

Subject Electronics Rack Wiring, Grounding, and AC Power Connection	Effective Date 2/19/93	Initiated <i>M. Norris</i> Electrical and Electronic Engineering Division
	Supersedes New	Approved <i>[Signature]</i> Engineering Department Head

Applicability

This standard is applicable to all new installations of electronic equipment racks at PPPL. The schedule for bringing existing installations into conformance with this standard will be at the discretion of the PPPL management, with appropriate ES&H emphasis on a case-by-case basis.

Introduction

This standard describes the requirements for electronics rack wiring, grounding, and AC power connection.

Reference Codes, Standards, Specifications, Guidelines

NATIONAL ELECTRICAL CODE (NEC) [particularly Article 250].
This is the "bible" of the electrical industry, put out by the National Fire Protection Association. It is referenced here because grounding for small-signal noise suppression must be compromised in favor of the safety-driven NEC requirements. At PPPL, the only exceptions (with administrative safeguards) to the NEC are made for some aspects of single-point grounding systems within limited access areas near tokamaks. **Only the ES&H Division can grant exception to the NEC.**

Interpretation of the NEC is often not obvious. It is best to consult an expert—see the ES&H Division. Also see the LLNL grounding guidelines for a simple description of an important portion of the NEC requirements.

TFTR DIAGNOSTICS GROUNDING SPECIFICATION, TFTR - 9A2 - 010.
This specification, TFTR - 9A2 - 010, is available in the TFTR Operations Center.

Additional Reading

Jensen, B & Epps, R., GROUNDING GUIDELINES: PRACTICAL EXAMPLES FOR POWER SYSTEMS AT LLNL, UCID 19752, July 1, 1983.

An LLNL publication that is a simplified description of power grounding to meet NEC requirements—it does not address TFTR single-point-ground systems.

Ott, Henry W., NOISE REDUCTION TECHNIQUES IN ELECTRONIC SYSTEMS, 2nd ed. 1988.

This general interest text is recommended for an overview of the subject. Small signal topics predominate. The sections on signal cable shield grounding are especially effective.

White, Donald R. J., A HANDBOOK ON SHIELDING DESIGN METHODOLOGY AND PROCEDURES, 1986.

This has a "cookbook" approach that is somewhat narrow in scope. It is recommended for the order of magnitude contributions to noise suppression, and radiation for various parts of instrumentation from the PC board design to the enclosure.

White, Donald R. J., HANDBOOK SERIES ON ELECTROMAGNETIC INTERFERENCE & COMPATIBILITY (VOLUMES 1-6).

This is a compilation of handbooks previously published separately. The 6 volumes are in the PPPL library, reference section. They are not recommended as tutorials—they are best used to look for help for a specific problem.

Standard

Definition of Permanent Premises Wiring

The interface of NEC specified "permanent premises wiring" and internal rack (or other equipment enclosure) wiring is defined by PPPL as the first connection at the rack. Example—the AC power connection to an EMI filter on/in the rack is permanent premises wiring; internal wiring thereafter is not. No devices external to the rack shall be allowed to plug into the internal power strip (except for instruments used temporarily for troubleshooting/testing of the rack).

Power Strips for Rack Internal Power Distribution

Commercial power strips are UL-certified and are (usually) manufactured with a flexible wire and plug. It is generally not good practice to modify a UL-tested device. When permanent premises wiring into a rack ends at an EMI filter or junction box, it is permissible to cut the plug from the power strip flexible wire, and hardwire-attach the power strip. This is allowed because "permanent premises wiring" stops at the junction box and there is no requirement/need for UL certification of rack internal equipment. Refer to figures ES-ELEC-001-1, -2, -3, and -4 for recommended power strip types.

Rack Wiring, Grounding, and AC Power Connection

Rack AC power and ground connections are not obvious. There are special requirements involved with single-point grounding at TFTR. OSHA and the NEC must be satisfied.

Figures ES-ELEC-001-1, -2, -3 and -4 show how to connect rack AC power and grounds for four cases that should (by combining information) cover all PPPL applications. These figures address major OSHA/NEC compliance issues of concern at PPPL; e.g., flexible AC cable interfacing with permanent premises wiring.

Ground wires shall be sized per NEC table 250-94 depending on the application, with #8 AWG the minimum size. The exception is the single point grounded rack of Fig. ES-ELEC-001-4, for which a #2 AWG rack ground must be used for isolation and stepdown transformers rated up to 75 kVA. The maximum allowable length of the rack ground wire is 100 feet. Larger transformers or longer ground wire lengths will require special analysis. Consult the ES&H Division

NOTE: Figures ES-ELEC-001-1, -2, -3 and -4 are not installation drawings or wiring diagrams—they are intended as conceptual-level input to an electrical drafter/designer/engineer. (Examples of information not included are overcurrent protection and NEC installation details.)

Attachments

FIG. ES-ELEC-001-1

EQUIPMENT RACK GROUNDING AND AC POWER CONNECTION PER NATIONAL ELECTRIC CODE (NEC)

This is the rack wiring configuration to be used when there are no special considerations such as location near a tokamak.

FIG. ES-ELEC-001-2

EQUIPMENT RACK GROUNDING AND AC POWER CONNECTION TO AN EMI FILTER OR JUNCTION BOX

This is similar to the configuration of Fig. EE-ELEC-001-1, except that a junction box or EMI filter is shown.

FIG. ES-ELEC-001-3

EXPERIMENTAL EQUIPMENT RACKS WITH ISOLATION TRANSFORMER GROUNDING AND AC POWER CONNECTION PER NATIONAL ELECTRICAL CODE (NEC), TYPICAL TFTR INSTALLATION WHERE GROUND LOOPS ARE NOT A CONSIDERATION

The isolation transformer, for this case, is used for common mode noise rejection—not for ground isolation. The grounding must satisfy the NEC.

FIG. ES-ELEC-001-4

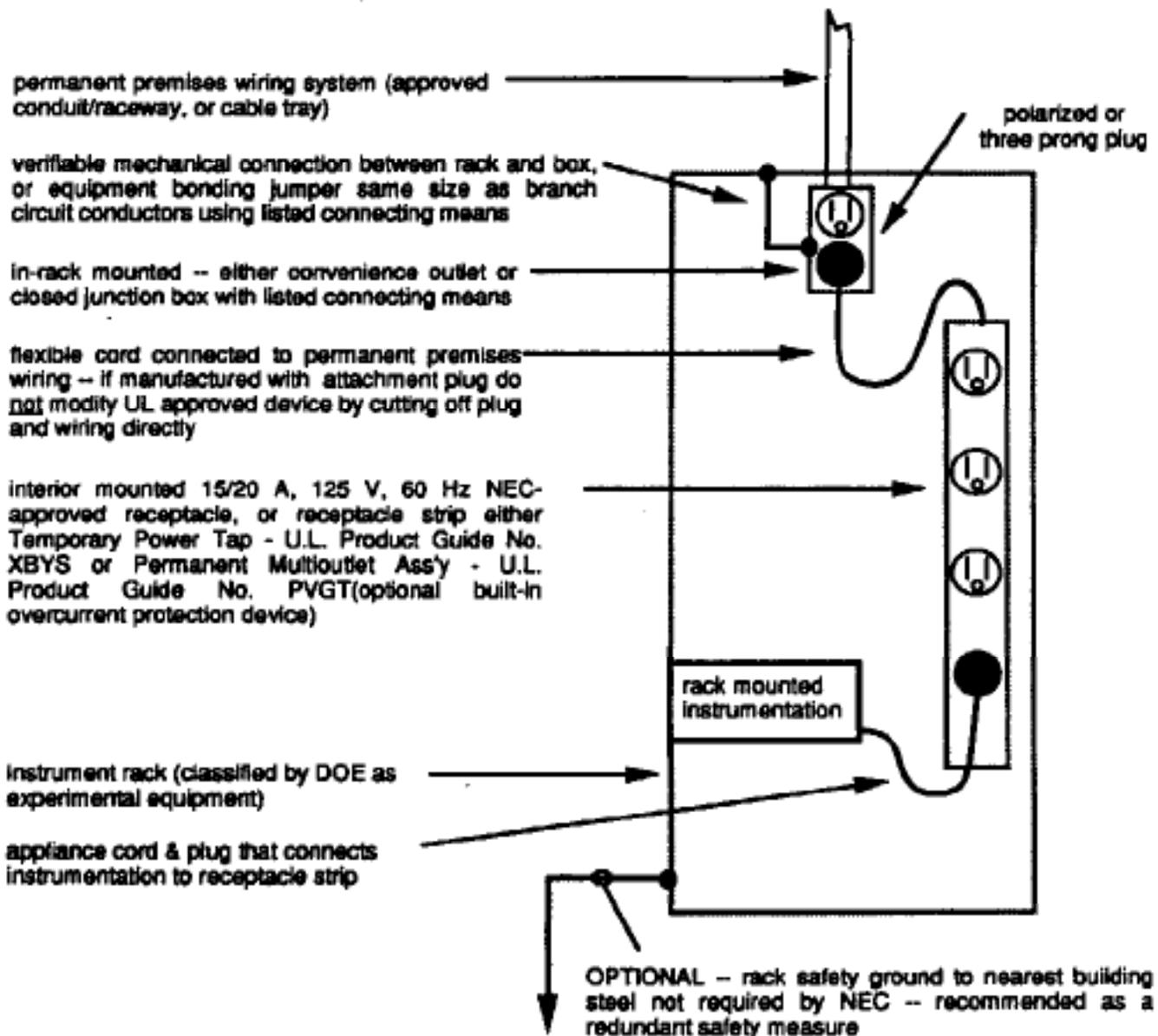
GROUND ISOLATED EXPERIMENTAL EQUIPMENT RACKS, GROUNDING AND AC POWER CONNECTION, TYPICAL TFTR INSTALLATION

This is the configuration used for TFTR single-point-ground systems such as diagnostics racks in the DARM. The grounding method requires ES&H approval for exceptions to the NEC. The issues involved were investigated for approval of the Diagnostics Grounding Specification. Those issues are:

- (1) The touch potential hazard during tokamak operation is avoided because it is a limited access area.
- (2) When access is allowed, a major bus fault to building steel is calculated to produce a touch potential from diagnostics ground to building steel that is not a hazard.
- (3) The equipment grounding conductor connections at the rack and ground bus locations are either (a) crimped or cadwelded, or are (b) tagged & labeled to warn against disconnection.

**FIG. ES-ELEC-001-1
EQUIPMENT RACK* GROUNDING AND AC POWER CONNECTION
PER NATIONAL ELECTRIC CODE (NEC)**

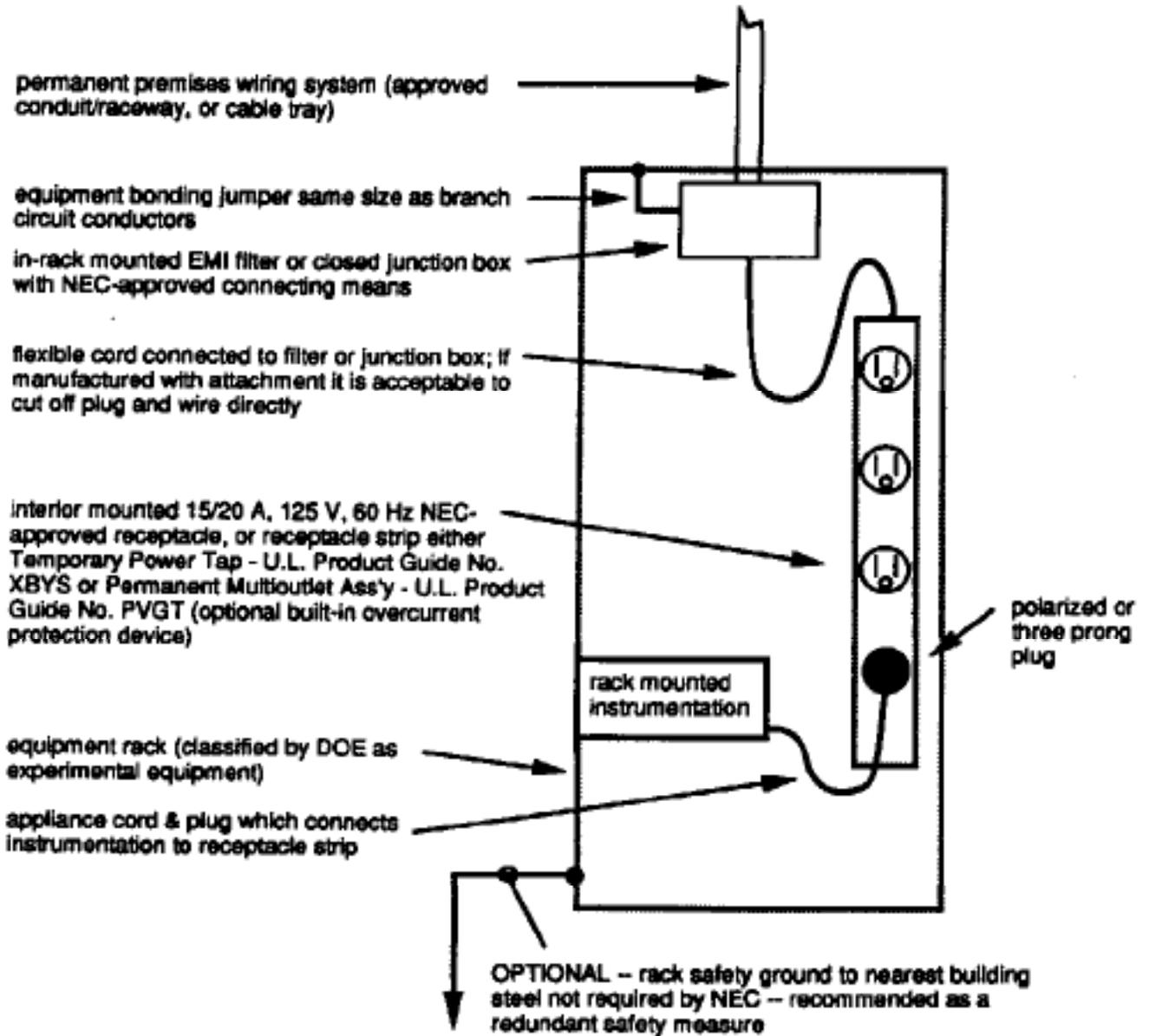
* typically 19-inch electronics rack, not a power-devices enclosure



NOTE: Installation must conform to National Electrical Code (NEC).
See ES&H if in doubt.

**FIG. ES-ELEC-001-2
EQUIPMENT RACK* GROUNDING AND AC POWER CONNECTION
TO AN EMI FILTER OR JUNCTION BOX**

*typically 19-inch electronics rack, not a power-devices enclosure



NOTE: ac power installation must conform to National Electrical Code (NEC). See ES&H if in doubt.

**FIG. ES-ELEC-001-3
EXPERIMENTAL EQUIPMENT RACKS^① WITH ISOLATION TRANSFORMER^②
GROUNDING AND AC POWER CONNECTION PER NATIONAL ELECTRICAL
CODE (NEC), TYPICAL TFTR INSTALLATION WHERE GROUND LOOPS ARE
NOT A CONSIDERATION**

① typically 19-inch electronics rack, not a power devices enclosure

↑ GENERAL ACCESS AREA
↓ ELECTRICAL INTERLOCKED AREA

permanent premises or experimental wiring system

② isolation transformer used for common mode noise rejection (not used for ground decoupling)

permanently mounted EMI filter and/or junction box (wiring shown is for typical filter)

flexible cord

15/20 A, 125 V, 60 Hz NEC approved receptacle, or receptacle strip either Temporary Power Tap - U.L. Product Guide No. XBYS or Permanent Multioutlet Ass'y - U.L. Product Guide No. PVGT (optional built-in overcurrent protection device)

NOTE: installation must conform to National Electrical Code (NEC). See ES&H if in doubt.

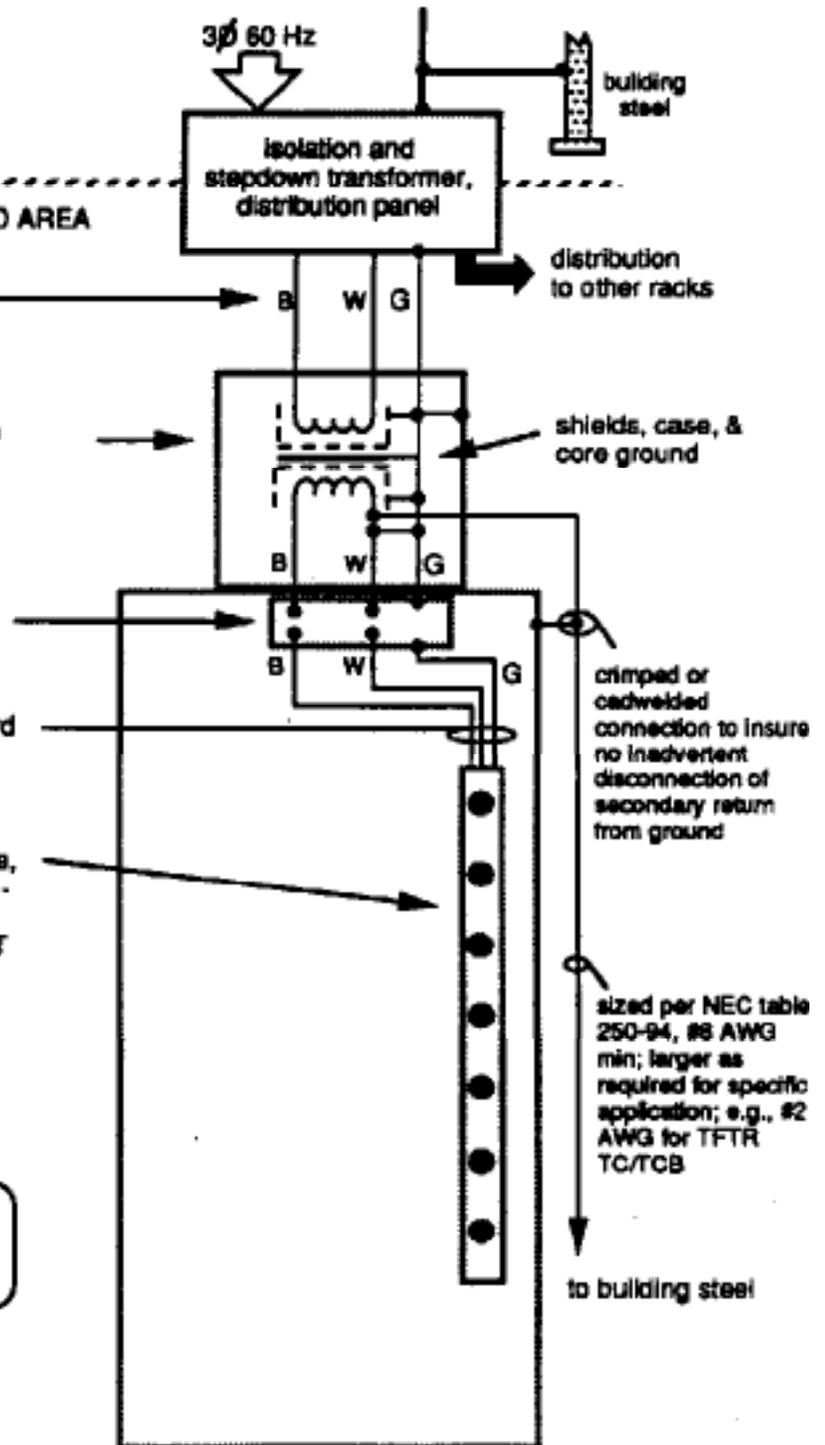
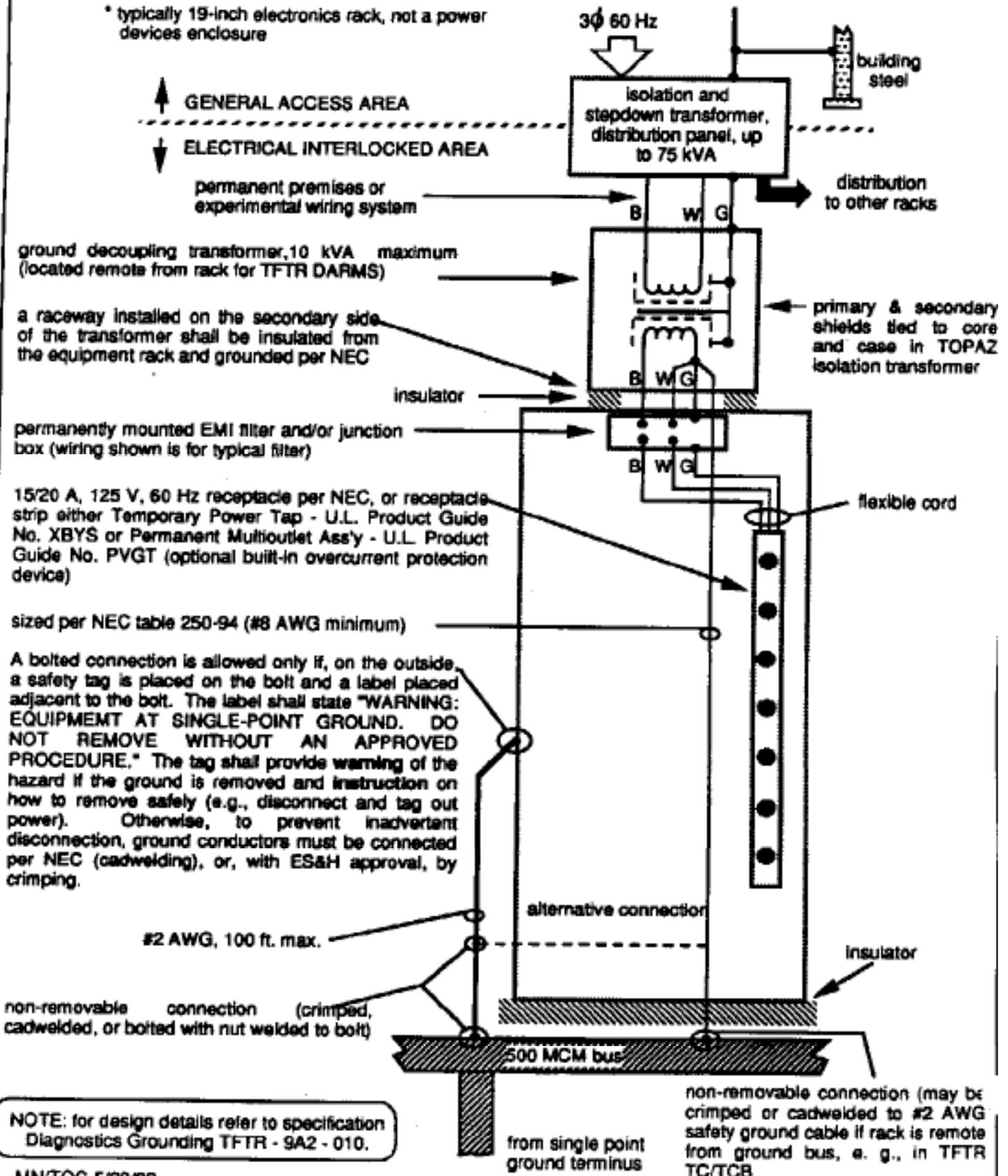


FIG. ES-ELEC-001-4 SINGLE POINT GROUNDED EQUIPMENT RACKS*, GROUNDING AND AC POWER CONNECTION, TYPICAL INSTALLATION

* typically 19-inch electronics rack, not a power devices enclosure



NOTE: for design details refer to specification
Diagnostics Grounding TFTR - 9A2 - 010.

MN/TOC 5/28/92