Data Sheet 515
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Temporary electrical wiring for construction sites

Construction work requires electrical power for many purposes. However, exposure to weather, frequent relocation, rough use and other conditions not normally encountered with conventional wiring systems necessitate special consideration not required in other applications or in completed structures. The application of this data sheet is limited to the electrical distribution system within the construction area from power supply service connections to receptacle outlets.

1. Even when installed properly, a temporary electrical system can become hazardous as construction progresses because of damage, wear, and extensions or alterations by unauthorized persons. To help make sure temporary wiring is in safe and efficient operating condition, strict enforcement of installation and maintenance standards should be established as part of the project safety program.

2. Specific responsibility and authority should be assigned to supervisors and key employees to control work practices involving temporary wiring. A safe, efficient temporary wiring system protects the client, the employer and the employee by minimizing serious injuries, fires, power failures and downtime. The recommended procedures in this data sheet are intended to eliminate the unsafe practices that can disrupt the functioning of the system and create unnecessary hazards.

Electrical injuries

3. Because circuits most commonly used for construction-site wiring are 120-240 volts, serious injuries can result if workers come in contact with them. It is the amount and duration of current flow and the pathway through the body that most directly affect the severity of the shock.

4. In a shock situation, the body resistance of the involved individual, together with the resistance of contact to ground, is the important variable. It is the voltage divided by this resistance (Ohm's Law) that determines the amount of current that will pass through the body.

5. Dry skin has relatively high resistance (100,000 to 600,000 ohms), but moisture, such as perspiration, can cause a rapid decrease in body resistance to as little as 1,000 ohms. Open cuts or exposed blisters also can reduce body resistance. Therefore, at 120 volts, 120 milliamperes could pass through the body. This current level

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(slightly less than 1⁄8 ampere) could cause ventricular fibrillation and almost certain death (Tables I and II).

6. Lower current levels can cause severe discomfort, freezing to the circuit and burns, thereby reducing body resistance to levels that could eventually result in electrocution. Constant use of 120 and 240 volt equipment by workers on a jobsite frequently results in virtual contempt for the hazards involved. Yet these voltages produce about 50 percent of all electrocutions annually.

Fire hazards

7. Fires endanger workers, damage materials and equipment, and often cause structural damage that subsequently requires removal and reconstruction. Fire hazards, some of them inherent, are numerous on construction sites. Electric power must be recognized as a serious source of ignition, as well as injury. Construction activities, moreover, are not routine or systematized. This affords many opportunities for the common errors that can lead to short circuits, ground faults, overloads, arcing faults and overheating, all of which can cause ignition.

Power failures

8. Loss of electric power on all or part of a construction project also can be serious and costly. Failure of the lighting system may result in the hazard of darkness for workers. A hoist that goes out of commission may well close down a job. Systems should be designed to minimize the extent of the outage, should one occur.

Design requirements

9. The electrical distribution system should be designed and installed to provide adequate capacity for the maximum anticipated load. Consideration should be given to the growing demand for job lighting, power tools, welders and other equipment required as the job progresses.

Table I. Effect of electric current on humans

Note: Data is based on limited experimental tests and is not intended to indicate absolute values.

Effect	Current in Milliamperes					
	Direct		Alternating			
			60 Hz		10,000 Hz	
	Men	Women	Men	Women	Men	Women
Slight sensation on hand	1.0	0.6	0.4	0.3	7.0	5.0
Perception threshold	5.2	3.5	1.1	0.7	12.0	8.0
5 mA Ground fault circuit interrupter is activacted.						
Shock – not painful muscular control not lost	9.0	6.0	1.8	1.2	17.0	11.0
Shock – painful muscular control not lost	69.0	41.0	9.0	6.0	55.0	37.0
Shock – painful, let-go threshold	76.0	51.0	16.0	10.5	75.0	50.0
Shock – painful and severe muscular contractions breathing difficult	90.0	60.0	23.0	15.0	94.0	63.0
Shock – possible ventricular defibrillation effect from 3-second shocks	500.0	500.0	100.0	100.0		
Short shocks lasting t seconds			$165/\sqrt{t}$	$165/\sqrt{t}$		
High voltage surges	50.0*	50.0*	13.6*	13.6*		

** Energy in watt-seconds or joules*

10. The electrical standards for construction adopted by OSHA are based on the National Electrical Code, ANSI/NFPA 70 (NEC). State and local codes also generally follow the NEC. The electrical system should, therefore, be installed and maintained in accordance with the NEC together with the OSHA requirements, Title 29, Code of Federal Regulations, Part 1926; Subparts K and V.

Table II. Human resistance to electrical current

Type of Resistance	Resistance (Ω)
Dry skin	100K to 600K
Wet skin	1000
Internal body — hand to foot	400 to 600
Ear-to-ear	100

11. All circuits should be protected by fuses or circuit breakers of no higher current rating than that of the conductors. The allowable ampacities for insulated copper, copper-clad aluminum and aluminum conductors are located in Article 310— "Conductors for General Wiring"—NEC, sections 310-15.

12. A disconnecting means should be provided for each temporary circuit. Suitable plugs and connectors or disconnecting switches should be used for this function.

13. A disconnecting means should be provided for each motor and motor controller. The disconnect device should disconnect both the motor and controller. The disconnecting means should be visible from the controller location (it can be mounted in the same enclosure) and should be capable of being locked in the "off" (open) position.

14. All equipment should be listed by a nationally recognized testing laboratory, such as Underwriters Laboratories Inc. or Factory Mutual System, for the function, location and type of use for which it is installed. Care should be taken to ensure that indoor equipment is not used outdoors where it will be exposed to conditions for which it is not intended.

15. For protection from sharp edges or holes, conductors should enter and leave boxes and cabinets in conduit or through holes protected with insulating bushings. Cables must enter and leave boxes through bushings or box connectors approved for the purpose.

16. All equipment should be protected with suitable covers to prevent accidental contact with energized parts. Only authorized personnel should be permitted to remove covers and then only after the equipment has been de-energized.

System grounding method

17. In addition to providing for equipment grounding, the electrical system itself must be grounded, and it is ordinarily accomplished by connecting the neutral circuit conductor to a grounding electrode by means of a grounding electrode conductor at the service. Such a grounding system will minimize the difference in voltage that may be produced by lightning strikes or primary to secondary faults.

18. The grounding electrode system may consist of either a metal underground water pipe together with a rod, plate or pipe electrode; or it may consist of the metal frame of the building—an electrode encased in at least 2 inches of concrete or a grounding encircling the building. The NEC requires that where any or all of these electrodes occur on the jobsite, they must all be bonded together to constitute a system. Where none of them are available, a rod, plate or pipe electrode will suffice. However, such "made" electrodes must be checked for their resistance measurement to ground. If the resistance is greater than 25 ohms, one additional "made" electrode must be added. No additional measurement need be taken and no minimum resistance to ground is required.

Grounding of equipment

19. Portable electric tools and equipment, including floodlight stands, should be grounded by means of an equipment grounding conductor within the cord and grounding terminal in the receptacle and plug. The neutral conductor should never be used as an equipment grounding conductor. The mechanical protection and stranding of the grounding conductor should be equal to that of the circuit conductor. The metal guards of temporary lighting strings should be grounded.

20. When portable cords are made up, special care should be taken to make certain that the circuit and grounding conductors are not interchanged. Grounding conductors in portable cords may be insulated, but if coverings are provided, they should be green. Coverings for neutral conductors should be white or gray (see NEC Article 200 "Use and Identification of Grounded Conductors").

21. All metal enclosures of electrical equipment should be grounded, with the possible exception of fixed equipment located more than 8 feet vertically or 5 feet horizontally from the ground or any grounded metal object. Examples of metal enclosures are metal conduits, motor starter boxes, panel board enclosures, switch boxes, outlet boxes and metal fencing.

22. In shafts and tunnels, all metal enclosures, frames, light stands and reflectors should be effectively grounded by means of an equipment grounding conductor and the conductor connected to a suitable grounding terminal bar in the branch circuit panel board supplying the equipment.

23. Frames of portable electric generators supplying one kW(ac) or less are not required to be grounded to a ground electrode, ground rod or water pipe. Such a generator supplies only equipment mounted and bonded to the generator frame or plug-connected equipment. Such a generator that is used to feed a regular grounded system does require grounding and bonding to the ground of the regular system.

Ground fault protection

24. All 15 or 20 ampere, 20 volt, singlephase receptacles on construction sites that are not a part of the permanent wiring of the building structure, and which are in use by personnel, require ground fault protection. This personnel protection can be provided by the use of ground fault circuit interrupters or by an assured equipment grounding conductor program. An equipment grounding conductor is provided to ground conductive materials enclosing electrical conductors and equipment. This equipment is grounded to facilitate overcurrent device operation in case of ground faults to protect anyone using the equipment.

25. A GFCI is a device which detects current leaking from the electrical system—not returning on the intended conductors. When the amount of leakage current exceeds a predetermined level—5mA—the GFCI interrupts the circuit, thereby protecting the operator (Table I). GFCIs are available that can protect entire circuits or single receptacles. Because the protection is needed only while the receptacle is in use, a portable GFCI is usually more practical. An employee using the receptacle can plug in the portable GFCI while using equipment, then unplug it and take it with when finished. Portable GFCIs are of three general types—the plugin type, which provides one or two protected receptacles, the cord-connected type, which has a molded box with several protected receptacles, and a GFCI attachment plug that can be installed on a cord. GFCI receptacles can be used for installation in outlet boxes which are not cord connected.

26. If GFCIs are not used, then the assured equipment grounding conductor program is available.

Receptacles, attachment plugs, connectors

27. Receptacles should be of the grounding type. They should be used only on circuits of the voltage, class and current for which they are listed. The ANSI C-73 standard details configurations that ensure noninterchangeability.

28. All conductors should be terminated at the appropriate terminal of the receptacle, attachment plug or connector:

- Equipment grounding conductor at the green hexagonal screw or green colored lug
- Neutral (white wire) at the terminal “W” or “1vVH” and/or colored white or silver
- Ungrounded conductors at the brass colored terminals, which may be marked “X,” “Y,” and “Z.” Improper termination of conductors can cause equipment damage and/or personnel injury.

29. Attachment plugs and connectors should be designed to endure rough use and have cord grips designed to securely grip the cord without damaging the conductors. Each terminal and wire cavity should be isolated from other terminals to ensure that loose strands do not accidentally short. Attachment plugs should be of the “dead front” type. A plug with a separable insulating disk that can be lost is not considered to be dead front. Stranded conductors should never be tinned prior to terminating. Where attachment plugs and connectors are to be used in an environment where moisture, dust or other substances could create a hazard, the plugs and connectors should be suitable for use in such an environment or they should be protected by a suitable enclosure.

NEMA configurations for general-purpose, non-locking plugs and receptacles

		15 AMPERE		20 AMPERE		30 AMPERE		50 AMPERE		60 AMPERE	
		RECEPTACLE	PLUG	RECEPTACLE	PLUG	RECEPTACLE	PLUG	RECEPTACLE	PLUG	RECEPTACLE	PLUG
125V	1	002 1-15R	001 1-15P								
250V	2		2-15P	003 2-20R	003 2-20P	2-30R	2-30P				
125V	5	013 5-15R	013 5-15P	5-20R	064 5-20P	5-30R	5-30P	5-50R	5-50P		
250V	6	014 6-15R	014 6-15P	6-20R	068 6-20P	6-30R	065 6-30P	6-50R	134 6-50P		
277V, A.C	7	7-15R	7-15P	7-20R	7-20P	7-30R	7-30P	7-50R	7-50P		
125/250V	10			10-20R	10-20P	040 10-30R	040 10-30P	10-50R	009 10-50P		
3Ø 250V	11	11-15R	11-15P	11-20R	11-20P	11-30R	11-30P	11-50R	11-50P		
125/250V	14	14-15R	14-15P	14-20R	119 14-20P	14-30R	136 14-30P	016 14-50R	016 14-50P	14-60R	14-60P
3Ø 250V	15	15-15R	15-15P	15-20R	15-20P	15-30R	15-30P	15-50R	15-50P	15-60R	15-60P
3Ø Y 125/208V	18	18-15R	18-15P	18-20R	18-20P	18-30R	18-30P	18-50R	18-50P	18-60R	18-60P

Conductors

30. Branch circuit conductors should originate from a suitable device or distribution panel board. The conductors may be run as multi-conductor cable or cord or as open wiring. When run as open conductors, they should be fastened every 10 feet at ceiling height.

NEC Article 305 — "Temporary Wiring"

31. Nonmetallic sheathed cable (Type NM) is designed for dry locations. It should not be used where exposed to moisture either indoors or outdoors. For outdoor use and indoors in damp locations, Type NMC may be used, provided it is properly installed in accordance with NEC Article 336. Nonmetallic sheathed cable should not be run on the floor or ground.

Flexible cords and cables

32. Junior hard-service cord (Type SJ, SJO or SJT) may be used as portable cord both indoors and outdoors, but it should not be substituted indiscriminately for hard-service cord (Type 5, SO or SI). Hard-service cord has much greater resistance to abrasion and should be used where the cord will be subjected to extreme conditions, such as rocky ground, vehicle traffic, frequent moves along the ground and extended exposure to moisture (see NEC Article 400).

33. Cords should be used only in continuous lengths without splice unless the completed splice retains the insulation, outer sheath properties and usage characteristics of the original cord, or the cords are interconnected with suitable attachment plugs and connectors. Worn or frayed cords should not be permitted.

34. Cords should be protected from accidental damage. Cords should not be stapled or otherwise secured to walls, ceilings, etc., unless they are specifically designed for such applications. Cords should not be used as a substitute for permanent wiring.

35. As far as practical, cords and their connecting devices should not be run through water, mud, wet concrete, etc. Some plugs and connectors, when submerged, could cause leakage current of a sufficient magnitude to create a shock hazard and trip a GFCI.

Temporary lighting

36. Power tool circuits should be separate from lighting circuits so that outage on the power circuit will not affect the lighting circuit(s).

37. Lighting on barricades, sidewalk coverings and fences should be enclosed in a metal raceway. All lamps for general illumination should be protected from accidental contact or breakage.

38. Portable handheld lamps should be equipped with a heavy-duty cord and should not be suspended by their cords unless the cords and lamps are specifically designed for this purpose.

39. OSHA requires that portable handheld lamps used in moist and/or hazardous locations, such as drums, tanks, etc., operate at 12 volts or less. If protected by a GFCI, 120-volt lights may be used.

40. All portable handheld lamps should be equipped with lamp guards unless the reflector is designed so the lamp is recessed. Uninsulated metallic lamp guards should be grounded. Nonmetallic or insulated metal lamp guards need not be grounded.

41. Portable handheld lamps should be listed for the purpose and should not be constructed with paper-lined, brass-shell lampholders. Lamps should be guarded.

Power lines

42. Overhead electric lines are constant hazards in a construction area. If a power line must be protected or moved, contact utility company personnel so they can take the necessary action.

43. Lines installed for temporary use should be routed so as not to interfere with the construction process

or equipment. Where this is not possible, the lines can be raised to provide sufficient vertical clearance or installed underground.

44. If the lines are raised to obtain the necessary clearance, a stripe should be painted around the pole about 10 feet above the grade. Frequent checks should be made to ensure construction has not reduced the clearance or has not affected the stability of the pole.

45. Warning signs indicating substandard clearance afford some protection where it is impractical to raise existing lines.

Control of work practices

46. Control of work practices through enforcement of job rules is essential to ensure safety. Each worker should be made aware of the rules, and violations should not be tolerated. The rules should not be merely prohibitive but should provide means for corrective action.

47. Training of workers should emphasize proper handling of electrical conductors in the work area.

48. Good housekeeping and a well planned layout of temporary wiring will reduce the dangers of fire and shock hazards. Workers should be schooled in mouth-to-mouth resuscitation and cardiopulmonary resuscitation as well as methods of freeing fellow workers from electrical circuits.

49. Personal protective equipment appropriate for the work should be provided and its use enforced.

Maintenance

50. On every job, a procedure should be established and rigidly followed for maintenance and extension of the electrical system. Competent and authorized employees should be assigned to make all connections that are more complicated than merely plugging into an established receptacle.

51. Maintenance standards should demand good quality workmanship and equipment, regular inspections and provision for out-ofservice notices and other precautions.

52. There should be a periodic program for testing and repair of tools even if they are employee owned. Workers should be instructed not to use defective tools, but to turn them in for repair.

Written description of an assured equipment grounding conductor program. Suitable to comply with the requirements of 29CFR Part 1910.304 (b)(ii) and Part 1926.400 (h)

1. Scope – This procedure describes the requirements to assure the installation and maintenance of equipment grounding conductors for temporary wiring on construction sites in accordance with paragraph (b)(ii) of Part 1910.304 of Occupational Safety and Health Standards and paragraph (h)(3) of Part 1926.400 of Safety and Health Regulations for Construction.

2. Policy – GFCIs are not required for 120-volt, singlephase, 15- and 20-ampere receptacle outlets where all of the requirements of this procedure are implemented at the construction site. Employees shall not use any equipment which has not met the requirements of this procedure.

3. Jobsite information

- Name or description of construction site
- Employer complying with this procedure
- Person designated to implement the procedure

and authorized to take prompt corrective measures

4. Requirements – Equipment grounding conductors shall be installed and maintained in accordance with this procedure.

4.1. Installation equipment grounding conductors shall be installed as follows:

- All 120-volt, single-phase, 15- and 20-ampere receptacles shall be of the grounding type and

their contacts shall be grounded by connection to the equipment grounding conductor of the circuit supplying the

receptacles in accordance with the applicable requirements of the National Electrical Code.

- All 120-volt cord sets (extension cords) shall have an equipment grounding conductor which shall be connected to the grounding contacts of the connector(s) on each end of the cord.
- The exposed non-current carrying metal parts of 120-volt cord- and plug-connected tools and equipment that are likely to become shall be grounded in accordance with the applicable requirements of the National Electrical Code.

4.2. Visual inspection – Employees shall be instructed to visually inspect receptacles, flexible cord sets (extension cords), except those that are fixed and not exposed to damage, and equipment connected by cord and plug before each day's use for external defects such as deformed or missing pins or insulation damage and for indication of possible internal damage Where there is evidence of damage, the damaged item shall be taken out of service and tagged until tested and any required repairs have been made.

4.3. All 120-volt, single-phase, 15- and 20-ampere receptacles which are not a part of the permanent wiring of the building or structure, 120-volt flexible cord sets, and 120-volt cord- and plug-connected equipment required to be grounded shall be tested as follows:

- All equipment grounding conductors shall be tested for continuity and shall be electrically continuous.
- Each receptacle and attachment cap or plug shall be tested for correct attachment of the equipment grounding conductor. The equipment grounding conductor shall be connected to its proper terminal.

4.4. Testing schedule – All required tests shall be performed:

- Before first use
- Before equipment is returned to service following any repairs
- Before equipment is used after any incident which can be reasonably suspected to have caused damage (for example, when a cord set is run over)

4.5. Test record – Test verification shall be by means of numeric or color coded marking tape on the receptacle, cord set or equipment to identify that it has passed the test and to indicate the date (month or quarter).

5.0. Coding scheme – This written description and the test record required in 4.5 shall be available at the jobsite for inspection and copying by the assistant secretary and any affected employee.

Coding schemes for assured equipment grounding conductor test record

Month or Quarter	Color Coding Scheme		Numeric Coding Scheme
	Quarterly	Monthly	Monthly
January	White	White	1
February		White & Yellow	2
March		White & Blue	3
April	Green	Green	4
May		Green & Yellow	5
June		Green & Blue	6
July	Red	Red	7
August		Red & Yellow	8
September		Red & Blue	9
October	Orange	Orange	10
November		Orange & Yellow	11
December		Orange & Blue	12
Repair or Incident	Brown	Brown	0

Sources of information

National Fire Protection Association, 1 Batterymarch Park Quincy, Massachusetts USA 02169-7471

National Electrical Code, NFPA 70. 1 Batterymarch Park Quincy, Massachusetts USA 02169-7471

Accident Prevention Manual for Industrial Operations, Engineering and Technology, 14th ed., 2015. Chapter 17, "Hand and Portable Power Tools."

Industrial data sheets:

OSHA 29 CFR 1910.304 Wiring design and protection