

1
2
3
4
5 **FESHM 9111: APPROVAL OF UNLISTED ELECTRICAL**
6 **EQUIPMENT**
7
8
9

10
11 **Revision History**
12

| Author | Description of Change | Revision Date |
|---------------|------------------------------|----------------------|
| David Mertz | Initial release Chapter 9111 | July 2020 |

13

TABLE OF CONTENTS

| | | |
|----|-----------------|--|
| 14 | | |
| 15 | | |
| 16 | 1.0 | INTRODUCTION AND SCOPE..... 2 |
| 17 | 2.0 | DEFINITIONS 3 |
| 18 | 3.0 | RESPONSIBILITIES..... 4 |
| 19 | 3.1 | Division, Section, or Project (D/S/P) Heads4 |
| 20 | 3.2 | Electrical AHJ4 |
| 21 | 3.3 | Department managers, experiment spokespersons, electrical coordinators, task managers, and construction coordinators5 |
| 22 | 3.4 | Persons specifying, designing, constructing, and installing electrical equipment5 |
| 23 | | |
| 24 | 4.0 | PROGRAM DESCRIPTION 5 |
| 25 | 4.1 | Electrical equipment inspections.....6 |
| 26 | 4.1.1. | User, visitor, and institution owned equipment 6 |
| 27 | 4.1.2. | Standards to which equipment is to be inspected 6 |
| 28 | 4.1.3. | Inspection criteria for Non-Listed and Modified NRTL-Listed Electrical Equipment 6 |
| 29 | 4.1.4. | Unlisted facility equipment..... 9 |
| 30 | 4.1.5. | Electrical equipment systems 10 |
| 31 | 4.1.6. | Multiple identical units..... 11 |
| 32 | 4.2 | Inspection documentation and archive12 |
| 33 | 4.2.1. | Equipment documentation..... 12 |
| 34 | 4.2.2. | Electrical inspection forms 12 |
| 35 | 4.2.3. | Other acceptable inspection documents..... 13 |
| 36 | 4.3 | Inspected equipment labeling13 |
| 37 | 4.4 | Equipment that is salvaged, excessed, abandoned in place, or removed13 |
| 38 | 4.5 | Equipment that retrieved from salvage, excess, or abandonment14 |
| 39 | 4.6 | Equipment received from other DOE sites and laboratories14 |
| 40 | 4.7 | Subcontractor-owned unlisted electrical equipment14 |
| 41 | 4.8 | Rental equipment.....14 |
| 42 | | |
| 43 | 5.0 | REFERENCES 15 |
| 44 | 6.0 | TECHNICAL APPENDIX 16 |
| 45 | 6.1 | Custom-built and Modified NRTL-Listed Electrical Equipment (page 1 of 2).....17 |
| 46 | (6.1 continued) | Custom-built and Modified NRTL-Listed Electrical Equipment (page 2 of 2)18 |
| 47 | | |
| 48 | 6.2 | Facility Unlisted Electrical Equipment Approval Form.....19 |
| 49 | 6.3 | Unlisted Commercial Electrical Equipment Approval Form20 |
| 50 | 6.4 | Electrical System Approval Form (page 1 of 3).....21 |
| 51 | (6.4 continued) | Electrical System Approval Form (page 2 of 3)22 |
| 52 | (6.4 continued) | Electrical System Approval Form (page 2 of 3)23 |
| 53 | 6.5 | Form for additional identical units under a single unlisted equipment inspection.....24 |
| 54 | | |
| 55 | | |

56

57 **1.0 INTRODUCTION AND SCOPE**

58

59 All electrical equipment in use at the Fermilab site or in its leased spaces that contains or produces
60 hazardous electrical energy, as defined in section 6.1 of FESHM Chapter 9100, shall be listed and
61 labeled by a nationally recognized testing laboratory (NRTL), field inspected by a NRTL, or
62 approved by the Fermilab Electrical Authority Having Jurisdiction (AHJ) or designee prior to use.
63 Listed equipment that has been modified or is used outside its use defined by the listing or
64 manufacturer's instructions shall also be approved by an AHJ prior to use. Fermilab Site
65 management shall:

- 66 • Ensure NRTL-listed electrical equipment is purchased and utilized if it exists, and
- 67 • Ensure that all equipment containing an electrical hazard that is not NRTL listed has been
68 approved by the electrical AHJ.

69

70 Evaluation and approval of unlisted electrical equipment applies to electrical equipment used by
71 employees and employees of subcontractors or organizations. All unlisted or modified NRTL-listed
72 electrical equipment requires evaluation and approval prior to use. These requirements apply as
73 follows:

- 74 • New unlisted electrical equipment shall be approved by the electrical AHJ before use.
- 75 • Unlisted equipment previously used at Fermilab without examination shall be approved by
76 the electrical AHJ prior to being placed into service for a new application or restarting a
77 decommissioned system.
- 78 • Equipment that has been modified, repaired, or is used outside of its original intent, shall be
79 approved by the electrical AHJ.

80

81 This chapter provides standard criteria for evaluation, labeling, and documentation of unlisted
82 electrical equipment. The Occupational Safety & Health Administration (OSHA) requires explicit
83 approval of all electrical equipment in the workplace to ensure it is free from recognized hazards
84 that are likely to cause death or serious physical harm to employees.

85

86 NRTL-listed equipment shall be purchased and utilized if it exists. For new or replacement
87 equipment, a NRTL-listed product shall be purchased instead of an unlisted product if both exist.
88 All NRTL-listed equipment shall be used for its intended purpose in accordance with the
89 manufacturer's instructions. Otherwise, the equipment has to be treated as unlisted and is required
90 to be approved by the AHJ.

91

92 Equipment that is not NRTL-listed and is unable to receive approval through a NRTL or AHJ field
93 inspection shall not be placed into use at Fermilab until corrective measures are implemented to
94 gain approval. In exceptional cases that meet the criteria in FESHM Chapter 1010, a variance or
95 exception may be pursued to permit operation in violation of this Chapter.

96

97 **2.0 DEFINITIONS**

98

99 **Approved Equipment** – Equipment acceptable to the AHJ consisting of: (1) NRTL-listed
100 equipment being used in accordance with its listing or labeling for the manufacturer’s intended
101 purpose; (2) equipment that is field inspected and approved by a NRTL inspector as safe for its
102 intended purpose or, (3) equipment that is inspected and approved by an AHJ electrical inspector
103 as safe for its intended purpose.

104 **Electrical Equipment** – Equipment that uses electrical energy for electronic, electro
105 mechanical, or chemical operations; heating; lighting; or similar purposes. Electrical equipment
106 includes equipment used in laboratory research and development (R&D), other specialized
107 equipment, as well as utility, facility, and shop equipment.

108 **Electrical Inspector** – A qualified electrical inspector is one who has been determined by
109 his/her AHJ, or designee, to have the skill, knowledge, and abilities to safely perform the work to
110 which he/she is assigned. In addition, he/she shall have knowledge of the applicable electrical
111 safety requirements, as well as demonstrated field experience in the design, installation, and/or
112 operation of facility or R&D electrical systems. He/she also performs field evaluations,
113 approves, labels and documents electrical equipment installations and work.

114 **Facility Electrical Equipment** – Electrical equipment that is considered an integral part of a
115 facility or building and is generally not under direct control by R&D or office personnel.
116 Examples include building pumps; compressors; heating, ventilation, air conditioning
117 equipment; fixed general lighting fixtures that are permanently attached to the building
118 structure; and facility power distribution equipment, such as panelboards, disconnect switches, and
119 transformers.

120 **Field Evaluation** – The process used for one-of-a-kind, limited production, used, or modified
121 products that are not listed or labeled under a full listing and certification program. The process
122 is completed at the point of manufacturing, interim points of distribution, in the evaluating
123 company’s facilities, or at the final installation site or a combination of the above. Note that
124 independent testing agencies, including NRTLs, can perform a field evaluation, generally in
125 accordance with NFPA790/791. A contractual relationship is often set up directly between the
126 manufacturer/distributor and the testing entity, which provides a simpler and more robust
127 mechanism for resolution of non-compliant issues prior to Fermilab receiving the equipment.
128 The AHJ approves the testing entity and the field report prior to the equipment being placed into
129 service.

130 **In-House-Built Equipment** – Electrical equipment designed and/or fabricated by employees of
131 a facility, including employees of subcontractors, other research organizations, including
132 universities, other laboratories, and other research institutions.

133 **Low-Hazard Equipment** – Equipment that contains only negligible or low electrical
134 hazards. This equipment will not have capability, under both normal operation and fault
135 conditions, to deliver alternating or direct current, or contain stored energy, in excess of the
136 hazardous energy thresholds listed in FESHM Chapter 9100 section 6.1, or emit radio frequency

137 energy above the thresholds given in FESHM Chapter 4320..

138 **Modified Equipment** – NRTL-listed equipment that has been modified or is being used for a
139 purpose other than intended by the manufacturer/builder, and or NRTL or AHJ approved
140 electrical equipment that is being used in a different location or for a different purpose than what
141 it was to be used for when the inspection was conducted. Modified equipment includes
142 equipment that is not used in accordance with the standard under which it listed, or the
143 manufacturer’s/builder’s installation, use, or maintenance instructions.

144 **Nationally Recognized Testing Laboratory (NRTL)** – An organization (e.g., Underwriters
145 Laboratory, or UL) That is recognized by OSHA in accordance with Appendix A of 29 CFR
146 1910.7. A list of the current roster of NRTLs can be found at the OSHA website.
147

148 **Listed Equipment** – Equipment, included in a list published by an NRTL and used in
149 accordance with any instructions included in the product standard under which it is listed and
150 follows all manufacturer instructions or other documentation. Listed equipment includes
151 industrial control panels built by firms participating in the UL Industrial Control Panel Shop
152 Program that bear the firm’s UL label.

153 **Non-listed Equipment** – Equipment, that is not included in a list published by an NRTL. For
154 the purposes of this Chapter, the term non-listed equipment also includes equipment that is listed,
155 but is used for purposes that are not described in the product standard under which it is listed or
156 does not follow any manufacturer instructions or other documentation.

157 **System** – A combination of components integrated into a unit to perform a specific task that is
158 unlikely to change.

159 **Unlisted Equipment** – Equipment that has not been listed by an NRTL.

160 **3.0 RESPONSIBILITIES**

161

162 **3.1 Division, Section, or Project (D/S/P) Heads**

163 The D/S/P heads are responsible for ensuring that any and all instances in which electrical
164 equipment, other than low-hazard equipment, are not NRTL listed or are NRTL listed but not used
165 in conformance with its listing standard and manufacturer’s instructions, receive AHJ approval
166 through a NRTL or AHJ field inspection.
167

168 **3.2 Electrical AHJ**

169 The Electrical AHJ is responsible for approval of electrical equipment in conformance with 29 CFR
170 1910. The Electrical AHJ develops the electrical inspection program for non-listed equipment,
171 inspects non-listed electrical equipment, and designates other laboratory individuals who may also
172 inspect non-listed electrical equipment.
173

174 **3.3 Department managers, experiment spokespersons, electrical coordinators, task**
175 **managers, and construction coordinators**

176 Department managers, experiment spokespersons, electrical coordinators, task managers, and
177 construction coordinators are responsible for communicating requirements for listed equipment and
178 for complying with the equipment inspection process to persons specifying, designing,
179 constructing, and installing electrical equipment.
180

181 **3.4 Persons specifying, designing, constructing, and installing electrical equipment**

182 Persons specifying, designing, constructing, and installing electrical equipment are responsible for
183 understanding the requirement to use NRTL-listed equipment wherever possible, and where not
184 possible, to provide the non-listed equipment, engineering and specification documents, and other
185 materials as required by the inspector, whether NRTL or the Electrical AHJ or designee, to conduct
186 the equipment inspection. Guidance for the design and construction of custom-built electrical
187 equipment can be found in Fermilab's *Electrical Design Standards for Electronics to be used in*
188 *Experimental Apparatus at Fermilab* ([https://esh-docdb.fnal.gov/cgi-](https://esh-docdb.fnal.gov/cgi-bin/ShowDocument?docid=2781)
189 [bin/ShowDocument?docid=2781](https://esh-docdb.fnal.gov/cgi-bin/ShowDocument?docid=2781)), and Chapter 13 of the 2013 edition of the DOE Electrical Safety
190 Handbook, DOE-HDBK-1092-2013.
191

192 **4.0 PROGRAM DESCRIPTION**

193
194 The unlisted electrical equipment program has two goals. The first is to assure that all electrical
195 equipment purchased, made, or otherwise provided to Fermilab and used at Fermilab or its leased
196 sites has been approved by the electrical AHJ. The second goal is to provide centralized records
197 and equipment markings that expedite the process of obtaining inspection records and the
198 supporting documentation for each piece of unlisted equipment.
199

200 Throughout its history, Fermilab's mission has required the use of specialized, and often unique,
201 equipment that was and is not commercially available. The vast majority of this equipment was
202 produced and used in accordance with the standards that existed at the time of its manufacture. It
203 often exceeded those minimum requirements in the interest of operational reliability. Following the
204 principle established by NFPA 70, *National Electrical Code*, for the electrical distribution system,
205 existing non-listed equipment that has remained in its present service, other than for repair and
206 scheduled shutdowns, will not be required to be inspected. The electrical AHJ does have authority
207 to require equipment be retrofitted to mitigate risks to employees or facilities regardless of the
208 equipment's service history.
209

210 The unlisted electrical equipment program is administered by the Electrical AHJ. The AHJ will
211 identify the resources to be used to comply with the program. The AHJ will also designate personnel
212 who are authorized to perform unlisted electrical equipment inspections. Such designees are
213 responsible for understanding the limitations of their expertise and to seek additional help when
214 inspecting portions of equipment with portions or components beyond their expertise.
215

216 **4.1 Electrical equipment inspections**

217

218 A successful electrical inspection is required before non-listed electrical equipment is energized or
219 operated. The inspection is requested by the person or manager responsible for the equipment from
220 the AHJ or an AHJ designee. The equipment will be assigned a simple serial identification number.
221 Multiple pieces of identical equipment may be assigned the same inspection number.

222

223 It is recommended that the inspection process begin in the early design stages of custom fabricated
224 equipment, or at least before the equipment is specified and purchased. This allows changes needed
225 to meet the requirements in lab standards to be incorporated with the least impact to schedules and
226 budgets and will expedite the final review prior to operation. This is strongly encouraged for
227 equipment that is particularly complex or employs novel or unusual methods or components.

228

229 **4.1.1. User, visitor, and institution owned equipment**

230

231 Fermilab hosts many tests and experiments that consist of equipment and materials that are
232 and will remain the property of persons or institutions other than Fermilab and its employees
233 and subcontractors. Such equipment is required to comply with the same regulations and
234 standards as equipment owned by Fermilab and will be inspected by the electrical AHJ. It
235 will not, however, be assigned an identification number.

236

237

238 **4.1.2. Standards to which equipment is to be inspected**

239

240 The equipment shall be inspected according to the standard most applicable to the type and
241 purpose of the equipment. In unusual cases, more than one standard may apply. The
242 electrical AHJ should be consulted if it is not clear which standard should be applied. These
243 following is a list of the most common standards which non-listed equipment at Fermilab
244 must follow. It is not an exhaustive list of all the standards that might apply.

245 UL 508A Standard for Industrial Control Panels

246 UL 60950 Information Technology Equipment - Safety

247 UL 61010 Safety Requirements for Electrical Equipment for Measurement, Control,
248 and Laboratory Use

249

250 **4.1.3. Inspection criteria for Non-Listed and Modified NRTL-Listed Electrical** 251 **Equipment**

252

253 The inspection shall review the following list of features, requirements, and identifying
254 information and shall record the results of the inspection in an appropriate document as
255 described in section 5. Information already present in equipment documentation submitted
256 with the request for inspection does not have to be repeated in the inspection document.

257

- 258 • Equipment owner name (optional), Badge # (optional), group/organization

- 259
- 260
- 261
- 262
- 263
- 264
- 265
- 266
- 267
- 268
- 269
- 270
- 271
- 272
- 273
- 274
- 275
- 276
- 277
- 278
- 279
- 280
- 281
- 282
- 283
- 284
- 285
- 286
- 287
- 288
- 289
- 290
- 291
- 292
- 293
- 294
- 295
- 296
- 297
- 298
- 299
- Equipment name
 - Equipment manufacturer
 - Equipment model number
 - Equipment serial number and property number, if applicable
 - Equipment location (optional)
 - Equipment status: new, modified, not previously approved, in-use, etc.
 - Equipment type (optional):
 - Stand-alone custom built
 - System
 - Powered rack
 - Appliances and electrical tools
 - Powered workbench
 - Extension cords and relocatable power taps
 - Other
 - Function
 - Usage:
 - Operating Environment
 - Conditions of Usage/comments
 - Electrical inspection identification number
 - Date examined and approved/rejected
 - Name of electrical inspector who examined and approved/rejected the equipment
- Other than modified NRTL-listed electrical equipment shall be examined at a minimum, checking for the following items as appropriate:
- External Inspection:
 - Enclosure
 - Operator is not exposed to any hazard
 - Is not damaged
 - Is of appropriate material
 - Protects contents from operating environment
 - Cords, other than incoming power, run outside of enclosure are properly supported
 - Power Source
 - Cords and Plugs
 - Proper voltage and ampacity rating for plug and cord
 - Grounding conductor included, if required
 - Are not frayed or damaged
 - Proper wiring of plug and properly torqued
 - Proper strain relief on cord
 - Direct wired into facility power
 - Proper voltage and ampacity rating for wiring method
 - Installation according to the National Electric Code (NEC)

- 341 • Clearance/creepage distances for high-voltage
- 342 • Listed conductors, if applicable
- 343 ▪ Other Internal Issues
- 344 • Neat workmanship
- 345 • Listed components used, if applicable
- 346 • Proper management of conductors
- 347 • Free of sharp edges
- 348 • Adequate cooling
- 349 • Automatic discharge of high-voltage capacitor
- 350 • Tests performed as deemed appropriate by electrical inspector
- 351 ▪ Ground continuity (less than an ohm)
- 352 ▪ Polarization of cord and plug
- 353 ▪ Auto discharge of high-voltage capacitor
- 354 ▪ Functional tests (e.g. ground fault circuit interrupter (GFCI), emergency
- 355 shut-off etc.)
- 356 • Failure Analysis
- 357 ▪ Effect of ground fault
- 358 ▪ Effect of short circuit
- 359 ▪ Effect of interlock failure
- 360 ▪ Effect of overload
- 361 ▪ Effect of incorrect setting
- 362 • Maintenance
- 363 ▪ Any safety issues with access and maintenance
- 364 • Hipot (high voltage) Testing
- 365 ▪ The local AHJ may also choose to perform an ac/dc Hipot test to include
- 366 Dielectric Withstand, Ground Bond/Continuity, Earth Leakage, and
- 367 Insulation Resistance test per IEC/UL 61010-1 & CSA 22.2 for Laboratory
- 368 Control Test & Measurement Equipment. There are commercially available
- 369 test systems that are designed to autonomously perform a prescribed test
- 370 sequence on cord-and-plug laboratory and analytical equipment. This test
- 371 can be performed in lieu of, or in addition to, the requirements in Section
- 372 10.6.1 at the AHJ's discretion.

374 **4.1.4. Unlisted facility equipment**

375
 376 The need for unlisted facility equipment is expected to be extremely rare. In the event that
 377 no existing listed facility equipment will meet application requirements, the following items
 378 should be inspected on the selected non-listed equipment:

- 380 • Suitability for installation and use in conformity with 29 CFR 1910 Subpart S,
- 381 and/or, the NEC;

- 382 • Mechanical strength and durability, including for parts designed to enclose and
- 383 protect other equipment, and the adequacy of the protection is thereby provided;
- 384 • Wire bending and connection space;
- 385 • Electrical connections and insulation;
- 386 • Heating effects under normal condition of use and also under abnormal conditions
- 387 likely to arise in service;
- 388 • Arcing effects;
- 389 • Classification by type, size, voltage, current capacity, and specific use; and
- 390 • Other factors that contribute to the practical safeguarding of persons using or likely
- 391 to come in contact with the equipment.

392 4.1.5. Electrical equipment systems

393 Combining two or more pieces of electrical equipment into a system can result in hazards

394 if not carefully executed. Inspections of such systems are often done in the context of other

395 lab programs, such as ORC inspections. These inspections should document the following:

396 Reference information:

- 400 • The items required to be evaluated for system field evaluation;
- 401 • Conditions of use/comments;
- 402 • System description;
- 403 • Subsystems;
- 404 • System name;
- 405 • Manufacturer;
- 406 • Date built;
- 407 • Date last modified;
- 408 • Number of pieces of equipment (e.g., 3 power supplies, 2 modulator racks);
- 409 • System status;
- 410 • System owner name (optional), Badge etc.#(optional), group/organization;
- 411 • Equipment location (optional);
- 412 • Specific tests performed for approval;
- 413 • Immediate improvements, required modifications (with a due date) and
- 414 compensatory measures taken in the meantime;
- 415 • Name of division and group electrical inspector(s) who examined and
- 416 approved/rejected the system; and
- 417 • Electrical inspector tracking number if equipment is approved.

418 Site organizations may approve unlisted electrical equipment as systems, with Site AHJ

419 approval. Systems shall be examined at a minimum as follows:

- 420 • Hazard Assessment to include:
 - 421 ○ Electrical hazard classification);
 - 422 ○ Stored electrical energy in capacitors (voltage and energy);

- 423 ○ Batteries, including uninterruptible power supplies (UPS);
- 424 ○ Electromagnetic fields produced (dc to 300 GHz, pulsed);
- 425 ○ Infrared, optical, and UV;
- 426 ○ X-rays;
- 427 ○ Heat and sparks;
- 428 ○ Acoustic energy; and
- 429 ○ Other (e.g., chemical high pressure, cryogen, etc. This may require other
- 430 subject matter expert (SME) review.
- 431 ● Evaluation for operation to include:
 - 432 ○ Enclosure, isolation. There are no exposed hazardous energized conductors,
 - 433 no unused openings;
 - 434 ○ Grounding. All conductive enclosures exposed to personnel that may
 - 435 become energized shall be properly grounded;
 - 436 ○ Overcurrent protection. Overload protection, ground fault, and short circuit
 - 437 protection are in place;
 - 438 ○ Failure analysis. There are adequate electrical and fire protection systems for
 - 439 failure modes. (e.g. wiring, component failures etc.);
 - 440 ○ Operation safety analysis and controls are documented; and
 - 441 ○ System is labeled appropriately.
- 442 ● Evaluation for working on system to include:
 - 443 ○ Method(s) of energy isolation (e.g., plug control, LOTO, Kirk key);
 - 444 ○ Automatic methods of stored energy removal;
 - 445 ○ Proper design for the manual removal and/or verification of capacitively
 - 446 stored energy; and
 - 447 ○ Documentation for entry and work on system.

4.1.6. Multiple identical units

450
451 For the case where multiple units of a full-custom or semi-custom design are incorporated
452 into an installation or system, and those units contain hazardous electrical energy, whether
453 built by a commercial manufacturer or built in-house, a determination is needed as to the
454 consistency of the manufacturing materials and methods as they pertain to safety as part of the
455 inspection process. Generally, the inspector should evaluate the quality of workmanship of the
456 first unit to be inspected in making the determination as to how many units need to be inspected.
457 The inspection of a minimum of 2 units is recommended, with additional inspections added
458 depending on the findings. The following guidelines should be employed:

- 459 a. Units having sub-standard workmanship compared to industry standards are an indication
460 that multiple inspections are needed.
- 461 b. Identical models with different manufacturing dates should be checked to ensure that the
462 same quality of manufacturing regarding materials and methods have been employed.
- 463 c. Similar models with different model numbers (e.g. Model 100A → Model 100B) should
464 be checked to ensure that nothing has changed regarding the electrical safety aspects.

- 465 d. Units without model numbers or dates of manufacturing should be considered as different
 466 models.
- 467 e. Units without professional documentation should be considered as different models.
- 468 f. Units without serial numbers should be considered as different models. If safety issues are
 469 found, it is recommended that serial numbers be applied as part of the remediation process.
- 470 g. Any single unit having safety issues should necessitate additional units being
 471 inspected. Multiple units having the same safety issue may be used as a basis to fail
 472 all units without inspecting each and every unit.

473 The inspector may elect to cover the inspection of multiple units in a single field inspection.
 474 If no safety issues are found in any of the units, the same inspection identification
 475 number may be used for multiple identical make and model units/systems. The serial
 476 number, lab property number, or other unique identifier of each identical model
 477 unit/system identified as approved is documented on the same approval form used to
 478 document the approval of the representative sample,
 479

480 **4.2 Inspection documentation and archive**

481

482 The documents used by and produced by the inspection process will be archived in a location
 483 accessible to the electrical AHJ and designees, and preferably to others involved in electrical design,
 484 operation, and maintenance work. This is presently provided on the Electrical Safety Subcommittee
 485 Sharepoint site. The purpose of this archive is two-fold. The first is to comply with the requirement
 486 to maintain testing records of custom-built equipment found in the definition of Acceptable in 29
 487 CFR1910.399. The second purpose is to provide a central, readily accessible resource for finding
 488 records and information regarding non-NRTL equipment. This second objective recommends a
 489 policy to be minimally restrictive in the types and kinds of documents permitted to be stored in this
 490 archive.
 491

492 The archive shall consist of records, which are assigned a serial record number. Each record number
 493 is specific to a particular manufacturer and model of equipment. Where variants of a model of
 494 equipment exist that have different components or construction, separate records shall be created
 495 for each variant. Optional or auxiliary equipment, such as plug-in modules, should be assigned
 496 separate record files. The title of each record should include both the record number and a brief
 497 identification of the equipment covered.
 498

499 **4.2.1. Equipment documentation**

500

501 Documents that provided data used to perform the inspections shall be stored in the archive
 502 for future reference. It is also recommended that other documents related to the equipment,
 503 such as installation, operation, and maintenance manuals also be put in the archive.
 504

505 **4.2.2. Electrical inspection reports**

506

507 The technical appendices of the chapter contain inspection forms that may be used to
508 document the inspections performed. While not required, these forms do provide a ready
509 means to ensure that the items identified in section 4.1 of this chapter are addressed during
510 the inspection. The titles of inspection reports saved in a record file shall contain the file
511 record number and the serial number of the equipment inspected. Where multiple pieces of
512 identical equipment are inspected at the same time, the date of the inspection can be
513 substituted for the serial number in the inspection report.

514 **4.2.3. Other acceptable inspection documents**

515 Prior to the development of this chapter, Fermilab had already developed robust and mature
516 design evaluation and equipment inspection procedures and documentation systems.
517 Archives of the documents used and produced by these processes are often specific to and
518 only accessible by the organizational unit that produced them. While entry of inspection
519 and resource documents into the archive managed under this chapter is mandatory,
520 recording and archiving of these same documents in other locations is permitted. Those
521 archiving the documents in alternate locations are advised to incorporate robust version
522 control into such documents.

523 **4.3 Inspected equipment labeling**

524 Key to efficient use of this program are clear indications of the inspection status of each piece of
525 unlisted equipment. Three types of labels are to be used, each one will identify the type of label in
526 permanent black ink and provide a space to write in the record number and the initials of the
527 inspector.

- 528 a. A green “approved” label will be applied to equipment that has successfully completed
529 inspection.
- 530 b. A yellow “conditional” label will be applied to equipment on which the inspector has placed
531 restrictions on the use of the equipment, time duration, or equipment which does not meet
532 inspection requirements but has been given permission to operate through the variance or
533 exception process in FESHM 1010.
- 534 c. A red “rejected” label will be applied to equipment that has not passed inspection and is not
535 permitted to operate.

536 A white label, simply marked “NRTL Listed” and with a place for the inspectors initials, may be
537 used to indicate that a piece of equipment is NRTL listed, but the location of its NRTL seal and
538 where the equipment is installed make it difficult to see the seal.

539 **4.4 Equipment that is salvaged, excessed, abandoned in place, or removed**

540 The AHJ approval is invalidated for unlisted equipment that is no longer in service, other than for
541 period of maintenance, repair, or periods of operational shutdowns. The inspection label may be
542 kept on the equipment for tracking purposes, but the word “approved” shall be struck through with
543 permanent black ink. Equipment with conditional approval shall also have its conditional approval

550 invalidated for the same conditions as approved equipment, and additionally when any of the
551 conditions of approval are no longer true. The word “conditional” on its label shall be similarly
552 struck through.

553

554 All AHJ inspection labels shall be removed from any equipment for which ownership is transferred
555 to any entity other than other sites and laboratories that are administered by the DOE or its
556 contractors. The DOE and its contractors that receive Fermilab equipment either on loan or through
557 transfer of ownership have the option of accepting Fermilab’s AHJ approval through use of the
558 inspection reciprocity program described in FESHM Chapter 9110.

559

560 **4.5 Equipment that retrieved from salvage, excess, or abandonment**

561

562 Unlisted equipment retrieved from salvage, excess, or abandonment shall be inspected prior to re-
563 energization following the same process as for newly built or acquired equipment. If there are
564 previous inspection reports, those may be used as a resource for the inspector. If the equipment was
565 previously assigned a record number, the same record number should be retained, the new
566 inspection reports added, and the previous reports placed in a “superseded” subdirectory. In
567 addition to standards requirements, the inspection should also check for deterioration that could
568 occur due to age, periods of disuse (e.g., electrolytic capacitors), environmental conditions, and
569 infestation.

570

571 **4.6 Equipment received from other DOE sites and laboratories**

572

573 Depending on the laboratory from which unlisted equipment is received and the inspection records
574 that the providing laboratory supplies, the equipment may be eligible for a reduced receiving
575 inspection scope under the reciprocity program described in FESHM Chapter 9110 at the discretion
576 of the electrical AHJ. If the other site or laboratory retains ownership of the equipment, a Fermilab
577 record does not need to be generated. If Fermilab receives ownership of the equipment, a record
578 shall be generated for it.

579

580 **4.7 Subcontractor-owned unlisted electrical equipment**

581

582 Subcontractors are required to follow the same requirements as Fermilab through the flow-down of
583 10 CFR 851. Only in the most unusual circumstances should a subcontractor have a legitimate need
584 to use unlisted equipment. 29 CFR 1910 clearly requires that listed equipment is to be used if it
585 exists. Subcontractors are required to request approval of unlisted equipment in advance of needing
586 to use it, and the task manager / construction coordinator should recommend alternate methods
587 before requesting an inspection, due to the additional burden placed on lab resources. If a
588 subcontractor has a legitimate need to use unlisted equipment, the record of the inspection is to be
589 retained by the construction coordinator or task manager. The assignment of a record identification
590 number to subcontractor-owned equipment is not recommended.

591

592 **4.8 Rental equipment**

593
594 Equipment that is rented by Fermilab or by its subcontractors is subject to the same requirements
595 as equipment they might own. The requirement to supply NRTL-listed equipment should be
596 identified in any rental contract. Non-listed equipment for which a listed equivalent does not exist
597 shall be inspected. The assignment of a record identification number to rented equipment is not
598 recommended. The person responsible for the rental equipment is responsible for maintaining
599 documentation of the equipment and of the inspection for the duration of the rental period.
600

601 Rental equipment, whether NRTL listed or not, is arguably at greater risk of deficient conditions
602 due to misuse, abuse, or inadequate repairs. Task managers / construction coordinators should
603 inspect all subcontractor's equipment, rented or not, for physical condition and notify the Fermilab
604 ES&H construction representatives of any potentially deficient equipment conditions or absent
605 NRTL seals.
606

607 **5.0 REFERENCES**

608
609 Fermilab's *Electrical Design Standards for Electronics to be used in Experimental Apparatus at*
610 *Fermilab* (<https://esh-docdb.fnal.gov/cgi-bin/ShowDocument?docid=2781>)
611

612 DOE HDBK-1092-2013, *Electrical Safety Handbook*
613

614 **6.0 TECHNICAL APPENDIX**

615
616 The following inspection forms are based on those included in Appendix C of the 2013 edition of the
617 DOE Electrical Safety handbook. Guidance for using these forms can be found in section 7 of
618 Appendix C.
619

DRAFT

620 **6.1 Custom-built and Modified NRTL-Listed Electrical Equipment (page 1 of 2)**

| | | |
|--|---|---|
| SECTION 1 – Information | | |
| Group: | Responsible Person: (optional) | employee#: (optional) |
| Equipment Name: Multiple Single | | |
| Manufacturer: | | |
| Model Number: | | |
| Serial number of piece of equipment actually evaluated (see attached form for multiple units): | | |
| Property number of piece of equipment actually evaluated (see attached form for multiple units): | | |
| Location Site: | Bld: | Room: |
| Identify Equipment Status: | New Modified Not Previously Approved In Use | |
| Equipment Type: | Stand-alone custom built or other System Powered rack | |
| | Appliance/electrical tools Powered workbench Extension cord/relocatable power taps <input type="checkbox"/> Other | |
| Function and Use (duty cycle): | | |
| Operating Environment: | Indoor/dry Outdoor/wet/damp Flammable vapor/dust/flyings | |
| SECTION 2 – External Inspection | | |
| Enclosure: | | Foreign Power Supplies and Equipment: |
| Operator not exposed to any hazard: | | Connected to facility power with appropriate adapters: NA: |
| Not damaged: | | Correct voltage, frequency, and phasing: NA: |
| Appropriate Material: | | Correct wire ampacity for U.S. use: NA: |
| Protects contents from operating environment: | | Overcurrent Protection: |
| Will contain any arcs, sparks, electrical explosions: | | Overcurrent protection: Equipment Branch Circuit: NA: |
| Power Source – Cord and plugs: | | Marking Requirements: |
| Proper voltage and ampacity rating for plug and cord: NA: | | Hazards, including stored energy: Yes NA: |
| Grounding conductor included if required: NA: | | Power requirements (voltage, current, frequency) |
| Not frayed or damaged: NA: | | Restriction and limitations of use: Yes NA: |
| Proper wiring of plug: NA: | | Make/Model/Drawing number: |
| Strain relief on cord: NA: | | Other Requirements: |
| Power Source – Direct wired into facility | | Documentation adequate: |
| Proper voltage and ampacity rating for wiring method: NA: | | Procedures to use (IWD): Yes No |
| Installation according to NEC: NA: | | Training and qualification to use: Yes No |
| Proper loading and overcurrent protection in branch circuit: NA: | | Secondary Hazards: |
| Grounding: | | RF hazards: Yes No |
| Ground from cord or other is properly terminated: NA: | | dc electric or magnetic fields: Yes No |
| All non-current carrying exposed metal is properly bonded: NA: | | IR, visible, or UV: Yes No |
| All non-current carrying internal subsystems are properly bonded: NA: | | X-rays: Yes No |
| Equipment ground is run with circuit conductors: NA: | | Fire, electrical explosion: Yes No |
| Auxiliary ground permitted: Check Termination: NA: | | |

621
622

623 **(6.1 continued) Custom-built and Modified NRTL-Listed Electrical Equipment (page 2 of 2)**

| PART 2 – Internal Inspection | |
|---|---|
| Internal Wiring | Tests Performed |
| Polarity correct: NA: | Ground continuity (less than 1 ohm): |
| Phasing correct: NA: | Polarization of cord and plug: |
| Landing of ground correct: NA: | Auto discharge of high voltage capacitor: NA: |
| Separated – line voltage and high voltage from low voltage: NA: | Functional test (e.g., GFCI, emergency shut-off): NA: |
| Wiring terminals and leads ok: | Others: |
| Wire sizes adequate: | |
| Proper dielectric: | Failure Analysis: |
| Clearance/creepage distances for high voltage ok: NA: | Effect of ground fault: |
| Listed conductors, if applicable: | Effect of short circuit: |
| Other Internal Issues: | Effect of interlock failure: NA: |
| Neat workmanship: | Effect of overload: |
| Listed components used, if applicable: NA: | Effect of incorrect setting: NA: |
| Proper management of conductors: | Others: |
| Free of sharp edges: | Maintenance: |
| Proper cooling: | Any safety issues with access and maintenance: Yes No |
| Automatic discharge of high voltage capacitor: NA: | Explain |
| Electrical inspector Tracking Number of Piece of Equipment Actually Evaluated (See next page for additional Tracking numbers of identical equipment if individual numbers were assigned): | |

624

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

Condition of Usage/comments: (Include all designer/builder instructions, drawings, or information that is relevant to the safe installation and use of this equipment. Attach additional sheets as necessary.):

625
 627 This equipment is **APPROVED** for installation and use at FERMILAB. IF THIS EQUIPMENT IS MODIFIED,
 628 DAMAGED, OR UTILIZED FOR OTHER THAN THE INTENDED USE STATED ABOVE, THIS APPROVAL
 629 IS VOID, PENDING RE-EXAMINATION.

| | | |
|-------|---|--|
| DATE: | AHJ approved -Electrical inspector Printed Name: | AHJ approved -Electrical inspector Signature |
| | | |

630
 631 This equipment is **REJECTED** for use at FERMILAB (see comments above).

| | | |
|-------|---|--|
| DATE: | AHJ approved -Electrical inspector Printed Name: | AHJ approved -Electrical inspector Signature |
| | | |

632
 633

634 **6.2 Facility Unlisted Electrical Equipment Approval Form**

| SECTION 1 – Information | | | | |
|--|-----------------------------------|---------------------------|---------------------------------------|--------|
| Group: | Responsible Person: (optional) | Employee #: (optional) | | |
| Equipment Name: Multiple Single | | | | |
| Manufacturer: | | | | |
| Model Number: | | | | |
| Serial number of piece of equipment actually evaluated (see attached form for multiple units): | | | | |
| Property number of piece of equipment actually evaluated (see attached form for multiple units): | | | | |
| Location Site: | Bld: | Room: | | |
| Identify Equipment Status: | New | Modified | Not Previously Approved | in Use |
| Equipment Type: | Stand-alone custom built or other | System | Powered rack | |
| | Appliance/electrical tools | Powered workbench | Extension cord/relocatable power taps | Other |
| Function: | | | | |
| SECTION 2 – Inspection | | APPROVE | REJECT | |
| 1. Suitability for installation and use in conformity with 29 CFR 1910 Subpart S and/or NEC. | | | | |
| 2. Mechanical strength and durability, including for parts designed to enclose and protect other equipment, the adequacy of the protection thus provided. | | | | |
| 3. Wire bending and connection space. | | | | |
| 4. Electrical insulation. | | | | |
| 5. Heating effects under normal conditions of use and also under abnormal conditions likely to arise in service. | | | | |
| 6. Arcing effects. | | | | |
| 7. Classification by type, size, voltage, current capacity, and specific use. | | | | |
| 8. Other factors that contribute to the practical safeguarding of persons using or likely to come in contact with the equipment. | | | | |
| Electrical Inspector Tracking Number of Piece of Equipment Actually Evaluated (See next page for additional Electrical Inspector Tracking Numbers of identical equipment if individual numbers were assigned): | | | | |

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

Condition of Usage/comments: (Include all designer/builder instructions, drawings, or information that is relevant to the safe installation and use of this equipment. Attach additional sheets as necessary.):

636
637
638 This equipment is **APPROVED** for installation and use at FERMILAB. IF THIS EQUIPMENT IS MODIFIED,
639 DAMAGED, OR UTILIZED FOR OTHER THAN THE INTENDED USE STATED ABOVE, THIS
640 APPROVAL IS VOID, PENDING REEXAMINATION.

| | | |
|-------|---|--|
| DATE: | AHJ approved -Equip. Inspector Printed Name: | AHJ approved -Electrical Inspector Signature |
| | | |

641
642 This equipment is **REJECTED** for use at FERMILAB (see comments above).

| | | |
|-------|---|--|
| DATE: | AHJ approved -Equip. Inspector Printed Name: | AHJ approved -Electrical Inspector Signature |
| | | |

644 **6.3 Unlisted Commercial Electrical Equipment Approval Form**

| | | | |
|---|-----------------------------------|---------------------------|----------------|
| SECTION 1 – Information | | | |
| Group: | Responsible Person: (optional) | Employee #: (optional) | |
| Equipment Name: Multiple Single | | | |
| Manufacturer: | | | |
| Model Number: | | | |
| Serial number of piece of equipment actually evaluated (see attached form for multiple units): | | | |
| Property number of piece of equipment actually evaluated (see attached form for multiple units): | | | |
| Location Site: | | Bld: | Room: |
| Identify Equipment Status: New Modified Not Previously Approved in Use | | | |
| Function: | | | |
| SECTION 2 – Inspection | | | APPROVE |
| REJECT | | | |
| 1. The case is grounded through the power cord to the grounding pin on the plug. | | | |
| 2. The plug is polarized, if necessary. | | | |
| 3. The equipment input voltage and frequency match those of the building’s electrical system. | | | |
| 4. The equipment construction is suitable for the intended operating environment. | | | |
| 5. The equipment is in its original, unmodified and undamaged condition. | | | |
| 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 the equipment is safe for use) | | | |
| Electrical Inspector Tracking Number of Piece of Equipment Actually Evaluated (See next page for additional Electrical Inspector Tracking Numbers of identical equipment if individual numbers were assigned): | | | |

645

| | |
|---|--|
| NOTE: APPROVED EQUIPMENT WILL BE INSTALLED AND USED IN ACCORDANCE WITH THE INSTRUCTIONS PROVIDED BY THE DESIGNER/BUILDER AND AHJ. | |
| Conditions of Usage: <input type="checkbox"/> Indoor Only <input type="checkbox"/> Damp/Wet Locations <input type="checkbox"/> Hazardous Classified Locations (Flammable/Explosive) | |
| Comments: (Include all designer/builder instructions, drawings, or information that is relevant to the safe installation and use of this equipment. Attach additional sheets as necessary.): | |

646
647
648 This equipment is **APPROVED** for installation and use at FERMILAB. IF THIS EQUIPMENT IS MODIFIED,
649 DAMAGED, OR UTILIZED FOR OTHER THAN THE INTENDED USE STATED ABOVE, THIS APPROVAL IS
650 VOID PENDING REEXAMINATION.

| | | |
|-------|---|--|
| DATE: | AHJ approved -Equip. Inspector Printed Name: | AHJ approved -Electrical Inspector Signature |
| | | |

651
652 This equipment is **REJECTED** for use at FERMILAB (see comments above).

| | | |
|-------|---|--|
| DATE: | AHJ approved -Equip. Inspector Printed Name: | AHJ approved -Electrical Inspector Signature |
| | | |

654 **6.4 Electrical System Approval Form (page 1 of 3)**

| | | |
|---|---|---------------------------|
| SECTION 1 – Information | | |
| Approval is for intended use within the approving organization only | | |
| Group: | Responsible Person: (optional) | Employee #: (optional) |
| System Name: | | |
| System Description: | | |
| Manufacturer, if any: | # of pieces of equipment in system: | |
| Model Number, if any: | | |
| Serial Number of System Actually Evaluated (see attached for additional serial numbers of identical equipment): | | |
| Date Built: | Date Last Modified: | |
| Location Site: | Bld: | Room: |
| Identify Equipment Status: | New | Modified |
| | Not Previously Approved | in Use |
| Function and List of Subsystems: | | |
| SECTION 2 – Hazard Assessment | | |
| Determine all electrical and non-electrical hazards that could injure an employee, including operation and maintenance workers. | | |
| 1 | Electrical hazard classifications | |
| 2 | Stored electrical energy in capacitors (E and V) | |
| 3 | Batteries, including UPSs | |
| 4 | Electromagnetic fields produced (dc to 300 GHz, pulsed) | |
| 5 | IR, optical, or UV produced | |
| 6 | X-rays (give voltage value in vacuum) | |
| 7 | Heat and sparks | |
| 8 | Acoustic energy | |
| 9 | Other (chemical, high pressure, cryogen, etc.) | |

 655
 656

657 **(6.4 continued) Electrical System Approval Form (page 2 of 3)**

| SECTION 3 – Evaluation for Operation: Determine that engineering controls adequately protect the operators and users during system operation. | | APPROVE | REJECT |
|--|--|----------------|---------------|
| 1 | Enclosure, isolation. No exposed hazardous energized conductors, no unused openings. | | |
| 2 | Grounding. All conductive enclosures exposed to personnel properly grounded. | | |
| 3 | Overcurrent protection. Provision for overload, ground fault, and short circuit | | |
| 4 | Failure analysis. Adequate electrical and fire protection systems for failure modes. | | |
| 5 | Operation safety analysis and controls documented where? E.g., IWD | | |
| 6 | System is labeled as approved, how? | | |
| 7 | Other, explain. | | |
| SECTION 4 – Evaluation for Working on System: Determine that engineering controls are implemented, in conjunction with work control to safely enter into and work on the system. | | APPROVE | REJECT |
| 1 | Method(s) of energy isolation (e.g., plug control, LOTO, Kirk key) | | |
| 2 | Automatic methods of stored energy removal, if necessary | | |
| 3 | Proper design for the manual removal and/or verification of capacitively stored energy | | |
| 4 | Documentation for entry and work on system where? E.g., IWD | | |
| Electrical Inspector Tracking Number: | | | |

658
 659 **NOTE: System will be installed and used in accordance with the instructions provided by**
 660 **the designer/builder and AHJ approval.**
 661

Comments/conditions of use: (Include all designer/builder instructions, restrictions on use, drawings or information that is relevant to the safe installation and use of this equipment. Attach additional sheets as necessary)

662
 663 This system and its associated electrical equipment are **APPROVED** for installation and use at
 664 FERMILAB. IF THIS SYSTEM IS MODIFIED, DAMAGED, OR REPAIRED IN A MANNER THAT AFFECTS
 665 SAFETY, THIS APPROVAL IS VOID, PENDING RE-EXAMINATION BY AN ELECTRICAL INSPECTOR.

666
 667 This system is **REJECTED** for use at FERMILAB. (See comments above.)
 668
 669

670 Note: The following signatures indicate that these electrical inspector(s) have reviewed some or all
 671 parts of this system for safety. In some cases, an electrical inspector inspects only sections of the
 672 system for which their group is responsible. The head electrical inspector (if any) ensures that all
 673 components have been reviewed by one or more group electrical inspectors.

675 (6.4 continued) Electrical System Approval Form (page 2 of 3)

| SECTION 5 – Approval Signatures | | | | |
|--|-------|--|--------------------------------------|-----|
| Division/Group | Date: | Lead Equipment Inspector Printed Name | Lead Electrical Inspector Signature: | |
| Division/Group | Date: | Equip. Insp Printed Name | Equip. Inspector Signature: | |
| Division/Group | Date: | Equip. Insp Printed Name | Equip. Inspector Signature: | |
| Division/Group | Date: | Equip. Insp Printed Name | Equip. Inspector Signature: | |
| Division/Group | Date: | Equip. Insp Printed Name | Equip. Inspector Signature: | |
| SECTION 6 – Specific Tests Performed for Approval | | | Date | Who |
| List tests performed relevant to safety. | | | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| SECTION 7 – Immediate Improvements | | | Date | Who |
| List required modifications (with a due date) and compensatory measures taken to ensure safety if system is operated before modifications. | | | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |

676
677

