Mechanical Specifications - Variable Frequency Drives

TR150 DRIVE – STANDARD FEATURES

The TR150 Drive
The TR150 Drive Series is a microprocessor-based, high frequency IGBT-based, PWM AC drive with control functions and software designed solely for the unique needs of HVAC systems. The TR150 Drive uses state-of-the-art Voltage Vector Control to supply full rated motor voltage at rated load and frequency, full motor performance without derating, high efficiency for both drive and motor, and a nearly perfect output sine wave. The diode-bridge rectifier and DC-link reactor provide a high displacement power factor at all speeds and loads and minimize power line harmonics. The TR150 Drive utilizes a common user interface for all units.

Input Power
The TR150 Drive is equipped with an automatic sustained power or phase loss circuit. The TR150 Drive will provide a full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to operate with reduced output power, without faulting, with an input voltage as low as 85% of the nominal voltage as required by EN/IEC 61800-3.

DC-Link Reactor
A dual, 5% DC-link reactor on the positive and negative rails of the DC bus is standard equipment on the TR150 Drive. This reactor reduces the level of harmonics reflected back into the building power system without causing a voltage loss at the drive's input and reducing efficiency as an external AC line reactor would. This reactor also improves input power factor. The reactor is non-saturating (linear) to provide full harmonic filtering throughout the entire load range. In performance, the DC-link reactor is equivalent to a 5% AC line reactor.

Power Line Protection
Power line voltage surge protection is provided by means of input Metal Oxide Varistors (MOVs). This protects the diodes in the TR150 Drive's 3-phase full wave diode bridge. The DC-link reactor also acts to reduce input current caused by power line disturbances.

Galvanic Isolation of Control Terminals
All control terminals and output relay terminals are galvanically isolated from the power line. This means the drive controller is completely protected from the input current. The output relay terminals require their own grounding. This isolation meets the stringent protective extra-low voltage (PELV) requirements for isolation and ensures safe connection to building management systems.

Adjustable Acceleration / Deceleration Rates
The TR150 Drive can provide two individually controlled sets of acceleration/deceleration rates each from 1 to 3600 seconds. The shape of these curves may be automatically contoured to prevent tripping. The TR150 shall also provide an S-Curve shaped acceleration/deceleration ramp.

Slip Compensation
The TR150 compensates for the motor slip by giving the frequency a supplement that follows the measured motor load keeping the motor speed almost constant.

Carrier Frequency
By using IGBTs, the TR150 Drive can employ high switching frequencies, so the motor current is practically sinusoidal. Audible motor noise can also be minimized by adjusting the switching frequency. These frequencies can be set or adjust themselves automatically to fit the application.

Automatic High Ambient Derate
If the ambient temperature exceeds the normal limit, the drive can be set to warn of its over temperature and continue to run, keeping the HVAC system functional. To control its temperature, the drive will reduce the output carrier frequency and then, if necessary, reduce the output current.

Plenum Rated
The TR150 drive is recognized by UL for installation in air handling compartments.

TR150 DRIVE – APPLICATIONS

Flying Start
Allows starting into a “windmilling” fan at any speed, in either direction. This function makes it possible to catch a motor which is spinning freely due to a mains drop-out.

Built-in Communications
The TR150 Drive is fully equipped for serial communication (EIA–485).
Communicates directly with BACnet MS/TP, Johnson Controls Metasys (N2), Siemens FLN-P1, and Modbus RTU with no hardware changes or additional costs.

Firefighter’s Override Mode
Overrides all other commands to provide desired operation. Ignores most alarms including overload, overcurrent, over temperature, and phase loss.

Intelligent HVAC Controller
Two-feedback auto-tuning PI controls the drive, eliminating external controllers and reducing cost.

- Proportional: The proportional gain dictates the rate at which the deviation between actual and desired feedback signal is corrected. The higher the gain, the faster the response, but too high a gain can cause hunting and a large overshoot.
- Integral Time: The integral time continually compares the feedback value with the desired setpoint over time to make sure the setpoint is reached. The greater the integral time, the longer it takes to actually achieve the setpoint, but improves the system stability.

Run Permissive Circuit
Ability to accept a "system ready" signal assures that dampers or other auxiliary equipment are in the proper state for drive operation. This feature also provides the ability for the drive to send a “start signal applied” signal to the system to notify the auxiliary equipment of the drive’s request to start.

Sleep Mode
Automatically stops the drive when speed drops below set "sleep" level for specified time. Automatically restarts when speed command exceeds set "wake" level. Saves energy and reduces wear on driven equipment.

Automatic Energy Optimization Circuitry
The Automatic Energy Optimization (AEO) function adapts the output of the drive to the specific motor and load connected. This circuit optimizes the system efficiency as system loads change. The AEO function regulates the output voltage on the basis of the reactive current and the effective current. A savings of 3 to 10% in power consumption can be obtained with this function.

Automatic Restarts
The TR150 Drive can be automatically restarted up to 20 times or infinitely at 0 to 600 second intervals. If the application causes the drive to trip more than the number of trials set, the drive will stop operating and display the fault on the display screen. A manual reset will be required by means of the reset key, a digital input, or EIA–485 command. In cases of severe trips, as a safety feature, the drive's input power may have to be cycled to restart a fault.

Automated Frequency Avoidance and Lockouts
For applications where it may be necessary to avoid specific frequencies due to mechanical resonance problems in the driven equipment, the TR150 Drive, with its Critical Frequency Lockout Function, makes it possible to set up to three different frequency ranges which will be avoided during operation of the drive. This feature can be programmed by simply activating the feature and pushing OK at the top and bottom points that you wish to avoid.

- Each critical frequency setting can avoid a frequency band which is from 1 to 100 Hz wide. If the reference signal defines that the TR150 Drive is to operate within this critical frequency range, the critical frequency lockout function will keep the drive operating continuously within this range.
- When the frequency reference signal rises above the critical frequency maximum limit, the TR150 Drive will allow the motor to accelerate through the critical frequency at the rate set by the acceleration rate.

Preset Speeds
The TR150 Drive allows for a maximum of 16 programmable preset speeds to be selected from the digital inputs.

TR150 DRIVE– MOTOR AND DRIVE INTERACTION

Automatic Motor Adaptation (AMA)
Knowing motor stator resistance, the drive automatically optimizes performance and efficiency. The motor does not have to be run or decoupled from the load for the AMA setup to be performed.

Advanced Motor Protection
The TR150 Drive features integrated electronic, thermal motor protection. The VFD calculates the motor temperature based on current, frequency, and time. This system allows for changing cooling conditions as speed and load vary. The drive can predict motor overheating and reports a % of thermal load.

Constant-Torque Start
The TR150 Drive's constant-torque start mode provides full torque to accelerate different loads until the drive reaches the setpoint. Breakaway current can be set up to 160% for up to 0.5 seconds for starting high friction loads.

Current Limit Circuit
Adjustable from 0 to 110% of the TR150 Drive's rated current (factory set at 110%). If during acceleration the current required to accelerate the load exceeds the current limit, the TR150 Drive will stop accelerating until the motor current is reduced to normal levels, at which time the load will continue to accelerate at the rate set by the acceleration time.

Three-Phase Output Current Measurement
The TR150 Drive's software measures output current on all three phases. Phase grounding is detected instantly. Output contactors may be repeatedly used with no damage to the drive. Multiple motors may be run from one drive.

Short Circuit Protection
The TR150 Drive provides inherent short circuit protection with a very fast acting fault trip circuit by sensing current on all three drive output phases. The use of insulated gate bipolar transistors (IGBT) in the TR150 Drive means very high-speed switching and rugged performance.

Motor Preheat Circuit
This preheat function can be activated to avoid condensation on the motor windings when it is stopped.

Stall Protection
The TR150 Drive provides protection against a stalled motor. When activated, this function can provide a warning or a fault condition caused by excessive motor current at low speeds.

Broken Belt, Loss of Load
A minimum motor current value can be set to indicate the motor is not using any more current than to run at idle. This can be used to indicate a broken belt or coupler. This feature can also be used to detect when a motor is disconnected from the drive.

TR150 DRIVE– OPERATOR INTERFACE

Fully Graphic, Multilingual Display

The TR150 Drive uses a large, bright, backlit graphic display to provide complete drive information at a glance. The logical arrangement of all elements simplifies the setup, operation and monitoring of the drive. Choose from various items to display, including speed/flow, pressure and power units relative to motor speed.
After programming one drive, the keypad can be used to transfer the same settings to all other drives. Drive can run without the keypad in place to assure tamper-proof operation. Drive status is shown even with the keypad removed.

Application-Specific Software

The TR150 Drive was designed specifically for the HVAC market. A quick setup menu with factory presets for typical HVAC parameters is provided on the VFD.

LED Indication

Three LEDs are provided on the TR150 Drive for indication of power applied, warning and fault. Upon power up, all LEDs will briefly light as a lamp test.

- ***Fault*** – Will flash red when the drive has registered a fault condition which has caused the drive to shut down.
- ***Warning*** – Will flash yellow to indicate a situation exists that exceeds the normal drive/system parameters, and if that condition continues, a trip may be imminent.
- ***On*** – Will glow green to indicate that the VFD is connected to AC power (line voltage is present).
- Operating Keys
- ***Hand On*** – Starts the drive regardless of remote start/stop contact (assuming safety interlock is closed). The speed of the drive will generally be controlled manually via the keypad "+" and "−" buttons.
- ***Off Reset*** – Shuts the drive down regardless of other commands. Will reset any trip level fault (not trip lock) if the drive is not set for infinite automatic fault resets.
- ***Auto/On*** – The drive will start and stop via the external contact closure (BAS time clock). The speed is generally controlled via the BAS signal (4 to 20 mA, 0 to 10 V DC, etc.).

Programming Keys

- *Status* – Used to display operational data and status.
- *Quick Menu* – Used for programming the TR150 Drive for the most typical applications.
- *Main Menu* – Used to access all parameters for programming. It can switch directly from this mode to quick menu.
- *OK* – Used to confirm that the last programming change should be saved to memory.
- *Back* – Used to exit present display or menu to the previous display or menu.
- *Right / Left / Up / Down arrows* – Used as the electronic potentiometer to manually control the speed in the Hand/Start mode. All four keys are active during operation as well as programming. They provide the ability to move the cursor around the display, or sequence through display values.

Additional Keypad Features

- Hot-pluggable with upload and download capabilities
- On-screen scroll bars and graphs
- Plain language alarms and warnings
- Remote keypad mounting kits available
-

8.4.8 Control Card, RS485 Serial Communication

Terminal number	68 (P, TX+, RX+), 69 (N, TX-, RX-)
Terminal number	61 common for terminals 68 and 69

8.4.9 Control Card, 24 V DC Output

Terminal number	12
Maximum load	80 mA

8.4.10 Relay Output

Programmable relay outputs	2
Relay 01 and 02 (enclosure size H1–H5 & I2–I4)	01–03 (NC), 01–02 (NO), 04–06 (NC), 04–05 (NO)
Maximum terminal load (AC-1)[1] on 01–02/04–05 (NO) (resistive load)	250 V AC, 3 A
Maximum terminal load (AC-15)[1] on 01–02/04–05 (NO) (inductive load @ cosφ 0.4)[2]	250 V AC, 0.2 A
Maximum terminal load (DC-1)[1] on 01–02/04–05 (NO) (resistive load)	30 V DC, 2 A
Maximum terminal load (DC-13)[1] on 01–02/04–05 (NO) (inductive load)[2]	24 V DC, 0.1 A
Maximum terminal load (AC-1)[1] on 01–03/04–06 (NC) (resistive load)	250 V AC, 3 A
Maximum terminal load (AC-15)[1] on 01–03/04–06 (NC) (inductive load @ cosφ 0.4)[2]	250 V AC, 0.2 A
Maximum terminal load (DC-1)[1] on 01–03/04–06 (NC) (resistive load)	30 V DC, 2 A
Minimum terminal load on 01–03 (NC), 01–02 (NO)	24 V DC 10 mA, 24 V AC 20 mA
Environment according to EN 60664-1	Overvoltage category III/pollution degree 2

1) IEC 60947 parts 4 and 5. Endurance of the relay varies with different load type, switching current, ambient temperature, driving configuration, working profile, and so forth. It is recommended to mount a snubber circuit when connecting inductive loads to the relays.

2) Only frame sizex H6–H10 and I6–I8.

Programmable relay outputs	
Relay 01 terminal number (enclosure size H9)	01–03 (NC), 01–02 (NO)
Maximum terminal load (AC-1)[1] on 01–03 (NC), 01–02 (NO) (resistive load)	240 V AC, 2 A
Maximum terminal load (AC-15)[1] (inductive load @ cosφ 0.4)	240 V AC, 0.2 A
Maximum terminal load (DC-1)[1] on 01–02 (NO), 01–03 (NC) (resistive load)	60 V DC, 1 A
Maximum terminal load (DC-13)[1] (inductive load)	24 V DC, 0.1 A
Relay 01 and 02 terminal number (enclosure size H6, H7, H8, H9 (relay 2 only), H10, and I6–I8)	01–03 (NC), 01–02 (NO), 04–06 (NC), 04–05 (NO)
Maximum terminal load (AC-1)[1] on 04–05 (NO) (resistive load)[2][3]	400 V AC, 2 A
Maximum terminal load (AC-15)[1] on 04–05 (NO) (inductive load @ cosφ 0.4)	240 V AC, 0.2 A
Maximum terminal load (DC-1)[1] on 04–05 (NO) (resistive load)	80 V DC, 2 A
Maximum terminal load (DC-13)[1] on 04–05 (NO) (inductive load)	24 V DC, 0.1 A
Maximum terminal load (AC-1)[1] on 04–06 (NC) (resistive load)	240 V AC, 2 A
Maximum terminal load (AC-15)[1] on 04–06 (NC) (inductive load @ cosφ 0.4)	240 V AC, 0.2 A
Maximum terminal load (DC-1)[1] on 04–06 (NC) (resistive load)	50 V DC, 2 A
Maximum terminal load (DC-13)[1] on 04–06 (NC) (inductive load)	24 V DC, 0.1 A
Minimum terminal load on 01–03 (NC), 01–02 (NO), 04–06 (NC), 04–05 (NO)	24 V DC 10 mA, 24 V AC 20 mA
Environment according to EN 60664-1	Overvoltage category III/pollution degree 2

1) IEC 60947 parts 4 and 5. Endurance of the relay varies with different load type, switching current, ambient temperature, driving configuration, working profile, and so forth. It is recommended to mount a snubber circuit when connecting inductive loads to the relays.

2) Overvoltage Category II.

3) UL applications 300 V AC 2 A.

8.4.11 Control Card, 10 V DC Output

Terminal number	50
Output voltage	10.5 V ±0.5 V
Maximum load	25 mA

8.4.12 Ambient Conditions

Enclosure protection rating	IP20, IP54
Enclosure kit available	IP21, TYPE 1
Vibration test	1.0 g
Maximum relative humidity	5–95% (IEC 60721-3-3; Class 3K3 (non-condensing) during operation
Aggressive environment (IEC 60721-3-3), coated (standard) enclosure sizes H1–H5	Class 3C3
Aggressive environment (IEC 60721-3-3), non-coated enclosure sizes H6–H10	Class 3C2
Aggressive environment (IEC 60721-3-3), coated (optional) enclosure sizes H6–H10	Class 3C3
Aggressive environment (IEC 60721-3-3), non-coated enclosure sizes I2–I8	Class 3C2
Test method according to IEC 60068-2-43 H2S (10 days)	
Ambient temperature	See maximum output current at 40/50 °C (104/122°F) in *chapter 8.2.2 3x380–480 V AC.*
Minimum ambient temperature during full-scale operation	0 °C (32 °F)
Minimum ambient temperature at reduced performance, enclosure sizes H1–H5 and I2–I4	-20 °C (-4 °F)
Minimum ambient temperature at reduced performance, enclosure sizes H6–H10 and I6–I8	-10 °C (14 °F)
Temperature during storage/transport	-30 to +65/70 °C (-22 to +149/158°F)
Maximum altitude above sea level without derating	1000 m (3281 ft)
Maximum altitude above sea level with derating	3000 m (9843 ft)
Safety standards	EN/IEC 61800-5-1, UL 508C
EMC standards, Emission	EN 61800-3, EN 61000-6-3/4, EN 55011, IEC 61800-3
EMC standards, Immunity	EN 61800-3, EN 61000-3-12, EN 61000-6-1/2, EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6
Energy efficiency class[1)]	IE2

1) Determined according to EN 50598-2 at:

- *Rated load.*
- *90% rated frequency.*
- *Switching frequency factory setting.*
- *Switching pattern factory setting.*

Certification		IP20
EC Declaration of Conformity	CE	✓
UL Listed	c UL us	✓
RCM		✓
AHRI	AHRI CERTIFIED	✓

Table 1.2 Certificates and Approvals

The frequency converter complies with UL 508C thermal memory retention requirements. For more information, refer to the section *Motor Thermal Protection* in the product-specific *design guide.*

TYPICAL CONTROL CONNECTIONS

Base TR150 Drive I/O – Refer to Submittal Drawings for additional details.

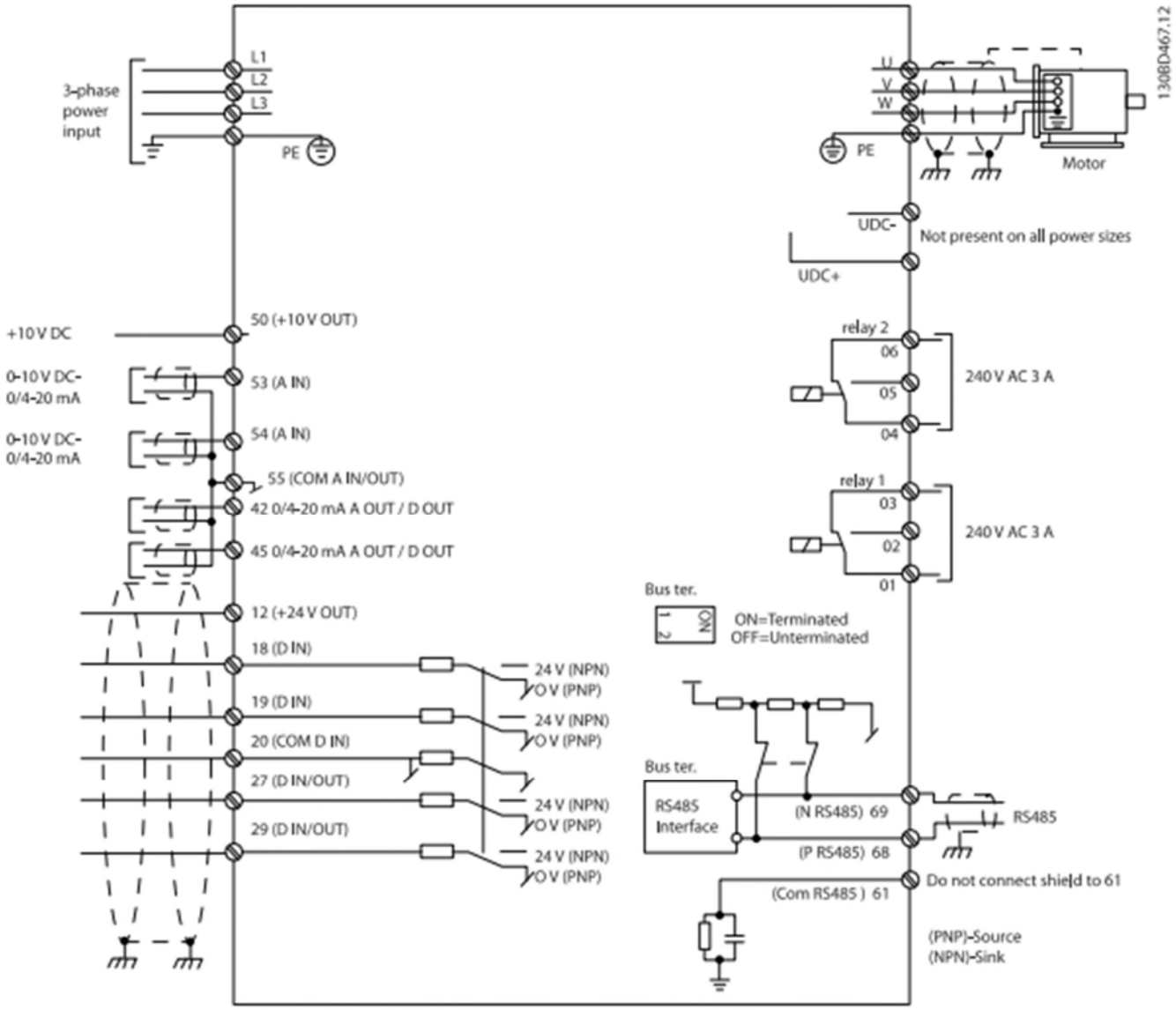

Illustration 3.15 Basic Wiring Schematic Drawing

3.2.3 Fuses and Circuit Breakers

Branch circuit protection

To prevent fire hazards, protect the branch circuits in an installation - switch gear, machines, and so on - against short circuits and overcurrent. Follow national and local regulations.

Overcurrent protection

Provide overload protection to avoid overheating of the cables in the installation. Overcurrent protection must always be carried out according to local and national regulations. Circuit breakers and fuses must be designed for protection in a circuit capable of supplying a maximum of 100000 A_{rms}(symmetrical), 480 V maximum.

UL/Non-UL compliance

To ensure compliance with UL or IEC 61800-5-1, use the circuit breakers or fuses listed in *Table 3.5*.

Circuit breakers must be designed for protection in a circuit capable of supplying a maximum of 10000 A_{rms} (symmetrical), 480 V maximum.

NOTICE

In the event of malfunction, failure to follow the protection recommendation may result in damage to the frequency converter.

	Circuit breaker		Fuse				
	UL	Non-UL	UL				Non-UL
			Bussmann	Bussmann	Bussmann	Bussmann	Max fuse
Power [kW (hp)]			Type RK5	Type RK1	Type J	Type T	Type G
3x200–240 V IP20							
0.25 (0.33)	-	-	FRS-R-10	KTN-R10	JKS-10	JJN-10	10
0.37 (0.5)			FRS-R-10	KTN-R10	JKS-10	JJN-10	10
0.75 (1.0)			FRS-R-10	KTN-R10	JKS-10	JJN-10	10
1.5 (2.0)			FRS-R-10	KTN-R10	JKS-10	JJN-10	10
2.2 (3.0)			FRS-R-15	KTN-R15	JKS-15	JJN-15	16
3.7 (5.0)			FRS-R-25	KTN-R25	JKS-25	JJN-25	25
5.5 (7.5)			FRS-R-50	KTN-R50	JKS-50	JJN-50	50
7.5 (10)			FRS-R-50	KTN-R50	JKS-50	JJN-50	50
11 (15)			FRS-R-80	KTN-R80	JKS-80	JJN-80	65
15 (20)	Cutler-Hammer EGE3100FFG	Moeller NZMB1-A125	FRS-R-100	KTN-R100	JKS-100	JJN-100	125
18.5 (25)			FRS-R-100	KTN-R100	JKS-100	JJN-100	125
22 (30)	Cutler-Hammer JGE3150FFG	Moeller NZMB1-A160	FRS-R-150	KTN-R150	JKS-150	JJN-150	160
30 (40)			FRS-R-150	KTN-R150	JKS-150	JJN-150	160
37 (50)	Cutler-Hammer JGE3200FFG	Moeller NZMB1-A200	FRS-R-200	KTN-R200	JKS-200	JJN-200	200
45 (60)			FRS-R-200	KTN-R200	JKS-200	JJN-200	200
3x380–480 V IP20							
0.37 (0.5)	-	-	FRS-R-10	KTS-R10	JKS-10	JJS-10	10
0.75 (1.0)			FRS-R-10	KTS-R10	JKS-10	JJS-10	10
1.5 (2.0)			FRS-R-10	KTS-R10	JKS-10	JJS-10	10
2.2 (3.0)			FRS-R-15	KTS-R15	JKS-15	JJS-15	16
3.0 (4.0)			FRS-R-15	KTS-R15	JKS-15	JJS-15	16
4.0 (5.0)			FRS-R-15	KTS-R15	JKS-15	JJS-15	16
5.5 (7.5)			FRS-R-25	KTS-R25	JKS-25	JJS-25	25
7.5 (10)			FRS-R-25	KTS-R25	JKS-25	JJS-25	25
11 (15)			FRS-R-50	KTS-R50	JKS-50	JJS-50	50
15 (20)			FRS-R-50	KTS-R50	JKS-50	JJS-50	50
18.5 (25)			FRS-R-80	KTS-R80	JKS-80	JJS-80	65
22 (30)			FRS-R-80	KTS-R80	JKS-80	JJS-80	65
30 (40)	Cutler-Hammer EGE3125FFG	Moeller NZMB1-A125	FRS-R-125	KTS-R125	JKS-R125	JJS-R125	80
37 (50)			FRS-R-125	KTS-R125	JKS-R125	JJS-R125	100
45 (60)			FRS-R-125	KTS-R125	JKS-R125	JJS-R125	125

	Circuit breaker		Fuse				
	UL	Non-UL	UL				Non-UL
			Bussmann	Bussmann	Bussmann	Bussmann	Max fuse
Power [kW (hp)]			Type RK5	Type RK1	Type J	Type T	Type G
55 (70)	Cutler-Hammer JGE3200FFG	Moeller NZMB1-A200	FRS-R-200	KTS-R200	JKS-R200	JJS-R200	150
75 (100)			FRS-R-200	KTS-R200	JKS-R200	JJS-R200	200
90 (125)	Cutler-Hammer JGE3250FFG	Moeller NZMB2-A250	FRS-R-250	KTS-R250	JKS-R250	JJS-R250	250
3x525-600 V IP20							
1.5 (2.0)	-	-	FRS-R-20	KTS-R20	JKS-20	JJS-20	20
2.2 (3.0)			FRS-R-20	KTS-R20	JKS-20	JJS-20	20
3.0 (4.0)			FRS-R-20	KTS-R20	JKS-20	JJS-20	20
3.7 (5.0)			FRS-R-20	KTS-R20	JKS-20	JJS-20	20
5.5 (7.5)			FRS-R-20	KTS-R20	JKS-20	JJS-20	20
7.5 (10)			FRS-R-20	KTS-R20	JKS-20	JJS-20	30
11 (15)	-	-	FRS-R-30	KTS-R30	JKS-30	JJS-30	35
15 (20)			FRS-R-30	KTS-R30	JKS-30	JJS-30	35
18.5 (25)	Cutler-Hammer EGE3080FFG	Cutler-Hammer EGE3080FFG	FRS-R-80	KTS-R80	JKS-80	JJS-80	80
22 (30)			FRS-R-80	KTS-R80	JKS-80	JJS-80	80
30 (40)			FRS-R-80	KTS-R80	JKS-80	JJS-80	80
37 (50)	Cutler-Hammer JGE3125FFG	Cutler-Hammer JGE3125FFG	FRS-R-125	KTS-R125	JKS-125	JJS-125	125
45 (60)			FRS-R-125	KTS-R125	JKS-125	JJS-125	125
55 (70)			FRS-R-125	KTS-R125	JKS-125	JJS-125	125
75 (100)	Cutler-Hammer JGE3200FAG	Cutler-Hammer JGE3200FAG	FRS-R-200	KTS-R200	JKS-200	JJS-200	200
90 (125)		-	FRS-R-200	KTS-R200	JKS-200	JJS-200	200

Table 3.5 Circuit Breaker and Fuses