The Cold Hard Facts about Using Mobile Computers in Cold Storage Environments

Introduction

Coats, hats and gloves are essential in order for warehouse workers to function for more than a few minutes in cold storage areas. In much the same way, mobile data-collection computers must be built to perform under these demanding conditions. Unless mobile computers, associated barcode readers and wireless networking equipment have been designed with features required specifically for use in cold environments, the level of their reliability will fall right along with the temperatures.

Standard data collection devices deliver less than substandard performance if they are consistently used inside freezers or exposed to frequent temperature changes. In fact, moving the computer between normal and cold areas is extraordinarily hard on just about every part of the device, even if it's ruggedised. In the short term, LCD screens fog up, batteries are unable to release enough energy, and processors may not perform as intended. This all equates to reduced user productivity. Long-term use of non-optimised equipment in cold conditions causes screens and housings to become brittle, and repeated condensation can cause internal components to corrode, short-circuit and fail.

Low temperatures don't have to mean reduced reliability and productivity. There are mobile computers, wireless networking equipment and data-collection peripherals available that are specifically made for prolonged use in cold, moist and freezing conditions. This white paper describes the conditions where cold environment computers are necessary, the warning signs that indicate when devices aren't up to their environmental requirements, and explains the key differences between standard and cold environment rugged data-collection computers.

What Changes in the Cold?

Cold air, frost and condensation - each of these elements creates a specific challenge for rugged mobile computing equipment. The insulation used to keep refrigerated and frozen storage areas cold also poses problems when it comes to wireless connectivity. Here's a brief overview of how these conditions impact mobile computer performance.

Frost

- Frost obscures LCD screens, so users can't see prompts or verify the data they enter. Productivity and accuracy both suffer.
- Barcode readers and image capture devices will not function if frost covers their optical ports. In these cases, workers must resort to manual data entry, which severely reduces productivity and increases error rates.
- Frost can also cause keys to stick if the device is improperly constructed or insufficiently sealed. Error rates grow exponentially.

Condensation

- Condensation causes the same problems as frost by making screens and scanners unusable.
- Condensation presents more of a problem because it can occur inside the screen or scan window, and can't easily be cleared away. Condensation is a very serious problem because it can cause internal components to corrode, short-circuit and fail, making the device unusable until it is repaired or replaced.

Cold Air

Battery-powered mobile devices are challenged by cold air because batteries can't release their energy when temperatures drop below certain levels. The result is reliability and productivity problems that threaten on-time performance and reduce overall efficiency.

Temperature Changes

Most rugged mobile computers won't stop working if they're occasionally taken into a freezer for very short periods of time, or if used longer-term in lightly refrigerated areas. The amount of exposure to extreme cold conditions, and the frequency of transition from cold to normal temperatures are the key considerations for determining if specialised cold-environment equipment is needed.

Standard computers will generally perform normally at temperatures down to approximately -10°C, which is appropriate for common refrigerated environments. Computers that are used consistently at those temperatures or in freezers (which are often kept at -30°C) should be made specifically for those conditions.

Temperature changes are especially hard on computers because condensation often results and can cause complete failure in relatively short order. Rugged cold environment models should be used if the equipment will experience travel through normal, refrigerated and frozen areas throughout the day as part of normal picking and put-away operations. Extreme temperature swings are the most dangerous, as in the summer when a forklift may be moving from a -30°C freezer to a loading dock.

Evaluating a Device for Use in Cold Storage

Any handheld computer can be carried in a case or holster, but that superficial protection doesn't render the device suitable for prolonged use in cold temperatures. True rugged cold-temperature computers use parts, materials and manufacturing processes specifically designed for the environment. Practically every component of a mobile computer – from the casing to the internal circuitry, can be optimised for use in cold conditions. This section explains how true cold-temperature computers are different from standard models and identifies key features and specifications to look for.

Heaters

Integrated heaters are the components that truly set cold-environment computers apart. Heaters are factory-installed options that ensure reliable computer performance in several key ways. Most importantly, heaters can prevent condensation, the most detrimental result of cold storage environments in both the short-term and long-term. Condensation typically forms on unheated displays and the scan windows of barcode readers, causing them to fog over and productivity to plummet.

Accuracy suffers if workers attempt to use the unreadable terminal by continuing to enter data if they can't verify what they are entering. Barcode reading accuracy is also compromised if there is condensation on the scan window, but it is more likely that the barcode reader won't function at all for as long as the condensation is present.

Condensation forces workers to enter data manually and prevents them from taking advantage of on-screen prompts. Heaters are therefore essential for cold-environment use. Internal heaters are recommended if computers will be consistently used at temperatures of -10°C and below, or will frequently move in and out of cold areas. Touch-screens and scanning windows should be equipped with heating elements in order to prevent condensation.

Housing

Standard computers may not perform up to their specified drop rating when used in cold environments because the housing may become brittle. Mobile computers for cold storage should be made from durable material suitable for industrial applications and be well constructed to limit the effects of exposure. Drop tests should be done at temperatures of -30°C. A strong seal is essential for preventing moisture and condensation from damaging the inside of the computer.

Batteries

Mobile computers typically use Li-Ion batteries. Cold temperatures prevent common Li-Ion batteries from releasing their charge, making the powered device unusable

until the battery is warmed. Li-Ion batteries also tend to fail completely when temperatures reach -30°C, which is common in frozen storage areas.

Low-impedance lithium-ion batteries specially formulated for cold-temperature use are available. These batteries will release their charge at colder temperatures than standard models, and have lower failure points.

Lead acid batteries are another alternative. They suffer less cold degradation than Li-Ion batteries, but are less power efficient relative to their weight.

Components

As noted, it is critical to protect internal components from moisture and condensation. The external housing and seal provide the first and best line of defence, but the computer manufacturer's choice of components is also an important factor. Components can be given a protective coating that will prevent short circuits if condensation does occur. Coating adds a step and expense to the manufacturing process, but provides protection against much more expensive replacement costs.

A less effective option is to seal a desiccant packet inside the device. This is akin to the silica packets that are sometimes included in consumer electronics packaging. Desiccant packets provide a measure of protection against condensation by absorbing moisture. The problem is that the benefit is temporary and the packets need periodic replacement, a maintenance step that's commonly overlooked.

Connectors

Connectors that link the computer to peripherals or power sources (e.g. the battery on a vehicle-mounted computer) are another important variable to reliability. Most connectors clip into place. Screw-in connectors are less common, but are a superior choice for cold environments. Not only does the screw threading provide a stronger connection that is less likely to detach, it provides a seal against the moisture that can damage the connector.

Ergonomics

Just as you can't judge a book by its cover, you can't judge a cold-environment computer by its outward appearance. Manufacturers typically make cold-environment computers with large, well-spaced keys to facilitate easy use by gloved operators. A glove-friendly keypad layout is useful, but ergonomics won't overcome inferior housing, components or environmental protection, which are often the true differentiators between standard and purpose-built cold environment computers. Users report that overall size and weight are more important than keypad configuration for overall satisfaction and ease-of-use.

The following table summarises the differences between computers that are suitable for common and cold environments.

Feature	Standard mobile computer	Cold environment model	Comments
Internal heater	No	Yes	
Heating elements	No	Yes	Computers can have heated displays and heated scanning windows even if they do not have internal heaters.
Housing	Standard	Formulated to resist cracking when dropped in cold temperatures	Standard computers may not perform up to their specified drop rating when used in cold environments because the housing may become brittle.
Connectors	Clip-in or plug-in	Screw-in	Screw-in connectors provide a seal against moisture.
Battery	Standard lithium ion	High-grade lithium ion formulated for cold conditions; or lead-acid.	Battery comments apply to handheld computers only. Vehicle-mounted units are powered by the vehicle's battery.
Internal components	Standard	Conformal coated	Conformal coating protects against moisture from condensation, which may cause short circuits & device failure. Desiccant packets (e.g. silica) also reduce moisture, but need to be changed.

Wireless Infrastructures in the Cold

Popular industrial wireless communication technologies, including Bluetooth and IEEE 802.11-standard wireless networks, can be used in cold storage and freezer environments. Some adjustments may be required to wireless LANs to ensure consistent, quality performance.

Access points (APs) often need to be installed directly in refrigerated or frozen storage areas to provide coverage there, because thick walls and insulation can block signals from APs outside the cold zone. When access points are installed in refrigerated or freezer zones, they should be put into a heated enclosure to protect against condensation and cold.

The multi-path effect is a real concern for any insulated, cold or damp environment, and is especially so for cold storage facilities, where all these conditions are present. There are specialised antennas that can be used with common access points to correct for the multi-path effect. Such antennas are highly advantageous for providing wireless LAN connectivity to mobile computers used in cold storage environments.

Barcode Readers

Barcode scanners need a direct line of sight to the label for accurate reading and decoding, so fogging or condensation on the scanner optics can present a problem. The best solution is to have the barcode reader integrated as a component of the handheld computer, to take advantage of the computer's internal heater to function properly.

Handheld computers are available with long-range scanners, and can be used with powered vehicle-mount cradles. This makes them an intriguing option for forklifts in cold storage areas. However, handheld devices may not always be a viable option on forklifts, and the wireless or tethered handheld scanners that are typically used in conjunction with true vehicle-mount devices are not available with internal heaters. In these cases, heated holsters can be used to mitigate problems with condensation.

Bluetooth is a popular option for interfacing barcode scanners and other peripherals to mobile computers. Bluetooth is especially valuable in cold environments, because the wireless interface eliminates worries about connector failures from condensation.

Alternative Data-Collection Options

Speech recognition is an alternative to barcode for accurate data entry that has several advantages for cold environments. Speech recognition terminals are worn on a belt or shoulder holster, rather than carried, and can be worn under a coat. Terminals worn under coats aren't exposed to the temperatures cold enough to cause problems.

Conclusion

Thriving in cold conditions requires the ability to adapt to the environment. Mobile computers can be adapted for cold-environment use with heaters, housings, components and peripherals that set them apart from standard models. Without these adaptations, mobile computers are at significantly elevated risk for failure, putting organisations at risk for lost productivity as well as unnecessary repair and replacement costs. Seemingly minor problems such as frequent battery changes and devices periodically being unusable because of condensation problems drive up operating costs by reducing productivity and threatening on-time performance.

