METROLINX

# Motor Starters and Contactors Specification

Specification 26 29 10

Revision 01
Date: March 2023

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an Agency of the Government of Ontario

## Amendment Record Sheet

| Amendment in Clause No. | Date of Amendment | Description of Changes |
|---|---|---|
| Cover page | March 2023 | Removed 'Capital Projects Group' |
| 1.2.3, 1.3.2, 2.5 | March 2023 | Added 'the latest version of' and Updated numbering on Identification and Nomenclature specification |

## LIST OF CONTENT

# 1. GENERAL

## 1.1. SCOPE OF WORK

1.1.1. Labor, Products, equipment, tools, supervision and services necessary for motor starters Work in accordance with the Contract Documents.

## 1.2. DESIGN REQUIREMENT

1.2.1. The equipment furnished and the equipment installation, wiring methods and materials used shall conform to the latest edition of the Ontario Electrical Safety Code, Electrical Safety Authority (ESA) Bulletins and Supplements issued by the Electrical Safety Authority, and the applicable Metrolinx Standards. In case of any conflicts, the more stringent requirement shall apply.

1.2.2. Design Electrical equipment and systems to all applicable standards of CSA, ULC IEEE, ESA.

1.2.3. Design electrical equipment and systems to the latest version of GO DRM.

1.2.4. Design electrical equipment and systems to standards and codes to be latest editions adopted by and enforced by local authorities having jurisdiction (AHJ).

1.2.5. Design products as per item 2.1 of this section.

## 1.3. RELATE WORKS

1.3.1. Section 26 05 00 – Electrical General Requirements.

1.3.2. 26 05 53 – Electrical Identification and Nomenclature

1.3.3. Section 26 23 00 – Low Voltage Switchgear.

1.3.4. Section 26 13 26 – Metal Clad Switchgear.

1.3.5. Section 26 24 19 – Motor Control Centres.

1.3.6. Section 26 28 23 – Disconnect Switches.

1.3.7. Section 26 28 00 - Circuit Breakers and Fuses.

1.3.8. Section 25 05 10 – Building Automation System.

## 1.4. REFERENCE STANDARDS

1.4.1. Ontario Electrical Safety Code (OESC).

1.4.2. Ontario Building Code (OBC).

1.4.3. Metrolinx Standards, Drawings and Specifications.

1.4.4. GO Design Requirement Manual (DRM).

1.4.5. Metrolinx Electrical Safety Document.

1.4.6. CSA Z462, Workplace Electrical Safety.

1.4.7. CAN3 C235, Preferred Voltage Levels for AC Systems, 0 to 50,000V.

1.4.8. CAN/CSA C22.2 No. 5, Moulded Case Circuit Breakers.

1.4.9. CAN/CSA C22.2 No. 14, Industrial Control Equipment for Use in Ordinary (Non-Hazardous) Locations.

1.4.10. IEC 947 4 1, Part 4, Contactors and Motor Starters.

1.4.11. NEMA, National Electronic Manufacturers Association.

1.4.12. NEMA ICS 2-2000 (R2005), Controllers, Contactors and Overload Relays Rated 600 V.

## 1.5. SPARE PARTS

1.5.1. Spare parts for each different size and type of starter provided under Contract.

a) 3 contacts, stationary.

b) 3 contacts, movable.

c) 3 contacts, auxiliary.

d) 3 control transformers

e) 3 operating coils

f) 2 fuses.

g) 10 % indicating lamp bulbs used.

1.5.2. Maintenance Materials

a) Keys, tools, special devices, and other related maintenance materials.

## 1.6. TRAINING

1.6.1. Provide training as noted below:

a) Operation Training:

1) Allow for minimum of 2 hours of total on-Site time to train in all aspects of equipment and system(s) operation(s), per group to be trained; and

2) Schedule separate training sessions for each group on separate days.

b) Maintenance Training:

1) Site Electricians: Allow for minimum of 8 hours of total in-class and on-Site time to train in all aspects of equipment and system(s) operation(s), repair and maintenance, per group to be trained.

c) Provide training for Metrolinx maintenance personnel to depth that troubleshooting and maintenance can be carried out by Metrolinx; and

d) Training to be specific to equipment, model number, and version installed. Provide material for each participant and include record drawings and comprehensive operating and maintenance manual for equipment installed.

## 1.7. WARRANTY

1.7.1. The contractor shall provide a manufacturer warranty for the work of this section with a minimum warranty period of five years after acceptance by Metrolinx.

## 1.8. DELIVERY, STORAGE AND HANDLING

1.8.1. Deliver, store, and handle materials in accordance with manufacturer's written instructions.

1.8.2. Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.

1.8.3. Storage and Handling Requirements

a) Store materials in accordance with manufacturer's recommendations and in a clean, dry, and well-ventilated area.

b) Store and protect contactors from nicks, scratches, and blemishes.

c) Replace defective or damaged materials with new.

## 1.9. SUBMITTALS

1.9.1. Product Data Package:

a) Submit manufacturer's Product data indicating:

1) Technical data, supplemented by bulletins, component illustrations, detailed views, technical descriptions of items, and parts lists;

2) Manufacturer's instructions, printed product literature and data sheets for contactors and include product characteristics, performance criteria, physical size, finish, and limitations;

3) Performance criteria, compliance with appropriate reference standards, characteristics, limitations, and troubleshooting protocol; and

4) Product transportation, storage, handling, and installation requirements.

1.9.2. Shop Drawings Package:

a) Submit manufacturer's Shop Drawings indicating:

1) Mounting method and dimensions;

2) Starter size and type;

3) Layout of identified internal and front panel components;

4) Enclosure types;

5) Complete electrical wiring diagrams for each type and style of starter/VFD including electrical schematics and external field device interconnection;

6) Electrical wiring diagrams with clearly identified terminal numbers, to field connection, power and control devices such as motor, safety devices, remote push button station etc; and

7) PLC Ladder Logic diagram showing complete "Rung" instruction and input/output identification.

1.9.3. Commissioning Package

a) Submit the following:

1) Commissioning Plan;

2) Commissioning Procedures;

3) Certificate of Readiness; and

4) Attach completed Pre-Start Health and Safety Review Report to the Certificate of Readiness.

1.9.4. Commissioning Closeout Package

a) Submit the following:

1) Deficiency Report; and

2) Commissioning Closeout Report.

1.9.5. Training

a) Submit Training Plan, Training Course Material and Training Schedule.

1.9.6. Closeout Submittals Package

a) Submit the following for incorporation into the Operation and Maintenance:

1) Motor Starters, VFD and Control Unit:

i) Operation and maintenance data for each type and style of starter; and

ii) Equipment operation and maintenance manuals.

2) Including, but not limited to, the following:

i) Instruction books;

ii) Recommended renewal parts list; and

iii) Provide Ladder Logic (soft copy).

## 1.10. QUALITY ASSURANCE

1.10.1. Refer to Section 26 05 00.

1.10.2. Installers' qualifications: Perform work of this Section by manufacturer approved skilled, qualified, and experienced workers trained in installation of Work of this Section.

# 2. PRODUCTS

## 2.1. GENERAL

2.1.1. If more than 3 single starters are required, then a MCC shall be used to house the starters and controls.

2.1.2. Motor starters must be able to be controlled and monitored by the BAS and SCADA.

2.1.3. Motor controllers shall comply with the applicable standards codes and as shown on the Contract Documents.

2.1.4. Motor controllers shall be separately enclosed, unless part of another assembly. For installation in motor control centers, provide plug-in, draw-out type motor controllers up through NEMA size 4. NEMA size 5 and above require bolted connections.

2.1.5. Motor controllers shall be combination type, with magnetic controller and with one of the following, if required:

a) Circuit breaker;

b) Fused switch;

c) Motor circuit protector; or

d) Disconnecting means, with external operating handle with lock-open padlocking positions and ON-OFF position indicator.

2.1.6. Fuses in starters to be CSA certified Form 1, current and energy limiting type 200 kA interrupting capacity with NEMA Class "J" rejection type mountings.

2.1.7. Size fuses installed in starters or in disconnect switches used in conjunction with magnetic starters, for motor and branch circuit protection in accordance with fuse manufacturer's recommendations.

2.1.8. A control unit shall start or stop the motor via the motor starter. This control unit can consist of a Programmable Logic Controller (PLC), basic hard-wired circuitry or other means as indicated on the Contract Documents.

2.1.9. Starters feeding external circuits, exposed to lightning, shall include surge arrestor protection.

2.1.10. Starter control wiring shall be minimum, gauge 2.5 sq. mm (# 14 AWG) RW90 insulated.

## 2.2. MAGNETIC MOTOR CONTROLLERS (STARTERS)

2.2.1. Controllers shall be general-purpose, Class A magnetic controller for induction motors rated in horsepower. Minimum size shall be NEMA size 0.

2.2.2. Where combination motor controllers are used, combine the controller device and the disconnect device in a common enclosure.

2.2.3. Provide phase loss protection for each controller, with contacts to de-energize the controller upon loss of any phase.

2.2.4. Unless otherwise indicated, provide full voltage non-reversing across-the-line mechanisms for motors less than 75 HP, closed by coil action and opened by gravity. For motors 75 HP and larger, provide reduced-voltage or variable speed controllers. Equip controllers with 120 VAC coils and individual control transformer unless otherwise noted.

2.2.5. Hand Off Automatic (H-O-A) switch is required. H-O-A switch shall be operable without opening enclosure door. H-O-A switch is not required for manual motor controllers.

2.2.6. Incorporate into each control circuit a 120 V, electronic time-delay relay (ON delay), minimum adjustable range from 0.3 to 10 minutes, with transient protection. Time-delay relay is not required where H O A switch is not required.

2.2.7. Unless noted otherwise, equip each motor controller with not less than two normally open (N.O.) and two normally closed (N.C.) auxiliary contacts added as.

2.2.8. Provide green (RUN) and red (STOP) pilot lights.

2.2.9. Motor controllers incorporated within equipment assemblies shall also be designed for the specific requirements of the assemblies.

## 2.3. MAGNETIC STARTER REDUCED VOLTAGE PART WINDING

2.3.1. Two-step reduced voltage, part winding starter of size, type, rating and enclosure type as indicated, with components as follows:

a) Two-3 pole contactors;

b) Adjustable electronic timer; and

c) Six manual reset overload relays.

2.3.2. Three step reduced voltage part winding starter of size, type, rating and enclosure type as indicated, with components as follows:

a) Three-3 pole contactors;

b) One set starting resistors;

c) Six manual reset overload relays; and

d) Accessories:

1) Pushbuttons and/or selector switches and indicating lights as indicated;

2) Indicating lights: LED NEMA 12 type and color as indicated; and

3) Auxiliary control devices as indicated.

## 2.4. MAGNETIC STARTER REDUCED VOLTAGE STAR-DELTA

2.4.1. Reduced voltage star-delta closed transition starter, of size, type, rating and enclosure type as indicated, with components as follows:

a) Two-3 pole delta contactors with auxiliary relays and interlocks;

b) One-3 pole star contactor with auxiliary relay and interlocks;

c) One-3 pole transition contactor;

d) One set of transition resistors;

e) Mechanical interlock, to interlock one delta contactor and the star contactor;

f) One timing relay;

g) Three pole automatic reset overload relays; and

h) Accessories:

1) Pushbuttons and/or selector switches and indicating lights as indicated;

2) Indicating lights: LED NEMA 12 type and color as indicated; and

3) Auxiliary control devices as indicated.

## 2.5. MULTI-SPEED STARTERS

2.5.1. Two speed starters of size, type, rating and enclosure type as indicated. Starter suitable for variable torque type motor and with components as follows:

a) One-3 pole contactor for each winding for separate winding motors;

b) One-3 pole and one-5 pole contactor for each reconnectable winding for consequent pole type motors; and

c) Three overload relays with 3 heater elements and manual reset for each speed.

2.5.2. Accessories

a) Pushbuttons and/or selector switches and indicating lights as indicated.

b) Indicating lights: LED NEMA 12 type and color as indicated.

c) Auxiliary control devices as indicated.

## 2.6. VARIABLE SPEED /DRIVES MOTOR STARTERS

2.6.1. Motors shall be provided with UL Listed variable frequency drive (VFD) control systems.

2.6.2. The VFD shall have been evaluated by ULc and found acceptable for mounting in a plenum or other air handling compartment. Manufacturer shall supply a copy of the ULc plenum evaluation upon request.

2.6.3. The VFD shall be tested to UL 508C. The appropriate UL label shall be applied. VFD shall be manufactured in ISO 9001, 2000 certified facilities.

2.6.4. The VFD and any optional panels, of any type (bypass, etc.) shall be UL listed for a short circuit current rating of 100 kA and labeled with this rating.

2.6.5. The VFD shall convert incoming fixed frequency three-phase AC power into an adjustable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for the driven load and to eliminate the need for motor derating. When properly sized, the VFD shall allow the motor to produce full rated power at rated motor voltage, current, and speed without using the motor's service factor. VFDs utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.

2.6.6. All standard and optional features requested shall be included within the VFD enclosure unless otherwise specified. Drives shall be for variable torque load, unless otherwise noted.

2.6.7. The VFD shall be capable of communicating with a remote device over a communications link. Protocol shall be as per Contract Documents.

2.6.8. The VFD shall provide full motor torque at any selected frequency from 20 Hz to base speed while providing a variable torque V/Hz output at reduced speed. This is to allow driving direct drive fans without high speed derating or low speed excessive magnetization, as would occur if a constant torque V/Hz curve was used at reduced speeds. Breakaway torque of 160% shall be available.

2.6.9. The VFD shall convert three-phase, 60 Hz utility power to adjustable voltage and frequency, three-phase, AC power for step less motor speed control from 10% to 100% of the motor's 60 Hz speed. Input voltage shall be 208 or 600 Vac, three-phase.

2.6.10. The VFD power input stage shall convert three-phase AC line power to a fixed DC bus voltage. This will be accomplished with a six-pulse input design, and the input voltage rectifier shall employ a three-phase full-wave diode bridge with metal oxide varistor (MOV) three-phase protection; VFDs utilizing controlled SCR rectifiers shall not be acceptable.

2.6.11. The VFD output power shall vary frequency to the motor from 6 to 60 Hz with resultant motor speed varying at the motor nameplate rated speed, with output voltage variation from zero to motor rated voltage for optimum volts per hertz (V/Hz) ratio for pump loads.

2.6.12. Output current shall be rated intermittently at 105% of motor full load amps (FLA) for 1 minute based upon VFDs variable torque FLA rating. The output must be a voltage source type generating a sine coded PWM waveform utilizing an asynchronous carrier frequency (output transistor switching frequency is to be independent of drive output frequency). This carrier frequency shall be adjustable to minimize harmonically induced noise or vibration. The VFD selected must be able to source 90% of the motor's full load nameplate amperage (fundamental RMS) on a continuous basis, and be capable of running the motor at its nameplate RPM, voltage, current, and slip without having to utilize the service factor of the motor.

2.6.13. A programmable automatic energy optimization selection feature shall be provided standard in the VFD. This feature shall automatically and continuously monitor the motor speed and load to adjust the applied voltage to maximize energy savings.

2.6.14. VFD shall automatically boost power factor at lower speeds.

2.6.15. The VFD will be capable of running variable torque loads. In variable torque applications, the VFD shall provide a CT-start feature and be able to provide full torque at any speed up to the base speed of the motor. In either CT or VT mode, the VFD shall be able to provide its full rated output current continuously and 105% of rated current for 60 seconds.

2.6.16. An initial ramp function shall be available to provide a user selectable ramp, up to 60 seconds, for applications requiring a faster or slower ramp than the normal ramp.

2.6.17. Galvanic isolation shall be provided between the VFDs power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete digital I/O shall include additional isolation modules.

2.6.18. Switching of the input power to the VFD shall be possible without interlocks or damage to the VFD at a minimum interval of 2 minutes.

2.6.19. Switching of power on the output side between the VFD and the motor shall be possible with no limitation or damage to the VFD and shall require no additional interlocks.

2.6.20. The VFD shall have temperature-controlled cooling fans for quiet operation, minimized internal losses, and greatly increased fan life.

2.6.21. VFD shall provide full torque to the motor, given input voltage fluctuations of up to +10% to -10% of the rated input voltage (200 to 240VAC). Line frequency variation of ± 2% shall be acceptable. The VFD shall provide internal DC link reactors to minimize power line harmonics and to provide near unity power fa factor. DC Link reactor shall be installed so that power fluctuations to the DC Capacitors shall be reduced to increase Capacitor life.

2.6.22. VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD operation while reducing motor noise. VFDs with fixed carrier frequency are not acceptable.

2.6.23. All VFDs shall contain integral EMI filters to attenuate radio frequency interference conducted to the AC power line.

2.6.24. To be capable of operation from an emergency generator without concern. The VFD shall provide a 3% impedance line side reactor.

2.6.25. Displacement power factor shall not be less than 0.95 throughout the speed range.

2.6.26. Configure for a soft motor start the time parameters to take a motor to the defined speed with full torque at low motor RPM while avoiding inrush current peaks, achieve the energy efficiency and product reliability required for the applications.

2.6.27. Provide the ability for reversing and /or 2 speed capability to meet the application.

2.6.28. Provide all the information and manuals on motor control consisting of a Start ramp, acceleration to motor synchronous speed, and a Stop ramp. Provide the configuring information required for Mains Frequency, Ramp Time, Fixed Frequency, Mode Selection and Motor FLA (protection). The method of adjusting the setting must be easily and clearly done with only a small screwdriver.

2.6.29. The components must easily snap in place.

2.6.30. Protective Features

a) A minimum of Class 20 $I^2t$ electronic motor overload protection for single motor applications shall be provided. Overload protection shall automatically compensate for changes in motor speed.

b) Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature. The VFD shall display all faults in plain language. Codes are not acceptable.

c) Protect VFD from input phase loss. The VFD should be able to protect itself from damage and indicate the phase loss condition. During an input phase loss condition, the VFD shall be able to be programmed to either trip off while displaying an alarm, issue a warning while running at reduced output capacity, or issue a warning while running at full commanded speed. This function is independent of which input power phase is lost.

d) Protect from under voltage. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output, without faulting, with an input voltage as low as 70% of the nominal voltage.

e) Protect from over voltage. The VFD shall continue to operate without faulting with an input voltage as high as 130% of the nominal voltage.

f) VFD shall include a "signal loss detection" algorithm with adjustable time delay to sense the loss of an analog input signal. It shall also include a programmable time delay to eliminate nuisance signal loss indications. The functions after detection shall be programmable.

g) VFD shall function normally when the keypad is removed while the VFD is running. No warnings or alarms shall be issued as a result of removing the keypad.

h) VFD shall catch a rotating motor operating forward or reverse up to full speed without VFD fault or component damage.

i) VFD shall include current sensors on all three output phases to accurately measure motor current, protect the VFD from output short circuits, output ground faults, and act as a motor overload. If an output phase loss is detected, the VFD will trip off and identify which of the output phases is low or lost.

j) The VFD shall have temperature-controlled cooling fan(s) for quiet operation, minimized losses, and increased fan life. At low loads or low ambient temperatures, the fan(s) may be off even when the VFD is running.

2.6.31. The following display/control parameters shall be located on the front of the enclosure:

a) Hand/Off/Auto selector to start and stop the motor. In the auto position, the drive shall start/stop from a remote contact closure. In the auto position, motor speed shall be determined by the follower signal. In the manual position, motor speed shall be determined by manual adjustment.

2.6.32. The three-contactor bypass shall include the following interface and control features:

a) Mode selection via a four position DRIVE/OFF/BYPASS/TEST switch;

b) DRIVE Mode: Both the drive input and output contactors are closed and the motor is operated via VFD power;

c) OFF Mode: DRIVE input, drive output and bypass contactors are all open;

d) BYPASS Mode: Bypass contactor is closed and motor is operating from line power. Both the drive input and drive output contactors are open for servicing of the VFD without power;

e) TEST Mode: Bypass contactor is closed and the motor is operated from line power. The drive input contactor is closed but the drive output contactor is open. This allows for the testing and programming of the VFD while the motor is operated via line power;

f) Three-Contactor bypass shall be provided that allows operation of the motor via line power in the event of a failure of the VFD. Motor control selection shall be through either a VFD output contactor or a bypass contactor that are electrically interlocked to ensure that both contactors are not energized simultaneously. A third contactor, the drive input contactor, shall be supplied as standard. This allows the powering of the VFD with the motor off or operating in bypass mode for testing, programming and troubleshooting purposes;

g) Power on indication that the VFD is being supplied by the power line;

h) Fault indication that the VFD has tripped on a fault condition; and

i) Display shall indicate load parameters such as load percent frequency or running load amps.

## 2.7. CONTROL TRANSFORMER

2.7.1. 150 VA single phase, dry type, control transformer with primary voltage as indicated and 120 V secondary, complete with secondary fuse, installed in with starter as indicated. Capacity shall be increased where indicated on the Contract Documents.

2.7.2. Size control transformer for control circuit load plus 25% spare capacity.

2.7.3. Power supply to be downstream of main disconnect device supplying power to the starter.

2.7.4. The secondary shall be fused on one leg and grounded on the other (X2).

2.7.5. Primary fuses shall be installed on both legs on all starters.

2.7.6. Control fuses shall be H.R.C. type.

2.7.7. Accessories

a) Pushbutton: LED illuminated, NEMA 12 as required.

b) Selector switches: heavy duty, oil tight as required.

c) Indicating lights: LED, heavy duty, oil tight, type and colour as indicated.

## 2.8. MANUAL MOTOR STARTERS:

2.8.1. Single or three phase manual motor starters of size, type, rating, and enclosure type as indicated, with components as follows:

a) Switching mechanism, quick make and break; and

b) One or three overload heaters, manual reset, trip indicating handle.

2.8.2. Accessories

a) Indicating light: LED NEMA 12 type and colour as indicated.

b) Locking tab to permit padlocking in "ON" or "OFF" position.

## 2.9. FULL VOLTAGE MAGNETIC STARTERS

2.9.1. Combination magnetic starters of size, type, rating, and enclosure type as indicated with components as follows:

a) Contactor solenoid operated, rapid action type;

b) Motor overload protective device in each phase, manually reset from outside enclosure. Overload heater elements: Eutectic Alloy;

c) Wiring and schematic diagram inside starter enclosure in visible location;

d) Identify each wire and terminal for external connections, within starter, with permanent number marking identical to diagram; and

e) Combination type starters to include circuit breaker with operating lever on outside of enclosure to control disconnect.

## 2.10. CIRCUIT BREAKERS (WHERE APPLICABLE)

2.10.1. Bolt-on thermal-magnetic type with a minimum interrupting rating as indicated on the Contract Documents.

2.10.2. Equipped with automatic, trip free, non-adjustable, inverse-time, and instantaneous magnetic trips for less than 400A. The magnetic trip shall be adjustable from 5x to 10x for breakers 400A and greater.

2.10.3. Additional features shall be as follows:

a) A rugged, integral housing of molded insulating material;

b) Silver alloy contacts;

c) Arc quenchers and phase barriers for each pole;

d) Quick-make, quick-break, operating mechanisms; and

e) A trip element for each pole, a common trip bar for all poles, and one operator for all poles.

## 2.11. FUSED DISCONNECTS (WHERE APPLICABLE)

2.11.1. Quick-make, quick-break type.

2.11.2. Minimum duty rating shall be NEMA classification General Duty (GD) for 208/240 Volts and NEMA classification Heavy Duty (HD) for 575-600 Volts.

2.11.3. Horsepower rated, and shall have the following features:

a) Copper blades, visible in the OFF position;

b) An arc chute for each pole;

c) Fuse holders for the sizes and types of fuses specified or as shown on the Contract Documents; and

d) Motor Circuit Protectors (where applicable).

2.11.4. Bolt-on type with a minimum interrupting rating as indicated on the Contract Documents.

2.11.5. Equipped with automatic, adjustable magnetic trip. Magnetic trip shall be adjustable up to 1300% of the motor full load amperes.

## 2.12. ENCLOSURES

2.12.1. Enclosures shall be NEMA-type rated 1, 3R, 4X or 12 as required per the installed environment.

2.12.2. Enclosure doors shall be interlocked to prevent opening unless the disconnecting means is open. A "defeater" mechanism shall allow for inspection by qualified personnel with the disconnect means closed. Provide padlocking provisions.

2.12.3. All metal surfaces shall be thoroughly cleaned, phosphatized, and factory primed prior to applying light gray baked enamel finish.

## 2.13. MOTOR CONTROL CIRCUITS

2.13.1. Shall operate at not more than 120 Volts.

2.13.2. The power for the control circuit shall be from the downstream of the breaker supplying power for the motor.

2.13.3. Shall be grounded, except where the equipment manufacturer recommends that the control circuits be isolated.

2.13.4. For each motor operating over 120 Volts, incorporate a separate, heavy duty, control transformer within each motor controller enclosure.

2.13.5. Incorporate primary and secondary over current protection for the control power transformers.

## 2.14. OVERLOAD RELAYS

2.14.1. Thermal, Induction, Temperature Probe Thermal Relay, Electronic type, as specified. Devices shall be NEMA type.

2.14.2. One for each pole.

2.14.3. External overload relay reset pushbutton on the door of each motor controller enclosure.

2.14.4. Overload relays shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

2.14.5. Thermal overload relays shall be tamperproof, not affected by vibration, manual reset, sensitive to single-phasing, and shall have selectable trip classes of 10, 20 and 30.

## 2.15. AUXILLIARY RELAYS

2.15.1. Provide general purpose industrial grade auxiliary control relays.

2.15.2. Relays shall include a minimum of four (4) contacts and a maximum of eight (8) contacts.

2.15.3. Each relay shall have a minimum of one (1) unused normally open and one (1) normally closed contact unless indicated otherwise on the Contract Documents.

2.15.4. Relays shall be totally enclosed plug-in type when indicated on the Contract Documents.

2.15.5. Operating coil and contact ratings to suit requirements shown on the Contract Documents.

2.15.6. Manufacturers: Allen-Bradley, Square D, Eaton or approved equivalent.

## 2.16. CONTACTORS

2.16.1. Contactors: to CSA C22.2 No.14.

2.16.2. Electrically held controlled by pilot devices as indicated and rated for type of load controlled. Minimum size: NEMA 1.

2.16.3. Fused switch combination contactor as indicated on the Contract Documents.

2.16.4. Operating coil and contact ratings to suit requirements shown on the Contract Documents.

2.16.5. Complete with 2 normally open and 2 normally closed auxiliary contacts unless indicated otherwise.

2.16.6. Include following options in cover:

a) Red indicating lamp;

b) Reset; and

c) Controls as indicated on Contract Documents.

## 3. EXECUTION

### 3.1. INSTALLATION

3.1.1. Install starters, control panels, connect power and control as indicated.

3.1.2. Ensure correct fuses and overload devices elements installed.

3.1.3. Install starters and VFDs as a standalone unit or as part of motor control centre in suitably sized buckets as indicated in the Contract Documents. Ground doors in accordance with OESC.

3.1.4. Starters and VFDs components, accessories and safety requirements to be identical for standalone or motor control centre installation.

3.1.5. Provide output filter (dv/dt filter) as standalone unit in a separate enclosure, complete with drip hood external to VFD unit.

3.1.6. Install control unit enclosure adjacent to respective VFD units as a stand-alone unit unless indicated otherwise.

3.1.7. Install contactors and connect power wires and auxiliary control devices.

3.1.8. Identify contactors with nameplates or labels indicating panel and circuit number.

### 3.2. COMMISSIONING

3.2.1. Place As-Built wiring diagram of installed equipment in motor starters.

3.2.2. Perform Commissioning in accordance with Metrolinx Standards, manufacturers' recommendation and NETA standards.

3.2.3. Manufacturer's technical representative to be present for commissioning at no extra cost to Metrolinx.

3.2.4. Testing

a) Perform starters tests in accordance with Metrolinx Standards and manufacturer's instructions.

b) Operational and functional checks of VFDs, starters, control unit and spare parts.

c) Perform starting and stopping sequences of contactors and relays.

d) Operational and functional checks of sequence controls, BAS interface, interlocking with other separate related starters, equipment, control devices, operate as indicated in Contract Documents.

e) Manufacturer technical representative shall be factory trained with periodic updates and have experience with same model of VFDs, motor starters, PLC controller (where present) on job site. Sales representatives not acceptable to perform this Work.

f) Manufacturer technical representative to provide technical direction and assistance in general assembly of equipment, installation as specified in manufacturer's installation instructions, wiring, application dependant adjustments, and verification of proper operation.

**END OF SECTION**