Safety Guide
For
Installation, Maintenance, and Operation
Of
Logistics Automatic Identification Technology (AIT) Equipment

October 30, 2000

Prepared for

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Under Contract 263-96-D-0327

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Safety Guide
Installation, Maintenance, and Operations
Logistics AIT Equipment

1. Purpose

This guide is intended to assist installers, maintainers, and operators of logistics Automatic Identification Technology (AIT) equipment. There are many makes and models of logistics AIT equipment, therefore this guide is written as generically as possible. The first priority is safety of personnel and secondly to protect equipment and on-line data through safe installation, maintenance, and operation. This guide is not intended to be all-inclusive but rather a supplement to vendor equipment manuals and other safety related publications. It includes rationale along with each recommendation to give the reader a better understanding of its intent. Since the guide covers a wide range of topics, ranging from technical to operational, the intended audience varies accordingly. As a result, the level of supporting technical material is limited. More detailed technical information can be found in referenced documents for system designers, installers, and maintainers.

2. References

- *National Electric Code* (NEC), 1999[1]
- National Fire Protection Association (NFPA) Publication 780, *Standard for the Installation of Lightning Protection Systems, 1977*[1]
- NFPA Publication, *Electrical Installations in Hazardous Locations*, by Peter L. Schram and Mark W. Earley[1]
- NFPA Publication 495-1996, *Explosive Materials Code* (pertaining to ammunition, dynamite, and blasting power)[1]
- ANSI Z-136.1, *American National Standard for the Safe Use of Lasers*, 1993
- U.S. Air Force, AFM 161-8, *Laser Health Hazards Control*, 1980
- U.S. Army, *Control of Hazards to Health from Laser Radiation*, 1975.

3. Site Survey and Installation

This is a job for trained technical personnel who understand logistics AIT operational parameters and have the necessary experience to configure the best mix of system components. Site planners will need to work with key people at the site such as the Safety Officer,

[1] Selected references are available from the National Fire Protection Association, Inc., One Battery Park, Quincy, Massachusetts 02269, Phone number: (800) 344-3555 or (617) 770-3000

Facilities/Public Works Officer, Operations Officer, Site Radio Frequency Manager, Network Administrator, and the Information Technology Officer. Make contact with site personnel early to determine site location and working conditions; e.g., hard hat areas, requirements for special uniform or safety equipment, and work schedules of site personnel. **A physical inspection of the facility is recommended.**

4. Safety Equipment, Tools, and Instrumentation

Safety gear should be considered as circumstances dictate. Candidate items include: hard hat, safety glasses, safety shoes, hearing protection, static free clothing (if working in hazardous locations), linemen's gloves (if working around high voltage), climbing equipment such as a safety harness and rope, communication equipment such as a cell phone, and a first aid kit. Tools and instrumentation include: digital camera, Global Positioning System (GPS) receiver with maps, wheel/tape measurer, multimeter (capable of measuring the highest voltage expected to encounter), and a spectrum analyzer. An assortment of common hand tools includes screwdrivers, wrenches (socket set and box/open end), and hammer. Electrician hand tools to consider include: wire cutters (also called diagonal pliers), needle nose pliers, heavy flat nose pliers with side cutter, wire stripper, crimp sleeve pliers, and a sledge hammer for driving ground stakes when installing a lightning protection system.

5. Connecting to Power

Installation of AIT system components (such as radio transmitters/receivers) on poles or other structures often requires the installation of additional electrical branch circuits. When this is the case, power is tapped directly from the utility power transformer, through an over current protection device (pole mounted circuit breaker), or from the facility electrical power distribution equipment; e.g., electrical supply cabinets or junction boxes. This is a task for a qualified electrician. The AIT installation team should coordinate this effort with local facility engineering and utility power company personnel. The following precautions are offered to anyone working with power lines:

- Existing power equipment may not have been installed in accordance with the National Electric Code (NEC), especially at locations outside the United States. Experienced AIT installers have reported accidents when working in unsecured, unmarked electrical supply cabinets containing high voltage. The precaution is to always assume the voltage is high when unmarked, and use suitable instrumentation and safety equipment when making voltage measurements.

- Disconnect power at the circuit breaker box before working with power lines and place a notice or a safety tag on the circuit breaker box instructing that specific numbered breakers be kept in the "off" position. This step cannot be over emphasized. An assistant should be standing by the power distribution box while power lines are being handled. Before switching on the power, ensure the power supply cables include a ground conductor (bare conductor, or conductor with green insulation covering) and insure that the grounding wire is securely connected to the grounding bus bar within the circuit breaker box.

- It is likely that installers will be connecting to electrical power through both "cord and plug" and "hard wire" connections. Hard wiring involves connecting the AIT device directly to the installation power lines. The precaution here is to secure connections within a junction box and ensure that the box is the type approved for the specific location; e.g., outside, inside hazardous location, or inside non-hazardous location.

- Always follow instructions provided by the Original Equipment Manufacturer (OEM) when connecting power. This guide is not intended to supersede the OEM's guidance.

6. Electrical Connections

When making hard wired connections, ensure that the equipment's power requirements (voltage and amperage) fall within the safe limits of the power supply circuit rating. For cord and plug connections, the NEC specifies unique physical configurations for keying plugs to mating receptacles for various voltage and amperage levels. Since this code requirement may not be in force at all locations, installers must first know the voltage and ampere requirements of the equipment to be installed. Second, they must know the rating of the power supply circuit, e.g., 120-volt, 20-ampere, 240-volt, 20-ampere. Always follow instructions provided by the OEM when connecting power. This guide is not intended to supersede the OEM's guidance.

7. Grounding for Lightning Protection

A well-designed lightning protection system is needed to protect both operational equipment and on-line data. The National Fire Protection Association (NFPA) Publication 780, *Standard for Lightning Protection*, listed in Section 2, should be used as a guide when designing for a specific application. Key design parameters include soil type, average moisture content, size of the equipment to be protected, extent the mounting structure is in contact with the earth, height and relative proximity to other structures, geographical location (severity of expected lightning), and the extent of protection needed. A conceptual lightning protection system is illustrated in Appendix A.

The first objective in designing any system is to divert a strike. Secondly, should a lightning strike occur at or near the equipment, the objective is to provide a low impedance path for the high level of energy to travel to earth via lightning rods, sometimes referred to as air terminals, and the associated grounding system components (main conductor and grounding devices). The first line of protection is termed dissipative or elimination. The electrical energy (air charge) is collected at the lightning rod where it travels down the conductor and into earth via the "made electrode" conductors before it builds to strike potential.

Lightning rods come in various designs, shapes, and sizes. For example, one type has the appearance of a chimney brush while another is umbrella shaped. The brush and umbrella designs are referred to as multi-path air terminals and are most effective in dissipating the energy before it reaches strike potential. Should an actual strike occur, the system must be capable of handling the higher voltage and current (amperage) associated with strikes. This is termed "strike" protection. The design of a lightning protection system could include a combination of the different types of rods, umbrellas, and brushes. The principle is that a multi-path system provides the lowest impedance path for the energy to travel to earth, therefore providing more protection.

8. Power Protection Equipment

There are a variety of undesirable conditions that may occur on the power distribution system that could result in loss of critical data or damaged equipment. The conditions and their causes are discussed below:

- Power sags – This can occur when turning on heavy equipment like large electrical motors and switching power mains. This condition could result in memory loss and data errors, or damaged equipment.

- Electrical line noise – This can come from electric motors, control devices, broadcast transmissions, microwave radiation, and distant electrical storms.

- Power failure – Possible causes are a tripped circuit breaker, power distribution failure, or utility power failure.

- Frequency variation - May be caused by erratic operation of emergency power generators or unstable frequency power sources.

- Power surges – These can be caused when heavy electrical equipment is being turned off.

- High voltage spikes or switching transients – Likely causes are lightning strikes, switching operations, arcing faults, and static discharge.

- Brownouts – Could be caused by heavy equipment being turned on, starting large electrical motors, switching power mains (internal or utility), or overloaded circuits.

Protection against these conditions can be provided by connecting to power through a Uninterruptible Power System (UPS). There are a variety of UPSs available depending on the degree of protection needed and the operational environment. UPS types are 1) standby, or off-line; 2) line-interactive; and 3) on-line. The on-line UPS is ideally suited for critical equipment operation. It protects against all types of power problems and continuously uses its inverter to create 100% new, clean, regulated AC power. Since protection of data and equipment is critical, a UPS between the AIT Business Process Server and the utility power system is recommended. Should other operational equipment be located in close proximity to the UPS, such as radio frequency (RF) access points or RF interrogators, then these components could also be connected to the UPS for total system protection.

9. Transient Voltage Surge Suppression (TVSS) Protection

TVSS protection devices are designed to protect the equipment and data from supply line surges resulting from lightning, or a transient voltage emanating from within the electrical supply system. TVSS devices can be installed inside the circuit breaker box, directly to the equipment to be protected, and at data carrying conductor connection points. The TVSS employs a metal oxide varistor to sense a voltage transient and shunt it to ground. Although TVSS devices offer some level of protection, they should not take the place of a UPS which affords a higher level of protection.

10. Ground Fault Circuit Interrupter (GFCI) Protection

The NEC requires installation of GFCI devices for personnel protection at various locations; e.g., outside locations, garages, bathrooms, near sinks (within 6 feet), pools, and construction sites. The locations and corresponding exceptions are covered in Sections 210, 305, 426, 427, 511, 550, 551, 555, 680 of the NEC. AIT devices may be connected to electrical power at outside locations that require GFCI protection, specifically at outside locations where the outlet box is accessible to individuals standing at ground level (below 6 foot, 6 inches). Simply stated, **GFCI devices are designed to protect personnel against electrocution.** This safety feature is needed because the standard ground fault circuit will conduct fault current until the current reaches the maximum allowed by the circuit breaker.

The GFCI is designed to sense a very low level of fault current and disconnect the power quicker than a circuit breaker. It does this by detecting minute differences in current levels between the two normal current carrying conductors. A current imbalance results when current is flowing through a parallel (fault) path to ground, possibly through an individual in contact with the charged equipment. The GFCI device immediately shuts off the current within seven milliseconds when a difference of five milliamperes is detected between the two conductors. The GFCI device is more sensitive and faster than the circuit breaker, therefore safer.

A variety of GFCIs is available, including portable plug-in types, circuit breaker types, and receptacle types. Each has a test button for periodically checking the GFCI device for proper operation. Exercise caution when plugging into outside outlets that are reachable from the ground to **ensure that the power supply circuit is GFCI protected**. Contact your local facility electrician if there is a question.

11. Hazardous Locations

Observe all precautions when working in hazardous locations as defined by the NEC Class I, II, or III, Divisions 1 and 2. The following table provides a summary of classes I, II, and III hazardous locations.

Summary of Hazardous Locations[2]

CLASSES	GROUPS	DIVISIONS	
		1	**2**
I. Gases, vapors, and liquids (Art. 501)	A: Acetylene B: Hydrogen, etc. C: Ether, etc. D: Hydrocarbons, fuels, solvents, etc.	Normally explosive and hazardous	Not normally present in an explosive concentration (but may accidentally exist)
II. Dusts (Art. 502)	E: Metal dusts (conductive,* and explosive) F: Carbon dusts (some are conductive,* and all are explosive) G: Flour, starch, grain, combustible plastic or chemical dust (explosive)	Ignitable quantities of dust normally are or may be in suspension, or conductive dust may be present.	Dust not normally suspended in an ignitable concentration (but may accidentally exist). Dust layers are present.
III. fibers and flyings (Art. 503)	Textiles, wood-working, etc. (easily ignitable, but not likely to be explosive)	Handled or used in manufacturing	Stored or handled in storage (exclusive of manufacturing)

*NOTE: Electrically conductive dusts are dusts with a resistivity less than 10^5 ohm-centimeter

The NEC does not classify areas for the manufacture, transportation, storage, and use of explosive materials, such as ammunition and blasting materials. Information on the classifications of this material can be found in the National Fire Protection Association (NFPA) publication 495-1996, *Explosive Materials Code*. For information on hazardous locations in general, including background on the classification of areas, equipment protection systems, ignition sources, static electricity, lightning, and requirements that apply outside the United States, see publication, *Electrical Installations in Hazardous Locations*, by Peter J. Schram and Mark W. Earley. Determine the specific classification of the hazardous location as defined by the NEC or NFPA publications. There is a wide range of classifications and the associated precautionary levels vary accordingly. **Always consult the local facility's safety engineer or officer and strictly comply with his or her guidance and all local safety rules**. The following are offered as general guidance when operating in hazardous locations, but are not substitutes for local rules.

- Maintain a safe separation distance between the emitter antenna and any explosive device or material when operating any RF emitter (transmitter), handheld or otherwise. The safe separation distance is based on the frequency and power level of the RF emitter, the characteristics of the explosive device or material, and the safety rules of the facility. The distance must be determined by the local facility's safety engineer or officer for the particular case, or may be approved in advance by appropriate authority. Note that RF emission by a component of a logistics AIT system may not be obvious. Refer to each specific vendor AIT equipment manual regarding proper handling in hazardous locations.

- Do not charge or change batteries in hand held scanners/interrogators, RF tags or any other equipment (even flash lights) as doing so could result in a spark.

[2] http://www.osha-slc.gov/doc/outreachtraining/htmlfiles/hazloc.html

- Do not change PCMCIA (Personal Computer Memory Card International Association) cards in hand held collection devices as this could also result in a spark.

- Wear appropriate safety clothing. Electrical discharge (arcing) can result from the build up of static electricity on clothing.

12. Pole Location

Use existing utility poles or other structures to mount fixed RF transceivers whenever feasible, but first:

- Verify absence of overhead wiring or other obstructions.

- Consult with the local public works or facilities/utility coordinator before proceeding with any construction or excavation, since underground utility lines pose as great a threat as overhead lines.

- Determine that there is sufficient height to accommodate the RF component.

- Remain at least four feet away from all electrical power lines or adhere to local codes, whichever distance is greater.

- Determine optimum location for new poles if existing utility poles or structures are not available. Ensure poles will not interfere with traffic, obstruct gate traffic, or otherwise hinder operations. Follow local codes when setting poles and maintain a safe distance from power lines and roads.

13. Batteries

Use proper procedures when disposing of batteries. Nickel-cadmium, lithium-ion, and lead acid batteries contain chemically active materials that are hazardous to the environment. **Never attempt to incinerate these batteries; doing so could cause an explosion.** Check with the local Property Disposal Office for guidance before disposing of unusable batteries.[3]

14. RF Transmitters

Do not transmit data **unless the antenna is connected.** The transmitter's final power amplifier must be "loaded" with a matching antenna in order to transmit RF energy into space. If the antenna is not connected, RF energy will be reflected back into the circuitry and possibly damage the transmitter. Further, do not operate (key the transmitter) within two feet of another transceiver. Doing so could overload and damage sensitive receiver circuits (primarily related to hand held transceivers).

[3] Some batteries are only replaceable by the original equipment manufacturer. Consult the vendor's technical manual.

15. Hand Held Scanners

Hand held scanners incorporate LASER (Light Amplification by Stimulated Emission of Radiation) light to scan labels. The LASER is coherent, or focused, light as opposed to random light waves from other sources. Although there is a relatively low level of LASER light energy, caution should be exercised to avoid looking into the LASER light as it could cause injury. Further, do not leave a LASER emitting device unsecured around unauthorized personnel, especially children. Safety standards pertaining to LASER energy are listed in paragraph 2 of this guide.

Appendix A
Conceptual Lightning Protection System

Figure A-1 (not to scale) illustrates the essentials of a lightning protection system. The grounding method illustrated is conceptual. Article 250 of the *National Electric Code* along with the National Fire Protection Association (NFPA) Publication 780, *Standard for Lightning Protection* describes various methods of grounding and should be used when designing for a specific application.

The RF Interrogator, illustrated on the mast, was selected as an example from the variety of logistics AIT fixed mounted RF components. Other pole-mounted components are Access Points and RF relay transceivers.

Grounding for lightning protection

Figure A-1 depicts a RF interrogator mounted on a mast with a lightning rod installed above and directly over it. An earth-grounding conductor may, or may not, be needed depending on circumstances. If the lightning rod is clamped to a metal structure and the structure is sufficiently grounded at its base, then a conductor and "made electrode" system would not be needed. Since the extent of grounding would not be apparent by visual inspection, a qualified electrician should perform a test. It is envisioned that **most installations will require an earth-grounding conductor along with a "made electrode" system** because of the predominance of non-metallic mounting structures.

The earth-grounding conductor, between the lightning rod and "made electrode" system, should be size number 2 copper or larger and uninsulated, in accordance with NFPA Publication 780, *Standard for lightning Protection*.

Ensure that the earth-grounding conductor is not wrapped around the mast or other mounting hardware. Coiled wire takes on the characteristic of an inductor and results in an undesirable condition. The inductance will present a high impedance path for lightning current, which is the opposite of what is intended. Further, it could act as a "pick up" and possibly induce the lightning energy into the equipment being protected. It could also induce the energy into the central electrical system and damage other equipment. The point is to run the conductor as straight as possible and form wide radius bends when making turns.

The earth-grounding conductor should be continuous rather than pieced. Further, it should be run on the opposite side of the mast from the power supply and data carrying cables.

When driving ground rods, dig out and drive them about six inches below grade. Then trench between the rods and connect the earth-grounding conductor to each rod using approved underground grounding fasteners. Back fill as soon as this step is completed to avoid an accident.

Data protection

The center conductor of a shielded coaxial cable is used to conduct data from the antenna to its entry point at the process computer/server. The outer shield is made up of fine, braided wire and is in contact with connectors at each end of the cable. The outer shield is grounded when the cable is connected to the chassis of the operational AIT component via the power input cable ground. This is the first line of defense against RF interference and spurious electrical disturbances such as lightning. Data on the center conductor is protected because it is contained within the shield. However, when the electrical disturbance is picked up by the antenna and is conducted directly onto the coax center conductor, a second line of defense is needed. Protection is needed for both RFDC and RFID systems having antennas mounted remotely from the transceiver, e.g., RFDC access points and RFID relays and gate readers. The recommendation is to install a lightning suppressor device in line with the coax cable between the antenna and transceiver and make a ground connection to the nearest earth ground. The manufacturer of the AIT system being installed should be consulted to determine the recommended lightning suppressor unit and associated mounting hardware.

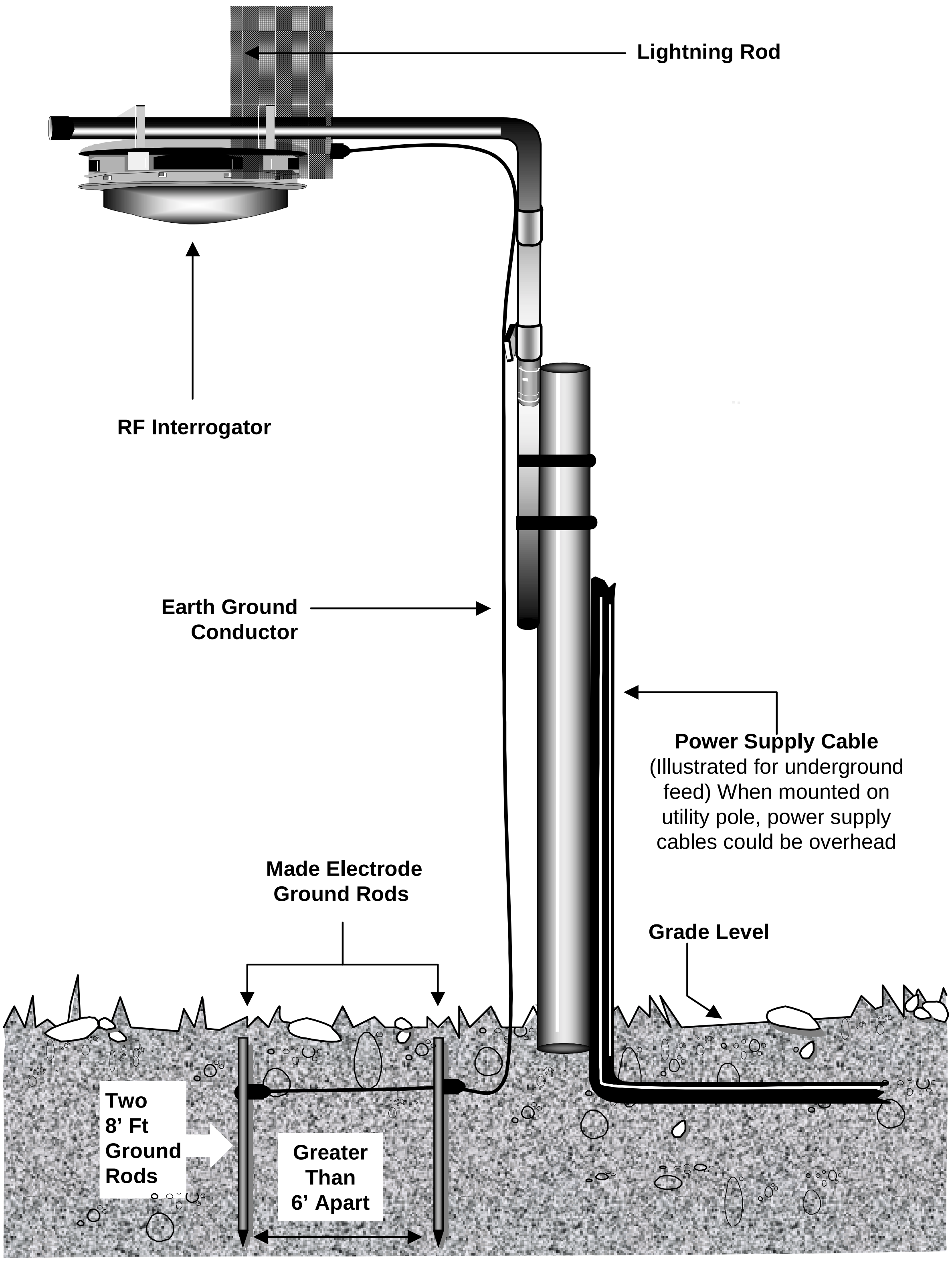

Figure A-1. Conceptual Lightning Protection System