Understanding Ruggedized Mobile Computer Specifications

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Purpose:

Once a very small portion of the mobile computing market, demand for industrial strength mobile computers is growing at a rapid rate, and being deployed for use in an ever-increasing amount of mobile applications. Industrial computers, in either handheld or vehicle mount form, continue to be sold in large numbers for use in traditional warehouse and manufacturing applications. However, rugged mobile computers are now being used in a great number of diverse applications including distribution, field service, direct sales, maintenance, military, and the list goes on.

Customers are realizing that repair and replacement costs, along with downtime and decreased productivity, can greatly decrease profitability. Although the initial cost of a truly ruggedized computer can be much greater when compared to a standard commercial device, the long-term benefits clearly outweigh the initial savings.

As demand for ruggedized mobile computers continues to grow, so does the number of different products offered to the market. This has led to a large number of devices that claim industrial ruggedization, but in many circumstances these devices are simply enhanced commercial designs that include limited benefits. Many of these devices are manufactured for use in very specific environments.

Background:

A truly rugged industrial device is engineered, from the ground up, to operate in the most extreme hostile environments. The industrial engineering design is not only limited to the external housing, but includes internal components, special coatings, sealants, and other design features allowing computers to be exposed to extreme humidity, dust, temperatures, vibration and shock.

Included in the mix is a class of products manufactured explicitly for use in hazardous or explosive environments. These devices are usually designed for specific industries, and have very strict intrinsically safe approval requirements. Understanding the differences between a truly ruggedized computer and an enhanced commercial design can be a challenging proposition for even the most informed customer.

Customers must rely on the product's specifications to evaluate the amount of ruggedization included in the product's design. However, there is not a "gold-standard" to apply to all mobile computing products. Specifications vary from product to product and market to market. However, to help standardize the evaluation process there is a number of ratings and standards established by various government agencies, industry organizations, and independent laboratories that allow for a better comparison of a product's industrial ruggedization.

However, to add to the confusion, certain ratings and standards are subject to interpretation, and closer scrutiny reveals inconsistencies. This paper will focus on the common standards that exist for ruggedized mobile computers, and attempt to clarify what each of these standards truly mean for the consumer, along with a discussion of design characteristics to look for to determine a product's true capabilities and limitations. These design characteristics are not always known, and in some instances are purposely not disclosed. Therefore, in certain circumstances it may be important to obtain detailed testing information from the manufacturer to verify the product's ability to operate in certain environments. Understanding an industrial computer's ruggedization specifications can be the most important information when purchasing a ruggedized device. Not understanding these specifications can lead to improper evaluation of a product's performance, and result in a bad purchasing decision that can cost an organization greatly in the long run.

Common Specifications For Ruggedized Mobile Computers:

Listed below are some of the more common ratings and standards frequently used by manufacturers to define a product's degree of ruggedization.

IP Ratings (Ingress Protection)

Ingress protection ratings are standards for electrical enclosures. The rating refers to the equipment's ability to permit solids and liquids to penetrate the computer's enclosure. The protection standards are defined by the IEC (International Electrotechnical Commission). A mobile computer's IP Rating is expressed as a two-digit number (Example: IP-66). The first number designates protection from solids, while the second number designates protection from liquids. Please refer to the table below for specific IP rating information.

If a device is truly ruggedized for use in an industrial environment, then an IP rating will be specified. If a computer is being used in an environment where dust and moisture are prevalent, then the IP rating must be considered. If the IP rating is not specified, then you can assume a computer will not be resistant to dust and moisture. Any computer product being used in a truly industrial environment should have an IP rating of IP-65 in order to be fully protected from dust and liquids. Dust and moisture can cause major problems to internal computer components. Even if a device is not used in an industrial environment, it can become exposed to levels of dust and moisture that can eventually cause major problems.

It is important that manufacturers have their equipment certified by an outside laboratory to verify the product's IP rating. UL and CENELEC are two such laboratories, but many different laboratories exist that provide this service. The important thing is that the product is certified by an outside organization. If IP ratings are specified on a product's data sheet, then an approval certification number should also be included (Example: EN 60 529 or Approved to IEC 529). Another important consideration is that every configuration of the product is IP certified, and not only one specific configuration. Many manufacturers will claim a certain IP rating, but this rating is only achieved with one specific, and usually expensive configuration. All available configurations should be IP rated for proper protection to allow the customer flexibility when ordering a mobile computer.

IP Rating Table:

Solids - (First Number)		Liquids - (Second Number)	
0	No Protection	0	No Protection
1	Protected Against Objects > 50mm (hands)	1	Protected Against Dripping Water Or Condensation
2	Protected Against Objects > 12mm (fingers)	2	Protected Against Sprays Of Water 15º From Vertical
3	Protected Against Objects > 2.5mm (tools/wires)	3	Protected Against Sprays Of Water 60º From Vertical
4	Protected Against Objects > 1 mm (small tools)	4	Protected Against Water Sprayed From All Directions
5	Protected Against dust, limited ingress	5	Protected Against Low Pressure Jets Of Water
6	Totally protected against dust	6	Protected Against Heavy Seas
7	N/A	7	Protected Against The Effects Of Immersion
8	N/A	8	Protected Against Submersion
An IP Rating of IP-68 Would Indicate a dust tight device that can withstand total submersion in water.			

(Data in table obtained from the Underwriters Laboratory website, http://www.ul.com/hazloc/ref/ingress.htm, 2004)

NEMA (National Electrical Manufacturer Association)
NEMA ratings are standards that are useful in defining the types of environments in which an electrical enclosure can be used. The NEMA rating system is defined by the National Electrical Manufacturer Association, and frequently signifies a fixed enclosure's ability to withstand certain environmental conditions. Please refer to the table below for specific NEMA type designations.

NEMA ratings are rarely applied to mobile devices, and are mainly applied to fixed enclosures. For example, a NEMA rating would be applied to a fixed electrical box mounted outside, or a fixed enclosure used to house a wireless access point. Most enclosures rated for use in an outside environment include a NEMA 4 rating. NEMA ratings have more stringent testing requirements to verify protection from external ice, corrosive materials, oil immersion, dust, water, etc. These stringent testing requirements can rarely be applied to mobile devices, but there is a correlation between NEMA ratings and IP Ratings. However, this correlation is limited to dust and water. Included below is a table that provides a comparison between NEMA Ratings and IP Ratings. It is important to realize that this comparison is only related to the protection provided against dust and moisture. For this reason, this table can only be used to convert NEMA Ratings to IP Ratings, but not vice versa. A few manufacturers of mobile computers will include NEMA ratings in their specifications, and it is important to understand how the NEMA specification correlates to a product's IP Rating.

NEMA Type Designation Table:

NEMA Rating	Intended Use and Description
1	Indoor use primarily to provide a degree of protection against limited amounts of falling dirt.
2	Indoor use primarily to provide a degree of protection against limited amounts of falling water and dirt.
3	Outdoor use primarily to provide a degree of protection against rain, sleet, wind blown dust and damage from external ice formation.
3R	Outdoor use primarily to provide a degree of protection against rain, sleet, and damage from external ice formation.
3S	Outdoor use primarily to provide a degree of protection against rain, sleet, windblown dust and to provide for operation of external mechanisms when ice laden.
4	Indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, hose-directed water and damage from external ice formation.
4X	Indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, hose-directed water, and damage from external ice formation.
5	Indoor use primarily to provide a degree of protection against settling airborne dust, falling dirt, and dripping noncorrosive liquids.
6	Indoor or outdoor use primarily to provide a degree of protection again hose-directed water, and the entry of water during occasional temporary submersion at a limited depth and damage from external ice formation.
6P	Indoor or outdoor use primarily to provide a degree of protection against hose-directed water, the entry of water during prolonged submersion at a limited depth and damage from external ice formation.
7	Indoor use in locations classified as Class I, Division 1, Groups A, B, C or D hazardous locations as defined in the National Electric Code (NFPA 70) (Commonly referred to as explosion-proof).
8	Indoor or outdoor use in locations classified as Class I, Division 2, Groups A, B, C or D hazardous locations as defined in the National Electric Code (NFPA 70) (commonly referred to as oil immersed).
9	Indoor use in locations classified as Class II, Division 1, Groups E, F and G hazardous locations as defined in the National Electric Code (NFPA 70) (commonly referred to as dust-ignition proof).
10	Intended to meet the applicable requirements of the Mine Safety and Health Administration (MSHA).
12 and 12K	Indoor use primarily to provide a degree of protection against circulating dust, falling dirt, and dripping noncorrosive liquids.
13	Indoor use primarily to provide a degree of protection against dust, spraying of water, oil, and noncorrosive coolant.

Comparison Table - "NEMA" Type and "IP" Rating Designations:

Conversion Of "NEMA" Type To "IP" Rating Designations*	
Type Number	**IP Designation**
1	IP10
2	IP11
3	IP54
3R	IP14
3S	IP54
4 and 4X	IP56
5	IP52
6 and 6P	IP67
12 and 12K	IP52
13	IP54

*Table cannot be used to convert "IP" Codes to "NEMA" Types

(Data in table obtained from the Hoffman Online website, http://www.hoffmanonline.com/PDFCatalog/SpecifiersGuide/A-DAppendicesPDF/Arating.pdf, 2004)

MIL-STD (Military Standard) or MIL-SPEC (Military Specification)
The MIL-STD specification is a series of guidelines established by the U.S. Department of Defense in order to define specific performance and manufacturing requirements for all types of equipment. In most cases, products must be designed in accordance with the MIL-STD to be considered acceptable for use by the U.S. Department of Defense. A product's MIL-STD compliance is also a consideration for many state and local governments when purchasing mobile computers for use in public safety, emergency services, maintenance, etc. The MIL-STD 810F standard was released on January 1, 2000 (superseded MIL-STD 810E). MIL STD 810F includes testing protocols to simulate environmental stresses from rain, humidity, salt fog, sand/dust, vibration, shock, temperature, etc. A copy of MIL-STD 810F can be downloaded from the United States Army Developmental Test Command at http://www.dtc.army.mil/pdf/810.pdf.

The MIL-STD 810F standard is an all-encompassing standard that is frequently used for ruggedization testing by mobile computer manufacturers. Many manufacturers and laboratories will design their ruggedization testing in accordance to the MIL-STD 810F guidelines. However, it is important to note that when the MIL-STD 810(x) specification is listed on a product's data sheet this usually only applies to vibration and shock, and does not mean that protection is included from salt fog, corrosion, rain, humidity, temperature, etc. Therefore, IP Ratings are frequently used to signify protection from liquids and solids and the MIL-STD is used to specify protection from shock and vibration. Since MIL-STD 810(x) includes many different tests, the manufacturer must state which section of the standard they are using. For example, section 514.5C-3 of MIL-STD 810(x) includes vibration and shock testing parameters. Also, it is important to pay close attention when manufacturers claim MIL-STD 810F because vibration and shock testing can be performed on non-operating units, and the units are turned on after the test. The units must be tested while in operation to achieve an accurate performance rating. Also, many manufacturers will include actual testing parameters on specification sheets (Example: 40g Shock, 28g Peak Vibration), rather than claim MIL-STD 810F. This could signify that the testing used does not meet MIL-STD 810F requirements.

Drop Specifications:
All hand held or laptop computers should include a drop specification that describes the device's ability to withstand the shock of a fall to a hard surface. For obvious reasons, the drop specification is extremely important for mobile computers and cannot be overlooked. If a device cannot withstand a drop from a reasonable distance, then its' life will be extremely short. Most ruggedized hand held computers or laptops can withstand a 4ft drop to concrete.

Another important aspect to consider is the testing procedures used to verify a product's drop specification. A product should be dropped on all sides to verify its' ability to withstand shock from any direction. For example, a computer's display can be very sensitive to the shock associated with a drop. The drop test should include all sides to verify that the display, and other sensitive components will withstand the shock and operate properly. It is important to pay close attention to the details included with the drop specification because many manufacturers will claim 6ft drops to a "hard surface". This can be misleading because the term "hard surface" is open for interpretation. Concrete is usually the standard surface used for proper testing, and the drop specification should be questioned if this is not clearly stated. It is also important to verify that the standard product meets the drop specification and a separate protective accessory is not required (i.e. case, rubber boot, etc).

Temperature Specifications:
All ruggedized computers will include operating and storage temperature specifications. Industrial strength computers can be exposed to extreme temperatures, especially if a device is used outside, or in a freezer (cold storage) environment. Cold storage environments usually require that a device operate in -30C (-22F) temperatures. In order for a device to successfully operate in this extremely cold environment, an internal heater is usually required. The heater warms components to an acceptable operating level and eliminates condensation when exiting the cold storage environment and entering a warmer environment. Conformal coatings are also used to eliminate condensation build-up on internal components.

Intrinsically Safe (I-Safe, IS) Specifications:
IS is a term representing the Hazardous Location classifications as described in the National Fire Protection Association's (NFPA) National Electrical Code (Article 500). The National Electrical Code (NEC) defines Hazardous Locations as those areas "where fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings."

Many ultra ruggedized mobile computers will include intrinsically safe (I-Safe) specifications or approval ratings. Understanding I-Safe approval ratings can be a difficult proposition for even the most informed customer. Intrinsically safe areas are hazardous environments where flammable gases, vapors and liquids are stored and manufactured. These areas are prevalent in many of today's manufacturing facilities including chemical plants, paint manufacturers, oil refineries, textile mills, etc.
Each designated hazardous environment has specific certification requirements for all equipment used in the I-Safe area. Intrinsically safe equipment must carry a label, which specifies the exact I-safe rating for the equipment and the name of the NRTL (Nationally Recognized Testing Laboratory) who tested it. Testing laboratories have very stringent certification requirements that vary according to the level of I-safe approval desired. Therefore, each intrinsically safe device is certified for different levels of I-safe approval, and can only be used in specific hazardous environments. The bottom line is that close attention must be given to the specific I-safe approval certification for each individual piece of equipment. Just because a device has an I-safe rating, does not mean that the device can be used in any I-safe area.

I-Safe approval certifications are made up of multiple classes, groups and divisions that correspond to the specific hazardous environment a device is approved to operate in. Each class consists of two divisions and certain classes have multiple groups. For example, Class I includes flammable gases, Class II includes flammable dust, and Class III includes flammable fibers. Each class has two divisions. Division 1 includes environments where explosive material is present in the air at all times. Division 2 includes environments where explosive material is stored in sealed containers, and explosive material is only present for short time intervals (when a failure occurs or during maintenance). Also, Classes I and II are broken down into groups that correspond to the explosive properties of each specific material. For example, Group A includes Acetylene and Group E includes aluminum dust. In addition, I-safe approval ratings differ significantly from country to country. A device that is I-Safe certified for use in the U.S. may not be certified in Europe. Needless to say, understanding the differences between I-Safe approval certifications can be a full time job, and can make the purchasing decision for an I-safe device a very difficult and lengthy process. However, to ensure the safety of your facility and personnel this verification process is extremely important, and cannot be overlooked. In order to create a "gold standard" for I-Safe products, in June 2003 I-Safe equipment will require ATEX certification. This certification standardizes I-Safe approval ratings and will be used in the U.S. and Europe. This should help make understanding I-Safe approval ratings much easier.

Summary of Class I, II, III Hazardous Locations			
CLASSES	**GROUPS**	**DIVISION 1**	**DIVISION 2**
I. Gases, vapors and liquids	A: Acetylene B: Hydrogen, etc. C: Ether, etc. D: Hydrocarbons, fuels, solvents, etc.	Normally explosive and hazardous	Not normally present in explosive concentrations (but may accidentally exist)
II. Dusts	E: Metal dusts F: Carbon dusts G: Flour, starch, grain, plastic, chemical dust	Ignitable quantities normally or possibly in suspension	Dust not normally suspended in an ignitable concentration (but may exist)
III. Fibers and flyings	Textiles, wood-working, etc.	Handled or used in manufacturing	Stored or handled in storage

Hazardous locations are classified into zones to facilitate the selection of appropriate ruggedized computers as well as the design of suitable electrical installations. The following table contains an overview of the zones and allocation of equipment (equipment category according to 94/9/EC) for the relevant zones.

Gases, Vapours, Mists	Dusts	Definition (94/9/EC) explosive atmosphere is present:
Zone 0 – Category 1 G	Zone 20 – Category 1 D	Continuously or longtern or frequently
Zone 1 – Category 2 G	Zone 21 – Category 2 D	occasionally
Zone 2 - Category 3G	Zone 22 – Category 3 D	Infrequently or short period
G = gases, D = dusts		

It would be uneconomical and sometimes not even possible to design all explosion protected ruggedized computers in such way that it always meets the maximum safety requirements, regardless of the use in each case. For this reason, the equipment is classified into groups and temperature classes in accordance with the properties of the explosive atmosphere for which it is intended.

The maximum surface temperature of ruggedized computers and other electrical apparatus operating in these extreme environments, can be split in temperature classes according to IEC. That maximum surface temperature will always be lower than the ignition temperature of the gas/air or vapour/air mixture in which it is used. Of course, equipment classified in a higher temperature class (eg T4) may also be used for applications in which a lower temperature clas is required (eg T2 or T3). In North America there is a system incorporating further classification according to temperature subclasses.

Temperature Classes according to IEC			
Temperature class IEC/EN* NEC 505-10	**Max. surface temperature of equipment (C)**	**Ignition temperatures of the flammable substance (C)**	**Temperature class NEC 500-3 CEC 18-052**
T1	450	>450	T1
T2	300 280 260 230 215	300-450 280-300 260-280 230-260 215-230	T2 T2A T2B T2C T2D
T3	200 180 165 160	200-300 180-200 165-180 160-165	T3 T3A T3B T3C
T4	135 120	135-200 120-135	T4 T4A
T5	100	100-135	T5
T6	85	85-100	T6

* IEC = International Electrotechnical Commission / EN = European Standards

Ex. Classification of Gases and Vapours into Explosion Groups and Temp. Classes						
	T1	**T2**	**T3**	**T4**	**T5**	**T6**
I	Methane					
II A	Acetone Ethane Ethyl ethanoate Ammonia Benzol (pure) Ethanoic acid Carbon oxide Methane Methanol Propane Toluene	Ethanol i-Amyl acetate n-Butane n-Butyl alcohol	Benzine Diesel fuel Aircraft fuel Heating oils n-Hexane	Acetaldehyde Ethylether		
II B	Coal gas	Ethylene				
II C	Hydrogen	Acetylene				Carbon disulphide

Data contained in I-Safe charts above obtained from the Westminster website, 2003, http://www.wg-plc.com/international/fire/intrinsafe2.html

Summary

To truly understand an computer's "ruggedness", you need to not only understand ruggedness specification definitions, but also how a vendor determined a particular product's specifications. The initial cost of a truly industrial rugged terminal may be more than the cost of a non-industrial terminal, but long-tem it's more than worth it due to significant savings on both repair and replacement costs, and the increase in productivity associated with the units remaining on the job.

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