements. You'll get clear, reliable communication under tough conditions – something you can't be sure of with a competitor's battery.

For more test details and specific measurement results, visit the Proven Tough Web site, www.proventough.com.

Choosing a battery that meets your business' needs

Long cycle life

Every business is different and has different needs. But every business needs to communicate ... continuously. That's why you want a battery that will provide a long cycle life so you can use it over and over again, without it losing its ability to hold a charge. Selecting a battery that holds the longest charge and gives you the ability recharge the battery multiple times is a necessity.

Impedance and other concerns

The term impedance, quite simply, is anything that "impedes" the electrical flow between circuits. Ideally, batteries with the lowest impedance give you the best possible radio performance. If a battery experiences a sudden impact, it can increase impedance because the electrical current may be interrupted at a solder joint or damaged cell.

When a battery's impedance level exceeds the radio's design limits, the battery can literally shut down the reception circuits. In addition, a sharp rise in impedance can cause the radio receiver to "desense," which is the radio's ability to pick up a clear signal while the radio is receiving.

It's normal for battery impedance to increase at the end of the discharge cycle, however, most newer-model radios provide a "Low Battery" alert feature that appears before impedance affects reception or transmission strength. To get the best possible radio performance, look for a battery that has low impedance levels during the discharge cycle as well as throughout the battery's life cycle. **Note:** Batteries incorporating FM, MSHA or any other type of similar safety approval will have slightly higher impedance levels (and slightly less operation time per cycle) due to the additional protective circuits.

Motorola engineers design extremely tight impedance limits for each battery component, ensuring that the transmission and reception circuits, antenna and battery all operate within specifications.

Battery chemistries for different needs

As you evaluate the type of batteries you need, consider the how your business works. How often will your batteries need to be recharged? Will you need a battery that provides the longest cycle life possible? Will your batteries be exposed to extreme temperature conditions? Answers to these questions will help determine the type of battery you need.

Impedance

It is the measure of opposition to an electric current, and high impedance can negatively impact radio performance. Both lab and field testing show high battery impedance (resistance) harms transmissions and reception sensitivity, and since impedance exists wherever an electrical path within the cell or battery pack is interrupted (such as at solder joint, weld connection or within a weak or damaged cell), it's important to set tight impedance limits for each battery component.

- **Nickel Cadmium (NiCd)** batteries are the most cost-effective option because they provide a longer cycle life. They're ideal for radio users who works in extreme conditions of cold and heat (-30C° to +50°C). However, NiCd batteries can experience "memory effect" and may not return to full capacity if they're recharged before being fully discharged. **Note:** Motorola impres™ batteries using impres™ chargers can help that from happening.
- **Nickel-Metal Hydride (NiMH)** batteries, compared to NiCd batteries of similar size, usually operate 40% to 50% longer between charges. However, they do not operate as efficiently in extreme temperatures. Also, NiMH batteries are more environmentally friendly because they contain fewer toxic chemicals.
- **Lithium Ion (Li-ion)** batteries offer the best of both worlds by providing a higher energy-to-weight ratio than NiMH batteries and they offer a major advantage of not experiencing "memory effect."

Memory effect

When a NiCd or NiMH battery is consistently recharged before it's fully discharged, it can over time develop "memory effect." This is a condition where the battery charge will get progressively shorter after each recharging session. The battery loses its ability to accept a full charge, which means shorter time working time and requires the battery to be recharged more often.

Excess heat during charging causes an accumulation of gas bubbles and the formation of irregularly shaped crystals which stick to the cell plates inside the battery. These bubbles and crystals keep the battery from being fully charged, no matter how long it stays in the charger.

By appropriately managing the charge process for each type of battery, Motorola chargers employ features that minimize the conditions that allow memory effect to occur. Motorola impres™ chargers manage the entire process for you, making sure you get the most value from your battery purchase.

Battery quality differences – what to look for

To make your job easier in selecting the right battery, it's important to understand the differences in battery quality. Battery components and manufacturing processes are not all alike. Knowing these differences can help you make the best purchase decision and choose the right battery for your business.

When manufacturing batteries, Motorola employs the highest standards of quality and consistency to ensure its batteries meet the rugged requirements of real-world use.

1. Motorola only uses premium grade battery cells from reliable suppliers. Battery cells must provide high capacity, long cycle life, low impedance and be able to operate in a wide temperature range (-30C° to +50°C), as well as provide the best shock resistance available.
2. Connecting circuitry between battery components can be a common source of battery failure. Motorola uses soft film copper flex circuitry to "give" in the case of an impact – unlike the thin wires found in other battery brands. Soft film copper flex circuitry also enables the most efficient flow of electrical current, which reduces impedance and improves performance. Circuitry that is soldered, rather than welded, to components minimizes aging and impedance buildup.

3. Motorola uses a variety of pliable shock absorbing materials to hold battery components in place and to protect the cell back and flex circuitry. Damping vibration inside the battery housing helps reduce component damage during sudden impact.
4. For battery casings, Motorola uses tough polycarbonate plastic, which has significantly more tensile strength (the ability to resist lateral forces) and flexural strength (the ability to withstand flexing or bending) than ABS plastic.
5. Motorola's ISO 9000 manufacturing environment, powered by state-of-the-art, computer-controlled equipment, ensures automated, monitored and consistent assembly for every battery produced. Surprisingly, many competitive batteries are assembled by hand, which can result in lower quality construction due to inconsistent, non-automated manufacturing processes. In addition, Motorola batteries are performance-matched to the corresponding Motorola two-way wireless radio, optimizing all parts of the communications system: radios, batteries, antennas and reception/transmission circuits.
6. Finally, all Motorola battery models have to pass a stringent Accelerated Life Testing (ALT) process that simulates five years of product use by subjecting the batteries to five weeks of grueling tests. ALT and other tests include being dropped and shaken as well being subjected to electrostatic discharge, cold and hot temperatures, humidity and rain.

ALT testing specifically includes ...

- Rain test – a steady rainfall and wind for 30 minutes on every surface
- Salt fog test – exposure to an atomized salt solution for 48 hours
- Dust test – six hours of dust blowing on all surfaces
- Vibration test – up to nine hours of exposure to vibration
- Shock test – 18 shocks with a minimum of 40 Gs of force

Motorola also tests radios and batteries as a system to ensure they'll operate within the specifications required.

Why buy Motorola batteries?

When lives and livelihoods depend on critical communication, you shouldn't compromise on the batteries you buy. Motorola designs, engineers and manufactures its batteries using some of the most stringent specifications and criteria in the industry ... all to ensure its batteries can withstand the toughest work environments.

The comprehensive tests these batteries undergo inarguably demonstrate that Motorola batteries are manufactured to be tough, and most importantly, have been proven to be tough. So why risk having to continuously replace batteries that fail in the field – now that you know how Motorola batteries stack up against other batteries. And Motorola backs it up with industry-leading warranties so you can rest assured that the Motorola batteries you buy are the best for your business.

Motorola Manufactured Battery Warranty Information

Product

NiCd impres^{TM**} Batteries
 NiMH impres Batteries and Li-ion impres Batteries
 NiCd Premium Batteries
 NiMH and Li-ion Premium Batteries
 NiCd, NiMH Power Batteries

Warranty*

24-month capacity
 18-month capacity
 18-month capacity
 12-month capacity
 12-month capacity

* All Motorola Manufactured Batteries have a 24-month workmanship warranty with the exception of Power batteries which carry a 12-month workmanship warranty.

** impres batteries carry an additional 6-month warranty only when used with an impres charger

Motorola will replace any of these two-way radio batteries if they fall below 80% of their rated capacity during the period shown above. For complete warranty details, including exceptions, contact your Motorola Authorized Two-Way Radio Dealer or visit http://commerce.motorola.com/consumer/QWhtml/warranty_twoway.html.

Intrinsically safe

Intrinsically safe products are designed with enhanced protection against potential sparking which could ignite flammable gasses or combustible material. Motorola's batteries and radios also conform to the "intrinsically safe" standard: certified and rated by an approval agency as intrinsically safe for use in classified hazardous areas where flammable gasses or combustible dusts or fibers may be present.

How does Motorola make batteries intrinsically safe? Actually it's the battery, radio and accessories in combination as a system that is tested to determine if they are intrinsically safe. The following agencies approve and certify Motorola two-way radios and batteries: the Factory Mutual Corporation (FM), the Canadian Standards Association (CSA), the Mine Safety and Health Administration (MSHA) and/or CENELEC Approval Agencies.

Note: You cannot field upgrade a Motorola radio to an intrinsically safe approval rating. Radios must be ordered with the Intrinsically Safe option and ship from the Motorola manufacturing facility.