ANSI E1.6-4 – 2013
Portable Control of Fixed-Speed Electric Chain Hoists in the Entertainment Industry

Rig/2010-2008r2N

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The PLASA Technical Standards Program

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The Rigging Working Group, which authored this Standard, consists of a cross section of entertainment industry professionals representing a diversity of interests. PLASA is committed to developing consensus-based standards and recommended practices in an open setting.

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Interest category codes:

CP = custom-market producer	DE = designer
DR = dealer rental company	G = general interest
MP = mass-market producer	U = user

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Scope

This standard covers the minimum requirements for the selection and use of portable electric chain hoist control systems. These controllers are for use with electric link chain hoists having a capacity of 2 tons or less, fixed speed, used in the entertainment industry. Permanently installed systems are outside the scope of this standard. Construction or design of controllers is governed by standards such as UL508A and as such are outside the scope of this standard.

1.2 Intent

The intent of this document is to define and classify portable electric chain hoist control systems, establish guidelines for selection and use and establish operating protocol. These guidelines represent the minimal requirements for safe and dependable operation of chain hoist control systems in accordance with risk mitigation.

1.3 Mandatory Rules, Permissive Rules, and Explanatory Material

1.3.1 Mandatory Rules: Mandatory rules of this document are those that identify actions that are specifically required or prohibited and are characterized by the use of the terms *shall* or *shall not.*

1.3.2 Permissive Rules: Permissive rules of this document are those that identify actions that are allowed but not required, are normally used to describe options or alternative methods, and are characterized by the use of the terms *shall be permitted*, *shall not be permitted*, *should*, or *should not.*

1.3.3 Explanatory Material: Explanatory material such as references to other standards or related information to a rule is included in this document in the form of fine print notes (FPN). Fine print notes are not a requirement of this document.

2 DEFINITIONS

2.1 automation: Operations performed electro-mechanically from pre-programmed criteria defined by the operator or manufacturer.

2.2 automated motion: The movement of a load system to a specific position or sequence of positions by one or more pre-programmed moves.

2.3 bumping: The momentary operation of a hoist.

2.4 Class A Controller: A simple control system designed to operate 1 hoist.

2.5 Class B Controller: An elementary control system used to operate hoist(s) from a single control device. It optionally incorporates feedback.

2.6 Class C Controller: A complex controller incorporating feedback.

2.7 closed loop: A system that monitors the outcome of a process and uses that information to affect the process.

2.8 competent person: A person who is capable of identifying existing and predictable hazards in the workplace, and who is authorized to take prompt corrective measures to eliminate the hazards.

2.9 command, Stop: A command within the controller that stops movement of the hoist(s).

2.10 command, No Start: A command within the controller that prevents movement of the hoist(s).

2.11 control device: The part of the system that is responsible for activation of a movement. It can be referred to as a human machine interface or man machine interface. It may control a single hoist (see pickle) or multiple hoists (see pendant and remote station).

2.12 controller: A unit designed to allow for the operation of one or more hoists at a time, that (1) activates the power or control circuit of the hoist or both; and (2) allows for the removal of power from the hoist. It may be operated by a control device built-in or attached via an external connector.

2.13 controller with feedback: A unit designed to allow for the operation of more than one hoist at a time, that (1) activates the power or control circuit or both; (2) that allows feedback from the hoist that may include, but is not limited to, such data as position, load, amperage, and voltage; and (3) that provides an E-Stop function. It may be operated by a control device built-in or attached via an external connector.

2.14 controller, direct control: A controller with which the direction control of the hoist is achieved by phase reversing contactors located in the controller, not in the hoist.

2.15 E-Stop: A system designed to stop hoist movement by removing power from the hoists, whether integral to the controller or an externally connected system.

2.16 E-Stop, Category 0: Category 0 is an uncontrolled stop achieved by immediately removing power to the hoists.

2.17 cable, extra hard usage: Flexible cable Listed by a Nationally Recognized Testing Laboratory as suitable for "extra hard usage" in accordance with Article 400 of ANSI/NFPA 70, the National Electrical Code.

2.18 cable, hard usage: Flexible cable Listed by a Nationally Recognized Testing Laboratory as suitable for " hard usage" in accordance with Article 400 of ANSI/NFPA 70 , the National Electrical Code.

2.19 hoist: A serially manufactured electric link chain hoist having a capacity of 2 tons or less, fixed speed, and used in the entertainment industry.

2.20 hoist power/control cable: The cable or cables that connect the hoist tail to the controller providing power or control or both power and control.

2.21 hoist tail: Electric cable(s) that exit the hoist that allow for the connection of the hoist power/control cable.

2.22 input power supply cables: Cables that feed power to the controller.

2.23 load monitor: A device designed to measure and report weight (mass).

2.24 Listed Product: A product bearing the mark of an OSHA Nationally Recognized Testing Laboratory (NRTL).

2.25 manufacturer: The entity responsible for fabricating and assembling a piece of equipment.

2.26 pendant: Remote station.

2.27 pickle: A manually operated handheld control device used for single hoist operation; connected to the hoist.

2.28 pinout: The assignment of a function to a particular terminal of a connector.

2.29 portable electric chain hoist control system: A combination of interconnect-able devices, that allow for the operation of one or more hoists. It includes a controller; a control device; the required cabling; and any accessories designed to enhance or augment the controller and/or hoist.

2.30 positioning monitor: A device designed to provide positional feedback to the controller.

2.31 power distribution: The circuit from the power source to the hoist. It may be integral to the controller or separate.

2.32 readily accessible: Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc.

2.33 remote station: An external control device for a multi-hoist controller used to enable the operation of one or more hoists.

2.34 safety function: A function to be implemented by a safety-related system, or external risk reduction facilities, which is intended to achieve or maintain a safe state for the equipment, in respect of a specific hazardous event.

2.35 unattended: Whenever the operator is not in position to operate the system.

3 SYSTEM CLASSIFICATIONS

3.1 Class A, Single Hoist Control System

See Figure 1, section 15

A control system that consists of a control device, a power cable, and a control cable.

A class A system is designed to operate a single hoist.

3.2 Class B, Multiple Hoist Control System

See Figure 2, section 15

A control system that consists of a controller, a control device, an input power supply cable, and hoist power/control cables.

A Class B system is designed to operate multiple hoists singly or in groups via a single control device.

A Class B system may include feedback devices such as warning signals or those that allow the operator to monitor the weight, or position of the system.

3.3 Class C, Automated Multiple Hoist Control System

See Figure 3, section 15

A control system that consists of controllers with feedback input capability, control devices, hoist power/control cable, input power supply cable, data feedback cable, and any accessories required to provide feedback that may include but are not limited to: positional information, load sensing, electrical current draw, or voltage.

A Class C system is designed to operate multiple hoists, singly or in groups, via a single control device with an E-stop system, and implementing feedback capability to allow automated motion, stop commands, or no start commands based on provided data.

4 SYSTEM REQUIREMENTS

4.1 General

4.1.1 All classifications of control systems shall have a readily accessible means to remove power from the hoist such as a switch in the control device, an emergency stop system, or a disconnect switch.

4.1.2 All control systems shall only be operated by a competent person.

4.1.3 All control systems shall be designed to prevent inadvertent or unintended operation.

4.1.4 All unattended control systems shall have the power removed or otherwise disabled.

4.1.5 All control systems shall be designed to shut down safely in the event of a power failure and to prevent the system from restarting automatically upon restoration of power.

4.2 Class A Systems

4.2.1 A Class A system shall only be used to operate a single hoist.

4.2.2 The control device may be a low voltage type or direct control type as discussed in section 5.

4.2.3 Disconnecting the power cable from the hoist shall be permitted as a 4.1.1 compliant power removal method.

4.3 Class B Systems

4.3.1 A Class B system shall be permitted to operate multiple hoists singly or in groups via a single control device.

4.3.2 A Class B system shall be designed so that it is not capable of operating a hoist singly or in group mode from multiple points of control simultaneously.

4.3.3 Class B systems shall be designed to allow the operation of multiple controllers from a common control device.

4.3.4 Class B systems shall be permitted to operate with feedback devices designed to provide the operator with displayed data and/or warnings about conditions such as weight, voltage, current draw, position or movement.

4.4 Class C Systems

4.4.1 A Class C system shall operate with feedback devices designed to provide the operator with displayed data and/or warnings about conditions such as weight, voltage, current draw, position or movement.

4.4.2 A Class C system shall be designed so that the inadvertent, unintended, or incorrect operation of one or more hoists will be terminated automatically by the control system, prior to overloading the

anchorage or any rigging, hoist or load system component. It shall be possible for the operator to terminate the motion of one or more hoists at any time.

4.4.3 A Class C system shall be designed to monitor hoist data feedback with network data speeds capable of initiating control changes, stop, or no start commands before overloading the anchorage or any rigging, hoist or load system component.

4.4.4 Stop commands and no-start commands shall be based on feedback such as:

- Movement in the wrong direction
- Lack of movement when commanded
- Unintended movement
- Overweight condition
- Underweight condition
- An unplugged hoist
- Overcurrent

4.4.5 Depending on the risk analysis, higher levels of risk mitigation would utilize one or more of the following:

- Automated action based on motion faults
- Automated action based on positional faults
- Automated action based on weight faults

4.4.6 A Class C system shall incorporate an emergency stop system as described in section 10.

5 CONTROL DEVICES

5.1 General

5.1.1 Control Devices shall control any or all hoists in either direction by a single normally open momentary push button. The circuit shall be “non-latching,” and require continuous activation.

5.1.2 Operation shall be permitted to occur from an internal control device on a controller or an externally connected device.

5.1.2.1 Where multiple devices govern the same controller, they shall operate exclusive of each other.

5.1.2.2 Where E-Stop systems are employed on the control device they shall be functional on all controllers connected to the device.

5.2 Class A Control Device (Pickles)

5.2.1 Class A control devices shall activate the control signal to the hoist (in the case of a contactor drive hoist) or reverse phase rotation of hoist power (in the case of a direct control hoist).

5.2.2 The voltage at the handheld portion of a class A control device shall not exceed 150 VAC.

5.2.3 When released, the pickle’s controls shall return to the off position and the hoist’s operation shall stop. The contacts shall be interlocked to prevent simultaneous direction commands and they shall be rated to handle the voltage and current required.

5.2.4 Pickles for use with multi-pin hoist tails shall be used with an inline adapter or with a system specifically designed to interrupt the control circuit from the controller while not affecting the power circuit. The inline adapter shall be suitably labeled.

FPN: In applications using dual connectors (one for power and one for control), the pickle may be connected to the control connector at the hoist. This requires that the control portion of the cable is disconnected from the hoist in order to connect the pickle. In applications where multi-pin cables are used for power and control, the pickle is typically connected by an additional tail from the hoist that is wired in parallel with the control cable connections. Unless the controller has been designed to allow the removal of the control circuit in these situations, there are now two points of control for the hoist. This can result in hazardous conditions. See Figures 4 and 5, section 15

5.3 Class B & C Control Device (Remote Station)

5.3.1 The circuitry of the remote station shall be less than 50V and the removal of this control device shall prevent operation of the hoist by de-energizing the control circuit and removing power to the hoists.

5.3.2 The remote station shall provide a method for selecting hoist(s) direction. This shall be accomplished in a manner that prevents simultaneous or contradictory commands to any single hoist.

5.3.3 The remote station shall clearly identify the hoist(s) selected for movement and its(their) direction.

5.3.4 The remote station shall have normally open momentary contacts that effect operation of the selected hoist(s). When released the controls shall return to the off position and the hoist's operation shall stop.

5.3.5 The remote station shall have the ability to remove power from the hoists via a switch. The switch shall be a normally closed, latching or mechanically maintained switch. The switch may also be an E-stop switch.

5.3.6 The remote station may be a programmable electronic system.

5.3.6.1 The programmable system shall inherit the characteristics of a standard remote station.

5.3.6.2 If the programmable system performs selection functions, the successful selection of a function shall be indicated by means of a feedback signal.

5.3.6.3 Equipment using reprogrammable logic shall have the means for verifying that the software is in accordance with the relevant program documentation.

5.3.6.4 In the event of a single failure, control systems incorporating software and firmware based controllers performing safety related functions shall:

- Not lead to the loss of the safety function and,
- Lead to the shutdown of the system in a safe state and,
- Prevent subsequent operation until the component failure has been corrected and,
- Prevent unintended startup of equipment upon correction of the failure, and
- Provide protection equivalent to that of control systems incorporating hardwired/hardware components.

6 PINOUTS

Pinouts as defined in this standard are the assignment of a function to a particular terminal in a connector. Some pinouts may be user selected as long as they are not in violation of any NEC, local electrical code, or independent testing agency guidelines. Other pinouts shall be defined by the manufacturer of the equipment. In general, pinouts that are employed in the hoist power/control cable have traditionally been end-user defined and as such, the following shall apply.

FPN: Annex A lists the suggested recommendation of connector type and pin designation for hoist power and control connections (Informative).

6.1 A grounding terminal or grounding type device shall not be used for purposes other than grounding.

6.2 The pin designations of the hoist power and control connectors shall be clearly identified on the hoist tail or hoist body and on the controller.

FPN: There are a large number of pinout variables within the entertainment industry. In almost every instance involving both multi-pin and dual connector applications, there is more than one pinout assignment for each connector or combination. The safest method to ensure proper operation and compatibility is to clearly identify the pinout assignment.

6.3 The pinout assignment shall be the same on both ends of the cables.

FPN: Crossing of pins could result in an out of phase condition or improper direction control to the hoist. In instances where cables may require repair in the field, the termination to the proper pins is imperative to safe operation.

6.4 It shall be permissible to have adapter cables where the pinouts are different on each end provided the adapter cable is 1m (3ft) long, or less, and suitably identified.

6.5 The pinout for control devices shall be determined by the manufacturer .

FPN: As the pinout for the control device determines the control protocol for the system, it shall be designed and determined by the manufacturer.

7 CONNECTORS

7.1 The circuit voltage and amperage shall not exceed the rating of the connector.

7.2 Connectors for dual connector systems shall be NEMA classified connectors or IEC-rated pin and sleeve connectors.

7.2.1 The power and control connector shall not be the same type.

7.2.2 The control connector shall be at a minimum a 3-pole, 4-wire connector.

8 CABLE

8.1 General

8.1.1 All cables shall be sized appropriately to allow for the following:

- The power requirements of the controller and hoists

- The allowable voltage drop
- The rating of the supply overcurrent protector

FPN: Cable Size Information can be found in Annex B. (Informative)

8.1.2 Cables shall be of an appropriate type and sufficiently durable for the intended application.

8.1.3 Cables shall be installed so that there is no strain on the cable connections.

8.2 Hoist Power/Control Cable

8.2.1 Hoist power/control cable shall be either two separate cables, one for power, one for control, or a single cable.

8.2.1.1 When two cables are used for power and control, in Class B and C systems, they shall be bundled as a single assembly.

8.2.1.2 When a single cable is used for power and control with two separate connectors, the jacketing material of the split shall be consistent with and of the same type as the cable.

8.2.2 Hoist power/control cables shall be rated to handle the voltage and current draw of the hoist.

8.2.3 Hoist power/control cable shall be Listed extra hard usage cable with the following exception.

8.2.3.1 In a single cable dual connector assembly, the jacketing for the split shall be permitted to meet the requirements of Listed, hard usage (junior hard service) cords where all of the following conditions are met:

- The cords are used to connect between a chain hoist controller and a chain hoist
- The longest cord in the split does not exceed 1.0 m (3ft)
- The split is protected from physical damage
- All branch circuits feeding the assembly are protected by overcurrent devices rated at not over 20 amperes
- The hoists are not operated at over 300 VAC

8.2.4 Where possible, the hoist power/control cable shall be constructed so that a center conductor (if provided) is not used. It shall be permitted to have center core filler that eliminates any conductor from stress of movement. Support strands shall be permitted as center filler.

FPN: Due to the nature of flex and movement of the hoist power/control cable, a center conductor is subject to extreme tension and pulling forces that can lead to the failure of the hoist to operate or ungrounded conditions, depending on the pinout of the control system.

8.3 Input Power Supply Cable

8.3.1 The input power supply cable shall be rated to handle the voltage and current draw of the hoists and controller.

8.3.2 The input power supply cable shall be Listed extra hard usage cable.

9 CONTROLLERS

9.1 General

9.1.1 Controllers shall be rated as to the current, voltage, phase(s) and maximum number of hoists allowed to be operated. They may also be rated as to the horsepower.

9.1.2 Controllers shall be rated for the environmental conditions they are intended to operate under.

9.1.3 Controllers shall be a Listed product.

9.1.4 Controllers shall provide power and control for multiple hoists from a single source of power.

9.1.5 Controllers shall provide a means to disconnect power to all hoists connected to them.

9.1.6 Controllers shall be permitted to provide phase reversal of the input power.

9.1.7 Controllers shall provide a means to monitor phase rotation and phase loss.

9.1.8 In three phase applications, the control system shall maintain phase integrity from the point of power input at the controller to the power distribution at each hoist.

> *FPN 1: The controller is the component of the system responsible for the distribution of power to the hoists via the hoist power/control cables. As such it is imperative that each phase of power is continuous and unchanged (other than the phase reversal circuitry) from the point of input to the point of delivery to the hoist.*
>
> *FPN 2: The hoist power/control cables are an important part of this system. Care shall be taken to ensure that the power and control cables are properly wired pin to pin on both ends and any cables found discrepant shall be clearly identified and removed from service for repair.*

9.1.9 Controllers shall operate all or any combination of motors selected by the control device in an up or down direction by a single momentary switch.

9.1.10 Operation shall be permitted to occur from an internal control device or an externally connected control device, operating exclusive of each other.

9.1.11 Controllers shall provide short circuit and overcurrent protection. In the case of direct control, shall also provide current overload protection.

9.1.12 Controllers shall provide a ground fault current path from the hoist to earth. In the event that dual twist power and control cables are used the ground fault path shall be accessed through both the control and power connectors.

9.1.13 The direction control outputs to the hoist shall be electromechanical.

9.1.14 The pin designations of the hoist output connectors shall be clearly identified on the controller.

9.1.15 Controller shall be constructed in a suitable fire resistant enclosure designed to prevent damage and exposure to detrimental environmental conditions, and to prevent contact with live parts.

9.2 Class C Controllers

9.2.1 General

9.2.1.1 Class C controllers shall allow for the interface of automated control equipment, which may be internal or external to the controller.

FPN: In applications where risk mitigation is required, the use of Class C controllers may be employed to assist. Positional feedback may be employed to ensure that hoists are moving in the proper direction as well as providing a means to maintain leveling. Load sensing may be employed to prevent overweight or slack chain conditions.

9.2.1.2 Class C controllers shall allow for monitoring and control based on feedback that may include the following.

9.2.1.2.1 The interface of data feedback with respect to position.

9.2.1.2.2 The interface of data feedback with respect to weight.

9.2.1.2.3 The interface of data feedback with respect to motion.

9.2.1.2.4 Class C controllers shall be permitted to monitor voltage.

9.2.1.2.5 Class C controllers shall be permitted to monitor current.

9.2.1.3 Class C controllers shall employ E-stop systems.

9.2.1.4 It shall be permitted to use a Class C controller as a manual control.

9.2.1.5 All movement shall be enabled and supervised by the operator at all times.

9.2.1.6 All class C controllers shall have an adequate response time designed to halt operation before a hazardous condition or damage occurs.

9.2.2 Positional Feedback Control

9.2.2.1 Class C controllers with positional control shall monitor the position, direction, and movement of the load and shall be required to shut down the system if the direction of movement is incorrect.

9.2.2.2 The position monitoring system shall be capable of displaying the information to the operator.

9.2.2.3 The control system with positional feedback shall be closed loop design.

FPN: Positional information shall be verified by the control system. Simply sending a command to move to a point such as in a DMX protocol is not sufficient to verify that the command has been received and the move has been completed.

9.2.3 Load-Sensing Feedback Control

9.2.3.1 Class C controllers with load sensing control shall monitor the weight of the lift at each hoist and shall be required to shut down the system if the weight of the lift at any point is outside safe parameters.

9.2.3.2 A load monitoring system could employ a spring scale, a dynamometer, or a load cell that works in conjunction with equipment that allows for access to the information.

9.2.3.3 The load bearing component of the load monitoring system shall have a design factor of 5:1 or greater. The working load shall not exceed the manufacturer's specifications.

9.2.3.4 The load sensing component of the load monitoring system shall be calibrated to an accepted industry standard such as ISO/IEC 17025 & ANSI/NCSL Z540-1.Recertification and/or calibration shall be performed annually by the manufacturer or as per manufacturer's specifications.

9.2.3.5 Records of certification shall be maintained by the owner of the equipment.

9.2.3.6 The load monitoring system shall be capable of displaying the information to the operator.

9.2.4 Motion feedback Control
Class C controllers with motion sensing control shall monitor the motion of the hoist and shall be permitted to shut down the system if there is any unintended movement.

9.2.5 Voltage Monitoring
Class C controllers with voltage monitoring shall monitor the voltage to each hoist and shall be permitted to shut down the system if the voltage is outside safe parameters such as:

- Over voltage
- Under voltage
- Loss of phase

9.2.6 Current Monitoring
Class C controllers with current monitoring shall monitor the current to each hoist and shall be permitted to shut down the system if the current draw is over the rating of the hoist (s).

10 E-STOP SYSTEM

10.1 General

10.1.1 Emergency stop devices shall have absolute priority over all other functions.

10.1.2 The emergency stop shall function as a Category 0 E-Stop.

> *FPN: When using hoists at a high speed (over 16fpm) extra consideration needs to be given due to inertial load displacement into the structure. The consideration shall be with respect to damping the inertial dynamic load as standard fixed speed controllers and Category 0 E-Stops will not address this situation.*

10.1.3 Where an E-Stop system is used, it shall have a hardwired push button device supervising each controller and operator control station, with additional locations as determined by qualified personnel.

10.1.4 The emergency stop shall be initiated by a single human action. It shall be permitted for Programmable Electronic System Safety Functions to initiate an emergency stop.

10.1.5 The emergency stop shall be manually reset.

10.1.6 Resetting of the E-Stop shall not restart the hoists but only permit them to be restarted.

10.1.7 The emergency stop devices shall be continuously operable and readily accessible.

10.1.8 The final removal of power shall be by means of electromechanical components.

10.2 Emergency Stop Actuator

10.2.1 E-Stop shall be activated by an E-Stop switch that has been designed for the application.

10.2.2 The emergency stop device shall have an actuator push button of the palm or mushroom button type.

10.2.3 The actuator of the emergency stop device shall be red and the background around the device when used shall be yellow. The red and yellow combination shall only be used for emergency stop applications.

FPN: Visibility and recognition of emergency stop devices is the primary concern.

10.2.4 The E-Stop actuator shall be a normally closed, latching or mechanically maintained switch.

10.2.5 The E-Stop actuator shall have positive direct opening contacts.

10.3 E-Stop Methods

10.3.1 E-stop shall be accomplished by any of the methods described below with the provision that all methods provide for the removal of power to the hoist, and are designed so that the removal or disconnection of any component of the E-Stop system shall cause the system to shut down.

10.3.1.1 External power distribution system with electrically held contactor.

10.3.1.2 External E-Stop control system that interconnects between the controller's control device and contactor.

10.3.1.3 Built-in E-Stop control circuit utilizing the contactor within the controller.

11 INSTALLATION

11.1 General

11.1.1 Prior to power up, verify that the supply voltage matches the voltage requirement for the controller and hoists.

11.1.2 Verify that the power and control cables are the correct wire gauge for length of cable run as applies to voltage drop. The hoist manufacturer’s recommendations shall be followed. Where the recommendations are not available, reference tables are provided in Annex B.

11.1.3 Prior to operation under load, verify that all hoists move in the direction selected on the control device.

11.1.3.1 It shall be permitted for the controller to provide a phase reversal system only to be used for correction of phase discrepancies.

11.1.3.2 In the case that the controller does not have a phase reversal system, it shall be permitted to reverse the phase rotation of the input power supply cable. If a transient connection is employed the reversal shall be done at the tie in. If a transient connection is not employed, the reversal shall be done at the first male plug closest to the power source.

11.1.3.3 Phase rotation correction shall not be permitted by modifying the hoist power/control cable assembly or the controller.

11.1.3.4 On multiple controller systems it is permissible to have the phasing of hoists grouped to a controller be a different phase rotation than hoists grouped to a different controller as long as the controller/hoist groups remain intact.

FPN 1: This would apply to cross renting control systems between equipment providers. Controllers can correct for phase discrepancies only as a group. Individual channel phase correction is not a design factor and is not recommended. Keeping the hoist/controller grouping intact will allow for safe operation of the system.

FPN 2 In a situation where a single hoist is not running in the same direction as others in the system, the correction of phase wiring shall be done in the hoist.

11.1.4 When multiple controllers are used on one load system, a single control device shall be capable of uniformly performing all functions on all controllers. Control devices shall not be modified in any way. Control interface shall use manufacture approved connection points.

FPN Multiple control systems used to lift a single load should not be allowed to be operated by multiple control devices either by one operator or multiple operators because of the increased difficulty in coordinating the simultaneous start and stop of the lift.

11.1.5 Multiple controllers on one load system shall be permitted to be controlled by multiple control devices where the following conditions have been met.

11.1.5.1 A manufacturer's approved method to link the go command for all control devices has been employed.

11.1.5.2 A manufacturer's approved method for linking E-Stop commands to all controllers has been employed.

11.2 Location

11.2.1 Systems shall be installed within their environmental operating specifications.

11.2.1.1 When the control equipment and cabling are designed for use in a dry environment and used outside of these parameters, precautions shall be taken. Such precautions include covering enclosures, or heating enclosures to prevent condensation.

11.2.2 Controller shall be installed so as to be readily accessible. When the controller is not readily accessible, i.e. mounted into the load system, power disconnect for the controller shall be readily accessible.

11.2.3 When controllers are mounted in the load system the following shall apply:

11.2.3.1 Controllers shall be securely affixed to the load system using industry accepted procedures designed to prevent movement. A redundant safety shall be provided.

11.2.3.2 The load system shall be electrically bonded to the controller. This can be accomplished through one of the following:

11.2.3.2.1 The use of a bonding wire and a grounding lug on the controller.

11.2.3.2.2 Bonding through the attachment hardware that is electrically bonded to the controller.

11.3 Power Requirements

11.3.1 The power supplying the system shall be of adequate capacity to operate the intended number of hoists and the input power supply cable shall be of adequate size.

FPN: Low supply voltage can cause unreliable hoist operation and shall be corrected. In addition improperly sized input power supply cable runs will compound the problem.

Since power requirements are based on the intended number of hoists to be run simultaneously, a careful analysis of system will be required in order to determine the maximum current load before specifying the power requirements.

FPN 1: When the intended number of hoists to be used is unknown; the system power requirements shall be based on the maximum capacity of the controller.

FPN 2: Annex B contains information that will assist in determining cable sizes.

11.3.2 If the supply voltage, whether under electrical load or not, is below the system voltage requirement, the use of mitigating equipment to correct the voltage is required.

11.3.3 The supply voltage shall be within the values indicated below.

11.3.3.1 The supply voltage for a single phase 120 VAC (HN) system shall not be below 110 VAC or above 126 VAC.

11.3.3.2 The supply voltage for a single phase 240 VAC (HH) system shall not be below 220 VAC or above 252 VAC.

11.3.3.3 The supply voltage for a three phase 208 VAC (HHH) system shall not be below 191 VAC or above 218 VAC.

11.3.3.4 The supply voltage for a three phase 208 Y/120 (HHHN) system shall not be below 191 Y/110 VAC or above 218 Y/128 VAC.

11.3.3.5 The supply voltage for a three phase 480 VAC (HHH) system shall not be below 440 VAC or above 504 VAC.

FPN: These values were taken from table 1 of ANSI C84.1 Electrical power systems and equipment voltage ratings.

11.3.4 Where pass-thru connectors are used, the pass-thru connector and all upstream components are subject to the total current load of all down stream components. Therefore, the system shall be designed so that the maximum capacity of the upstream cable or components are not exceeded.

FPN: Pass-thru connectors are generally included for convenience in applications where two or more controllers may be deployed but not used at the same time.. In applications where multiple controllers are to be run simultaneously, the pass-thru connector ratings shall be capable of handling the entire current load of the sum of all of the controllers or a separate feeder shall be run to each controller.

11.4 Verification of all operating features

11.4.1 Verify that channel assignment from control device to hoist is consistent throughout the system including hoist power/control cable, load sensing cables and positional data cables, by bumping each individual hoist without a load attached and verifying movement and proper direction.

FPN: Mismatched controller assignments can go undetected until a critical move involving one or more within the group is required.

11.4.2 Verify the operation of the E-Stop system by insuring the following:

- The hoist power is removed on activation of the E-Stop system.
- The hoist power is removed upon the disconnection of a component from the E-Stop system.
- The hoist power is restored on de-activation of the E-Stop system.

11.4.3 Make sure that all operating controls are functional.

11.4.4 Make sure that all indicators are functional.

11.4.5 Make sure that all electrical components are functional.

12 OPERATION

12.1 The operator shall be familiar with and observe all operating procedures as defined in the hoist manufacturer's and control systems manufacturer's instruction as well as any other safety requirements.

12.2 The operator shall be familiar with all operating controls and functions of the system.

12.3 All movement shall occur and continue only as long as the operator is actively involved. In Class A or B systems all movement shall be initiated and ended by means of a control device.

12.4 All movement shall be in the direction indicated by the control device.

FPN: Never operate the system when the direction of travel is contrary to the control device indicators. This may be symptomatic of control wiring issues or reversed phasing which shall be corrected before use.

12.5 Equipment that has malfunctioned, been dropped, damaged, mishandled, or shows signs of wear, shall be evaluated before being placed back into service.

12.5.1 Minor repairs as listed in the manufacturer's literature or authorized by the manufacturer shall be made by a qualified person.

12.5.2 Major repairs or modifications shall be made by manufacturer or an authorized representative.

12.6 All manufacturer's requirements for maintenance and service shall be followed.

13 DOCUMENTATION

13.1 The operator shall have access to the information necessary for installation, operation, and maintenance of the control systems.

13.2 The documentation shall be in an appropriate format including diagrams, drawings, charts, tables, and instructions. The following shall be included:

- Overview Diagrams
- Circuit Diagrams
- Operating Manual
- Maintenance Manual
- Parts List

13.3 The documentation shall be provided in paper or electronic format.

14 STORAGE

Ensure that all equipment is stored in a manner to prevent damage or hazardous conditions.

15 FIGURES

Class A, Single Hoist Control System

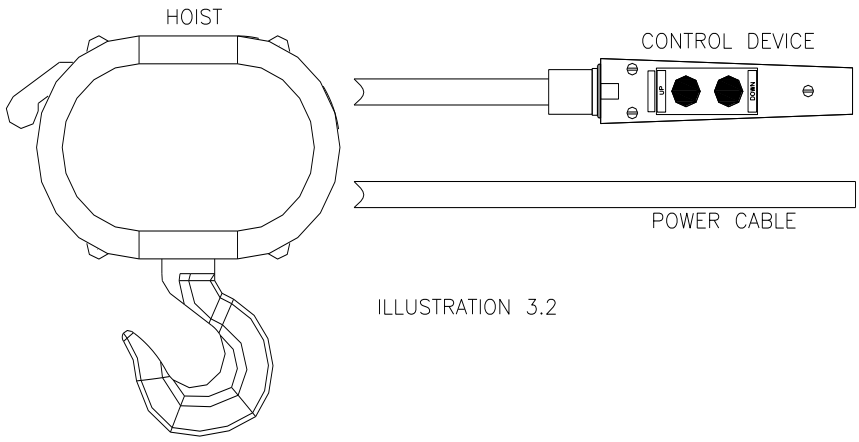

Figure 1

Class B, Multiple Hoist Control System

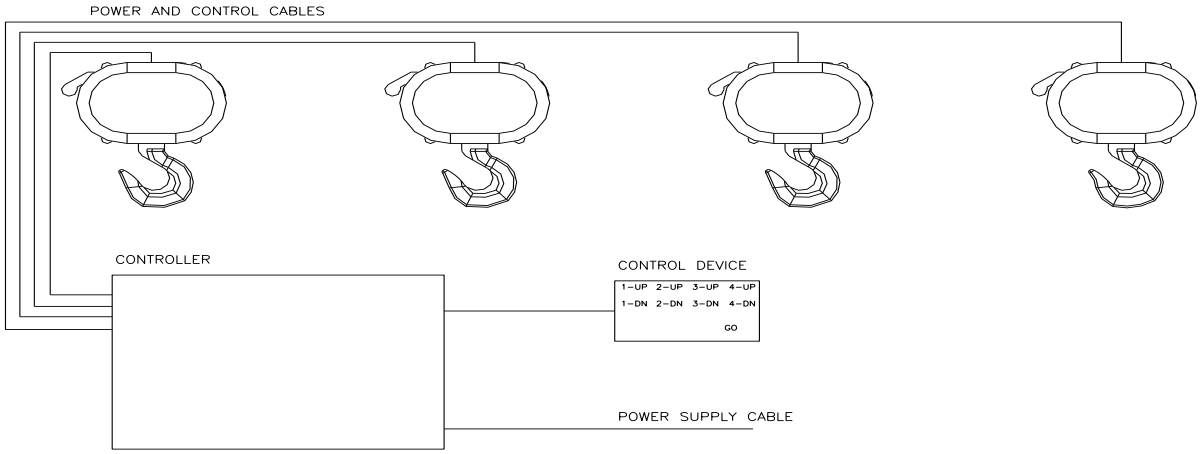

Figure 2

Class C, Automated Multiple Hoist Control System

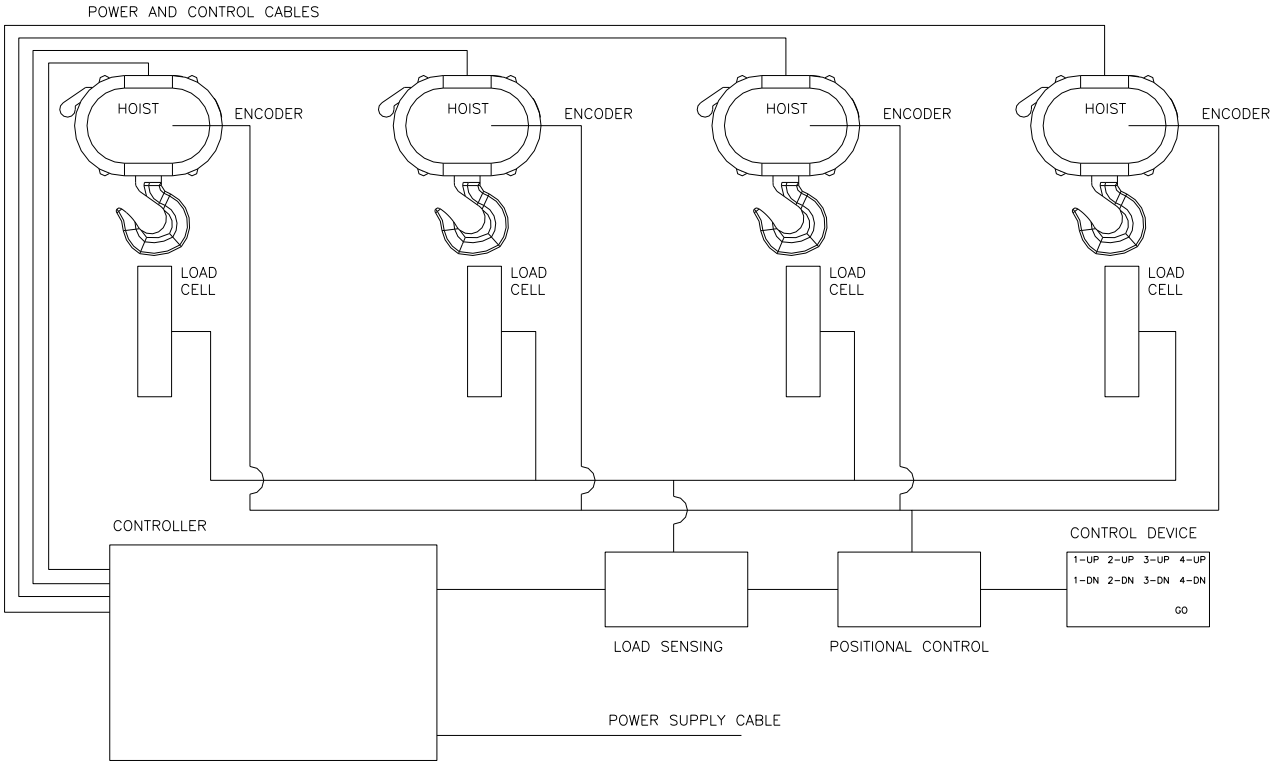

Figure 3

Example of two points of control

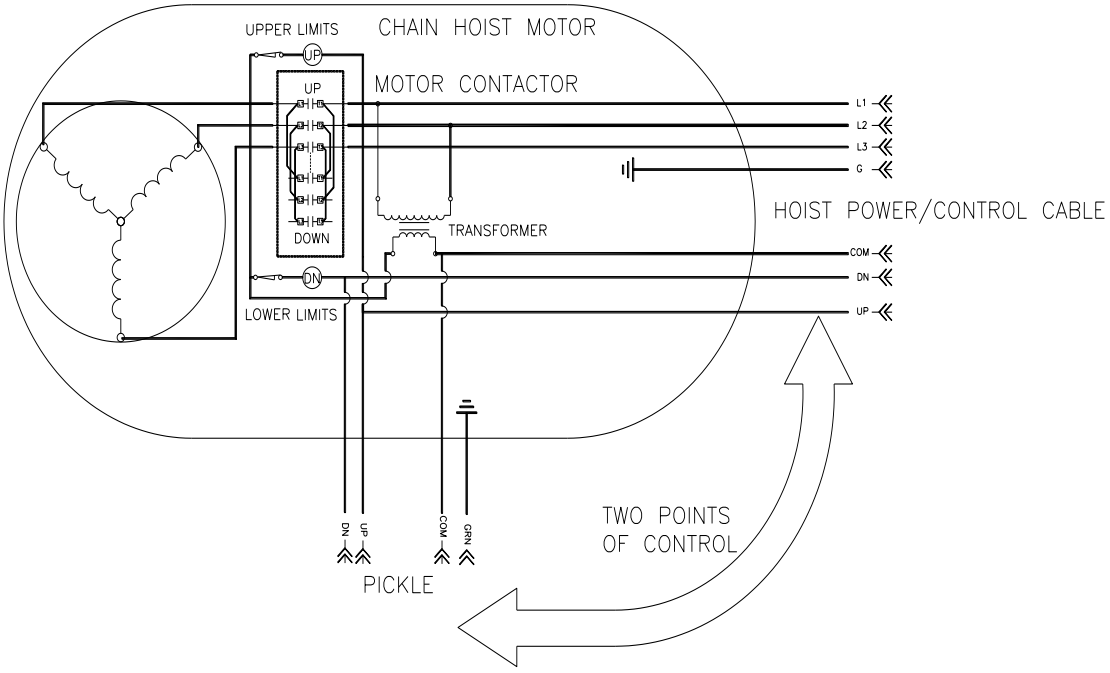

Figure 4

Second Control Signal removed from controller

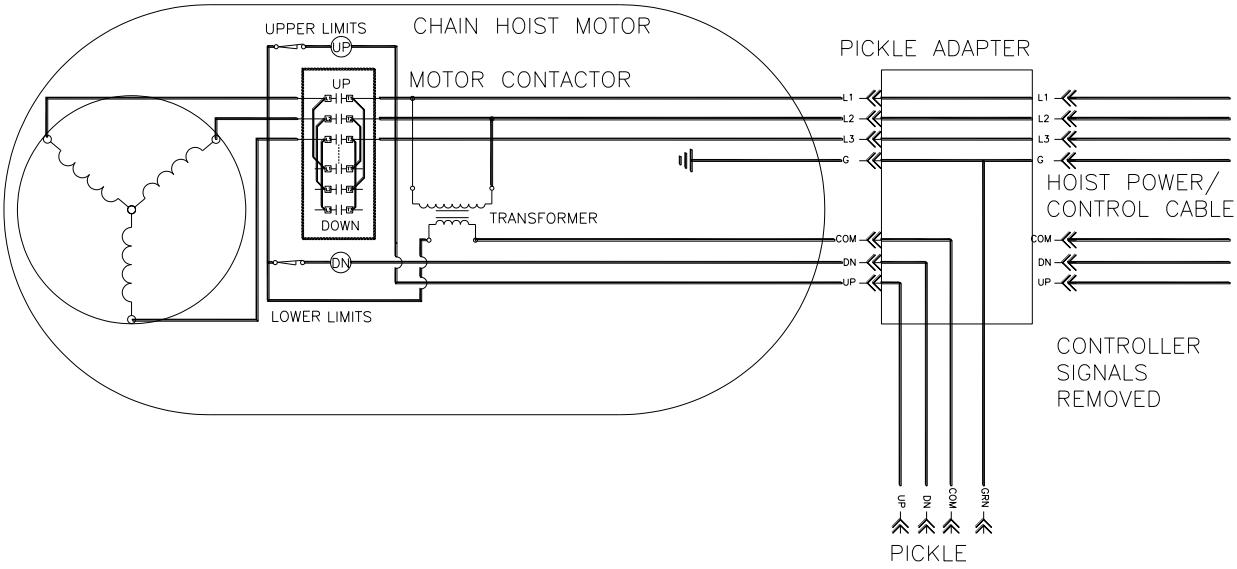

Figure 5

ANNEX A
Recommended Connector Choice and Pinout

A.1 Goal

The goal of a recommended connector pinout is to provide a level of standardization and safety to the industry that will allow for system compatibility between users. System compatibility will negate the use of adapters and possible cross wiring.

Requirements of section 6 apply.

A.2 Dual Connectors

A.2.1 Connector choice

A.2.1.2 Power connectors should be chosen so the rating of the connector matches or exceeds the supplied voltage.

A.2.1.3 Control connectors should be chosen where the pin configuration allows the connection of three terminals for UP, COMMON, and DOWN signal and

A.2.1.3.1 the ground terminal is not used as a current carrying conductor in the control circuit; and

A.2.1.3.2 the connector is not the identical type to the power connector.

A.2.2 Pinout

The pinout for the dual connector systems should be as follows:

A.2.2.1 Power Connector, Three-Phase
X = L1
Y = L2
Z = L3
G = Ground

A.2.2.2 Power Connector 208 V Single-Phase
X = L1
Y = L2
G = Ground

A.2.2.3 Power Connector 120 VAC
Brass = Hot
Silver = Neutral
Green = Ground

A.2.2.4 Control Connector
X = Common
W = Up
Y = Down
G = Ground

A.2.3 Twistlock selection

Twistlock connector selection should be based on NEMA numbers as follows:

A.2.3.1 480 VAC Three-Phase Systems
Power: L16-20
Control: L14-20

A.2.3.2 208 VAC Three-Phase Systems
Power: L15-20
Control: L14-20

A.2.3.3 208 VAC Single-Phase Systems
Power: L6-20
Control: L14-20

A.2.3.4 120 VAC Systems
Power: L5-20
Control: L14-20

A.2.4 Pin and Sleeve selection
Pin and Sleeve selection should be as follows:

FPN: The asterisk between the numbers in the Pin and Sleeve selections refer to the type of connector i.e.: plug, inlet, outlet, or connector body.

A.2.4.1 480 VAC Three-Phase Systems
Power: 420*7W
Control: 420*12W

A.2.4.2 208 VAC Three-Phase Systems
Power: 420*9W
Control: 420*12W

A.2.4.3 208 VAC Single-Phase Systems
Power: 320*6W
Control: 420*12W

A.2.5.4 120 VAC Systems
Power: 320*4W
Control: 420*12W

A.3 Multi-pin

A.3.1 All types of multi-pin are available for use in hoist power and control circuits including but not limited to; Circular style, Bayonet (1/4 turn) style, and Rectangular style.

A.3.2 All pin designations should begin with the power connections first then control in the following order with the exceptions for the ground position as per A.3.3.

L1
L2, or Neutral
L3, or not used
Up
Common
Down
Ground

A.3.3 Ground Location

The following conditions apply to the position of a ground conductor in a multi-pin application.

A.3.3.1 If any pin is bonded it should be used as the ground connection.

A.3.3.2 Any pin that makes first and breaks last should be used as ground.

A.3.3.3 Any pin that has a form different from the others either in size or shape should be used as ground.

A.4 Mults

A.4.1 Mults may be used to carry multiple hoist power and control connections to a breakout.

A.4.2 Mult pinouts should repeat the standard pinout for the required number of hoist circuits however there shall be only one ground connection as the last pin or as defined in A.3.3.

ANNEX B
VOLTAGE DROP AND CABLE SELECTION

B.1 The total voltage drop from the point of power supply shall not exceed 5%. That may be divided between the power supply cable and the hoist power/control cable. The installer should plan on a 2% drop for one and a 3% drop for the other. Be aware that the point of supply is considered to be at the service entrance and the design of the permanently installed feeder may have already included voltage drop calculations.

Table B1-1

2% Voltage Drop		
Voltage	Allowable Voltage Drop	Resulting Voltage
120 VAC	2.4 Volts	117.6 VAC
208 VAC	4.16 Volts	203.84 VAC
230 VAC	4.6 Volts	225.4 VAC
440 VAC	8.8 Volts	431.2 VAC
480 VAC	9.6 Volts	470.4 VAC

Table B1-2

3% Voltage Drop		
Voltage	Allowable Voltage Drop	Resulting Voltage
120 VAC	3.6 Volts	116.4 VAC
208 VAC	6.24 Volts	201.76 VAC
230 VAC	6.9 Volts	223.1 VAC
440 VAC	13.2 Volts	426.8 VAC
480 VAC	14.4 Volts	465.6 VAC

Table B1-3
Maximum Voltage Drop

Voltage	5%
120 VAC	114 VAC
208 VAC	198 VAC
230 VAC	218 VAC
440 VAC	418 VAC
480 VAC	456 VAC

B.2 For Hoist Power/Control Cable, Choose the appropriate table based on the operating voltage and cross reference the length of the cable against the current draw to determine the gauge (AWG) of wire.

Table B2-1, 208 VAC 3PHASE 2% DROP

DISTANCE IN FEET		10	25	50	75	100	125	150	175	200	225	250	300
CURRENT DRAW	0.6	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	1.1	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	1.4	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	1.9	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG
	2	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG
	2.3	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG
	2.8	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	14AWG	12AWG
	3.8	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	12AWG	12AWG	12AWG
	4.6	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	12AWG	12AWG	12AWG	12AWG	10AWG
	4.7	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	12AWG	12AWG	12AWG	12AWG	10AWG
	4.9	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	12AWG	12AWG	12AWG	10AWG	10AWG
	5.2	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	12AWG	12AWG	12AWG	12AWG	10AWG	10AWG
	7.6	16AWG	16AWG	16AWG	14AWG	14AWG	12AWG	12AWG	10AWG	10AWG	10AWG	10AWG	8AWG
	8.6	16AWG	16AWG	16AWG	14AWG	12AWG	12AWG	10AWG	10AWG	10AWG	10AWG	8AWG	8AWG
	15.4	12AWG	12AWG	12AWG	12AWG	10AWG	10AWG	8AWG	8AWG	8AWG	N/R	N/R	N/R

Table B2-2, 230 VAC 3PHASE 2% DROP

DISTANCE IN FEET		10	25	50	75	100	125	150	175	200	225	250	300
CURRENT DRAW	0.6	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	1.1	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	1.4	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	1.9	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG
	2	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG
	2.3	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG
	2.8	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	14AWG
	3.8	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	12AWG	12AWG	12AWG
	4.6	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	12AWG	12AWG	12AWG	10AWG
	4.7	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	12AWG	12AWG	12AWG	10AWG
	4.9	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	12AWG	12AWG	12AWG	12AWG	10AWG
	5.2	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	12AWG	12AWG	12AWG	12AWG	10AWG
	7.6	16AWG	16AWG	16AWG	14AWG	14AWG	12AWG	12AWG	12AWG	10AWG	10AWG	10AWG	8AWG
	8.6	16AWG	16AWG	16AWG	14AWG	12AWG	12AWG	12AWG	10AWG	10AWG	10AWG	8AWG	8AWG
	15.4	12AWG	12AWG	12AWG	12AWG	10AWG	10AWG	8AWG	8AWG	8AWG	N/R	N/R	N/R

Table B2-3, 480 VAC 3PHASE 2% DROP

DISTANCE IN FEET		10	25	50	75	100	125	150	175	200	225	250	300
CURRENT DRAW	0.6	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	1.1	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	1.4	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	1.9	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG

DISTANCE IN FEET		10	25	50	75	100	125	150	175	200	225	250	300
	2	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	2.3	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	2.8	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	3.8	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG
	4.6	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG
	4.7	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG
	4.9	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG
	5.2	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG
	7.6	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	14AWG	12AWG	12AWG
	8.6	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	12AWG	12AWG	12AWG
	15.4	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	10AWG	10AWG	10AWG	8AWG

Table B2-4, 120VAC SINGLE PHASE 2% DROP

DISTANCE IN FEET		10	25	50	75	100	125	150	175	200	225	250	300
	0.6	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	1.1	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG
	1.4	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	14AWG	12AWG
	1.9	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	12AWG	12AWG	12AWG
	2	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	12AWG	12AWG	12AWG	12AWG
	2.3	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	12AWG	12AWG	12AWG	12AWG	10AWG
	2.8	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	12AWG	12AWG	12AWG	10AWG	10AWG	10AWG
CURRENT DRAW	3.8	16AWG	16AWG	16AWG	14AWG	14AWG	12AWG	12AWG	10AWG	10AWG	10AWG	10AWG	8AWG
	4.6	16AWG	16AWG	16AWG	14AWG	12AWG	12AWG	10AWG	10AWG	10AWG	8AWG	8AWG	8AWG
	4.7	16AWG	16AWG	16AWG	14AWG	12AWG	12AWG	10AWG	10AWG	10AWG	8AWG	8AWG	8AWG
	4.9	16AWG	16AWG	14AWG	14AWG	12AWG	10AWG	10AWG	10AWG	8AWG	8AWG	8AWG	8AWG
	5.2	16AWG	16AWG	14AWG	12AWG	12AWG	10AWG	10AWG	10AWG	8AWG	8AWG	8AWG	N/R
	7.6	16AWG	16AWG	14AWG	12AWG	10AWG	10AWG	8AWG	8AWG	8AWG	N/R	N/R	N/R
	8.6	16AWG	16AWG	12AWG	10AWG	10AWG	8AWG	8AWG	8AWG	N/R	N/R	N/R	N/R
	15.4	12AWG	12AWG	10AWG	8AWG	8AWG	N/R	N/R	N/R	N/R	N/R	N/R	N/R

Table B2-5, 220VAC SINGLE PHASE 2% DROP

DISTANCE IN FEET		10	25	50	75	100	125	150	175	200	225	250	300
	0.6	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	1.1	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	1.4	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG
	1.9	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG
	2	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG
CURRENT DRAW	2.3	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	14AWG
	2.8	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	14AWG	12AWG
	3.8	16AWG	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	12AWG	12AWG	12AWG	10AWG
	4.6	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	12AWG	12AWG	12AWG	10AWG	10AWG
	4.7	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	14AWG	12AWG	12AWG	12AWG	10AWG	10AWG
	4.9	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	12AWG	12AWG	12AWG	12AWG	10AWG	10AWG

DISTANCE IN FEET		10	25	50	75	100	125	150	175	200	225	250	300
	5.2	16AWG	16AWG	16AWG	16AWG	14AWG	14AWG	12AWG	12AWG	12AWG	10AWG	10AWG	10AWG
	7.6	16AWG	16AWG	16AWG	14AWG	12AWG	12AWG	10AWG	10AWG	10AWG	10AWG	8AWG	8AWG
	8.6	16AWG	16AWG	16AWG	14AWG	12AWG	12AWG	10AWG	10AWG	10AWG	8AWG	8AWG	8AWG
	15.4	12AWG	12AWG	12AWG	10AWG	10AWG	8AWG	8AWG	8AWG	N/R	N/R	N/R	N/R

B.3 For power input cables, determine the total current draw of the maximum number of hoists to be run simultaneously then using the appropriate table based on the operating voltage; cross reference the length of the cable against the current draw to determine the gauge (AWG) of wire.

Table B3-1, 208 VAC 3PHASE 3% DROP

DISTANCE IN FEET		10	25	50	75	100	125	150	175	200	225	250	300
CURRENT DRAW	10	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	10AWG	10AWG	10AWG	8AWG
	15	12AWG	12AWG	12AWG	12AWG	12AWG	10AWG	10AWG	10AWG	8AWG	8AWG	8AWG	8AWG
	20	12AWG	12AWG	12AWG	12AWG	10AWG	10AWG	8AWG	8AWG	8AWG	8AWG	6AWG	6AWG
	25	10AWG	10AWG	10AWG	10AWG	10AWG	8AWG	8AWG	8AWG	6AWG	6AWG	6AWG	4AWG
	30	10AWG	10AWG	10AWG	10AWG	8AWG	8AWG	8AWG	6AWG	6AWG	6AWG	4AWG	4AWG
	35	8AWG	8AWG	8AWG	8AWG	8AWG	8AWG	6AWG	6AWG	6AWG	4AWG	4AWG	4AWG
	40	8AWG	8AWG	8AWG	8AWG	8AWG	6AWG	6AWG	6AWG	4AWG	4AWG	4AWG	2AWG
	45	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	4AWG	4AWG	4AWG	4AWG	2AWG
	50	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	4AWG	4AWG	4AWG	4AWG	2AWG	2AWG
	55	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	4AWG	4AWG	4AWG	2AWG	2AWG	2AWG
	60	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	2AWG	2AWG	2AWG	2AWG
	70	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	2AWG	2AWG	2AWG	2AWG	2/0
	80	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0
	90	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0
	100	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0
	110	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0
	120	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0
	130	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0	4/0
	140	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0	4/0
	150	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0	4/0	4/0
	160	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0	4/0	4/0
	170	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	4/0	4/0	4/0
	180	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	4/0	4/0	4/0
	190	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	4/0	4/0	4/0	4/0
	200	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM
	210	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM
	220	2/0	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	4/0	500MCM
	230	2/0	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	4/0	500MCM
	240	2/0	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM
	250	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	4/0	500MCM	500MCM
	260	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	4/0	500MCM	500MCM
	270	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM	500MCM

DISTANCE IN FEET		10	25	50	75	100	125	150	175	200	225	250	300
CURRENT DRAW	280	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM	500MCM
	290	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM	500MCM
	300	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM
	310	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM
	320	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM
	330	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM
	340	4/0	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM
	350	4/0	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM
	360	4/0	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM
	370	4/0	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM
	380	4/0	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM
	390	4/0	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM
	400	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM

NOTE: For the purposes of this document, parallel 4/0 may be substituted for 500MCM.

Table B3-2, 480 VAC 3PHASE 3% DROP

DISTANCE IN FEET		10	25	50	75	100	125	150	175	200	225	250	300
CURRENT DRAW	10	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG
	15	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	10AWG
	20	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	10AWG	10AWG	10AWG
	25	10AWG	10AWG	10AWG	10AWG	10AWG	10AWG	10AWG	10AWG	10AWG	10AWG	10AWG	8AWG
	30	10AWG	10AWG	10AWG	10AWG	10AWG	10AWG	10AWG	10AWG	10AWG	8AWG	8AWG	8AWG
	35	8AWG	8AWG	8AWG	8AWG	8AWG	8AWG	8AWG	8AWG	8AWG	8AWG	8AWG	8AWG
	40	8AWG	8AWG	8AWG	8AWG	8AWG	8AWG	8AWG	8AWG	8AWG	8AWG	8AWG	6AWG
	45	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG
	50	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG
	55	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG
	60	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG
	70	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG
	80	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG
	90	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG
	100	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG
	110	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG
	120	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG
	130	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG
	140	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG
	150	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0
	160	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0
	170	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0
	180	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0
	190	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0
	200	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0

DISTANCE IN FEET		10	25	50	75	100	125	150	175	200	225	250	300
CURRENT DRAW	210	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0
	220	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0
	230	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0
	240	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0
	250	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0
	260	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0
	270	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0
	280	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0
	290	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	4/0
	300	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	2/0	4/0
	310	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0
	320	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0
	330	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0
	340	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0
	350	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0
	360	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0
	370	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0
	380	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0
	390	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0
	400	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0

Table B3-3

120 VAC SINGLE PHASE 3% DROP

CURRENT DRAW	DISTANCE IN FEET	10	25	50	75	100	125	150	175	200	225	250	300
	10	12AWG	12AWG	12AWG	12AWG	10AWG	10AWG	8AWG	8AWG	8AWG	8AWG	6AWG	6AWG
	15	12AWG	12AWG	12AWG	10AWG	8AWG	8AWG	8AWG	6AWG	6AWG	6AWG	4AWG	4AWG
	20	12AWG	12AWG	10AWG	8AWG	8AWG	6AWG	6AWG	6AWG	4AWG	4AWG	4AWG	2AWG
	25	10AWG	10AWG	10AWG	8AWG	6AWG	6AWG	4AWG	4AWG	4AWG	4AWG	2AWG	2AWG
	30	10AWG	10AWG	8AWG	8AWG	6AWG	4AWG	4AWG	4AWG	2AWG	2AWG	2AWG	2AWG
	35	8AWG	8AWG	8AWG	6AWG	6AWG	4AWG	4AWG	2AWG	2AWG	2AWG	2AWG	2/0
	40	8AWG	8AWG	8AWG	6AWG	4AWG	4AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0
	45	6AWG	6AWG	6AWG	6AWG	4AWG	4AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0
	50	6AWG	6AWG	6AWG	4AWG	4AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0
	55	6AWG	6AWG	6AWG	4AWG	4AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0
	60	4AWG	4AWG	4AWG	4AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0
	70	4AWG	4AWG	4AWG	4AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0	4/0
	80	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0	4/0	4/0
	90	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	4/0	4/0	4/0
	100	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM
	110	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	4/0	4/0	4/0	4/0	500MCM
	120	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM
	130	2AWG	2AWG	2AWG	2/0	2/0	2/0	4/0	4/0	4/0	4/0	500MCM	500MCM
	140	2AWG	2AWG	2AWG	2/0	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM	500MCM
	150	2AWG	2AWG	2AWG	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM
	160	2AWG	2AWG	2AWG	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM
	170	2AWG	2AWG	2AWG	2/0	2/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM
	180	2AWG	2AWG	2AWG	2/0	2/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM
	190	2AWG	2AWG	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM
	200	2/0	2/0	2/0	2/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM
	210	2/0	2/0	2/0	2/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM
	220	2/0	2/0	2/0	2/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM
	230	2/0	2/0	2/0	2/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM
	240	2/0	2/0	2/0	2/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM	N/R
	250	2/0	2/0	2/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM	N/R
	260	2/0	2/0	2/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM	N/R
	270	2/0	2/0	2/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM	N/R
	280	2/0	2/0	2/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	N/R	N/R
	290	2/0	2/0	2/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	N/R	N/R
	300	2/0	2/0	2/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM	N/R	N/R
	310	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM	N/R	N/R
	320	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	N/R	N/R	N/R
	330	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	N/R	N/R	N/R
	340	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	N/R	N/R	N/R
	350	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	N/R	N/R	N/R	N/R
	360	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	N/R	N/R	N/R	N/R
	370	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	N/R	N/R	N/R	N/R
	380	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	N/R	N/R	N/R	N/R
	390	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	N/R	N/R	N/R	N/R
	400	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	N/R	N/R	N/R	N/R	N/R

NOTE: For the purposes of this document, parallel 4/0 may be substituted for 500MCM.

Table B3-4			220 VAC SINGLE PHASE 3% DROP									
DISTANCE IN FEET	10	25	50	75	100	125	150	175	200	225	250	300
CURRENT DRAW												
10	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	12AWG	10AWG	10AWG	10AWG	10AWG	8AWG
15	12AWG	12AWG	12AWG	12AWG	12AWG	10AWG	10AWG	8AWG	8AWG	8AWG	8AWG	6AWG
20	12AWG	12AWG	12AWG	12AWG	10AWG	10AWG	8AWG	8AWG	8AWG	6AWG	6AWG	6AWG
25	10AWG	10AWG	10AWG	10AWG	10AWG	8AWG	8AWG	6AWG	6AWG	6AWG	6AWG	4AWG
30	10AWG	10AWG	10AWG	10AWG	8AWG	8AWG	6AWG	6AWG	6AWG	4AWG	4AWG	4AWG
35	8AWG	8AWG	8AWG	8AWG	8AWG	6AWG	6AWG	6AWG	4AWG	4AWG	4AWG	4AWG
40	8AWG	8AWG	8AWG	8AWG	8AWG	6AWG	6AWG	4AWG	4AWG	4AWG	4AWG	2AWG
45	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	4AWG	4AWG	4AWG	4AWG	2AWG	2AWG
50	6AWG	6AWG	6AWG	6AWG	6AWG	6AWG	4AWG	4AWG	4AWG	2AWG	2AWG	2AWG
55	6AWG	6AWG	6AWG	6AWG	6AWG	4AWG	4AWG	4AWG	2AWG	2AWG	2AWG	2AWG
60	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	2AWG	2AWG	2AWG	2/0
70	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	4AWG	2AWG	2AWG	2AWG	2/0	2/0
80	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0
90	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0
100	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0
110	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0
120	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0	4/0
130	2AWG	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0	4/0
140	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	2/0	4/0	4/0
150	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	4/0	4/0	4/0
160	2AWG	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	4/0	4/0	4/0
170	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	4/0	4/0	4/0	4/0
180	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM
190	2AWG	2AWG	2AWG	2AWG	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM
200	2/0	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	4/0	500MCM
210	2/0	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	4/0	500MCM
220	2/0	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM
230	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	4/0	500MCM	500MCM
240	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM	500MCM
250	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM	500MCM
260	2/0	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM	500MCM
270	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM
280	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM
290	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM
300	2/0	2/0	2/0	2/0	2/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM
310	4/0	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM
320	4/0	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM
330	4/0	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM
340	4/0	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM
350	4/0	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM
360	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM
370	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM
380	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM
390	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM
400	4/0	4/0	4/0	4/0	4/0	4/0	500MCM	500MCM	500MCM	500MCM	500MCM	500MCM

NOTE: For the purposes of this document, parallel 4/0 may be substituted for 500MCM.