



*... for a brighter future*

# *Electrical Inspection in the PHYSICS Division*

*October 20, 2006 by Bruce G. Nardi*



U.S. Department  
of Energy

UChicago ►  
Argonne<sub>LLC</sub>



**Office of  
Science**

U.S. DEPARTMENT OF ENERGY

A U.S. Department of Energy laboratory  
managed by UChicago Argonne, LLC

# Overview and Background

## ■ The Electrical Equipment Inspection Program

### – Why are we doing it

- *The inspections are required by NEC [NFP 70: 110.2 and 110.3]*
- *And by OSHA [29CFR1910.303(a) and 29CFR1910.303(b)(2)]*
- *And most significantly, DOE requires us to abide by the above regulations as stated in 10CFR851.23(a)(3) for OSHA and 10CFR851.23(a)(13) for NEC.*
- *Inspections will enhance safety. The initial 100 inspections at APS had a 50% failure rate. In our own division, a student built a 120 VAC power distribution box that used male AC connectors for the outputs.*

## *What devices do not need to be inspected*

- Electrical equipment and devices such as computers, lamps, tools, etc. that bear a listing mark or label from an OSHA recognized Nationally Recognized Testing Laboratory (NRTL) do not need to be inspected. Examples of such laboratories include UL (Underwriters Laboratory), CSA (Canadian Standards Association), and FM (FM Global Technologies).

# Examples of NRTL Markings



## *Equipment Considered Non-hazardous*

- For 60 Hz AC, < 50 volts
- All other AC:
  - < 50 volts and < 1000 watts, or
  - > 50 volts and < 5 mA
- R&D DC:
  - < 100 volts and < 1000 watts, or
  - > 100 volts and < 40 mA
- Capacitors:
  - < 100 volts and < 100 joules, or
  - 100-400 volts and < 1 joule, or
  - > 400 volts and < .25 joule
- Batteries < 1000 watts

## *Equipment that needs to be inspected*

- All other electrical/electronic equipment, including unlisted office equipment and equipment that was built at the Lab, must be inspected by a Designated Electrical Equipment Inspector (DEEI). If the device has no identified markings from any of the NRTL labs appearing on the OSHA list, the equipment requires inspection, even if listed by another testing lab not on the list. Important note: CE is not an approved NRTL. If a piece of NRTL listed equipment is modified, the listing is voided and the equipment must be inspected.
- In a September 25, 2006 memo from EQO director, R. McCook it was stated that: “All new unlisted electrical equipment (acquired or built after June 10, 2006) is required to be inspected ***BEFORE it is put into service.***”

## *Temporary Approval for Users at User Facilities*

- From the ESH manual, ANL-East 9.3.3.9.
- Unlisted electrical equipment brought in by users to facilities such as the APS, IPNS, and ATLAS must be field evaluated prior to use. The DEEI will designate an expiration date corresponding with the end of the user's visit at the user facility. Approval labels must be applied to a removable tag, and the expiration date must be written on the tag and documented in the equipment inspection database. Equipment must be re-inspected if brought on site at a later date.

## *Who may perform the electrical inspections*

- Inspections must be performed by a Designated Electrical Equipment Inspector (DEEI) who has taken the appropriate training and who has sufficient electrical/electronic background.
- Our division DEEIs are Bruce Nardi, Don Phillips and Tom Mullen.



# Electrical Inspection Forms I Use

- In-house built, non-reputable manufacturer, or modified listed
  - ANL 678A
  
- Reputable manufacturer
  - ANL 678B
  
- System-A combination of equipment or components integrated into a unit to perform a specific task that is **unlikely** to change.
  - ANL 678C
  
- Facility Equipment- The distribution (rather than usage) of electrical power associated with the building, e.g. blowers, motors, pumps, compressors, etc.
  - ANL 678D

## Form ANL-678A

Used for equipment such as:

Argonne built chassis:

- custom built power supplies

- custom built data acquisition and control chassis

Argonne built racks

Equipment from a vendor that is not NRTL listed and the manufacturer is not on the list of reputable manufacturers

Listed equipment that has been modified

# ANL-678A – Non-NRTL/Modified NRTL Listed Electrical Equipment Approval Form

## Non-NRTL/Modified NRTL Listed Electrical Equipment Approval Form For use at Argonne National Laboratory

Division:  Manufacturer:   
 Equipment Owner:  Model Number:   
 Equipment Name:  Serial Number:   
 Equipment Location: Building  Room  ANL Property Number:

Label Number:   
 Multiple  Single

Unlisted equipment that is determined to be safe to operate will have a tracking sticker attached for identification. Equipment that does not pass this evaluation will have a REJECTED sticker attached.

Enclosure	Approve	N/A	Grounding	Approve	N/A
Operator not exposed to any hazard	<input type="checkbox"/>	<input type="checkbox"/>	Ground is properly terminated	<input type="checkbox"/>	<input type="checkbox"/>
Not damaged	<input type="checkbox"/>	<input type="checkbox"/>	All non-current carrying exposed metal is properly bonded	<input type="checkbox"/>	<input type="checkbox"/>
Appropriate materials used	<input type="checkbox"/>	<input type="checkbox"/>	All non-current carrying internal subsystems are properly bonded	<input type="checkbox"/>	<input type="checkbox"/>
Protects contents from operating environment	<input type="checkbox"/>	<input type="checkbox"/>	Equipment ground is run with circuit conductors	<input type="checkbox"/>	<input type="checkbox"/>
Adequate shock protection (components well secured)	<input type="checkbox"/>	<input type="checkbox"/>	Auxiliary ground is permitted	<input type="checkbox"/>	<input type="checkbox"/>
Will contain any arcs, sparks and electrical explosions	<input type="checkbox"/>	<input type="checkbox"/>	<b>Internal wiring</b>		
<b>Power source - cord and plug</b>			Polarity correct	<input type="checkbox"/>	<input type="checkbox"/>
Proper voltage and ampacity rating for plug and cord	<input type="checkbox"/>	<input type="checkbox"/>	Phasing correct	<input type="checkbox"/>	<input type="checkbox"/>
Grounding conductor included (if required)	<input type="checkbox"/>	<input type="checkbox"/>	Landing of ground correct	<input type="checkbox"/>	<input type="checkbox"/>
Not frayed or damaged	<input type="checkbox"/>	<input type="checkbox"/>	Separate line/high voltage from low voltage	<input type="checkbox"/>	<input type="checkbox"/>
Proper wiring of plug	<input type="checkbox"/>	<input type="checkbox"/>	Wiring terminals and leads ok (no tension on terminals)	<input type="checkbox"/>	<input type="checkbox"/>
Strain relief on cord	<input type="checkbox"/>	<input type="checkbox"/>	Proper wire size	<input type="checkbox"/>	<input type="checkbox"/>
<b>Power source - direct wired</b>			No loose parts (mechanical bracing)	<input type="checkbox"/>	<input type="checkbox"/>
Proper voltage and ampacity rating for wiring method	<input type="checkbox"/>	<input type="checkbox"/>	Proper overcurrent protection	<input type="checkbox"/>	<input type="checkbox"/>
Installation according to the NEC	<input type="checkbox"/>	<input type="checkbox"/>	Proper dielectric	<input type="checkbox"/>	<input type="checkbox"/>
Proper loading and overcurrent protection in branch circuit	<input type="checkbox"/>	<input type="checkbox"/>	Clearance/creepage distances for high voltage ok	<input type="checkbox"/>	<input type="checkbox"/>
<b>Foreign power supplies and equipment</b>			<b>Marking requirements</b>		
Connected to facility power with appropriate adapters	<input type="checkbox"/>	<input type="checkbox"/>	Power requirements (voltage, current, frequency)	<input type="checkbox"/>	<input type="checkbox"/>
Correct voltage, frequency and phasing	<input type="checkbox"/>	<input type="checkbox"/>	Restrictions and limitations of use	<input type="checkbox"/>	<input type="checkbox"/>
Correct wire ampacity for US use	<input type="checkbox"/>	<input type="checkbox"/>	Make, model and drawing number	<input type="checkbox"/>	<input type="checkbox"/>
			Hazards, including stored energy	<input type="checkbox"/>	<input type="checkbox"/>
			Requirements for access (LOTO, stored energy, PPE)	<input type="checkbox"/>	<input type="checkbox"/>

Page 2

Label Number:

Tests performed	Approve	N/A	Failure analysis	Approve	N/A
Ground continuity less than 1 Ohm	<input type="checkbox"/>	<input type="checkbox"/>	Effect of ground fault	<input type="checkbox"/>	<input type="checkbox"/>
Polarization of cord and plug	<input type="checkbox"/>	<input type="checkbox"/>	Effect of short circuit	<input type="checkbox"/>	<input type="checkbox"/>
Functional tests (GFCI, Emergency Shut Off)	<input type="checkbox"/>	<input type="checkbox"/>	Effect of interlock failure	<input type="checkbox"/>	<input type="checkbox"/>
Automatic discharge of high voltage capacitor	<input type="checkbox"/>	<input type="checkbox"/>	Effect of overload	<input type="checkbox"/>	<input type="checkbox"/>
			Effect of incorrect setting	<input type="checkbox"/>	<input type="checkbox"/>
<b>Other Issues</b>			<b>Secondary hazards</b>		
Neat workmanship	<input type="checkbox"/>	<input type="checkbox"/>	RF hazards	<input type="checkbox"/>	<input type="checkbox"/>
Proper management of conductors	<input type="checkbox"/>	<input type="checkbox"/>	DC electric or magnetic fields	<input type="checkbox"/>	<input type="checkbox"/>
Free from sharp edges	<input type="checkbox"/>	<input type="checkbox"/>	IR, visible or UV	<input type="checkbox"/>	<input type="checkbox"/>
Proper cooling	<input type="checkbox"/>	<input type="checkbox"/>	X-Rays	<input type="checkbox"/>	<input type="checkbox"/>
Switches and controls readily accessible	<input type="checkbox"/>	<input type="checkbox"/>	Fire or electrical explosion	<input type="checkbox"/>	<input type="checkbox"/>
<b>Maintenance</b>			<b>Documentation</b>		
Any safety issues with access and maintenance	<input type="checkbox"/>	<input type="checkbox"/>	Documentation adequate	<input type="checkbox"/>	<input type="checkbox"/>
			Operating procedures	<input type="checkbox"/>	<input type="checkbox"/>
			Training and qualifications to use	<input type="checkbox"/>	<input type="checkbox"/>

**NOTE: APPROVED EQUIPMENT SHALL BE INSPECTED AND USED IN ACCORDANCE WITH THE INSTRUCTIONS PROVIDED BY THE DESIGNER/BUILDER.**

Comments: Include all designer/builder instructions, restrictions on use, drawings or information that is relevant to the safe installation and use of this equipment.

- This equipment is approved for installation or use at ANL. **Operating Environment:**
- This equipment is rejected for use at ANL. (See comments above)  Indoor/Dry Locations
- This equipment has been removed from service at ANL.  Outdoor/Wet Locations
- Hazardous/Classified Locations

**IF THIS EQUIPMENT IS MODIFIED, DAMAGED OR UTILIZED FOR OTHER THAN THE INTENDED USE, THIS APPROVAL IS VOID, PENDING RE-EXAMINATION.**

Inspection Date:  Inspector (Name):  Inspector (Signed):

## ***Reputable Manufacturer – Form ANL-678B***

- **Use this form for equipment from a manufacturer that appears on the Argonne list of reputable manufacturers**
  
- Requirements for our list:
  - A manufacturer of recognized reputation supplying good quality products with good workmanship
  - Has a North American office/distributor
  - Services their products and provides technical support
  - Provides adequate documentation in English
  - A sample of products have been inspected and approved by a DEEI
  - If recently acquired equipment from a reputable manufacturer fail inspection or are judged to be the cause of one or more incidents, its reputable status can be re-evaluated and possibly rescinded.

## *Reputable Manufacturers Currently Recognized*

- Since our program is based on LANL's, we are starting with their list:
  - Allen-Bradley, Danfysik, DuKane Audio, Eberline,
  - Elgar, Fluke, Glassman, Granville Phillips, Hewlett Packard,
  - Honeywell, Keithley, Kepco, Lambda, LeCroy, Lindeburg,
  - Maxwell, National Instruments, Princeton Applied Research,
  - Ross, Sencore, Simpson, Square D, Superior Electric,
  - Systron Donner, Triplet, Varian, and WaveTek.

# ANL-678B – Reputable Manufacturer Unlisted Electrical Equipment Approval Form

**Reputable Manufacturer Unlisted Electrical Equipment Approval Form**  
For use at Argonne National Laboratory

Division:  Manufacturer:   
 Equipment Owner:  Model Number:   
 Equipment Name:  Serial Number:   
 Equipment Location Building  Room  ANL Property Number:

**Label Number:**   
 Multiple  Single

Unlisted equipment that is determined to be safe to operate will have a tracking sticker attached for identification. Equipment that does not pass this evaluation will have a REJECTED sticker attached.

Use the following factors when evaluating equipment [NEC 110-3]. APPROVE

1. The case is grounded through the power cord to the grounding pin on the plug.	<input type="checkbox"/>
2. The plug is polarized.	<input type="checkbox"/>
3. The equipment input voltage and frequency match those of the building's electrical system.	<input type="checkbox"/>
4. The equipment construction is suitable for the intended operating environment.	<input type="checkbox"/>
5. The equipment is in its original, unmodified and undamaged condition.	<input type="checkbox"/>
6. The equipment has externally accessible supplementary over current protection (e.g. fuses) that are properly sized. (Equipment not having this, needs evaluation to determine if it is safe for use).	<input type="checkbox"/>

**NOTE: APPROVED EQUIPMENT SHALL BE INSTALLED AND USED IN ACCORDANCE WITH THE INSTRUCTIONS PROVIDED BY THE DESIGNER/BUILDER.**

Comments: Include all designer/builder instructions, restrictions on use, drawings or information that is relevant to the safe installation and use of this equipment.

This equipment is approved for installation or use at ANL. **Operating Environment:**  
 This equipment is rejected for use at ANL. (See comments above)  Indoor Use Only  
 This equipment has been removed from service at ANL.  Damp/Wet Locations  
 Hazardous/Classified Locations

**IF THIS EQUIPMENT IS MODIFIED, DAMAGED OR UTILIZED FOR OTHER THAN THE INTENDED USE, THIS APPROVAL IS VOID, PENDING RE-EXAMINATION.** Expiration Date:

Inspection Date:	Inspector (Name):	Inspector (Signed)
<input type="text"/>	<input type="text"/>	<input type="text"/>

ANL-678B (3-06)

## *Multiple Identical Units*

- A representative sample is inspected using the appropriate form
- The remaining units are approved if visual external examination shows no damage or modification
- Each unit must be recorded in the documentation/database

# Proper use of Labels

## ■ Approved

- Only issued to DEEIs
- Applied after equipment passes inspection by a DEEI



## ■ Unlisted Approval Not Required

- May be applied to any unlisted equipment not requiring inspection due to voltage and power factors previously discussed



## ■ NRTL Approved Electrical Equipment

- Applied to the front of an unmodified NRTL listed piece of equipment to readily identify it as NRTL listed and not requiring inspection.





## Proper Use of Labels

### ■ Rejected – Do Not Energize Until Approved

- Apply to equipment that fails an inspection due to one or more serious deficiencies

REJECTED  
DO NOT ENERGIZE  
UNTIL APPROVED

### ■ Rejected – Equipment May be Used Pending Approval

- Apply to equipment not passing an inspection due to minor violations such as a minor labeling issue

REJECTED  
EQUIPMENT MAY BE USED  
PENDING APPROVAL

### ■ Out of Service Electrical Equipment – Must be Approved before Use

- Apply to equipment not being used or in storage
- Two different sizes. Larger size to mark large areas of storage (cage).

OUT OF SERVICE  
ELECTRICAL EQUIPMENT  
  
MUST BE APPROVED  
BEFORE USE

## *Notes and Lessons from my Inspections*

- Many pieces of equipment have failed the initial inspection. The most common failure is missing labels.
- The Inventory, inspections and repairs will be a major effort.

## *Action Items for now*

- Inspect newly purchased unlisted electrical equipment before it is put into service.
- Create the Physics Division inventory list and continue with inspections.
- December 15, 2006 – complete inventory spreadsheet of all equipment that needs inspection and deliver to ESH.
- Each January and July – send copy of current database of inspections completed to Electrical Safety SME, Joe Kilar.

## *The inventory - Why*

- An inventory, if complete, will allow us to see how many inspections need to be accomplished in the next five years (by June 9, 2011).
- Each year we will know if we are on pace with completing all inspections before the deadline.

## The Inventory - How

- We would like to try a programmatic approach to our inventory.
- ATLAS has already requested separate inventories from their groups, cryogenics, computer, etc.
- An inventory does not have to be performed by a DEEI. The person doing the inventory needs to know what type of equipment to look for and to recognize NRTL markings. (this presentation contains the information to complete an inventory.)
- I would like to ask each of you who have a lab, cage or experimental area to create an inventory list of equipment and return it to me by November 15, 2006. If you have questions please contact me.
- This will establish an accurate inventory if everyone participates.
- **Remember** the deadline for submitting the Physics division Inventory of unlisted electrical equipment needing inspection is December 15, 2006.

# Sample Inventory List

Non-NRTL Inventory

Room	Specific Location	Occupant	Manufacturer	Model #	Qty	Description	Priority (high moderate, low)	In Use (yes, no)

# Sample Equipment Inventory Spreadsheet

Energy Systems Non-NRTL Inventory										Total Items=	1024	
Passed Inspection												
Rejected - May Use												
Rejected - Do Not Use												
No.	Bldg.	Room	Specific Location	Occupant	Manufacturer	Model #	Qty	Description	Priority	In Use	Date Inspected	
53	202	B354	Cleanroom	Yershov, C	Oriel	Rack/Cu stom	1	UV Light	Moderate	Yes		
95	371	HiBay	West corridor	Shimcoski, D	ERLAB, Inc.	Toxicap 1324	1	Ductless Fume Hood	Moderate	Yes		
96	371	HiBay	West corridor	Shimcoski, D	Tripp-Lite	PR-20	1	DC Power Supply	Moderate	Yes		
97	371	HiBay	West corridor	Shimcoski, D	Clayton Indust.	CPE-50	1	Twin-Roll Emissions Ch	Moderate	Yes		
98	371	HiBay	West corridor	Shimcoski, D	ANL-APRF Custom		3	Warning Beacon Encl.	Moderate	Yes	(1) 4/27/06, (1) 5/02/06, (1) 5/03/06	
99	371	HiBay	West corridor	Shimcoski, D	ANL-APRF Custom		1	FuelScale e-stop Relay E	Moderate	Yes		
100	371	HiBay	West corridor	Shimcoski, D	Luxor		3	A.V. Equip. Cart	Moderate	Yes		
101	371	HiBay	West corridor	Shimcoski, D	ANL-APRF Custom		1	Oper/Driver Safety Alert	Moderate	Yes		
102	371	HiBay	West corridor	Shimcoski, D	EconOLine		1	Media Blaster	Moderate	Yes		
103	371	HiBay	West corridor	Shimcoski, D	ANL-APRF Custom		1	Patch Panel/Pwr. Supply	Moderate	Yes	4/21/2006	
104	371	Vehicle Soak Rm		Shimcoski, D	Hartzel-ANL Custom	22S-49- AVS3	1	Vehicle Air Velocity Simu	Moderate	Yes		
105	371	4WD Mezz	Mechanical Room	Shimcoski, D	Speedaire	6Z948B	3	AIHO-Elec. Drain Valve	Moderate	Yes		
106	371	4WD	Test Cell 6	Shimcoski, D	Triplite	PR-60	1	12 vdc Power Supply	Moderate	Yes		
107	371	4WD	Test Cell 6	Shimcoski, D	Tenma	72-6152	1	DC Power Supply	Moderate	Yes		
108	371	4WD	Test Cell 6	Shimcoski, D	Airgas		1	Hydrogen Distrib. System	Moderate	Yes		
109	371	4WD	Test Cell 6	Shimcoski, D	Hartzell Custom Blt		1	Vehicle Cooling Fan	Moderate	Yes	4/13/2006	
110	371	4WD	Test Cell 6	Shimcoski, D	Triplite	PV1000FC	1	12 VDC, 1000 Watt Inver	Moderate	Yes		
111	371	4WD	Test Cell 6	Shimcoski, D	Triplite	PR-20	1	12 vdc Power Supply	Moderate	Yes		
112	371	4WD	Test Cell 6	Shimcoski, D	Luxor		2	A.V. Equip. Cart	Moderate	Yes		
113	371	4WD	Test Cell	Shimcoski, D	B&K Precision	1689	2	DC Power Supply	Moderate	Yes		
114	371	LL	Attached to table	Bihari, B.	Temp. Controllers	Barber- Colman	2	Heater Supply & Controll	Moderate	Yes	(2) 4/27/2006	
115	371	LL	Optical table	Bihari, B.	Continwire	PowerLight	1	Nd Yag Laser & Power S	Moderate	Yes		
116	376	Hi-Bay	NW Corner	Longman, D.	L&R UltraSonic	650H	1	Parts Washer	Moderate	Yes		