a report by
Lind Electronics

Laptop Power Adapters
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This technology section article is written by LeRoy Lind, President of Lind Electronics. Lind Electronics designs, manufactures, and sells automobile and airline power adapters for laptop computers. The function of a power adapter is to convert the available power, typically 12 to 16 volts, to the power required by the laptop computer to operate and charge its internal batteries. This article will review the safety, the approval history and the status of adapters in relation to the needs of laptop users in the airline environment.

I do not know if this article will be seen as an historical review, an editorial or a confusing combination of fact, opinion and advocacy. These views are from an American adapter manufacturer that travels mostly in America and is in contact with the US airline industry. My objective is to be as informative and unbiased as possible. It is necessary to use a lot of acronyms that are identified at the end of the article.

Laptop computers were designed for mobile use and have been used in the mobile mode for sales applications for many years. Installation of airline in-seat power receptacles which allow laptops and other portable devices to be used by airline travellers has resulted in a major increase in mobile laptop usage. It now seems that most business travellers in an airport are carrying a laptop. Power adapters are used in automobiles primarily for charging the internal laptop batteries between sales calls but in the airline application, power adapters are in constant use. We are all adding to our productive working time. OK, some of us are playing solitaire or watching a DVD movie.

The increased mobile use of laptops has also been influenced by the increased use of GPS in automobiles, DVD movies, and games in all environments. Internet connections in hotels, airports and anywhere else via cellular telephones also add to the rate of mobile usage. Laptop improvements have resulted in higher power usage, therefore it has become necessary to obtain power outside the office from sources such as automobiles and airlines. Automobile and airline power adapters have gone from an accessory used by a small number of salesmen to a necessity for nearly all mobile laptop users. The alternative is carrying a pack of expensive, hard-to-recharge internal batteries that must be replaced at times and which interrupt our thought process, our work or our entertainment.

Common automobile power adapters were initially used with the airline in-seat power source. However, as laptop power requirements increased, and the duty cycle went from occasional battery charging to long periods of use, some automobile power adapters could not handle it, overheated, and failed. It was recognized that easily damaged adapters with no safety shut down circuits could cause problems for the airline and the airline passenger. It became apparent that an airline power adapter had to be designed to a higher standard of ruggedness, reliability and safety than the level acceptable in the automobile or other land-based environments.

Primex, a leading manufacturer of in-seat power units, sets standards of performance for the power adapters they recommended. These standards were higher than the normal automobile level of performance but were mostly concerned with Electromagnetic Interferance (EMI) within the aircraft. The in-seat power supply must meet a number of stringent FAA safety requirements but the manufacturer's responsibility for performance and safety ends at the power receptacle in the seat.

Some adapter manufacturers, particularly Lind Electronics, believe that the concerns of the laptop manufacturers and airline passengers should be fully taken into account. Discussions with laptop manufacturers showed that each had a unique concern about how their laptops should be powered in the airline environment. Some wanted added input voltage protections, others worried about adapter failure modes and some wanted safety agency approvals. Similar discussions with airline and FAA personnel uncovered very different viewpoints. Passenger satisfaction issues such as access to the seating area and avoiding the possibility of smoke emitting from the adapter if it failed, were their major concerns.

Information obtained from various segments of the airline industry, laptop manufacturers, and mobile computer users was taken into account and a set of airline power adapter design goals was written. (A summary of these goals is contained near the end of this article). These design goals were presented to FAA representatives and the attendees of AIRINC meetings in November 1997. The response was a general agreement with the goals but it was pointed out that neither the FAA nor AIRINC has the authority or responsibility to control the Portable Electronic Devices (PEDs) that airline passengers carry onto an airline. Laptop computers, power adapters, video games and tape players are all PEDs.

Individual airline regulations and the cabin personnel determine what comes onto the airline and how it is to be used. The airlines are of course concerned about safety but they are not able to set standards for the PEDs taken aboard and because of workloads and other considerations they cannot police the variety, performance or use of these devices. This leaves the major question of laptop and adapter safety up to the manufacturers of the laptops and the adapters. Perhaps this is where the responsibility should be. The manufacturers of these devices know better than anyone else the strengths and weaknesses of their design. They also know how the device is likely to fail and what results can be expected. They are also best equipped to correct and avoid potential problems.

A major concern of the laptop manufacturers (and everyone else) is the liability that they may face if failure of one of their devices results in a catastrophic event or injury. The probability of a an electronic device failure causing this type of problem in an office, home, automobile or airline is very low. There has been little concern about AC adapters failing in homes or schools. There is little or no fear that adapters in automobiles or emergency vehicles would cause liability problems. However, considering the worst case possible results of a given failure in an airline sends chills down the spine of the corporate legal world.

One response to this fear of litigation is to make the designers of the equipment put in all possible safety features: Imagine everything that can go wrong and assure that the device responds safely. Acceptable responses to abuse, component failure or system failure are: operate normally, shut down safely, or fail peacefully with no smoke, fumes or loud noises. Reducing or avoiding these problems will increase the cost of the device but it also may improve the reliability, performance and perhaps even customer satisfaction. Reduced warranty costs may also be a benefit to the manufacturer. Getting a lot of designers to think about safety can result in better and safer designs. Each designer has a 'pet' fear and as long as there are not design tradeoffs that weaken one design facet while over strengthening another, covering everyone's concerns can be a good thing.

Another response to fear of failure and litigation is to acquire safety agency approvals. This sounds good to legal departments: We are covered, we are approved, we have an excuse, there is some else to blame. The approach taken by many laptop legal departments is "We have always had UL approval on our AC power adapters so we must have UL approval on DC power adapters!". However, UL and most other safety agencies are concerned about shock hazard to personnel rather than safety in an airline environment.

Most UL and other safety specifications were not written with any applicability to equipment with voltages under 24 VDC. They were not meant to be applied to low voltage DC equipment. I understand that the legal departments are not equipped to understand the difference between AC and DC but they could obtain advice from someone. Will applying a specification written for AC equipment result in safer operation of a DC adapter in an airline? Probably not. Is that what we must do? Yes. This is the world we work in and these are the tools we have to work with.

Lind has tested automobile power adapters to specifications written for AC equipment at VDE, CSA, and three different UL labs. Some of the test

Explanation of acronyms used in this article

AC	Alternating current. 115 volts in the US 220 volts in Europe	Primex	Primex Aerospace Company. A manufacturer of in-seat power systems
AIRINC	Aeronautical Radio, Inc. Industry group, advisor to FAA	PED	Personal Electronic Device. Carried on to an airline by a passenger
CSA	Canadian Standards Association	RTCA	US Transport Standards Group
DC	Direct Current. Normally 11 to 16 volts for automobile and in-seat systems	TUV	TUV Product Services. Test laboratory with worldwide contacts
DVD	Digital Video Disc	UL	Underwriters Laboratories. US Nationally Recognized test laboratory
EMI	Electro Magnetic Interference		
FAA	US Federal Aviation Agency	VDC	Volts Direct Current
GPS	Global Positioning System	VDE	Verbaud Deutscher Elektrotechniker

requirements are appropriate but many are not. One automobile adapter requirement was that it must have a 36 inch input cable even though this allowed the adapter to interfere with the brake pedal. Why? The origin of this requirement was that the average distance from the top of a table to an AC power socket was determined to be 36 inches. The fact that this requirement degraded the safety of the adapter in its intended environment was not in all cases sufficient reason to break with tradition.

It was apparent in early 1999 that a new safety specification was needed to properly address the issues associated with the airline environment. The only available list of safety-related criteria was the automobile and airline adapter design goals presented in 1997. A summary of that list of design goals can be seen in top right box.

After this list was compiled in 1997, laptop manufacturers suggested high output voltage limiting, input spike voltage clipping, and reverse polarity protection as additional requirements.

These design criteria were presented to the Product Service division of TUV Product Services and they were asked to write a test specification for automobile - airline power adapters. TUV has broad experience in safety analysis and testing in a variety of fields including airlines and automobiles and was therefore uniquely able to consider all aspects of safety in a variety of environments. TUV accepted this challenging job and chose to write a broadly based specification that can be applied to all PED equipment brought on board an airline or used in an automobile environment.

The Lind adapter design criteria were used as a starting point but input from others in the airline and laptop industries were also considered and added to the specification. TUV has referenced applicable portions of existing specifications from US and European sources to define test levels and procedures. TUV has also required that the power adapter circuit be subjected to a risk and hazard analysis that determines the effect of failure of every part in the adapter circuit. Failure of any part must not result in smoke or noxious odours in the airline cabin.

The result is an all-encompassing but flexible set of standards that can be used for certification of a broad range of mobile products. Tests of the Lind line of automobile and airline power adapters have been completed and certification is expected in October, 1999. It is hoped that other adapters and PEDs will be tested and certified in the near future. The major overall goal is to improve the customer satisfaction, reliability and safety of all devices used in the airline environment.

A summary of the list of design goals

Package durability	*- must prevent mechanical damage and failure.* *- must withstand being rolled over by an airline service cart.*
Cable disconnect	*- must prevent laptop or adapter cable or receptacle damage.* *- must allow disconnect during emergency passenger exit.*
Cable lengths	*- that are compatible with easy passenger entry and exit.* *- that prevent placing the adapter in the seat pocket (no air flow).*
Proper V-I char	*- must emulate the essential laptop AC adapter characteristics.* *- keep laptop power input within laptop design limits.*
Short Circuit cut-off	*- must prevent adapter laptop damage with output overload.* *- to prevent adapter damage from an output short circuit.*
Current limit	*- where functionally required. Both input and output current.* *- to prevent output overload damage to adapter.*
Low input voltage cut-off	*- to prevent adapter damage with low input voltage (in-seat failure).* *- to prevent over discharge of the power source (automobile).*
Temperature protection	*- adapter circuit component temperature must be within ratings.* *- case temperature must not be uncomfortable to passengers.* *- must safely shut down with no air flow (the blanket test).*

Notes

1. Automobile and airline power adapters must be approved together to allow the mobile user to carry only one adapter. The operation and outputs are the same in each mobile environment but the safety and operational requirements of the two environments are different.
2. A copy of the original airline adapter design goals with explanations for these goals is available from Lind Electronics.

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