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Document 17.3
Low-Energy Initiator (LEI) Operations

Recommended for approval by the ES&H Working Group

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New document or new requirements

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17.3

Low-Energy Initiator (LEI) Operations*

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17.3

Low-Energy Initiator (LEI) Operations

1.0 Introduction

The purpose of this document is to provide the minimum safety criteria and controls to be used by LLNL personnel in all phases of low-energy initiator (LEI) operations.

The *DOE Explosives Safety Manual* defines low-energy electroexplosive devices (EEDs) (also referred to as low-energy initiators (LEIs)) as being all EEDs, except exploding bridgewire (EBW) detonators and exploding foil (slapper) detonators. These EEDs contain energetic materials that are initiated by 0.1 J or less at peak power levels of a few watts. An LEI requires less peak power than an EBW or slapper detonators, which are high-power devices typically requiring peak power levels of 10^5 – 10^6 watts to give a detonation output. LEIs are more electrically sensitive than either EBWs or slapper detonators, and their use requires greater control to maintain an acceptable level of risk.

LLNL prohibits the use of LEIs whenever high-power EEDs can be used for the same purpose. If an LEI that is initiated by 0.1 J or less must be used in a specific application, the experimenter shall supply information concerning the safety of the LEI to the ES&H Team explosives safety engineer responsible for the area and to the LEI Committee for review. Controls for handling and using LEIs shall be specified in an approved safety plan (OSP or FSP) and authorized by an Integration Work Sheet (IWS).

The LEI Committee is an interdisciplinary team of responsible scientists and engineers who review safety controls and handling, and characterization procedures for LEIs. The committee shall consists of the following members:

- B-Division Group Leader for Detonator/Detonation Physics (acting as the chair)
- Defense Technologies Engineering Division Initiation Systems Group Leader
- Hazards Control Department Explosives Safety Engineer
- C&MS Energetic Materials Program Element Leader

2.0 Hazards of LEIs

The major hazard from an LEI is personal injury or property damage caused by heat, blast, noise, fumes, and flying debris or projectiles from unintentional or inadequately controlled ignition or explosion of these devices. Injuries ranging from minor to fatal could include trauma, lacerations, eye injury, hearing impairment, and burns. Possible

consequences could range from mild decomposition to vigorous deflagration or detonation. Depending on what other explosives may be attached to the LEI, property damage could range from minor to major.

LEIs are initiated electrically. LEIs present the risk of injury or property damage exceeding that of EBWs and slapper-initiated devices. Among the reasons for this are the wide range of sensitive explosive materials that can be used, and the manufacturers' use of varying quality-control methods that may result in different levels of safety. Energy inputs shall be controlled in and around LEI operations. More specific hazards are listed below.

- Many LEIs are designed to contain initiating explosives or pyrotechnic materials. By their very nature, these materials are sensitive to heat and open flame.
- Direct lightning strikes, induced currents from nearby, or even distant lightning strikes can initiate LEIs.
- Radio-frequency (rf) energy may be accidentally coupled to an LEI through the electrical leads used to fire the device. If sufficient rf energy is coupled to the bridgewire(s), resistive heating may cause an accidental firing. The sensitivity of LEIs to rf energy varies widely because of LEI bridgewire design, materials, and rf energy that may be present.
- Induced electrical power in the firing cables can cause accidental firings. Such currents and voltages are best prevented by physically separating the LEI electrical leads and cables from all other electrical conductors, especially those carrying electrical power to equipment and those carrying high voltages and high currents.
- Static electricity presents a serious hazard in operations involving LEIs. Static electricity can build up on nonconductive materials, and if this charge is not dissipated in a controlled manner through a resistance path, it may accumulate to a dangerous level and finally discharge in an uncontrolled manner. If static-sensitive explosive materials are present, this discharge may cause an accidental firing of the device.
- Static charges can collect on personnel and their clothing. Fabrics such as rayon, wool, silk, nylon, and most synthetic materials readily become a source of static charges.
- Other sources of static electricity are plastic sheeting and bags, pressurized spray cans, and tapes. These materials generate significant voltages and appropriate precautions shall be taken when they are used in and near LEI operations.

3.0 LEI Controls

3.1 General

The safety plan controlling use of LEIs shall outline the hazards associated with these devices and specific actions to be taken to prevent accidental firings and injuries. The criteria for LEI operations are contained in the *DOE Explosives Safety Manual* (Chapter II, Sections 7 and 13.3.5) and this document.

The following requirements apply to all operations involving LEIs:

- The LEI shall be evaluated for possible thermal reactions if the explosive is subjected to any temperature above that usually found in normal testing environments (about 130°F). In the setup of experiments, LEIs shall be kept away from heat sources and potential areas of accidental fires. Soldering on LEI electrical leads is generally prohibited, except with appropriate safety controls as outlined in the safety plan.
- Although most known LEIs are not extremely sensitive to impact, such as an accidental drop from a normal work height, LEIs shall be protected by careful handling and proper packaging. Hitting LEIs with tools, such as hammers, is not permitted because of the sensitive explosive materials contained therein.
- LEIs shall not be used or handled during electrical storms or when lightning-detection equipment indicates a possible hazard. Exceptions for remote operations can be made with concurrence of the ES&H Team explosives safety engineer. See the specific safety plan controlling the use of LEIs for additional information.
- Because of the possibility of induced electrical power, electronic photoflash units shall not be used near LEI operations. Also, electrical energy arising because of galvanic action from dissimilar metals shall be considered in the design of equipment setup.
- Preventive measures shall be designed into the operation to reduce the buildup and storage of static charges. Proper selection of materials and electrical bonding are the preferred methods of control.
- Personnel handling static-sensitive explosive devices shall not wear clothing made of rayon, wool, silk, nylon, and other synthetic materials.
- Because of the potential risks of static electricity, LEIs shall be maintained at ground potential by shunting (pin-to-pin and pin-to-case) during handling.

3.2 Assignment of EED Category

Assignment of the EED category shall be based upon the LEI definitions (see Appendix A, "Terms and Definitions") and the available data. To categorize an EED, all available safety data, design drawings, and other information regarding safe handling and use shall be submitted to the LEI Committee for review and approval. This information shall be compiled on an Electroexplosive Component Data Sheet (see Appendix B). Testing and evaluation may be required when the manufacturer's data are incomplete or questionable, or when new lots of LEIs are to be approved.

3.3 Radio Frequency Energy Controls

Each safety plan shall include a statement outlining the measures for preventing or controlling sources of rf energy. If there is any question about sources of rf energy, an rf energy survey shall be done before handling the LEIs. Use Table 1 to determine safe distances between rf sources and LEI operations. Radio-frequency sources shall be kept beyond the safe distance, even if they are turned off. Some radio transceivers are not safe, even if they are turned off, because they may be activated by a signal from a central computer. LEI leads shall be shorted, both pin-to-pin and pin-to-case, until installed in the device.

Additional information concerning electromagnetic radiation hazards of EEDs, safe separation distances, and power density calculations can be found in Section 2.58 of Air Force Manual 91-201 (*Explosives Safety Standards*).

Examine all operations for stray currents and voltages between metal parts, the firing cables, and ground. Section C.4 of Appendix C (Procedure for Handling and Firing of LEIs) discusses specific voltage and current limits.

3.4 Purchasing LEIs

Use existing procurement channels to purchase LEIs. Anyone purchasing an LEI shall request from the manufacturer the following information and also specify the indicated requirements:

1. Details of construction (drawings), including the identity and quantity of explosives/pyrotechnics contained in the device.
2. All electrical characteristics, including no-fire and all-fire currents, and electrostatic sensitivity (pin-to-pin and pin-to-case). The manufacturer shall also state that the LEI meets the minimum requirement of 0.25 A for five-minute no-fire. (Ideally, the LEI should meet the 1 A/1 W five-minute no-fire criterion.)

Table 1. Minimum safe distances between mobile rf transmitters and LEI operations (from the *DOE Explosives Safety Manual*, DOE M440.1-1, Rev. 8, September 1996).

Transmitter power (watts)	Minimum safe distances (feet)				
	MF[a]	HF[a]	VHF(1)[a]	VHF(2)[a]	UHF[a]
5[b]	——	——	——	——	——
10	40	100	40	15	10
50	90	220	90	35	20
100	125	310	130	50	30
180[c]	——	——	——	65	40
250	200	490	205	75	45
500[d]	——	——	209	——	——
600[e]	300	760	315	115	70
1,000[f]	400	980	410	150	90
10,000[g]	1200	——	1300	——	——

[a]

MF	1.6 to 3.4 MHz	Industrial
HF	28 to 29.7 MHz	Amateur
VHF(1)	35 to 44 MHz	Public Use
	50 to 54 MHz	Amateur
VHF(2)	144 to 148 MHz	Amateur
	150 to 161.6 MHz	Public Use
UHF	450 to 460 MHz	Public Use

[b] Citizens band radio (walkie-talkie) 26.96 to 27.23 MHz: minimum safe distance is five feet.

[c] Maximum power for 2-way mobile units in VHF, 150.8- to 161.6-MHz range and for 2-way mobile and fixed-station units in UHF, 450- to 460-MHz range.

[d] Maximum power for major VHF, 2-way mobile and fixed-station units in35- to 44 -MHz range.

[e] Maximum power for 2-way, fixed-station units in VHF, 150.8- to 161.6-MHz range.

[f] Maximum power for amateur radio mobile units.

[g] Maximum power for some base stations in 42- to 44-MHz and 1.6- to 1.8-MHz bands.

The above information shall be collected by the Responsible Individual (RI) (experimenter/user) and submitted to the LEI Committee for review in advance of the intended date of use. As a general rule, no carbon-bridge systems and no conductive-mix initiation systems (where the conductive mix is used in place of a bridgewire) are permitted.

3.5 LEI Testing

If no safety-related information is available from the manufacturer or supplier, the new LEI shall be tested and evaluated. Also, if there is any question concerning the accuracy of the manufacturer's data, the RI shall ensure that adequate tests are performed on the LEI to remove any doubts. It is also advisable for the RI to verify the electrical characteristics of LEIs arriving at LLNL.

Testing of LEIs shall consist of at least an electrostatic-sensitivity test and a no-fire current test. The number of items to be tested will be determined on an individual basis by LEI Committee members. In the electrostatic-sensitivity test, there shall be no reaction or dudding of the component when it is subjected to the test circuit shown in Fig. 1. This test circuit is a more severe test than the traditional 20 kV, 600 pF, 500 Ω test circuit used by DOE. The circuit attempts to model electrostatic charge, which is distributed between the hand and arm (0.1 μH, 10 pF, 110 Ω) and the rest of the body (0.5 μH, 400 pF, 250 Ω). (DoD EEDs are tested at 25 kV, 500 pF and 500 Ω.) The electrostatic-sensitivity test shall be done in both pin-to-pin and pin-to-case discharge modes. A no-fire rating of 1 A/1 W for five minutes is recommended for LEIs and a *minimum of 0.25 A for five minutes at the no-fire level is required.*

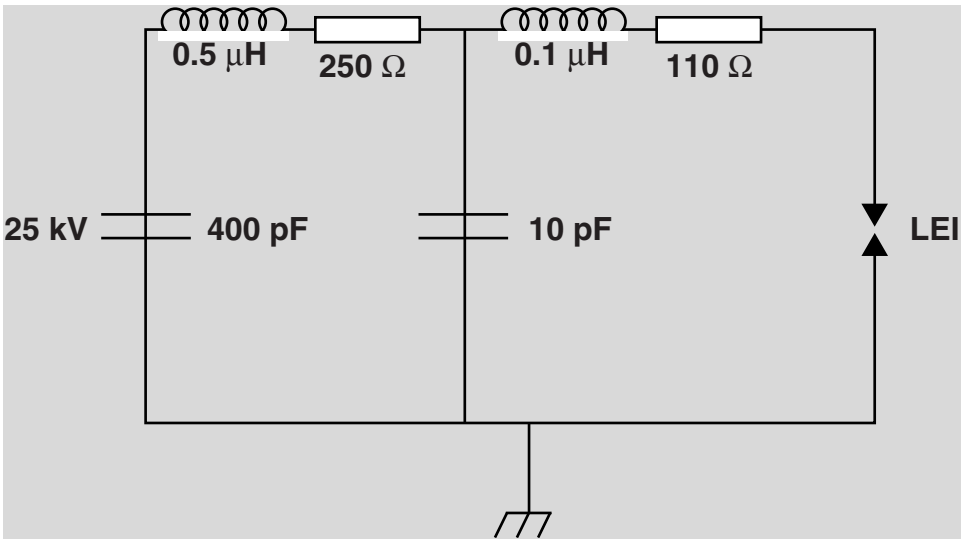

Figure 1. Circuit schematic and waveforms for circuit to be used to test EEDs for electrostatic sensitivity (from paper by R. J. Fisher published in 1989 *EOS/EOD Symposium Proceedings*).

3.6 Installation

Many LEIs are designed to be installed in an assembly and tightened to a pre-selected torque value that **shall not** exceed the manufacturer's recommendation. In some specific applications, an LEI may be installed in an assembly providing adequate shielding of personnel from fragments and blast. The total assembly may then be reclassified as a storage compatibility/handling control (SC/HC) Group S device. The assembly shall revert to its original explosives classification when it is dismantled and the LEI is exposed.

3.7 Modification

LEIs received from the manufacturer or supplier shall only be modified by knowledgeable people working under the direct control of an Operational Safety Plan (OSP) outlining the detailed steps involved. The LEI Committee, in addition to the normal reviewers, shall review the OSP.

3.8 LEI Work Area Controls

The work area shall include controls to eliminate extraneous sources of electrical energy, including rf and static charge. The use of portable radio transmitters, even if turned off, shall be restricted to a safe distance because they may be activated by a signal from a central computer. Grounding and electrical-bonding techniques are necessary for handling LEIs, but their use shall be limited to authorized LEI handlers. Appendix C provides general handling and firing requirements.

3.9 Labels

Each test unit, shot, or package containing an LEI shall be identified with a label to alert explosives handlers of the presence of an LEI and provide other specific safety information related to the LEI. Figure 2 shows the label that will remain on the item from receiving through firing or disposal. This label shall be used in addition to the Explosives ID Label (LL 4-299).

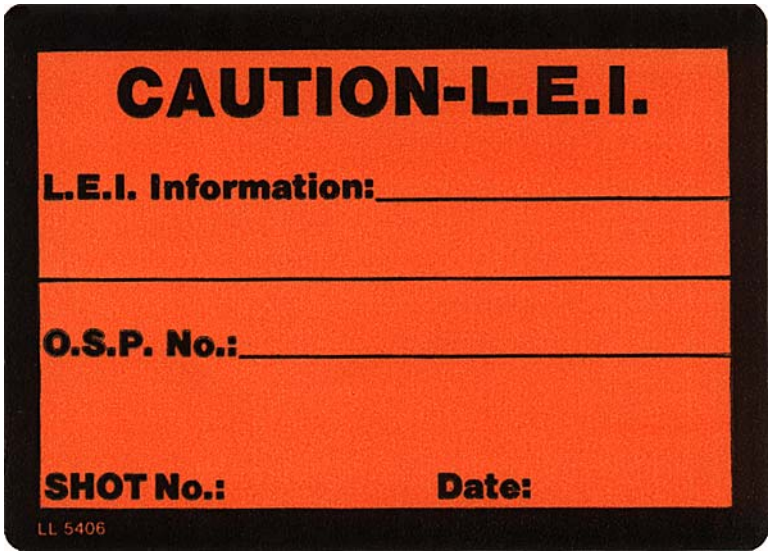

Figure 2. Orange and black warning label (LL-5406) to alert explosives handlers to the presence of an LEI.

4.0 Responsibilities

This section describes the responsibilities of individuals who review and use LEIs at LLNL. General responsibilities for all workers are described in Document 2.1, "Laboratory and ES&H Policies, General Worker Responsibilities, and Integrated Safety Management," in the *Environment Health & Safety (ES&H) Manual.*

4.1 Work Supervisors

- Ensure that explosives operations performed by workers comply with the requirements in this document, other *ES&H Manual* standards, and those in the *DOE Explosives Safety Manual*.
- Train and designate qualified LEI handlers. (At a minimum, the LEI Committee requires handlers have specific training in electrical bonding, grounding, static discharge, inductive coupling, and radio-frequency coupling.)

4.2 LEI Committee

- Review handling and safety procedures, the hazards, as well as evaluations of LEIs, following the recommendations set forth in *Low-Energy Initiators (LEIs), A Review: Recommendations and Implementation Plan for LLNL ManagementUCAR-10074* (July 1981).
- Review the Electroexplosive Component Data Sheet for completeness and determine if the safety aspects and hazard characteristics are properly identified.
- Review safety plans for LEI operations.
- Review, evaluate, and make recommendations on the use of LEIs at LLNL.
- Review and recommend appropriate handling procedures for each LEI category.
- Review and recommend sensitivity testing procedures for LEIs.
- Recommend procedures and training for handling LEIs.

4.3 Responsible Individual

- Obtain appropriate safety information on the EED to be used in the experiment. Tabulate this information on the Electroexplosive Component Data Sheet (see Appendix B) and submit the data sheet to the LEI Committee. Safety information on the data sheet allows the LEI Committee to assign the

device to the appropriate EED category and assists in developing necessary safety controls. If the information is incomplete, extra safety precautions will be necessary.

- Incorporate the minimum design features and controls into the experiment.

4.4 Qualified LEI Handlers

Qualified LEI handlers shall conduct their work in accordance with the requirements in this document and other applicable safety plans and associated procedures, and within the limitations established on each employee's explosives "Training Qualification Record" in Volume II of the *ES&H Manual*.

4.5 ES&H Team Explosives Safety Engineer

The ES&H Team explosives safety engineer is responsible for reviewing the Electroexplosive Component Data Sheet for a particular device planned for use and for providing guidance concerning the safe handling, storage, use, and disposal of these devices.

5.0 Work Smart Standards

DOE Order 440.1A, "Worker Protection Management for DOE Federal and Contractor Employees," Attachment 2, "Contractor Requirement Document," Sections 1-11, 13-18 (delete item 18.a), 19 (delete item 19.d.3) and 22.

http://www.directives.doe.gov/pdfs/doe/doetext/neword/440/o4401a.html

DOE M 440.1-1, DOE Explosives Safety Manual.

http://www.directives.doe.gov/pdfs/doe/doetext/neword/440/m4401-1.html

6.0 Resources for More Information

6.1 LLNL Contacts

Contact the following for further guidance or additional information:

- ES&H Team
- Explosives Safety Technical Leader
- B-Division Group Leader for Detonator/Detonation Physics

6.2 Lessons Learned (LLNL access only)

Refer to the following Intranet address for lessons learned applicable to the topic discussed in this document:

http://www-r.llnl.gov/es_and_h/lessons/lessons.shtml

6.3 Other Sources

Air Force Manual 91-201 (*Explosives Safety Standards*).

R. J. Fisher, *EOS/ESD Symposium Proceedings*, "Sandia Severe Human Body ESD Equivalent Circuit Model (1989).

Appendix A

Terms and Definitions

Electroexplosive device (EED)	A device containing some reaction mixture (explosive or pyrotechnic) that is electrically initiated. The output of the initiation is heat, shock, or mechanical action.
Exploding bridgewire (EBW) detonator	A type of EED where the electrical explosion of a bridgewire or bridgefoil in intimate contact with a low-density pressing of high explosives (e.g., PETN or RDX) initiates a detonation, which is transferred to a high-density pressing (booster). To produce an electrical explosion of sufficient violence to initiate the low-density pressing, a current source is required that can generate a current of several hundred amperes in a few microseconds at a peak power of several hundred kilowatts. Such unique current pulses (except for lightening discharge) cannot be supplied by unintended sources. An EBW will not react to low-level sources (such as rf) from a hand-held transmitter, induced magnetic fields from electrical machinery, and electrostatic discharge from a human body. Static charge on a large metal object charged to high voltage (or 120 V ac) power applied across the leads may lead to a violent deflagration. A lightning strike could lead to a detonation output.
Exploding foil initiator (EFI)	A type of EED (also known as a slapper initiator) in which the electrical explosion of a bridgefoil, in intimate contact with a thin sheet of dielectric material, propels the dielectric across a small gap to strike a pressing of high-density, high explosives. The impact produces a shock wave in the explosive material that promptly transitions to a detonation. The current pulse required for an EFI device to function is even more unique than for an EBW. The current must rise to a kiloampere (or more in a microsecond or less) and generate a peak power that is typically a few megawatts. The only unintended source that could cause detonation is lightning. Deflagration could result from 120 V ac power applied across the leads.

Low-energy initiators (LEI)	Electroexplosive devices (EEDs) containing energetic materials designed to be initiated by an energy of 0.1 J or less at peak power levels of a few watts. These include all EEDs except EBW and EFI devices.

Appendix B

Electroexplosive Component Data Sheet

1. Number or name used to identify this specific item:_____ Requestor:_____
_____ Date:_____
_____ Quantity:_____

2. *Name of supplier or manufacturer:_____ Category:_____
*Part No._____ /Lot No._____ Drawing No._____

3. Hazard Classification:
Manufacturer's Recommended Hazard Class:_____
Manufacturer's Recommended Compatibility Group:_____
Dept. of Transportation shipping Class:_____
Dept. of Transportation Shipping Name:_____
Specific DOT Approved Shipping Container:_____

4. Explosive, Pyrotechnic, or Propellant Composition, and makeup of part:
a. **Explosive** **WT./Unit** **Function** **Location in Device**

b. Total weight of explosiove in component:_____
c. Does any explosive contain metal additives?_____
If yes, explain:_____
_____

5. Recommended Shelf Life:_____
Thermal Limits: Upper_____ ˚F_____˚C
Lower_____ ˚F_____˚C
Other factors affecting shelf life or functioning:_____

6. Electrical Characteristics
*a. Max. No Fire (current)_____ A_____ W_____time
b. Min. All Fire (current)_____ A_____ W_____time
c. Max. Test (current)_____ mA_____time

* Minimum data required for categorization.

6. Electrical Characteristics (cont'd)
   d. Mean Firing (current)_____ A
   e. Recommended Firing (current)_____ A
   *f. Bridgewire Resistance_____ Ω ± _____Ω
   g. Bridgewire Material_____

7. Electrostatic Discharge Rating: DOE_____; DOD_____

8. RF Sensitivity Data:

Frequency	**Power to Fire (watts)**	**Modes (pin to pin) or (pin to case)**

9. Chart: Function time vs current

10. The following documents should be attached to this data sheet:
    a. Detail drawing of component showing dimensions, explosive constituents, electrical schematic.
    b. Descriptive drawing of any DOT specially approved shipping container.
    c. DOT correspondence assigning approved DOT class and shipping name.

11. **General**. Note any special features of this device (thin film bridge, arc-resistant construction, high-resistance paths, only secondary explosives, bridgwire pin-to-case grounds, toxic materials).

_____

_____

_____

_____

12. Any known failure modes?

_____

_____

Signature of person submitting data: _____

Signature of LEI Committee: (at least 2 signatures required, including Explosives Safety)

_____

_____

* Minimum data required for categorization.

Appendix C

Procedure for Handling and Firing of LEIs

C.1 General

This procedure is applicable to handling and firing low-energy initiators (LEIs) in LLNL facilities and in field operations and is to be used as a guide for developing new procedures when new LEI operations are being planned. Any operation with LEIs shall be covered by an approved safety plan and authorized by an Integration Work Sheet (IWS). Any apparatus containing an LEI shall be appropriately tagged and labeled. The person handling the LEI shall be trained and qualified specifically in this area.

C.2 Storage

A magazine or other approved storage is required for all explosives and small explosive devices. The magazine, cubicle, safe file, etc., shall be located and placarded as outlined in the LLNL standards or controlling safety plan. No sources of rf energy shall be brought into the storage area **even if the rf source is turned off**. LEIs shall be stored as outlined in Document 17.1, "Explosives," in the *ES&H Manual*.

C.3 Preparation of the Area and Equipment Prior to LEI Firing

The LEI handler is responsible for doing the following:

1. Ensuring the safety of all operations with the LEI. Stop the operation if you are doubtful of its safety and notify the ES&H Team explosives safety engineer of the situation.
2. Clearing the immediate area of *all* personnel whose presence is not required for the completion of the operation.
3. Verifying that LLNL standard safety signs are posted at all entrances to the work area to warn those who may enter.
4. Completing all adjustments to auxiliary and experimental equipment.
5. Verifying that all sources of significant rf energy have been located and moved to a safe distance. Trunk radio transceivers are not safe, even if they are turned off, because they may be activated by a signal from a central computer. (See Table 1 in this document for safe distances between rf sources and LEI operations.)
6. Verifying that all unnecessary sources of electrical energy in the immediate work area are turned off or otherwise rendered safe.

7. Wearing LLNL-approved eye protection. Make sure that all other persons inside an area of potential injury wear eye protection, and that handlers wear cotton clothing.

8. Ensuring that the work area is free of excessive combustibles and sources of ignition.

9. Verifying that the LEI is the exact item authorized by the OSP for the job before handling it.

   Note: Unless the LEI is positively identified, *do not* continue with the operation.

10. Hand-carrying the LEI from storage to the specific work area in a metal container (e.g., a metal ammo box) that is properly labeled and tagged to identify its contents. The LEI shall be physically segregated and held in place to prevent movement.

11. Ensuring that a Type-I electrical meter authorized by the High Explosives Instrument Committee is available. See Document 17.4, "Electrical Instruments for Use with Explosives Systems," in the *ES&H Manual* for details.

CAUTION

During any physical contact with the LEI, use electrical bonding techniques. Electrical bonding provides a conductive path between the explosives handler, the LEI, and the fixture of equipment involved to prevent development of an electrical potential between them. Measure and record the LEI resistance.

12. Ensuring that the electrical leads on both the LEI pin-to-pin and pin-to-case are shorted together at all times, except when required for testing and installation.

C.4 Installation and Firing

The LEI handler shall ensure that all the steps in Section C.3 have been completed before performing the following steps:

1. Using a Type-I meter capable of reading voltage and current, check for stray voltage and current between the ground and the equipment.

   Note: The voltages and currents (both ac and dc) shall be 50 mV or less and 1mA or less, respectively.

Do not continue the operation unless stray electrical energies are below the values given here.

2. Retain absolute control of the "safety key" (defined as any device that acts as a positive control of the energy source).

3. Remove the LEI from storage or from its container.

CAUTION

During any physical contact with the LEI, use electrical bonding techniques. Electrical bonding provides a conductive path between the handler, the LEI, and the fixture or equipment involved to prevent development of an electrical potential between them.

4. Identify the LEI and inspect it for mechanical damage. In the event that damage is detected, notify the ES&H Team explosives safety engineer for guidance.
5. Verify that the firing-set end of the firing cable is shorted and under administrative control. Check the firing cable for stray voltages and currents.

   Note: Make all measurements with a Type-I meter. Voltage and current (both ac and dc) on the firing cable shall be undetectable.
6. Position the LEI in the fixture or equipment as required by the operation. Ensure that the LEI identification warning label is visible and warns of existing hazard.
7. Connect the shorted firing cable to the LEI, leaving the LEI leads shorted if possible. Open the short between the leads of the LEI after making this connection.
8. Close the bunker door or firing-tank door, or use whatever approved mechanism that will provide protection from the blast or fragments.
9. Notify building or area personnel of the intended firing as required by existing procedures.
10. Check the LEI and firing cable assembly for electrical continuity. Use a Type-I meter.
11. Connect the firing cable to the firing unit and fire the shot as specified in the facility firing procedures.

C.5 Misfire

If no audible detonation is heard after triggering the firing circuit, the firing circuitry and the LEI(s) may be checked for continuity from *within* the protected location. If the firing circuits and LEI(s) appear operative, one or more attempts to fire may be made. If the LEI does not fire, the LEI handler shall take the following precautions:

1. Notify the ES&H Team explosives safety engineer of the misfire.
2. Disconnect and de-energize all shot electrical power sources.
3. Ensure all personnel in the danger zone are aware that a misfire has occurred and that they are to remain under cover until notified otherwise.

4. Before personnel are permitted to leave the cover of the protected location, *observe a pre-established waiting period*. In most situations, establish a waiting period of at least thirty minutes.
5. Initiate a careful and thorough review of the situation in consultation with another knowledgeable person.
6. Have one qualified person cautiously approach and examine the setup to verify that it is safe before personnel are permitted to leave the protected location.
7. With minimum personnel present, remove the unfired LEI and short the electrical leads if possible.
8. Package the LEI, label it as misfired, and move it to the storage area.
9. Arrange for disposal of the LEI. The following information shall accompany the LEI that is being disposed of:
    a. A description of the device.
    b. The Electroexplosive Component Data Sheet (or equivalent) describing the hazardous properties of the device.
    c. A brief description of any electrical, thermal, or dynamic testing to which the unit has been exposed.