IEEE Std 499-1997
(Revision of IEEE Std 499-1989)

IEEE Recommended Practice for Cement Plant Electric Drives and Related Electrical Equipment

Sponsor

Cement Industry Committee
of the
IEEE Industry Applications Society

Approved 19 September 1997

IEEE Standards Board

Abstract: All electric drives, including motors and control wiring associated with machinery or equipment commonly used in the manufacturing areas of cement plants are covered. Recommendations are not intended to apply to power distribution circuits. These recommendations apply to electrical equipment having a supply voltage of 13 800 V or less.
Keywords: cement plant, electrical drives, practices

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Introduction

(This introduction is not a part of IEEE Std 499-1997, IEEE Recommended Practice for Cement Plant Electric Drives and Related Electrical Equipment.)

Electrical equipment is the major factor in the powering and control of cement plants. As management demands more precision for quality control, greater production capacity, and less production cost, more and more emphasis is placed on the performance of the plant's installed electrical equipment.

The Cement Industry Committee has analyzed many areas pertaining to such requirements, and through the working groups recommended practices have evolved for this industry.

The recommended practices listed herein pertain to the Drives and Related Products Working Group. This evaluation update is in a form of an agreement reached by all members of the working group and the committee in general. Certainly, specific plant conditions could and probably would alter such a recommendation in a certain area; however, in general, it is hoped the practices are a good guideline for the industry.

This recommended practice is a revision of IEEE Std 499-1989.

At the time this recommended practice was completed, the Drives and Related Products Working Group had the following membership:

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IEEE Recommended Practice for Cement Plant Electric Drives and Related Electrical Equipment

1. Overview

1.1 Scope

This recommended practice applies to all electric drives including motors, control, and control wiring associated with machinery or equipment commonly used in the manufacturing areas of cement plants. The recommendations made here are intended as a guide and may be supplemented where special needs exist. They are not intended to apply to power distribution circuits.

These recommendations apply to electrical equipment having a supply voltage of 13 800 V or less. Voltages higher than this are not covered by this recommended practice.

1.2 Purpose

The purpose of this recommended practice is to define and recommend practice for electric drives and related electrical equipment for installation in the cement industry in order to promote the following:

— Safety to personnel and equipment
— Maximum reliability with minimum loss of production
— Reduced maintenance and increased life of equipment
— Clarification of needs and conditions to reduce special engineering and chance of error in specification
— Overall economy

1.3 Use of recommendations

It is urged that users and manufacturers cooperate with the working group to help formulate recommendations that will ensure the use of proven equipment and methods. The objective is to establish recommendations that will assist in preparing specifications for electric drives for cement plant equipment and their installation.

1.4 Terminology

The following words should be used as described:

nominal. An approximate or rated value; for the purposes of this recommended practice, ±10%.

should. Used to indicate that which, at the present time, is considered a recommendation (e.g., advised but not required).

1.4.1 Special use of terms

The terms “suitable,” “adequate,” “effective,” and “securely” denote conditions determined by the user or the user’s representative after taking cognizance of all codes, standards, or practices applicable to the situation.

1.5 Drawings

Electrical drawings should be labeled in English, neat and easily readable, and properly annotated to avoid confusion in referring from one drawing to another. Graphic and terminal markings symbols should be in accordance with the standards listed in Clause 9.

Prints of electrical drawings should be made on medium-weight print paper and be of such size that they can be neatly and conveniently folded to 8 1/2 in × 11 in (21.59 × 27.94 mm) size. Elementary (or schematic) electrical diagrams should be furnished by manufacturers whenever special electrical equipment is involved, or where two or more electrical devices (other than motor and control, except direct current) are interconnected to form an electrical system. Ratings of fuses, current transformers, potential transformers, circuit breakers, etc., should be designated on the diagram.

Installation, maintenance, and operating instructions (including a detailed parts list) should be furnished by machinery manufacturers, as required by users for each piece of electrical hardware.

Designation of electrical devices and machinery should be in accordance with the standards listed in Clause 2.

1.6 Nameplates or identification plates

Permanent noncorroding plates with deeply indented or highly raised characters should be securely fixed to each electrical machine or control assembly. Devices within enclosures should likewise have permanent noncorroding nameplates, but characters need not be indented or raised as for machines and assemblies whose plates are exposed directly to the weather and indiscriminate painting. Nameplates should be securely and permanently affixed to devices. Adhesive of any type should not be used.

2. References

This recommended practice shall be used in conjunction with the following publications. It is assumed that apparatus mentioned herein shall comply with the latest edition of the National Electrical Code® (NFPA 70-1996). Cognizance of local codes must also be taken by the user to ensure that equipment involved complies therewith. Compliance with NEMA and ANSI standards is also assumed where applicable to the equipment involved. When the following standards are superseded by an approved revision, the revision shall apply.

IEEE Std 113-1985, IEEE Guide on Test Procedures for DC Machines (ANSI).[1]

IEEE 142-1991, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (ANSI).[2]

IEEE 242-1986 (Reaff 1991), IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (ANSI).

IEEE Std 277-1994, IEEE Recommended Practice for Cement Plant Power Distribution (ANSI).

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[1]IEEE Std 113-1985 has been withdrawn; however, copies can be obtained from Global Engineering, 15 Inverness Way East, Englewood, CO 80112-5704, USA, tel. (303) 792-2181.

[2]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

IEEE Std 519-1992, IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems (ANSI).

NEMA ICS 1-1993, Industrial Control and Systems: General Requirements.[3]

NEMA ICS 2-1993, Industrial Control and Systems: Controllers, Contactors and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.

NEMA ICS 3-1993, Industrial Control and Systems: Factory Built Assemblies.

NEMA ICS 6-1993, Industrial Control and Systems: Enclosures.

NEMA MG 1-1993, Motors and Generators.

NFPA 70-1996, National Electrical Code® (NEC®).[4]

3. Voltage ratings

3.1 General plant

The voltage ratings for equipment in the general plant area should be as described in 3.1.1 through 3.1.6.

3.1.1 AC motors and controllers

The voltage ratings of ac motors and controllers should be in accordance with Table 1.

Table 1—AC motor and controller voltage ratings

Distribution system nominal voltage	Motor and controller power voltage rating
13 800	13 200
6900	6600
4800	4600
4160	4000
2400	2300
600	575
480	460
240	230
208	200
120	115

[3]NEMA publications are available from the National Electrical Manufacturers Association, 1300 N. 17th St., Ste. 1847, Rosslyn, VA 22209, USA.

[4]NFPA publications are available from Publication Sales, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101, USA.

3.1.2 Portable electric shovels

The voltage rating of portable electric shovels (with ac motors driving motor generator set conversion units) should be selected to suit the available system voltage with due consideration to the possibility of long lines and cables and related large voltage drop.

3.1.3 DC motors

Typical voltage ratings now in use for dc motors supported by motor-generator sets are listed below:

120 V	10 hp (7.5 kW) maximum
240 V	15–200 hp (11–150 kW) inclusive
250 V	Motors over 200 hp (150 kW)
500 V	Motors over 200 hp (150 kW)
700 V	Very large drives

Many other voltages are used, particularly with thyristor packaged drives.

3.1.4 Field excitation

The voltage rating for field excitation of separately excited machines should be 125 V or 250 V, except when some factors of special design require other voltages to be used.

3.1.5 DC controls

The voltage rating of dc controls should be 240 V nominal, except when other plant equipment requires other voltages and coordination.

3.1.6 Surge arresters

The voltage ratings of surge arresters and their systems should be in accordance with the recommendations of IEEE Std 277-1994.[5]

3.2 Plant wiring

Interconnecting (remote) wiring at the plant site used to interconnect drives and related control apparatus should be considered as plant wiring. Plant wiring should conform to the NFPA 70-1996 and applicable local codes and should be performed in a neat and workmanlike manner with trade approved devices. A plant grounding conductor of suitable size should interconnect all electrical equipment. The ground conductor should be installed in the same conduit with the phase conductors.

3.2.1 Motor-control conductors

Conductors to motors and conductors for control wiring should be of adequate cross section to minimize voltage drops and should be stranded for flexibility. Insulation should be of approved 600 V (or higher) types capable of a maximum operating temperature of at least 75 °C except in those locations where high ambients exist, such as those encountered near a kiln or clinker cooler, where higher temperature insulation should be

[5]Information on references can be found in Clause 2.

used. Minimum conductor size should be AWG No. 12 stranded for adequate strength during installation. Where physical strength does not determine size, control wiring may be smaller, and fixed by other factors. Conductors should be legibly and permanently tagged or marked at each end. Terminating points should also be clearly identified.

3.2.1.1 High-temperature applications

Mineral insulated conductors with corrosion-resistant sheaths may be used where electric circuits are attached to a kiln shell. Mineral insulated conductors may also be used in any high-temperature application within their ratings except where flexibility is required. Applicable terminating fittings should be used with mineral insulated cable. Sheaths should not be welded or brazed directly to supporting surfaces. Cables should be rigidly supported and protected from vibration.

3.2.1.2 Low-level signal cable

Shielded single or multiconductor cable should be used for low-level signals or sensitive control circuits and should be properly supported to protect insulation and conductors. The conductors should be stranded and of a cross section suitable for the application without reference to the size indicated in 3.2.1. Insulation may be approved for 300 V for low-level signal circuits and, in addition, should be suitable for the environment. The shield should be securely grounded to the plant grounding conductor at one point only. The preferable point is at the point of termination in the central control room or electrical equipment room. Fittings used with multiconductor cables should be dust-protecting to prevent the entrance of noncombustible dust. In atmospheres heavily laden with coal dust, Class II fittings should be used.

3.2.1.3 Terminal lugs

Terminal lugs should be of, or equal to, an approved compression type, and of ample size to minimize heating. Lugs should be installed with approved tools to provide low resistance termination. All terminations should be made with lugs or other approved devices in accordance with the desires of the user. Aluminum conductors, if used, should be terminated and connected in strict accordance with manufacturers' recommendations.

3.2.1.4 Splices

Conductor splices should only be in junction boxes, not within conduit runs. Taped splices should be made with permanently flexible tape that will not support combustion.

3.2.2 Conduit

Conduit used for motor and control wiring should be of approved metallic types and should not be smaller than 3/4 in (1.91 mm) nominal size. Conduit should be protected with a corrosion resistance finish and approved for the installation. Where protected from the elements and physical damage, such as in offices, electrical metallic tubing may be used. When conduit encloses a circuit that must be shielded from external magnetic fields, the conduit should be made of paramagnetic materials and the conductors should be twisted to minimize inductance and capacitance between circuits. Flexible connections to fixed equipment, such as belt connected motors and their motor mounted devices, limit switches requiring occasional adjustment, and other equipment that may require slight movement for adjustment should be made with a dust- or liquid-tight flexible metal conduit, or both.

Conduit fittings and terminating enclosures should be metal. Conduit runs should be terminated in suitable indoor dust-tight (NEMA Type 12) or outdoor rainproof (NEMA Type 3R) or indoor and outdoor dust-tight and watertight (NEMA Type 4) metallic enclosures. Conduit bushings should be of the insulated type. Flexible metallic conduit should be suitably terminated with approved fittings to prevent the entrance of dust or moisture.

3.2.3 Plugs and receptacles

Plugs and receptacles (except for small tools in walk-in operators' panels) should be of a locking type and have a grounding pole properly connected to the driven machine. They should be rated for the application in accordance with NFPA 70-1996. The plug should contain the male prongs and be attached to the portable machine. The receptacle should have a suitable dust-tight safety cover and should be NEMA Type 12 for indoors or NEMA Type 4 for outdoors. Flexible cords should have the flexibility specified and should otherwise conform to NFPA 70-1996 and local codes where applicable. Power wiring and control wiring should not be contained in the same cord.

3.2.4 Other support

Nothing contained within this recommended practice shall be construed to prevent the use of power or control cables placed in racks or otherwise well supported as required by the application and cognizant authority. Terminal devices used therewith should also be of types to conform with the intent of this recommended practice.

Metal enclosed bus may be used, where properly selected.

4. Overcurrent and undervoltage protection

4.1 Motor branch circuit overcurrent protection

In general, motor branch circuits should be protected against overcurrent in accordance with NFPA 70-1996 and state codes for low- and medium-voltage motors. Short-circuit protection may be obtained by the use of properly selected fuses or suitable circuit breakers.

Motor branch circuit conductors should be protected in accordance with NFPA 70-1996. Due consideration is to be given to 3.2.1, when selecting motor branch circuit conductors.

4.2 Motor overload protection

4.2.1 Requirements

All motors and devices should be protected against overload by the use of devices responsive either to motor currents, or to both motor currents and motor temperature, or to motor temperature alone where such is acceptable. The minimum number of such overload protective devices should be in accordance with NFPA 70-1996.

CAUTION—Conductors, motor-control equipment, and other branch-circuit components should be selected on the basis of the most severe duty cycle rather than solely on the basis of motor-current ratings as required by NFPA 70-1996.

4.2.2 Critical motors

Critical motors should be protected against overload by the use of temperature detectors embedded in stator windings, which cause the current to the motors to be interrupted. In many cases, such use of embedded temperature detectors may supplement other forms of overload protection.

4.2.3 Locked-rotor protection

Consideration should be given to the addition of locked-rotor protection. See also 5.4.

4.3 Undervoltage protection

Undervoltage protection should be provided to disconnect all motors that may cause damage to the driven equipment or injury to the operator should the motor automatically restart on the return of power following a power interruption.

5. Control circuits

5.1 Source of control power

The source of control power for the motor-control circuit, regardless of voltage or frequency transformations between the source and the control devices, should be on the load side of the main disconnect, wherever feasible.

For maximum safety of the personnel maintaining control circuits, control circuits should be arranged for positive isolation of all sources of voltage to any compartment. Where this is clearly impracticable, specific and easily read warning signs designed in accordance with the requirements of the user should be added to that compartment.

5.2 Control voltages

Motor-control circuits should be 115 V or 230 V ac nominal grounded.

Control voltages for operation of power-circuit breakers should not exceed 230 V ac or 250 V dc nominal.

5.3 Interlocking

Where operation of equipment in improper sequence can result in a hazard to personnel or damage to equipment, sequence interlocking or other effective safeguards should be provided.

When two or more motor controllers are to be electrically interlocked, it should be done with interlocks, relays, or motion switches, so connected that there is no electric connection from the load side of one controller disconnecting device to the load side of the disconnecting device of the other controller. Solid-state devices can also perform interlocking functions when properly used.

The control supply to friction clutches, which couple motors to their loads, should be interlocked to prevent clutch engagement before motors are running at full speed or, in the case of synchronous motors, before the motor field excitation has been applied.

5.4 Control circuit overcurrent protection

5.4.1 Control circuits supplied directly from motor branch circuits

The conductors of control circuits at line voltage should be protected against overload and short circuits in accordance with NFPA 70-1996. Minimum recommended practice is that all ungrounded conductors be fused.

5.4.2 Control circuits supplied through control transformer

Each ungrounded side of control circuits fed from a control transformer should be protected by an overcurrent device of a rating suitable to protect the control circuit and transformer.

5.4.3 Control circuit devices

For the cases indicated in 5.4.1 and 5.4.2, where it is also desired to protect against failures of control circuit devices due to short circuits, the recommendations of the control device manufacturer should be obtained.

5.4.4 Clutch controls

Controls for clutches should be coordinated with those of the motors involved.

6. Motor-control equipment

6.1 General application guidelines

All motor-control equipment should be installed in accordance with the requirements of NFPA 70-1996 and local applicable codes. Motor-control equipment should be located indoors in the cleanest practical area.

6.1.1 Control enclosures

Controller enclosures should be NEMA Type 1 or equivalent in clean areas. When they are located in other areas, the enclosure should be NEMA rated for the application. They should be provided with an integral ground bus and be securely grounded to the plant ground in accordance with NFPA 70-1996, IEEE 142-1991, and local codes.

6.1.2 Terminals

Fixed terminals of adequate size and design to minimize heating should be provided for all external connections. They should be readily accessible for making connections and marked to correspond with the markings on the connection diagram. Particular care should be exercised in the application of terminals for aluminum conductors. Codes and surrounding conditions should be satisfied. This requirement should not preclude the use of NEMA Type A motor-control centers.

6.1.3 Panel-mounted control devices

Panel-mounted control devices should be easily removable for maintenance and replacement, and wired accordingly. Where equipment must be back connected, a means for access to the rear of the panel should be provided without removal of the panel from the enclosure. Devices should also be plainly marked with manufacturer’s name, data, and specifications for easy identification. Miniature devices may be permanently marked with a code keyed to a suitable set of specifications. Similar devices housed inside the same enclosure should be marked twice: on their bodies and immediately adjacent to the devices on any part of construction. This is necessary to avoid confusion during replacement.

6.1.4 Controller-connection diagram

A controller-connection diagram showing panel wiring, line, load, and control connections with identifying numbers should be provided with each motor controller. The diagram, where practicable, should be secured to the inside of the controller or placed in a suitable metal pocket.

6.1.5 Documentation for maintenance

The user should also place a copy of the interconnection and elementary diagrams, which show connections to all related motors, control stations, limit switches, and other auxiliary equipment, where readily available to personnel working on the equipment.

6.1.6 Controller physical arrangement

Motor controllers located in motor-control centers should be grouped by departments and by the user in such a way that maintenance and repair of the assembly can be facilitated by de-energizing the motor-control center without affecting the operation of other departments in the cement plant that are or could be in operation at the time.

6.1.7 Frequency of starting

Controllers for large drives or those involving high inertia loads should protect motors from starting too frequently.

6.1.8 Short circuit and fault protection

Controllers for motors should have devices rated to handle short circuits and ground faults and should fully protect the powered machines.

6.1.9 Overcurrent protection

Three overcurrent devices are required for running overcurrent protection of three-phase ac motors by NFPA 70-1996.

Certain widely varying motor loads may require running overcurrent protection to be determined by motor temperature.

6.1.10 Personnel safety

Those interlocking contacts in a controller that may remain energized from another source when the controller is de-energized by its disconnecting device should at least be suitably marked as required by the user to warn personnel of possible hazards. However, all sources of power in the controller should be provided with a means of disconnection. See NFPA 70-1996, Section 430.

6.2 AC manual starters—600 V or less

6.2.1 Lockable disconnecting means

The starter should have an external operating handle with provision for locking in the off position unless an individual disconnecting means is provided for each motor starter. Devices operated by the operating handle should be sturdily constructed to eliminate accidental breakage through use or installation.

6.2.2 Thermal-overload protection

The starter should provide thermal-overload protection unless equivalent protection is provided elsewhere in the motor circuit. In this connection refer to 4.2.1.

6.2.3 Manual controllers

In general, the use of manual controllers is to be discouraged except for unusual drives of low horsepower.

6.3 AC magnetic controllers—600 V or less

6.3.1 AC magnetic controllers

AC magnetic controllers should be of the combination type, having a disconnecting device and controller in a common enclosure. The disconnecting device should have an external operating handle mechanically interlocked so that the enclosure door can be opened only when the disconnecting device is in the off position. Means should be provided for locking the handle in the off position. The disconnecting device may be a fusible motor circuit switch or circuit breaker. If a circuit breaker is used, it should have magnetic trip only. A non-fusible motor-circuit switch may be used where other short circuit protection has been provided. Devices operated by the external handle should be of sturdy construction to minimize breakage through use or installation.

6.3.2 Overload protection

The controller should provide overload protection for each motor, preferably by means of a manually reset thermal overload relay. Automatic reset is not recommended for cement plants and should be used only in conjunction with control equipment preventing start-up of the drive in case of thermal trip. When motor overloads are determined by motor temperatures, devices in their controllers, which are affected by currents in excess of motor nameplate ratings, should be coordinated with those motors. See 4.2.1.

6.3.3 Personnel safety

With the incoming power-line disconnecting means open, there should be no live parts exposed to accidental personal contact. This, in effect, may require a nonconductive or dead cover over the input terminals (and switch parts if switch is used) of the disconnecting means. See also 6.1.10.

6.3.4 Ground-fault protection

Control equipment may require sensitive ground-fault protection for selectivity.

6.4 Medium-voltage ac magnetic controllers

6.4.1 Magnetic controllers

Medium-voltage ac magnetic controllers should be of the combination type with isolating means (such as a disconnect switch or drawout mechanism), power fuses, magnetic contactors, and associated control devices in compartments suitably segregated according to voltage levels.

This does not preclude the occasional use of magnetic contactors or circuit breakers whose short-circuit capacities are adequate for the power system to which they are connected and in which power fuses are not required.

Power systems designed in accordance with IEEE Std 277-1994 will have ground-fault currents intentionally limited and suitable means should be provided to detect these currents and cause the motors to be de-energized.

6.4.2 Bus design

Power buses, if specified, should be located in an isolated compartment or area of the controller. Bus insulators should be of non-tracking material.

6.4.3 Disconnecting means

The isolating means (such as disconnect switch, circuit breaker, or drawout mechanism) should be externally operable and arranged with mechanical and electrical interlocking so that access to the associated high-voltage compartment or compartments is prevented, except when the controller is de-energized. With the isolating means in the open position, visible indication that the circuit is open and physically disconnected from the power source should be provided. The visible indication may be obtained with the door open, if required.

Provisions should be included for padlocking the isolating means in the open position with the compartment door either open or closed.

6.4.4 Fuse rating

The fused interrupting rating of these controllers should be at least 250 000 kVA at 2300 V, and 350 000 kVA at 4000 V and 4600 V (NEMA Class E2), and 500 000 kVA at 7200 V.

6.4.5 Construction

The main magnetic contactors should not be mechanically latched in the closed position. They should be removable (or drawout) or otherwise readily accessible for inspection and maintenance.

6.4.6 Low-voltage compartment

The low-voltage compartment should be accessible for maintenance and inspection of all wiring.

6.4.7 AC control power

AC control power should be supplied by a control transformer in each controller or for a group of controllers that are housed in the same enclosure. Wherever feasible, the primary of the transformer should be connected to the load side of the main isolating means through at least separate current-limiting fuses. The secondary should be 115 V or 230 V nominal grounded.

6.4.8 DC control power

When dc control power is required, it should be supplied through a disconnecting means furnished as a part of the controller.

6.4.9 Interrupting rating

When interrupting ratings in excess of those indicated in 6.4.4 are required, or circuit breakers are substituted for the contactors and current-limiting fuses or both occur, application should be in accordance with the applicable standards in Clause 2. Particular consideration should be given to the method of supplying control power for closing and tripping circuit breakers that are used for remote or automatic motor control, or both. Power should be available to trip the breaker under fault conditions. Generally, station batteries should be considered as the best source of tripping power, especially when a large number of circuit breakers can be served by one set of batteries.

6.4.10 Equipment protection

The control should include the basic features of undervoltage and overcurrent protection. In addition, consideration should also be given to:

- Locked-rotor protection
- Stall protection
- Overtemperature protection, using devices in the motor such as resistance temperature detectors, thermistors, and thermostats
- Differential protection for large or critical motors
- Phase-sequence protection
- Unbalanced-voltage protection
- Current balance
- High-speed protection against out-of-phase restoration of voltage. (This is usually accomplished by high-speed underfrequency and instantaneous undervoltage relays.)
- Ground-fault protection
- Anti-jog devices for larger motors

6.4.11 Synchronous motors

Synchronous motors, in addition to the considerations of 6.4.10, should have field application and field removal equipment. Adequate field discharge provisions are also necessary. Relaying indicating the loss of field should supplement the field removal logic. It is usually not desirable to automatically resynchronize if the field is removed due to motor pull-out. Exciters may be designed for adjustment while running, and are usually furnished with the overall motor control.

6.4.12 Wound-rotor motors

Wound-rotor motors need, in general, the same sorts of stator protection as in 6.4.10. In addition, some other features should be considered.

6.4.12.1 Incomplete sequence protection

Incomplete sequence protection should be provided to trip the primary starter if the secondary starting sequence is not completed in a preset time.

6.4.12.2 Stall protection

Stalls can occur, either as failure to accelerate or as a sudden stop. Logic, involving a speed switch and a timer, can be used to protect the motor against resultant thermal damage.

6.4.12.3 Secondary circuits

Secondary circuits may develop ground faults, which can be resistor limited and instantly detected. Secondary current unbalance is not necessarily sensed by primary relays, and may require separate relaying.

6.4.13 Lockout relays

Lockout relays are effective in guarding against operator reclosing before the fault condition is diagnosed and corrected.

6.4.14 Problem diagnosis

When troubles occur, diagnosis is aided by the proper use of relay targets, indicating lights, etc.

6.5 DC power supplies

6.5.1 Static power supplies

Static power supplies for drive motors should be located in a clean, well-ventilated area. The power supplies should be provided with adequate heat dissipating means, readily accessible for maintenance. Heating may be required to ensure proper firing under near freezing conditions. Since semiconductor devices have low inherent overload capacity, static power supplies should be designed to accommodate all operating conditions.

Static power converters, (ac to dc or ac to ac) should be designed to maintain desired output under varying input conditions. However, the input conditions should be defined for proper design.

It is recommended that ac or dc ground faults anywhere in the drive be limited to minimize damage. Such faults should cause instantaneous trip and lockout of the source power supply.

Criteria for selecting ground relaying should also include: operating speed range, possible leakage and capacitive currents that should not cause tripping, and sensitivity to faults significantly less than the theoretical maximum.

Solid-state devices in the power supply should be provided with adequate transient voltage suppression.

6.5.2 Control features

Although dc drives will maintain set speed fairly well without tachometer feedback, it is very common to use tachometers and accurate speed regulators. Other commonly required control features include the following:

— Protection against field loss, overspeed, overload, instantaneous overcurrent, and phase balance
— Gasketed enclosure for regulators
— Motor heating during shutdown (to minimize moisture in the motor) by reduced field current (field economy)
— Set point from process instrumentation
— Current transducer to isolate current signal
— Automatic current limit and field voltage to compensate for changes in field winding resistance
— Timed acceleration and deceleration adjustment
— Diagnostic aids
— Operating controls and instruments as needed

6.5.3 Harmonics

Harmonics appear in the dc output, and the motor should be designed with this in mind. Harmonics also appear in the ac source, and hence become a power system consideration; for more on this subject, see Clause 4 of IEEE Std 277-1994, NEMA MG 1-1993, IEEE Std 113-1985, and IEEE Std 519-1992.

6.6 Operator's panels or control cubicles (other than motor control)

6.6.1 Enclosures

Enclosures for operator's panels in clean areas may be NEMA Type 1. Panels exposed to plant atmosphere should be designed for the service and may be tightly enclosed or pressured with clean, dry air.

6.6.2 Walk-in enclosures

Walk-in types of operator's panels should have rear-of-board covers over devices having live terminals at a potential of 50 V or more, unless features of panel construction prevent accidental contact by personnel.

Adequate interior lighting and plug-in receptacles with grounding terminals for small tools should be provided.

6.6.3 Control-circuit protection

Low-voltage (115 V, 230 V nominal or below) control circuits for interlocking relays and devices, other than motor pilot or metering devices, mounted on the panel and supplied from internal source of control power should be protected by a circuit breaker or fusible switch.

6.6.4 Pilot devices

Push button stations, selector switches, and control switches should at least be the equivalent of the NEMA oil-tight heavy-duty type when exposed to process environment.

6.6.5 Stop buttons

Stop push buttons should be clearly identified. Lockout stop buttons should not be used.

6.6.6 Control panel layout

Operator's panels and control stations should be so designed that all push buttons and switches are easily visible and within easy reach of the operator.

6.6.7 Vibration isolation

Operator's panels containing electronic components, particularly on the burner floor, should be cushioned to minimize vibration and installed in such a manner to maintain their internal temperatures as low as feasible.

6.6.8 Terminations

Wiring should be terminated at fixed well-marked terminal blocks. Each end of interconnecting wiring should be plainly marked with firmly affixed indelible markers, sleeves, or tags. For multiconductor cables, the wire colors should be described in cabling documents or drawings. Wiring to devices mounted on hinged doors should be terminated on terminal blocks adjacent to the door and be at least as flexible as AWG No. 14 wire with 41 strands. Interconnecting control wiring inside panels, except for multiconductor cables or wiring in instruments or electronic assemblies, should not be smaller than AWG No. 14. Approved 600 V minimum insulation should be used. Wiring should be supported by harnessing, or in raceways, and fastened to structural members. Raceway material should not support combustion.

6.6.9 Instrumentation

Electrical instruments mounted remotely from their sources of power should, whenever possible, have their energizing circuits protected from overloads at their origin.

6.6.9.1 Instrumentation circuit designs

Where high accuracies (1% or better) are required for metering units such as watts and vars, it is important to give consideration to burdens to the current transformers imposed by leads and meters. It is also important to give attention in the application to the current transformer ratio, its capacity, and phase angle error (IEEE 242-1986).

6.6.9.2 Instrumentation protection

Voltmeters, frequency meters and the voltage-actuated portions of wattmeters, varmeters, and power-factor meters mounted remotely should have their energizing circuits protected by fuses or circuit breakers at their sources.

6.6.9.3 Meter protection

Remote meter movements responsive to dc at nominal potentials of 250 V dc or less should be fed by circuits with fuse protection located in the same enclosures with their shunts.

6.6.9.4 Meter isolation

Remote meter movements responsive to dc at nominal potentials greater than 250 V dc should be fed from circuits energized from transducers and one side of the circuit should be grounded. This isolation feature may also be desirable in other cases.

6.7 Individual pilot devices, push button stations, and related devices

6.7.1 Equipment selection

All separately mounted pilot devices should contain, within their enclosures, adequate wiring space and terminals of a size suitable for connections with No. 12 conductors and, in addition, shall have adequate provisions for termination of conduit. Devices such as solenoid valves, which do not have fixed terminals should have leads which extend at least 8 in (20 cm) beyond the enclosure. Enclosures of all pilot devices should be grounded securely to the plant ground.

6.7.2 Emergency stop

Emergency-stop push buttons should be of the palm or mushroom type.

6.7.3 Position-adjustable devices

Pilot devices such as limit switches that require position adjustment should be wired with liquid-tight flexible metal conduit.

6.7.4 Installation location guidelines

Installation of pilot devices such as limit switches should be done so that accumulations of foreign materials do not ultimately prevent effective operation of such devices. Pendant devices should not be suspended by their wiring and should be securely grounded to the plant ground.

6.7.5 Construction

Pilot devices including push button or selector-switch stations should be NEMA Type 4 when located in dusty areas or outdoors. In relatively clean areas indoors NEMA Type 1 or Type 12 enclosures should be used.

7. Motors and generators

Motors and generators should meet the requirements of the applicable ANSI and NEMA standards referenced in Clause 2. A permanent metal rotation arrow should be affixed to each motor sensitive to rotational direction. Frames of all motors and generators should be securely grounded to the plant grounding system in accordance with NFPA 70-1996 and applicable local codes.

7.1 Enclosures—General

The proper motor enclosure for any given application is dictated by the conditions under which it must operate and by any plant standards.

Conduit boxes should be large enough to facilitate connections to incoming conductors, including stress cones when used, and should be gasketed to prevent the entrance of dust or moisture, or both.

7.1.1 AC squirrel-cage motors

Open drip-proof motors will give satisfactory service and reasonable life expectancy in many locations. Where abrasive dusts (such as clinker dust), extreme quantities of any dust, moisture (from either condensation or precipitation), corrosive salts, or sprays, airborne slurries, etc., exist by themselves or in combination, a particular motor may require special enclosures. These enclosures may be totally enclosed fan-cooled, with space heaters, extra corrosive resistant treatments, special insulations, better bearing seals, or other suitable provisions, or all of these, to ensure reasonable life expectancy and maintenance costs. For motors rated over approximately 75 hp (55 kW) individual examination of the particular application factors pertaining to the specific drive motor should be made to determine if totally enclosed fan-cooled construction or if some form of open motor with perhaps some special features is desirable. Consideration should also be given to providing an enclosure and a separate cooling system to supply an adequate quantity of filtered cooling air where exposed to detrimental environments.

7.1.2 Other rotating equipment

Enclosures for commutators, slip rings, etc., may present special problems in certain areas. The most practical enclosures should be selected based on all factors. Particular attention should be given to magnetic friction-type clutches.

7.2 Shaft extensions

In most cases, economic advantages to the cement manufacturer will result from interchangeability and number of spare machines carried in stock by specifying all ac motors [100 hp (75 kW) or less] with driving shaft extensions either all long or all short.

7.3 Bearings

It is generally desirable to select the type of bearing whose housing can be most easily maintained and sealed from contaminating atmospheres. Housings for antifriction bearings are usually best in this respect and should generally be used. In addition, antifriction bearings that are usually grease-lubricated will withstand reasonable thrust loads continuously and will carry radial thrust in any direction. From a practical standpoint, however, extremely high-speed applications may limit their use, as may also their use for machines delivering more than 1 hp/(r/min) [750 W/(r/min)]. Each of the latter cases should be carefully examined on its own merits.

Sleeve-bearing motors should be connected to their driven machine by means that avoid transfer of forces to motor bearings with limited thrust capacity. Limited end float couplings are frequently used.

Installations of belt pulleys or chain sprockets on driving shafts should be as close to bearings as possible so as to minimize overhung loads on bearings and shafts.

7.3.1 Clutches

Clutches which may cause an injurious eccentric force to be exerted on motor bearings or on those of the driven machine should be equipped with pilot bearings. Motor and driven shafts should be maintained in accurate alignment to prevent excessive loading of the clutch pilot bearings.

7.3.2 Slip-type couplings

Bearings of slip-type couplings, including eddy-current couplings, should be in well-sealed housings and arranged for positive lubrication in the field. They should also be of an antifriction type most suitable for the application. Bearings with sealed-in lubricant have generally proved short lived due to the relatively high temperatures usually encountered in air-cooled couplings used in cement plants. High-temperature lubricant should be used.

7.3.3 Bearing electrical insulation

Where one bearing of a large machine is insulated to eliminate shaft currents, care should be exercised during the installation of equipment so that no parallel path is created which could by-pass this insulation.

7.4 Adjustable speed

Many drives, such as kilns and feeders, require speed control. Others, such as fans, find it economical to use speed control as an energy saving measure.

7.4.1 Speed control alternatives

Some of the available choices are:

- DC motors supplied by power supplies based on controlled semiconductor switches
- AC squirrel-cage motors supplied by adjustable frequency power supplies based on controlled semiconductor switches
- Energy recovery systems, in which slip energy from wound-rotor motors is converted to 60 Hz
- Synchronous motors supplied by adjustable frequency power supplies on base of controlled semiconductor switches

The above are relatively efficient drives, and are listed approximately in order of years of experience. Also available are hydraulic couplings and wound-rotor motors without slip energy recovery. The losses in these become greater as speed is reduced.

7.4.2 Adjustable speed drive selection

In selecting a drive, it is important to define more than what is needed for a constant speed drive. Added considerations are: speed range and speed torque curve (approximate times at various speeds also help), evaluation of dollars per kilowatt of loss, and type of performance required. With all of these factors considered, an economic comparison becomes feasible.

7.5 Efficiency

Efficiency should be considered in all drive selections. The possible use of high-efficiency type motors should be included when making comparisons. For convenience in comparisons, it is common to lump many factors (cost per kilowatt hour, hours per year, financial payback, etc.) into a single figure of dollars per kilowatt of loss. Methods are also available to estimate total cost of owning and operating a motor over its anticipated life. The calculation and definition of efficiency can differ among suppliers; it is therefore recommended that appropriate NEMA standards be used to define efficiency values.

7.6 Service-factor

To get more than rated capability, 1.15 service-factor is often specified. The extra capability is not 15% however, because standards establish higher insulation temperature at 1.15 load. For the same temperatures, the 1.15 service-factor motor will usually allow an increase in load of a little less than 10%. Torques are expressed with respect to the 1.0 per unit torque on the motor base horsepower, even in a 1.15 service-factor motor.

7.7 Power factor (PF)

Power factor (PF) is normally a system consideration, but a few factors pertinent to cement plants often point to the choice of 0.8 PF (lead) rather than 1.0 PF synchronous motors.

7.7.1 High pull-out torque

If high pull-out torque is needed, 0.8 PF may be economical.

7.7.2 Synchronous motors for PF correction

If many rectifiers are in the plant, synchronous motors for PF correction can be used rather than capacitors to minimize concerns over harmonics. See IEEE Std 519-1992.

7.7.3 PF correction capacitors

Capacitors may be switched with induction motors, but values beyond the recommended limit can result in transient torques. Capacitors should not be switched with induction motors connected to high inertia unless by a separate contactor. This practice should be employed to avoid potential damaging torque’s if momentary interruption and reconnection occurs.

7.8 Torsional vibrations

To reduce the possibility of excessive gear and coupling wear, it is possible to analyze the electromechanical system in the design stage. The drives most likely to merit such analysis are: synchronous motors driving high inertias, wide speed range drives with high load inertia, and two-motor drives (such as large mills and kilns).

7.9 Surge protection

It is recommended practice to equip all large [700 hp (500 kW) and above] medium-voltage motors with surge protection. Smaller motors may also require such protection if they are particularly exposed. One example is a fan motor whose frame is connected to nearby high structural steel, such as a preheater tower or a stack.

7.9.1 Surge capacitor location

For surge capacitors to be effective, they should be close to the motor terminals in the motor conduit box.

7.9.2 Surge arrestors

Surge protection may also include surge arresters. Under certain conditions, arresters may be useful even though not located at the motor.

7.9.3 Additional information

For more information on surge protection see IEEE Std 277-1994.

8. Specific applications

8.1 General

This clause covers additional recommendations applicable to specific cement plant drives and supplements those previously listed.

8.2 Grinding mills

8.2.1 High-speed motor construction

Large high-speed motors should be of the open drip-proof type with bearings supported in split end shields or brackets secured to the motor frame.

8.2.2 Low-speed motor construction

Large low-speed motors should be open pedestal-type, sleeve bearing, synchronous motors complete with base and stator shift constructions. Where required, guards for personnel safety should be added. If the motor is not in a clean air environment, additional protection against dust should be considered.

8.2.3 Sleeve-bearing motors

Sleeve-bearing motors that are coupled to the pinion shaft or gear reducer of the mill should have end float limited in accordance with NEMA MG 1-1993.

8.2.4 System voltage effects on motor selection

Squirrel-cage and synchronous motors should have higher than normal starting, accelerating, pull-in, and perhaps pullout torques. The actual system voltage during the starting and accelerating period and characteristics of the mill should be considered. When clutches are used only the pullout torque need perhaps be higher than normal. With direct connected mills, net torque requirements at motor output shaft may vary from 110–150% at locked rotor, depending on the mill and design of its lubricating system; 120–130% for pull-in and 150–200% for pullout to ride through momentary undervoltages for mill drives. With clutches, locked rotor and pull-in shaft torques required are small, but pullout should be at least 175% to allow clutch to be engaged fairly rapidly without stalling the motor.

Secondary resistors for wound-rotor induction motors should be at least NEMA Class 145. Starting torque required is usually approximately 150%. Portions of the resistor used for inching or spotting should be appropriately rated.

8.2.5 Environmental considerations

Motors located in humid climates should be equipped with space heaters, preferably automatically energized when the motor is not operating.

8.2.5.1 Insulation considerations

Motors located in humid climates should have moisture-impervious insulations and mechanical parts suitably protected.

8.2.5.2 Paint

Motors located in humid climates should be painted inside and out with corrosion resisting paint.

8.2.5.3 Dusty atmospheres

Motors located in a dusty atmosphere should be provided with abrasion-protected insulation.

8.2.6 Mill inching

Slow rotation of the mill for gear inspection or angular positioning of the mill should be provided. A suitable source of low frequency applied to the armature windings of a synchronous motor with field normally excited, or by a slow-speed gear drive arranged for suitable declutching and interlocked with main drive should be used. Sleeve bearings could be affected during low speed operation, which requires consideration.

8.2.6.1 Mill positioning

Angular positioning only of the mill may be provided by a clutch between the motor shaft and pinion shaft or by position de-energization of the drive.

8.2.6.2 Separate inching drive

When slow rotation of a mill is accomplished by clutch coupling to a reduction gear and relatively small motor, the clutch must be of a design that reliably and completely disengages when the main drive is energized. The clutch should also be interlocked to prevent overspeeding under normal operation or on mill rollback when the small motor is de-energized.

8.2.7 Metering

Minimum metering should include ac ammeter and wattmeter, plus dc ammeter for synchronous motors.

8.2.8 Synchronous motor controls

Controls for synchronous motor grinding mill drives should be designed to de-energize their motors and not to provide for re-synchronization when their protective devices function.

8.3 Kiln drives

8.3.1 Kiln power supplies

Motor-generator sets provide good characteristics, but have been replaced by static power supplies.

8.3.2 Kiln-drive motors

The kiln-drive motor(s) should be of antifriction bearing construction suitable for operation in a maximum ambient of 50 °C when the average plant ambient does not exceed 40 °C. Higher plant ambients may require correspondingly higher temperature rated kiln-drive motors. The minimum continuous operating speed ranges should be 3 to 1, with a minimum starting torque of 200% based on full load torque. Wider speed range and more torque are frequently specified. Since dc motors are sensitive to moisture and dust, enclosures should be selected to suit ambient conditions.

The use of other than dc drives is not precluded.

8.3.2.1 Overspeed protection

Protection against overspeeding the kiln motor(s) upon de-energizing should be provided when necessary. This protection should include loss of field and control of rollback.

8.3.2.2 Kiln-emergency drive

Kiln-emergency drives comprising small gear reducers and motors coupled to the main kiln drive through clutches should be arranged so that overspeeding of the emergency drive cannot occur. Clutches without pilot bearings and with positive separation when disengaged are recommended. Complete enclosures for these clutches are also recommended. When the emergency drive clutch is engaged, the main drive motor(s) should be effectively interlocked to prevent its operation.

8.3.2.3 Bearing protection

Since kiln-drive motors are mounted on an axial slope, special care should be exercised to provide adequate bearing protection. Water running along the shaft should be prevented from entering the motor.

8.4 Feeder drives

8.4.1 Motors driving feeders

Motors driving feeders should be at least drip-proof with well-sealed antifriction bearings. Dry feeder-drive motors, usually located in dusty atmospheres, should have well protected antifriction bearings and should have enclosures as the location and ambient conditions require. Each installation should be carefully analyzed to determine the proper temperature rating for feeder motors.

Eddy-current couplings used for adjustable-speed feeder drives should have enclosures compatible with those of their driving motors. Torque output capability at 100% slip should be ample to start the feeder chosen for the installation. At all slips less than 100%, torque capability should not be less than 100% of motor rating. Feeder drives may need high starting torque. Adjustable speed motors may have to be designed for rated torque at low speeds. This may require external forced cooling equipment.

8.4.2 Kiln feed—Speed control

Proportionality between kiln speeds and feeder speeds is usually desired. The feeder design should be such that the raw material fed to the kiln is of correct weight and density for each speed of the kiln. When using this method of proportionality control, the feeder speed is usually designed to vary either in an exact ratio to the kiln speed or some intentionally modified ratio exactly predetermined and followed. Controls for kiln feeders should permit the feeder to be run for maintenance regardless of whether the kiln is running. In addition, the feeder should be arranged to be started or stopped when the kiln is running.

8.4.3 Grinding department

In the grinding department the control of material feeds should be stepless. Where changes in feed rates are accomplished by changes in motor speeds the incremental adjustments of speed should be as small as possible.

8.4.4 Coal feeders

Increments of change in the feeding of coal for combustion should be as small as possible, especially for adequate firing of kilns.

Motors which are located in atmospheres heavily laden with coal dust may require dust-ignition proof enclosures, depending on local conditions.

8.4.5 Crusher feeders

Fineness of control of feed rates to crushers is usually a much less rigorous requirement than for feeds to other machines. Each application should be considered individually to determine the purpose for which it is desirable to control the feed.

8.5 Crusher drives

8.5.1 General

Each crusher installation requires thorough investigation and analysis. In addition to consideration of the drive requirements of the particular type of crusher to be used, the selection of the proper motor and control should also be based on the available system to supply the drive motor, to ensure that adequate torques and voltages are available for starting as well as running. Care should be exercised to prevent too frequent starting of the drive for its available thermal capability.

8.5.1.1 Motor enclosures

Drip-proof enclosures with sleeve or antifriction bearings, have, in most instances, proved adequate. Each installation should be carefully considered as to ambient conditions, however, to be sure of providing the proper enclosure for the drive motor. Atmospheres densely laden with dust require well-sealed antifriction bearings, special attention to insulation, and, if present, slip rings.

8.5.1.2 Torques

Motors should have adequate torque and thermal capacity to start and accelerate the crusher. Where high inertias are involved, the purchaser should advise the motor manufacturer of the inertia referred to the motor shaft to ensure adequate thermal capacity being provided in the motor. Synchronous motor pullout torques should be selected to match crusher requirements. For crushers whose torque requirements vary widely, temperature detectors embedded in motor windings, with other overload protection (if desired), should be used for this application. Particular attention should be given to the selection of drives for crushers subject to jamming that may require increased breakdown torques. Motors may be subjected to severe abuse by some methods used to clear jams. A speed switch with stall logic is sometimes specified.

Consideration should be given to the reduction in available torque, which results from the voltage drop caused by the starting or overloading of large drives.

8.5.1.3 Clutches

Although remotely actuated clutches are not normally required for crusher drives, under certain conditions their use can be advantageous. When this application is indicated, the clutch manufacturer should be consulted for a recommendation.

8.5.2 Gyratory crushers

High starting torque squirrel-cage motors should be used for driving small gyratory crushers. Wound-rotor motors should be used on large crushers or where power systems are inadequate for full-voltage starting of large motors. All motor applications should include review of reflected inertia of the driven machine. Jogging or jammed operation should not be permitted.

8.5.3 Hammer mills

Hammer mills may require motors capable of starting high inertia loads. Motor application should be made on the basis of reflected inertia at the motor shaft. Reversing controls may be considered to obtain maximum service life from the hammers.

8.5.4 Roll and jaw crushers

Motor application should be made on the basis of reflected inertia at the motor shaft for driving roll and jaw crushers. Power system capacity may dictate the use of wound-rotor motors, especially on large crushers. NEMA Design D motors or motors with over 5% slip are frequently used to drive these machines.

8.6 Fan drives

8.6.1 Motors

Motors should have adequate torque and thermal capacity to accelerate the fans (with the damper position considered). It is advisable to have the damper closed prior to starting the fan. Variations in damper performance with time may require additional torque. Consideration should be given to reductions in available torque caused by voltage drops resulting from starting large drives. Fan inertia referred to the motor shaft should be supplied to the motor manufacturer by the purchaser to ensure adequate thermal capacity being provided in the motor.

Since heating during acceleration may be critical, some means of limiting the frequency of starting may be desirable.

8.6.2 Space heaters

Where humid conditions exist, space heaters should be provided for fan-drive motors with provisions in the controller for automatically energizing the heaters when the motors are not operating.

8.6.3 Adjustable-speed drives

Adjustable-speed fan drives should be carefully considered in view of the energy saved by not using damper control. Adjustable-speed fan drives can be ac-variable frequency drives, slip-recovery drives, dc drives, eddy-current couplings, or fluid couplings. The economics of energy savings will advance the use of ac- or dc-adjustable speed drives.

8.6.4 Damper actuators

Squirrel-cage motors and reduction gears are frequently used for damper operators. When so used on high-temperature applications, polyphase motors with insulations and bearings suitable for the applications should be used. Thermal insulation should be placed between gear motors and dampers. Depending on the specific applications encountered, motor brakes may be required.

8.7 Conveyor drives

8.7.1 General

Motors should be of drip-proof construction with moisture and abrasion resistant insulation and well-sealed bearings. Consideration may be given to totally enclosed motors for severe duty or standardization. Motion detectors are frequently needed.

8.7.2 Belt conveyor

Motors for small, relatively short-belt conveyors may be of the squirrel-cage type with normal starting torques for full-voltage starting. Long-belt conveyors require very careful consideration, as do those belts with large drive motors, to prevent excessive belt stresses and raising of the belt off of the idlers during starting or stopping. In general, long belts will require controlled torque acceleration and possibly will require controlled torque deceleration. In extreme cases, multiple drives, each having the proper controlled torque for acceleration, may be required. Wherever controlled torques are required, wound-rotor induction motors, squirrel-cage motors driving through adjustable slip couplings or thyristor-type soft-start controllers should be used.

Inclined belt conveyors should be equipped with means to prevent reversal of the belt when the motor is de-energized. Additional mechanical means may be employed on the head pulley shaft to prevent reversal should the drive be removed for maintenance.

8.7.3 Drag and screw conveyors

High starting torque squirrel-cage motors should be used on these conveyors, unless unusual conditions indicate otherwise.

8.7.4 Bucket elevators

Squirrel-cage motors with high starting torques should be used on bucket elevators. Motor-mounted brakes or backstops should be used where the elevator may reverse direction when the motor is de-energized.

8.7.5 Vibrating pan conveyors

Design B, normal torque, squirrel-cage motors with full-voltage starting should be used on vibrating pan conveyors. Certain so-called resonant frequency conveyors using springs may require Design C, high-torque motors to initially compress the springs to start. Motors should be totally enclosed or specially protected against extreme abrasive dust conditions.

8.8 Clinker coolers

Clinker coolers should have drives in accordance with the cooler manufacturer's recommendations. In the case of rotary coolers, NEMA Design C, squirrel-cage motors should be considered. Totally enclosed construction should be employed where the motor is exposed to high concentrations of clinker dust. Where speed adjustability is required, torque output capabilities should be carefully considered from the minimum to the maximum output speed. Cooler drives, which require speed adjustability, may either be of the dc type or ac variable frequency type.

8.9 Coal mills

8.9.1 Motor selection

Coal mills are of several different types of construction. Some applications require high starting torque motors because of the requirement for starting when loaded. In most installations squirrel-cage induction motors should be used. Well-sealed antifriction bearings should be used. In humid climates, where dust prevails, consideration should be given to totally enclosed fan-cooled construction.

8.9.1.1 Controls

Controls should be interlocked with the mill feeder to prevent flooding the mill with coal when stopped.

8.9.2 Frequent starts

Coal-mill motors should be provided with protection against overheating due to too frequent starts.

8.9.3 Slip-type couplings

Slip-type couplings used to drive coal mills should be capable of transmitting at least 200% torque at 100% slip and should also have torque output capabilities of at least 100% motor torque at all lesser values of slip.

8.9.4 Explosion hazard

Motors used in coal preparation areas may require dust-ignition proof enclosures, depending on local conditions.

8.10 Storage cranes

8.10.1 Motors

Motors should be totally enclosed and equipped with antifriction bearing with windings braced for reversing plugging service. The frame size should be established not only from the horse power rating, speed, and type of enclosure, but also from the rms power required for the crane motion. Wound-rotor motors should be used for ac-powered cranes.

8.10.2 Brakes

8.10.2.1 General

Brakes should be designed with a minimum of simple adjustments. Parts should be easily accessible for replacement. Dry lubricants are recommended. Wheels should be an alloy cast iron (premium wheels should be deep carburized cast steel).

8.10.2.2 Brake application

Brakes should be sized to provide the torque for arresting motion and to provide the energy absorbing capacity. The holding and closing motions should have magnet brakes with a minimum torque rating of 200% of full-load motor torque. Through 75 hp (55kW), one brake is sufficient; with larger motors, two 100% torque brakes are recommended. The trolley drive should have a magnet brake sized at 200% of full-load motor torque, but capable of a reduced torque setting of 100% full-load motor torque. The bridge should have a 200% full-load motor torque hydraulic brake for service stopping. Brakes should be arranged for fail safe operation.

8.10.3 Controllers

Controllers should be of the static stepless type to provide controlled acceleration and deceleration. Two control stick operating mechanisms should be furnished, allowing control of the holding and closing motions with one hand and the bridge and trolley motions with the other hand. Enclosures should conform to 5.1.1, except the grounding should minimally be effected through the crane structure to the rails. Consideration may be given to the use of NEMA Type 1 gasketed enclosures pressurized with filtered air.

8.10.4 Resistors

Resistors should be of the nonbreakable corrosion resisting type, edgewound, or stamped steel. Resistors should be designed for the electrical equipment duty cycle, but not less than Class 160 series (15 s on, 30 s off).

8.10.5 Limit switch

A limit switch should be provided to prevent overtravel of the bucket in the hoisting direction. It should be of the power circuit type. A slowdown limit switch should be provided for hoisting speeds in excess of 200 ft/min (1 m/s).

8.10.6 Conductor systems

The conductor systems should be horizontally and vertically aligned with the crane rails. Festooned cables, eliminating the conductor collector arrangement, are recommended.

8.11 Stacker-reclaimers

8.11.1 Application

Storage cranes are almost entirely replaced by stacker-reclaimers in modern practice.

8.11.2 Characteristics

By and large, the drives are relatively small, and supplied by the mechanical vendor as part of the package. A variety of system designs can be proposed; normal factors such as enclosures, maintainability, ambient temperature, etc., should be considered.

8.12 Vibrating screens

8.12.1 General

Motors should be applied using the same considerations as for conveyor drives.

8.12.2 Vibrating screens with integral motors

Although more economical in installed first cost, this type of screen drive should generally be discouraged in the cement industry. The vibratory acceleration of the screen (approximately 5 times that of gravity) will, of necessity, increase bearing maintenance.

8.12.3 Vibrating screens with separate motors

This drive is more suitable for the cement industry since the motor does not vibrate with the screen.

8.12.4 Controls

Some screens that have high amplitudes of oscillation when coasting through their critical speeds, may require braking to a stop.

9. Bibliography

When the following standards are superseded by an approved revision, the revision shall apply:

[B1] ANSI C37.6-1971 (Reaff 1976), American National Standard Schedules for Preferred Ratings for AC High-Voltage Circuit Breakers Rated on a Total Current Basis.

[B2] ANSI C37.11-1979, American National Standard Requirements for Electrical Control for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis and a Total Current Basis.

[B3] ANSI C39.1-1981 (Reaff 1992), American National Standard Requirements for Electrical Analog Indicating Instruments.

[B4] ANSI C50.10-1990, American National Standard for Rotating Electrical Machinery – Synchronous Machines.

[B5] ANSI C50.13-1989, American National Standard for Rotating Machinery – Cylindrical Rotor Synchronous Generators.

[B6] ANSI C84.1-1995, American National Standard for Electric Power Systems and Equipment – Voltage Ratings (60 Hertz).

[B7] ANSI Y14.15-1966 (Reaff 1988), American National Standard for Electrical and Electronics Diagrams.

[B8] ANSI/ASME Y1.1-1989, Abbreviations for Use on Drawings and in Text.

[B9] IEEE Std 100-1996, IEEE Standard Dictionary of Electrical and Electronics Terms.

[B10] IEEE Std 315-1975 (Reaff 1989), IEEE Standard Graphic Symbols for Electrical and Electronics Diagrams (ANSI/DoD/CSA).

[B11] IEEE C37.04-1979 (Reaff 1988), IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis (ANSI/DoD).

[B12] IEEE C37.20.1-1993, IEEE Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.

[B13] IEEE C37.20.2-1993, IEEE Standard for Metal-Clad and Station-Type Cubicle Switchgear (ANSI).

[B14] IEEE C37.20.2b-1994, Supplement to IEEE Standard for Metal-Clad and Station-Type Cubicle Switchgear: Current Transformer Accuracies.

[B15] IEEE C37.20.3-1987 (Reaff 1992), IEEE Standard for Metal-Enclosed Interrupter Switchgear (ANSI).

[B16] NEMA EI 21.1-1993, Instrument Transformers for Revenue Metering (110 kV BIL and less).

[B17] NEMA EI 21.2-1991, Instrument Transformers for Revenue Metering (125 kV BIL through 350 kV BIL).

[B18] NEMA KS 1-1996, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

[B19] NEMA SG 3-1995, Low Voltage Power Circuit Breakers.

[B20] NEMA SG 4-1990, Alternating Current High Voltage Circuit Breaker.

[B21] NEMA SG 5-1995, Power Switchgear Assemblies.

[B22] NEMA WC 30-1976, Color Coding of Wires and Cables.