Starters and Variable Frequency Drives for

Centrifugal Chillers, WSC, WDC, WPV, WCC
Heat Recovery Chillers, HSC
Centrifugal Templifiers, TSC

McQuay Air Conditioning

Engineered for flexibility and performance.™

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Introduction

McQuay offers a wide selection of conventional motor starting equipment, as well as variable frequency drives (VFD) that perform the starting function, with the additional capability of varying compressor motor speed for improved chiller efficiency.

This manual refers to Models WSC and WDC, which are respectively, single and dual compressor, centrifugal, cooling-only chillers. All information herein applies equally to WCC dual compressor counter-flow chillers, HSC single compressor heat recovery centrifugal chillers, WPV single compressor centrifugal chillers, and to TSC single compressor Templifier water heating units.

Starters

Voltage Definitions: There is no universally accepted definition of where "medium" and "high" voltage categories separate. IEEE defines high voltage as above 1000V, the National Electric Safety Code as above 8700 volts, and many equipment suppliers as above 50,000V (50kV)! McQuay designates 10kV and above as high voltage since this is the point at which special considerations such as insulation thickness, creepage distance, and corona must be considered by designers.

Low voltage types: (200 through 600 volt) starters are available as solid state (description on page 7) or wye-delta closed transition (description on page 17).

Medium voltage types: (2300 to 7200 volt) starters are solid state (description on page 26), across-the-line full voltage (description on page 33), auto transformer reduced voltage, and primary reactor reduced voltage (descriptions on page 36).

High Voltage: (10kV and above) starters are solid state and across-the-line (description on page 41).

Mounting options: Starters can be factory-mounted and wired on the chiller unit for most sizes or they can be free-standing with field wiring between the chiller and starter provided by the installer. See page 4 for further information on mounting arrangements. A wide range of starter options is available for individual job requirements.

Variable Frequency Drives

While known and specified for their ability to control compressor motor speed for efficiency enhancement, VFDs also perform starting and motor protection functions. They are available for 3/60/380-480 and 3/50/380-400 electrical service.

When used, VFDs must be purchased only from McQuay and as part of the original chiller purchase.

Basic Electrical Terms

Locked Rotor Amps (LRA): The amount of current that a specific motor will draw at start-up, when full voltage is applied across the line. The LRA may be 6 to 8 times FLA, or possibly higher in some cases.

Inrush current: The amount of current that a specific motor and starter combination will draw during start-up. Normal inrush current will be substantially less than LRA for all starter types, except for across-the-line starters.

Full Load Amps (FLA): The maximum amps the motor is designed for.

Rated Load Amps (RLA): Actual amperage that the motor draws for a specific application. Centrifugal compressor motors operate at an RLA equal to, or below their maximum full load amps. RLA for a hermetic refrigerant motor-compressor is used to determine electrical component sizing such as wire size and disconnect switches.

Starting torque: Minimum torque required to begin the motor's rotation.

Interrupting capacity: The maximum fault current that a circuit breaker or fused disconnect can successfully interrupt. As the rating increases, the construction becomes heavier duty. For disconnect switches with fuses, the rating is the same for 0 to 600 volts. For circuit breakers, the voltage and amperage relationship is considered with interrupting capacity decreasing as voltage increases.

Short Circuit Current Rating (SCCR): Formerly known as withstand rating. The SCCR of a starter is the maximum short circuit current that it can safely interrupt without emitting sparks or debris.

Bypass contactor: Contactors that bypass solid state starter silicon controlled rectifiers (SCRs), after full motor speed is reached, and allow full power to reach the motor directly.

Phase amps: The current draw inside the delta connection of a wye-delta motor winding. It is equal to 0.577 x RLA of the motor for a specific load.

Open transition: A reduced voltage starter characteristic occurring when the motor is temporarily disconnected from power at the time the starter changes from the starting mode to the final running mode. A short duration (one-half to one cycle) inrush spike will occur which, may be as high as the locked rotor amps of the motor. McQuay does not recommend use of this type of starter.

Closed transition: A reduced voltage starter characteristic when the motor is NOT temporarily disconnected from the line during the transition from starting mode to operating mode. The electrical load is transferred to resistors during the transition phase and the second inrush spike is suppressed.

Mounting Arrangements

Low Voltage

Low voltage starters and VFDs can be supplied in several different mounting arrangements depending on the chiller size and starter type. See Table 1 for available arrangements.

- Factory-Mounted (Optional): The starter or VFD is mounted on the chiller unit with the back of the starter against the motor terminal box and factory-wired directly to the motor. Field wiring between the starter/VFD and chiller motor is not required. This arrangement is only available on WSC/WDC 063, 079, or 087 units (cover photograph).

  On models WSC/WDC 048/050, the starter or VFD is factory-mounted on the front of the chiller unit and connected to the motor with conduit and cable.

- Free-standing (Standard): Floor-mounted, separate from the chiller unit, and field wired to the compressor motor. This is available on all units (except WPV where factory-mounting is standard)) and is the only starter arrangement available for WDC 100 - 126 dual compressor units.
- Brackets and cable kit: Due to shipping width limitations, starters for WSC 100 through 126 single compressor units can be shipped separately from the chiller unit and furnished with mounting brackets and interconnecting cables for field mounting and connection by others. This option must be clearly specified when chillers are ordered since brackets are welded onto the evaporator during its construction and cannot be added after it is built.

Table 1, Low Voltage, Starter/VFD Mounting Arrangements

Size	Factory Mounted	Free-Standing	Brackets & Cables
WPV	X		
WSC/WDC 050, HSC/HDC 050, TSC 050	X	X	
WSC/WDC 063, HSC/HDC 063, TSC 063	X	X	
WSC/WDC 079, HSC/HDC 079, TSC 079	X	X	
WSC/WDC 087, HSC/HDC 087, TSC 087	X	X	
WSC 100-126, HSC 100-126, TSC 100-126		X	X
WDC 100-126		X	

Medium and High Voltage

All medium and high voltage starters are only available for free-standing applications.

Specification, Customer Furnished Starters

There can be circumstances when customers desire to supply their own starter rather than purchasing one through McQuay. This frequently occurs when there is an existing line-up of starters on the site.

Due to the extensive and critical coordination between the chiller unit and the starter, it is essential that the starter conform to certain requirements.

Detailed specification for customers wishing to specify and purchase their own starters are contained in McQuay Drawing (Specification) R35999901. Contact your local McQuay representative for a current copy.

VFDs must be ordered from McQuay and with the original chiller order.

Motors

Type

McQuay centrifugal compressor motors are semi-hermetic, squirrel cage induction, 3-phase, 50/60 Hertz, 2 pole, single speed 3550 rpm at nominal shaft horsepower at 60 Hertz, 2960 rpm at 50 Hertz. They are rated for continuous duty at a minimum of 20 years with a maximum number of starts expected of 15,000 and a minimum delay between starts of 20 minutes.

Leads

Low voltage motors, 600 volts and below, will have six leads and are suitable for use with wye-delta and solid state starters or VFDs. The leads carry phase amps (0.58 times RLA).

Medium/high voltage motors; 2300 to 10,000 volts, will have three leads and are suitable for solid state, across-the-line, auto transformer and primary reactor reduced voltage starters.

Codes & Standards

The starters are designed, manufactured, and tested at the factory to conform, where applicable, to the following industry standards and specifications:

ANSI .... American National Standards Institute

CSA .... Canadian Standards Association

IEEE .... Institute of Electrical & Electronic Engineers

UL .... Underwriters Laboratories

NEC .... National Electric Code

EEMAC .... Electrical & Electronic Manufacturers Association of Canada

NEMA ...... National Electric Manufacturers Association

OSHA .... Occupational Safety & Health Act

Low Voltage Starters (200 through 600 volts)

General Specifications

Agency Approvals

All starters are for continuous duty, constructed in accordance with National Electric Manufacturers Associations (NEMA) Standard for Industrial Controls and Systems (ICS). Underwriters Laboratory (C-UL-US) certification for Standard 508 is included and a UL label is provided. Starters can be modified to meet most federal, state and local codes.

Contactor Duty

Contactors are capable of carrying the specified current on a continuous basis and also handle locked rotor amps on a temporary basis without damage.

Storage and Operating Environment

Starters can be stored at temperatures from -40°F to 140°F (40°C to 60°C). Operating range is from 32°F to 104°F (0°C to 40°C) with a maximum relative humidity of 95%.

Enclosure and Cable Penetrations

Unless stated otherwise, the starter enclosures for low voltage starters are NEMA 1. Standard construction for free-standing starters allows the power supply to enter the top of the starter and load-side connections to exit as shown on specific unit drawings.

Adequate separation of high and low voltage sections and proper mechanical and electrical interlocks are provided to meet most safety and operating codes.

Starter Types

Two types of reduced inrush, low voltage starters are offered; wye-delta closed transition, and solid state starters. The objective of these starters is to reduce the starting inrush current, while allowing the motor to generate enough torque to start. The centrifugal chiller controller energizes the starter, starting the compressor. The chiller controller then loads or unloads the compressor in response to system load requirements. It also checks that the compressor is fully unloaded before giving a start signal to the starter or VFD.

Low Voltage, Solid State Starters

Description

Solid state starters are excellent for centrifugal compressor duty. McQuay is able to offer these superior starters at a price competitive with the traditional wye-delta starters. Solid state starters have become the starters-of-choice for most applications. These starters use solid state switching devices called SCRs (silicon controlled rectifiers) to control the flow of current to the motor during start-up.

During starting, the SCRs control the amount of voltage that reaches the motor, which in turn, controls the motor's acceleration and current inrush. Eventually, full voltage is applied and bypass contactors are energized. The contactors bypass the SCRs and allows full current direct to the motor. This reduces heat build-up to prolong the life of solid-state circuit boards, SCRs, and other starter components. The compressor size and motor characteristics determine the starter operational setpoints. Motor starting torque is reduced to the minimum required by the compressor/motor load. Solid state starters do not necessarily have significantly less current inrush than wye-delta starters.

Features

McQuay solid state starters provide precise motor/compressor acceleration: McQuay solid state starters have adjustable starting current and acceleration settings. This feature provides precise motor control that cannot be accomplished utilizing the fixed 33% starting torque available from a wye-delta starter, or other fixed level electro-mechanical starters. These adjustments are extremely important in assuring that the starter delivers exactly the amount of current and torque necessary to perform the smoothest start possible. In addition, if conditions change, i.e., temperature, bearing condition, unloading operation, to the point where the fixed level starter, such as wye-delta, cannot support the acceleration torque needed, the motor will simply hang up or worse, skip the first step of wye delta starting and proceed directly to a full voltage start. With the McQuay solid state starters, the motor will always ramp up to meet the torque level required in a smooth linear predictable time period-with no transition surge. McQuay solid state starters are defaulted to set levels that have been predetermined to provide the best start possible. Wye-delta starters are not capable of being programmed in such a manner; they are what they are.

McQuay solid state starters provide a smoother, softer start. Wye-delta starters and other electro-mechanical starters produce fixed amounts of torque that are generally in excess of that required by the compressor load. The McQuay solid state starter tapers accelerating current to just what is required by the compressor. No initial surges or transitional surges are experienced with a solid state starter. This fact translates directly to less mechanical stress on the motor/compressor drive train, extending the life of the compressor.

McQuay solid state starters provide better control of the motor inrush current. By controlling both voltage and current going to the motor, the solid state starter lowers the nominal inrush current to a desired level and also eliminates any transitional currents. The beneficial effects of this are extended motor life and less strain on the user's power distribution system.

McQuay solid state starters are extremely reliable. The McQuay solid state starters have an integral bypass contactor that takes the SCRs out of the system once the motor has been brought up to full speed. In addition, the McQuay solid-state starters have extensive, embedded self-diagnostic features that protect both the starter and the motor; not available in competitive wye delta starters.

McQuay solid state starters are extremely price competitive. McQuay International has been able to bring the price of solid state starters below the price of electro-mechanical starters such as wye-delta starters, giving the customer more control and better protection for less money. In addition, parts replacement of solid state starters is minimal compared to wye delta starters. The solid state starter is designed to protect itself from component failure.

McQuay solid state starters are simple to use. Care is taken to provide solid state starters that default to the most efficient settings. The starters have been tested in our lab to determine the best setpoints for maximum performance of the compressor. They are literally plug and play devices. In addition, the self-diagnostics of the solid state starter do their own trouble shooting and, when possible, take the proper steps (notification/shutdown) to correct a fault.

Motor Control Features

The starter provides closed-loop, current controlled, soft-starting, utilizing silicon controlled rectifiers (SCR). The current ramp, start profile is based on programmable motor RLA, initial current, final current and ramp time.

Enclosures

The basic structure is welded-type construction utilizing minimum 11-gauge sheet metal.

Doors are minimum 12-gauge sheet metal, pan-type with flanges formed to provide a sturdy, rigid structure.

Doors with circuit breakers or disconnect switches are interlocked to prevent the doors from being opened with power applied.

Doors are hinged to allow 120^{o} swing.

The standard starter enclosures are NEMA 1.

The enclosure finish is as follows:

Metal parts are given a thorough rust-resistant treatment.
Primer is a recoatable epoxy primer B-67 Series.
Finish is a high solid polyurethane Polate T plus F63 series.

Motor Protection Features

The starter monitors the motor with current and voltage feedback. If any condition occurs that could damage the compressor motor, the starter declares a fault condition, the run relays are de-energized, the fault contacts close, and the motor is immediately shut down. The starter is latched off until a reset command is received.

Overload

The starter monitors motor current through the current transformers (CTs) and performs an I^2t thermal overload calculation. If the calculated overload exceeds the maximum allowed, a fault condition is declared.

Overcurrent

The starter monitors motor current through the CTs after the motor is up to speed. If the current rises above a programmed trip level (in % of RLA) for a programmed length of time, a fault condition is declared.

Ground Fault

The starter monitors the motor current for residual ground fault currents. If the measured residual ground fault exceeds a programmed trip level for more than 3 seconds, a fault condition is declared.

No Current at Run

The starter monitors the phase #1 current through a CT. If the current is less than 10% rated for one second, a fault is declared.

Over/Under Voltage
The starter monitors the line voltages. If the voltage drops below, or rises above, programmed trip levels, a fault condition is declared.

Current Unbalance
The starter monitors individual phase currents. If the unbalance exceeds a programmed trip level for more than 10 seconds, a fault condition is declared.

Phase Rotation
The starter monitors the three-phase voltage sequence. If C-B-A phase sequence is detected (contrasted to standard A-B-C rotation) while the motor is stopped, an alarm condition is declared. If a start command is subsequently received while the sequence is C-B-A, a fault condition is declared and an attempt to start will not be made.

Shorted/Open SCR
The starter monitors individual phase currents and voltages and can determine when an SCR is shorted or opened. If either condition exists for 300 milliseconds, a fault condition is declared.

Standard Metering
The percent of rated load amps is displayed on the chiller interface touch screen.

Table 2, Solid State Starter Models

Free-Standing	Unit Mounted	Max RLA
RVSS14	RVST14	143
RVSS17	RVST17	179
RVSS20	RVST20	207
RVSS27	RVST27	276
RVSS34	RVST34	347
RVSS41	RVST41	415
RVSS47	RVST47	476
RVSS57	RVST57	570
RVSS67	RVST67	679
RVSS82	RVST82	828
RVSS96		963
RVSS2K		1200
RVSS4K		1400

NOTE: Models RVSS96 through RVSS4K are double-door and cannot be factory-mounted.

Options

Optional Metering
With the optional “Full Metering Option”, electrical data is displayed in color on the chiller VGA interface touchscreen. This display is unique to McQuay chillers and is an excellent operating and diagnostic tool. See page 43 for details.

The following are included:

- Phase and average amps
- Phase and average volts
- Unit kW-hours
- kilowatts
- Power Factor

Lightning Arrestors
Provide a safe path to ground for a lightning surge.

Ground Fault Protection

Protects equipment from damage from line-to-ground fault currents too small to trip the overcurrent or short circuit protection devices.

Pilot Lights

Red and green pilot lights on the front of the enclosure to indicate status.

NEMA Modifications (Free-Standing Only)

The standard enclosure is NEMA 1. Options are:

- NEMA 3R -- Rain resistant construction (contact McQuay sales office)
- NEMA 4 -- Dust tight/rain tight construction (contact McQuay sales office)
- NEMA 12 -- Dust tight construction (contact McQuay sales office)

Factory-mounted starters for WPV, WSC/HSC/TSC 063-087, WDC/HDC 063-087 are only available with NEMA 1 enclosures. Starters are mounted on the unit and the cabling is routed directly to the motor terminal box through an opening in the rear of the starter enclosure.

Extended Warranty for Parts Only, or Parts & Labor

The duration and type of the starter warranty is determined by the chiller warranty.

Power Factor Correction Capacitors

The McQuay chiller selection program prints out the unit power factor and will also calculate capacitor size if power factor correction is required. See page 60 for details.

California Code

Modifications are made to the starter to comply with California code requirements.

Disconnect and Circuit Breaker Options

Non-fused disconnect

A molded case switch without an automatic trip, includes a through-the-door handle which can be used to break all power to the starter and chiller.

Fused disconnect switch (less fuses)

A fused disconnect switch is identical to the non-fused disconnect except that fuse clips are added. It is industry practice for the installer to supply the fuses, so fuses are NOT included. The fuse clips are rated for 600 volts and the interrupting capacity will be dependent on the fuse type used. Typical interrupting rating is 200,000 amps. Refer to the chart below for fuse sizes.

Table 3, Fuse Sizes

RLA Range (amps)	Fuse Range (amps)	Fuse Class	Centerline Dim. Hole to Hole (in)	Mounting Pattern
81A to 156A	101A to 200A	200A, Class J	4.375	2 bolt
157A to 296A	201A to 400A	400A, Class J	5.25	2 bolt
297A to 444A	401A to 600A	600A, Class J	6.00	2 bolt
445A to 606A	601A to 800A	800A, Class L	6.25	2 bolt
607A to 888A	1000A to 1200A	1200A, Class L	6.25 (1), 9.375 (2)	4 bolt
889A to 1185A	1201A to 1600A	1600A, Class L	6.25 (1), 9.375 (2)	4 bolt
1186A to 1481A	1601A to 2000A	2000A, Class L	6.25 (1), 9.375 (2)	4 bolt

Notes:
1. Inside hole to inside hole
2. Outside hole to outside hole

Thermal-magnetic Circuit Breakers

Optional thermal-magnetic circuit breakers are available with standard, high, and high-high interrupting capacity as shown in the following table.

Table 4, Ratings and Interrupting Capacity (kA) for Disconnects & Circuit Breakers on Solid State Starters, 50 and 60 HZ

Max RLA	Non-Fused Disc.	Fusible Disconnect (Free-standing Only)			Standard Interrupting Circuit Breaker				
							Interrupting Capacity (kA)		
	Rating	Rating	Fuse Clip	Fuse Class	Frame	Rating	Up To 240 V	241V To 480 V	481V To 600 V
156	200	200	200	J	FD	250	65	35	18
296	400	400	400	J	JD	400	65	35	25
444	600	600	600	J	LD	600	65	35	25
606	800	800	800	L	MD	800	65	50	25
888	1200	1200	1200	L	ND	1200	65	50	25
1185	1600	1600	2000	L	PD	1600	65	50	25
1481	2000	2000	2000	L	RD	2000	65	50	25

Max RLA	High Interrupting Circuit Breaker					High-High Interrupting Circuit Breaker				
			Interrupting Capacity (kA)					Interrupting Capacity (kA)		
	Frame	Rating	Up To 240 V	241V To 480 V	481V To 600 V	Frame	Rating	Up To 240 V	241V To 480 V	481V To 600 V
156	HFD	250	100	65	25	CFD	250	200	200	100
296	HJD	400	100	65	35	CJD	400	200	150	100
444	HLD	600	100	65	35	CLD	600	200	150	100
606	HMD	800	100	65	50	CMD	800	200	100	65
888	HND	1200	100	65	50	CND	1200	200	100	65
1185	HPD	1600	100	65	50	CPD	1600	200	100	65
1481	HRD	2000	100	65	50	No Option				

Table 5, Starter Option Availability

Option	Factory-Mount	Free-Standing
Metering	X	X
Lightning Arrestors		X
Ground Fault Protection	X	X
Indicating Lights	X	X
4-Pole Auxiliary Relay	X	X
Power Factor Correction Capacitors		X
NEMA 3R		X
NEMA 4		X
NEMA 12		X
California Code	X	X
Non-Fused Disconnect	X	X
Fused Disconnect	Up to 444 RLA	X
Circuit Breaker	X	X
Extended Warranty	X	X

Connection Sizes

Low Voltage Solid State

Table 6, Solid State Connection Sizes, Power Block

Starter Model No. (Note 1)	Incoming Connection to Power Block	Outgoing Connection (Note 2)
RVSS14	(2) #6-300	0.5
RVSS17	(2) #6-300	0.5
RVSS20	(2) #6-300	0.5
RVSS27	(2) #6-300	0.5
RVSS34	(2) #6-300	0.5
RVSS41	(2) #6-300	0.5
RVSS47	(2) #6-350	0.5
RVSS57	(4) 1/0 - 750	0.5
RVSS67	(4) 1/0 - 750	0.5
RVSS82	(4) 1/0 - 750	0.5
RVSS96	(4) 1/0 - 750	0.5
RVSS2K	(4) 1/0 - 750	0.5
RVSS4K	(4) 1/0 - 750	0.5

NOTES:

1. Data is the same unit-mounted starters, RVST14, etc.
2. Outgoing are 2-hole NEMA pattern.
3. Outgoing connections are factory-wired to the motor on factory-mounted starters.
4. When connecting to a starter with the standard power block, either free-standing or unit-mounted, the incoming connection size is determined by the starter size as listed in the above table.

Table 7, Solid State, Connection Sizes, Disconnect & Circuit Breaker

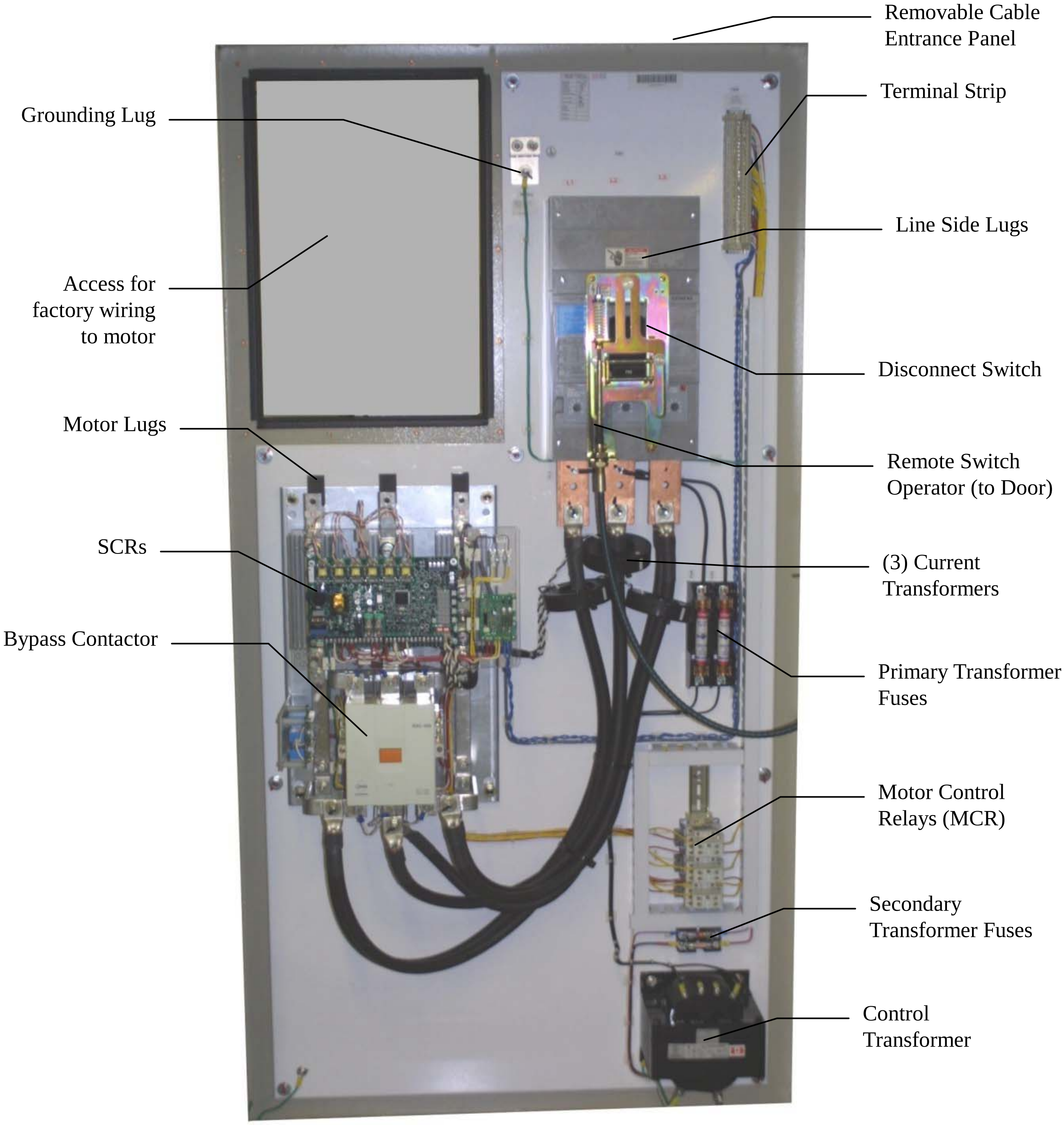
50/60 HZ Max RLA	Incoming Size Disconnect Switch	Incoming Size Circuit Breaker
74	#6- 350	#6- 350
93	#6- 350	#6- 350
148	#6- 350	#6- 350
163	#6- 350	#6- 350
185	(2) 3/0 - 500	(2) 3/0 - 500
296	(2) 3/0 - 500	(2) 3/0 - 500
444	(3) 1/0 - 500	(3) 1/0 - 500
593	(4) 250 - 500	(4) 250 - 500
889	(5) 300 - 600	(5) 300 - 600
1185	(5) 300 - 600	(5) 300 - 600
1481	(5) 300 - 600	(5) 300 - 600

NOTES:

1. For field wiring free-standing starters, the outgoing connection size is determined by the starter size as listed under the “Outgoing Lug Size” column in Table 6. Outgoing connections are factory-wired to the motor on factory-mounted starters.
2. When wiring to a starter (either factory-mounted or free-standing) with an optional disconnect switch or circuit breaker, the incoming lug size is determined by the amp rating of the device as shown in the above table. For standard power block, the incoming connections are as shown in Table 6.

Component Location

Figure 1, Solid State Starter with Circuit Breaker/ Disconnect Models RVSS47 – RVSS82, RVST47 – RVST82

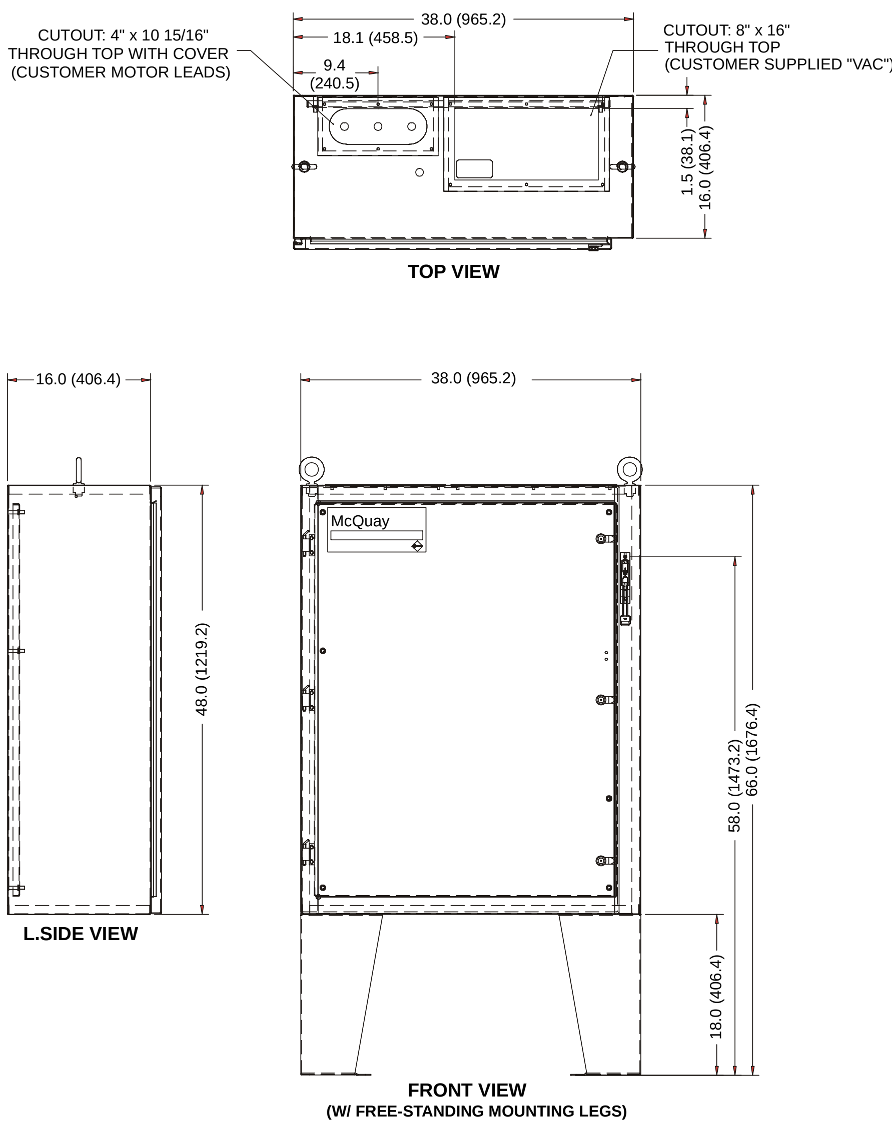


NOTES:

1. Free-standing Models RVST47 to RSVT 82 have 6-inch high feet not shown in photograph.
2. Free-standing Models RVST14 to RSVT 41 are similar in appearance but in a shorter enclosure. They have 18-inch high feet not shown in photograph.

Dimensions

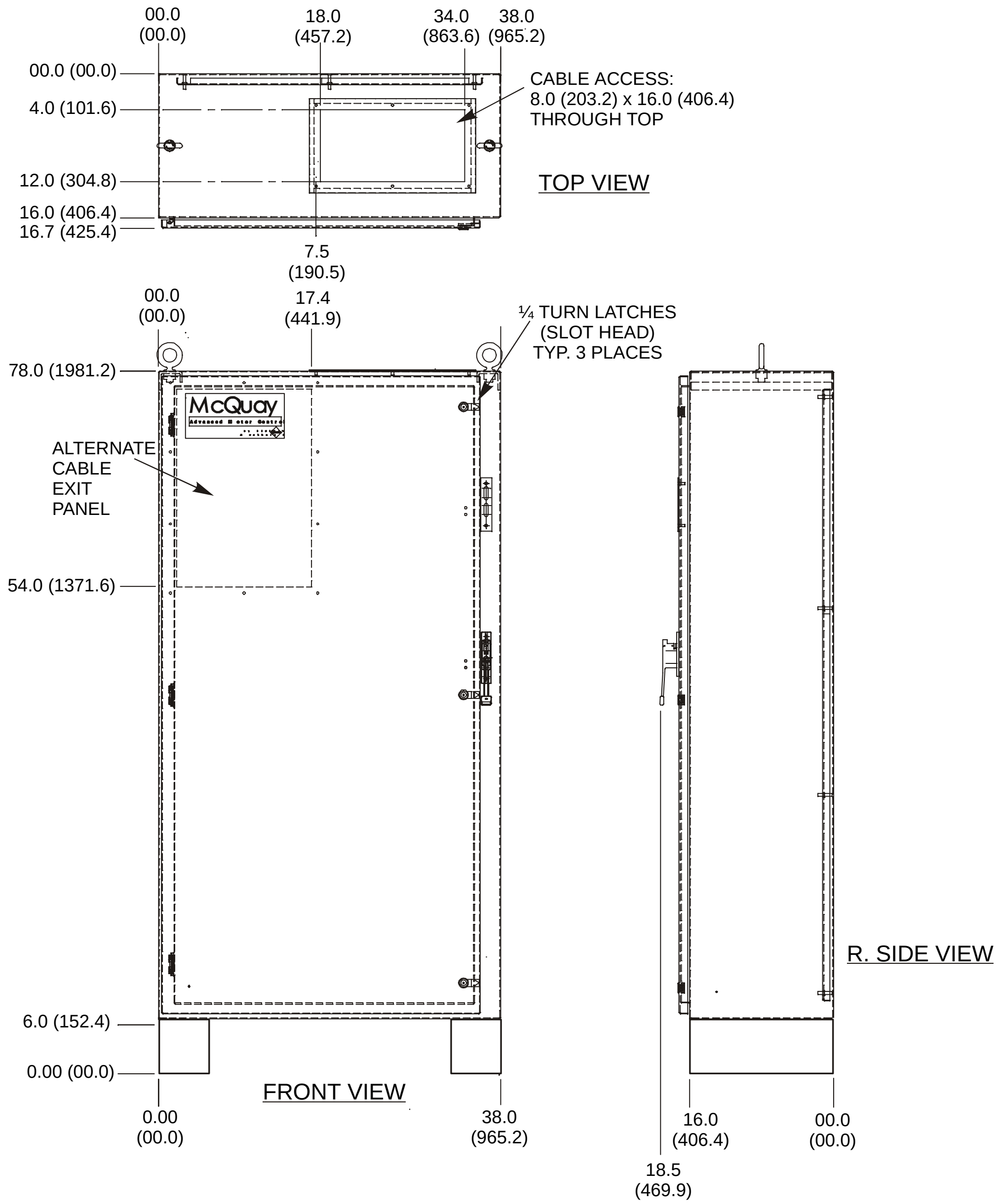
Figure 2, Solid State Starter, Free-Standing or Unit-Mounted Models RVSS14 to RVSS41, RVST14 to RVST41



NOTES:

1. All dimensions are in inches (mm).
2. The location of factory-mounted starters is shown on the chiller unit dimension drawing.
3. Free-standing Models RSVT have optional 18-inch legs as shown in front view.
4. Power factor correction capacitors cannot be mounted in this size enclosure.
5. Weight of free-standing model is 450 lbs (204 kg).
6. Incoming connections can be made through the removable plate on the top of the enclosure. If drilling is to be performed, the plate should be removed to avoid drill chips entering the enclosure.
7. For free-standing starters, the outgoing connections can be made through the top of the enclosure or through the upper-left rear area.

Figure 3, Free-Standing or Unit-Mounted, Solid State Starter Models RVSS47 to RVSS82, RVST47 to RSVT82



NOTES:

1. All dimensions are in inches (mm).
2. The location of factory-mounted starters is shown on the chiller unit dimension drawing.
3. The optional 6-inch high feet are for free-standing starters only.
4. Weight of free-standing models is 600 lbs (272 kg)
5. Incoming connections can be made through the removable plate on the top of the enclosure. If drilling is to be performed, the plate should be removed to avoid drill chips entering the enclosure.
6. For free-standing starters, the outgoing connections can be made through the top of the enclosure or through the upper-left rear area.

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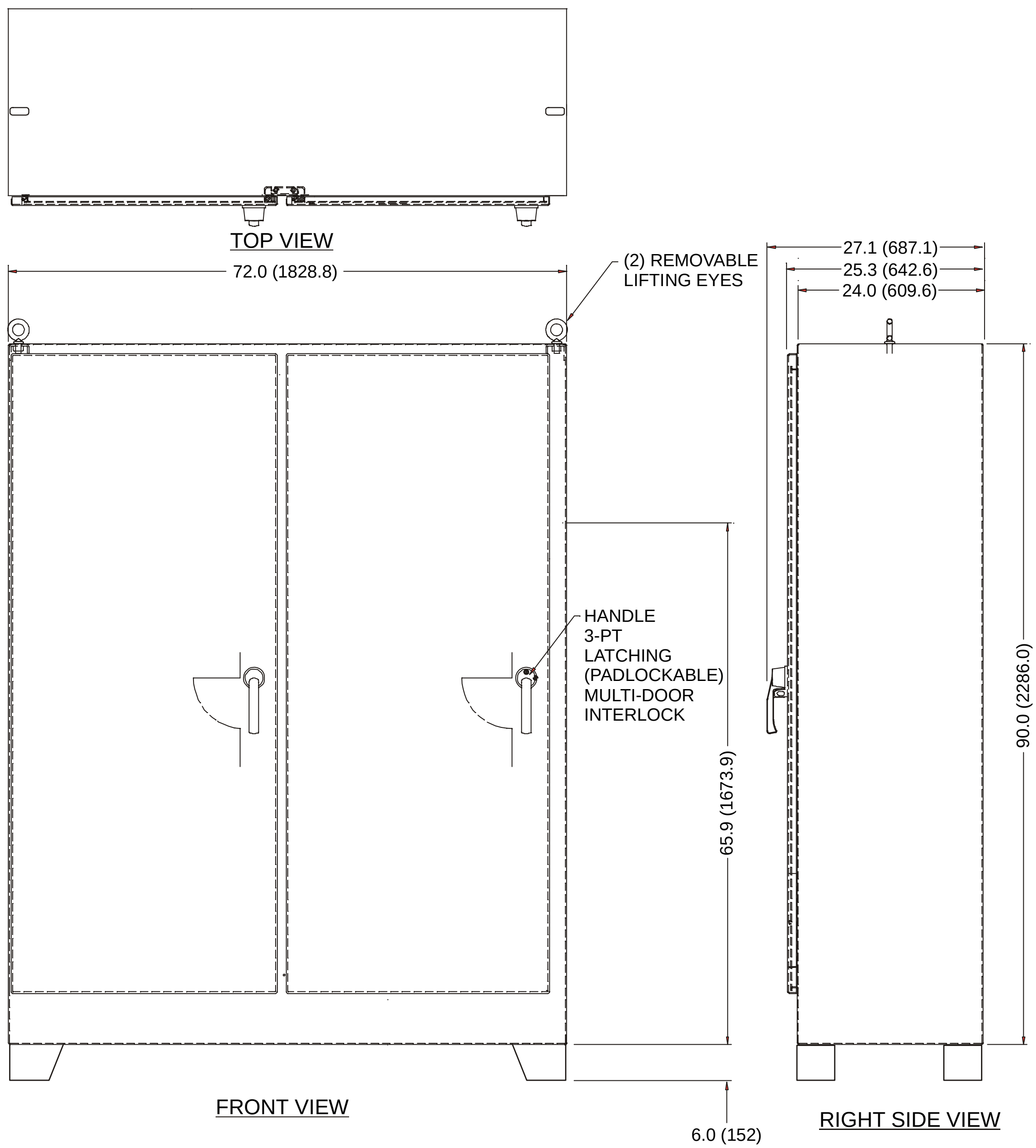
Figure 4, Solid State Starter, Free-Standing Only
Models RVSS96 to RVSS4K



NOTES:

1. All dimensions are in inches (mm).
2. Cable entry and exit through the enclosure top.

Low Voltage, Wye-Delta Closed Transition

Description

These starters, sometimes called “star-delta”, are a popular type for centrifugal chiller applications. They reduce inrush current by first connecting the three motor windings in a “wye” configuration to reduce the maximum inrush current to 33.3% of locked rotor amps and producing 33.3% of normal starting torque. After a brief delay (transition time), the electrical load is momentarily transitioned to resistors while the motor windings are changed to the delta configuration. The resistors minimize the second inrush current when the delta configuration becomes active. These starters are a good choice for centrifugal compressors because of the wye-delta’s low inrush current and low starting torque. Solid state starters, however, are becoming the starters of choice. Open transition starters (without the resistors) are not recommended.

Main Control Relays

Starters are equipped with redundant motor control relays, with coils in parallel and contacts in series, to interlock the starter with the chiller. These two relays constitute the only means of energizing the motor contractors. No other devices (manual or automatic) with the capability of energizing the starter can be used. The starter must be controlled solely by the chiller microprocessor.

Motor Protection and Overloads

Starters include devices to provide monitoring and protection functions. These controls include:

- Solid state overload (overcurrent) protection
- Phase unbalance protection
- Phase reversal and phase loss protection
- Under and over voltage protection
- Adjustable overload to closely match motor performance
- Three current transformers to measure motor current and a fourth current transformer for input to the chiller microprocessor.

Control Voltage Transformer

The starter is provided with a 3KVA control transformer with both secondary and primary fuses to supply control power to the chiller.

Surge Capacitors

Wye-delta starters are provided with surge capacitors as standard, either in the starter on unit mounted applications, or in the motor terminal box on free-standing starters. They protect the compressor motor from voltage “spikes”. Surge capacitors are not used with solid state starters.

Terminals

Solderless mechanical connectors are provided to handle wire sizes indicated by the NEC.

Table 8, Wye-Delta Starter Models

Free-Standing	Unit Mounted	Max RLA
D3WD11	D3WT11	110
D3WD12	D3WT12	129
D3WD14	D3WT14	146
D3WD15	D3WT15	155
D3WD25	D3WT25	255
D3WD31	D3WT31	310
D3WD34	D3WT34	344
D3WD43	D3WT43	431
D3WD62	D3WT62	620
D3WD65	D3WT65	650
D3WD86	-	862
D3WD1K	-	1241
D3WD2K	-	1400

Options

A variety of options are available for low voltage, wye-delta starters and some of which are dependent on the chiller mounting method. The options are listed below and their availability is shown in Table 11.

Auxiliary Relay

Four-pole relay, two normally open and two normally closed contacts.

Lightning Arrestors

Provide a safe path to ground for a lightning surge.

Ground Fault Protection

Protects equipment from damage from line-to-ground fault currents too small to trip overcurrent or short circuit protection devices.

Pilot Lights

Red and Green pilots on the front of the enclosure to indicate status.

Metering

Metering for the following are displayed in color on the chiller interface touchscreen. This display is a McQuay exclusive and a valuable operating tool.

Standard Amp Display: displays percent of unit rated full load amps, an approximation of percent load.

Optional "Full Meter Display": an impressive array of information is available with the addition of the full metering option. See page 43 for details. The following are included:

- Phase and average amps
- Phase and average volts
- Unit kW-hours
- kilowatts
- Power Factor

NEMA Modifications (Free-Standing Only)

The standard enclosure is NEMA 1. Optional enclosures are:

- NEMA 3R -- Rain resistant construction (consult McQuay sales office)
- NEMA 4 -- Dust tight/rain tight construction (consult McQuay sales office)
- NEMA 12 -- Dust tight construction (consult McQuay sales office)

Factory-mounted starters for WPV, WSC/HSC/TSC 063-087, and WDC/HDC 063-087 are only available with NEMA 1 enclosures. The starters are mounted on the unit and the conductors are routed directly to the motor terminal box through an opening in the rear of the starter enclosure.

Extended Warranty for Parts Only, or Parts & Labor

The duration and type of the starter warranty is determined by the chiller warranty.

Power Factor Correction Capacitors

The McQuay chiller selection program prints out the unit power factor and will also calculate capacitor size if power factor correction is required. See page 60 for details.

California Code

Modifications to the starter to comply with California code requirements.

Disconnect and Circuit Breaker Options

Non-fused disconnect

A molded case switch without an automatic trip, includes a through-the-door handle that can be used to break all power to the starter and chiller.

Fused disconnect switch (less fuses)

A fused disconnect switch is identical to the non-fused disconnect except that fuse clips are added. It is industry practice for the installer to supply the fuses so fuses are NOT included. The fuse clips are rated for 600 volts and the interrupting capacity will be dependent on the fuse type used. Typical interrupting rating is 200,000 amps. Refer to the following chart for fuse sizes.

Table 9, Fuse Sizes

RLA Range (amps)	Fuse Range (amps)	Fuse Class	Centerline Dim. Hole to Hole (in)	Mounting Pattern
81A to 156A	101A to 200A	200A, Class J	4.375	2 bolt
157A to 296A	201A to 400A	400A, Class J	5.25	2 bolt
297A to 444A	401A to 600A	600A, Class J	6.00	2 bolt
445A to 606A	601A to 800A	800A, Class L	6.25	2 bolt
607A to 888A	1000A to 1200A	1200A, Class L	6.25 (1), 9.375 (2)	4 bolt
889A to 1185A	1201A to 1600A	1600A, Class L	6.25 (1), 9.375 (2)	4 bolt
1186A to 1481A	1601A to 2000A	2000A, Class L	6.25 (1), 9.375 (2)	4 bolt

Notes:
1. Inside hole to inside hole.
2. Outside hole to outside hole

Thermal-Magnetic Circuit Breakers

Thermal-magnetic circuit breakers are available with standard, high, and high-high interrupting capacity.

Table 10, Ratings and Interrupting Capacity (kA) for Disconnects & Circuit Breakers on Wye-Delta Starters, 50 & 60 HZ

Max RLA	Non-Fused Disc.	Fusible Disconnect (Free-standing Only)			Standard Interrupting Circuit Breaker				
							Interrupting Capacity(kA)		
	Rating	Rating	Fuse Clip	Fuse Class	Frame	Rating	Up To 240 V	241V To 480 V	481V To 600 V
156	200	200	200	J	FD	250	65	35	18
296	400	400	400	J	JD	400	65	35	25
444	600	600	600	J	LD	600	65	35	25
606	800	800	800	L	MD	800	65	50	25
888	1200	1200	1200	L	ND	1200	65	50	25
1185	1600	1600	2000	L	PD	1600	65	50	25
1481	2000	2000	2000	L	RD	2000	65	50	25

Max RLA	High Interrupting Circuit Breaker					High-High Interrupting Circuit Breaker				
			Interrupting Capacity (kA)					Interrupting Capacity (kA)		
	Frame	Rating	Up To 240 V	241V To 480 V	481V To 600 V	Frame	Rating	Up To 240 V	241V To 480 V	481V To 600 V
156	HFD	250	100	65	25	CFD	250	200	200	100
296	HJD	400	100	65	35	CJD	400	200	150	100
444	HLD	600	100	65	35	CLD	600	200	150	100
606	HMD	800	100	65	50	CMD	800	200	100	65
888	HND	1200	100	65	50	CND	1200	200	100	65
1185	HPD	1600	100	65	50	CPD	1600	200	100	65
1481	HRD	2000	100	65	50	No Option				

Table 11, Starter Option Availability

Option	Factory-Mount	Free-Standing
Metering	X	X
Lightning Arrestors		X
Ground Fault Protection	X	X
Indicating Lights	X	X
4-Pole Auxiliary Relay	X	X
Power Factor Correction Capacitors		X
NEMA 3R		X
NEMA 4		X
NEMA 12		X
California Code	X	X
Non-Fused Disconnect	X	X
Fused Disconnect		X
Circuit Breaker	X	X
Extended Warranty	X	X

Connection Sizes

Table 12, Wye-Delta Connection Sizes, Standard Power Block

Starter Model No. (Note 1)	Incoming Connection Size, Power Block	Outgoing Connection Size (Note 2)
D3WD11	(2) #6 - 300	0.31
D3WD12	(2) #6 - 300	0.31
D3WD14	(2) #6 - 300	0.31
D3WD15	(2) #6 - 300	0.31
D3WD25	(2) #6 - 300	0.31
D3WD31	(2) #6 - 300	0.38
D3WD34	(2) #6 - 300	0.38
D3WD43	(2) #6 - 300	0.44
D3WD62	(2) #6 - 300	0.44
D3WD65	(2) #6 - 350	0.44
D3WD86	(4) 1/0 - 750	0.63
D3WD1K	(4) 1/0 - 750	0.63
D3WD2K	(4) 1/0 - 750	0.63

NOTES:

1. Also applies to unit-mounted starter, D3WT11, etc.
2. Outgoing connection is single hole, diameter in inches as shown.
3. Outgoing connections are factory-wired to the motor on factory-mounted starters.
4. When connecting to a power block, the connection size is determined by the starter size.

Table 13, Wye-Delta Connection Size, Disconnects & Circuit Breakers

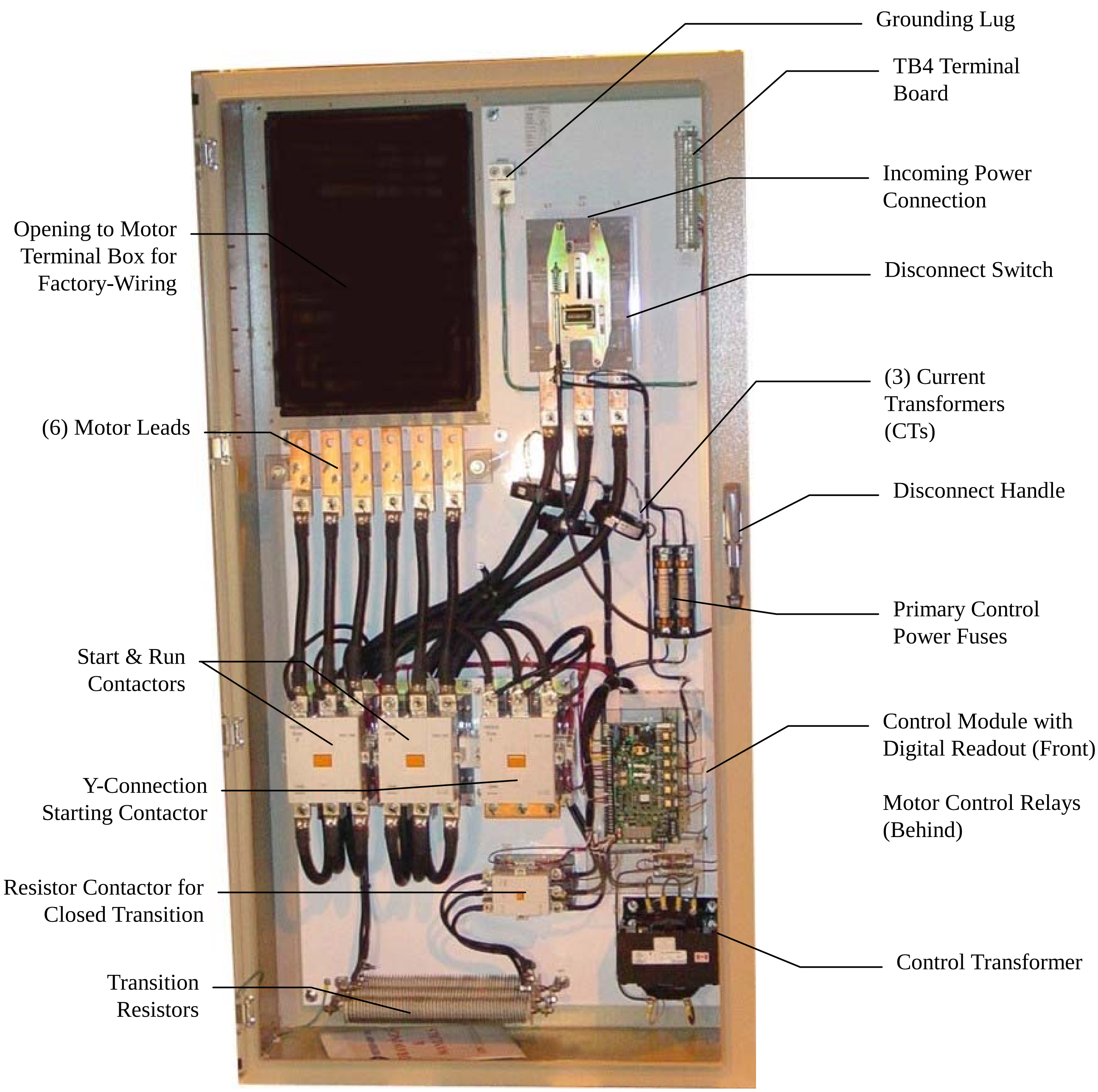
50/60 HZ Max RLA	Incoming Size Disconnect Switch	Incoming Size Circuit Breaker
74	#6- 350	#6- 350
93	#6- 350	#6- 350
148	#6- 350	#6- 350
163	#6- 350	#6- 350
185	2/C 3/0 - 500	2/C 3/0 - 500
296	2/C 3/0 - 500	2/C 3/0 - 500
444	3/C 1/0 - 500	3/C 1/0 - 500
593	4/C 250 - 500	4/C 250 - 500
889	5/C 300 - 600	5/C 300 - 600
1185	5/C 300 - 600	5/C 300 - 600
1481	5/C 300 - 600	5/C 300 - 600

NOTES:

1. For field wiring free-standing starters, the outgoing connection size is determined by the starter size listed in Table 12 under the “Outgoing Connection Size” column. Outgoing connections are factory-wired to the motor on factory-mounted starters.
2. When wiring to a starter with a disconnect switch or circuit breaker, the incoming connection size is determined by the amp rating of the device as shown above.

Component Location

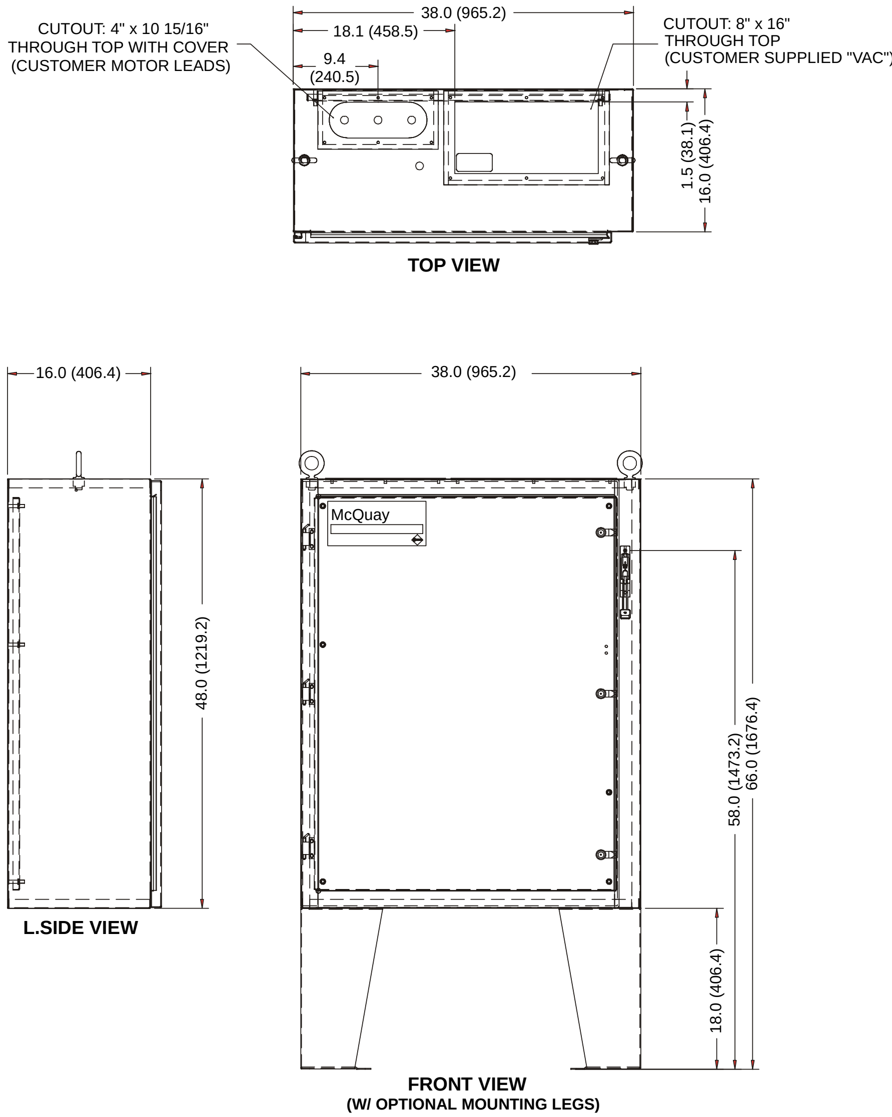
Figure 5, Models D3WD62 – D3WD65, D3WT62 – D3WT65 Wye-Delta, Closed Transition, Low Voltage Starter



NOTE: Models D3WD11 – D3WD43 and D3WT11 – D3WT43 are similar in appearance, but in a shorter cabinet.

Dimensions

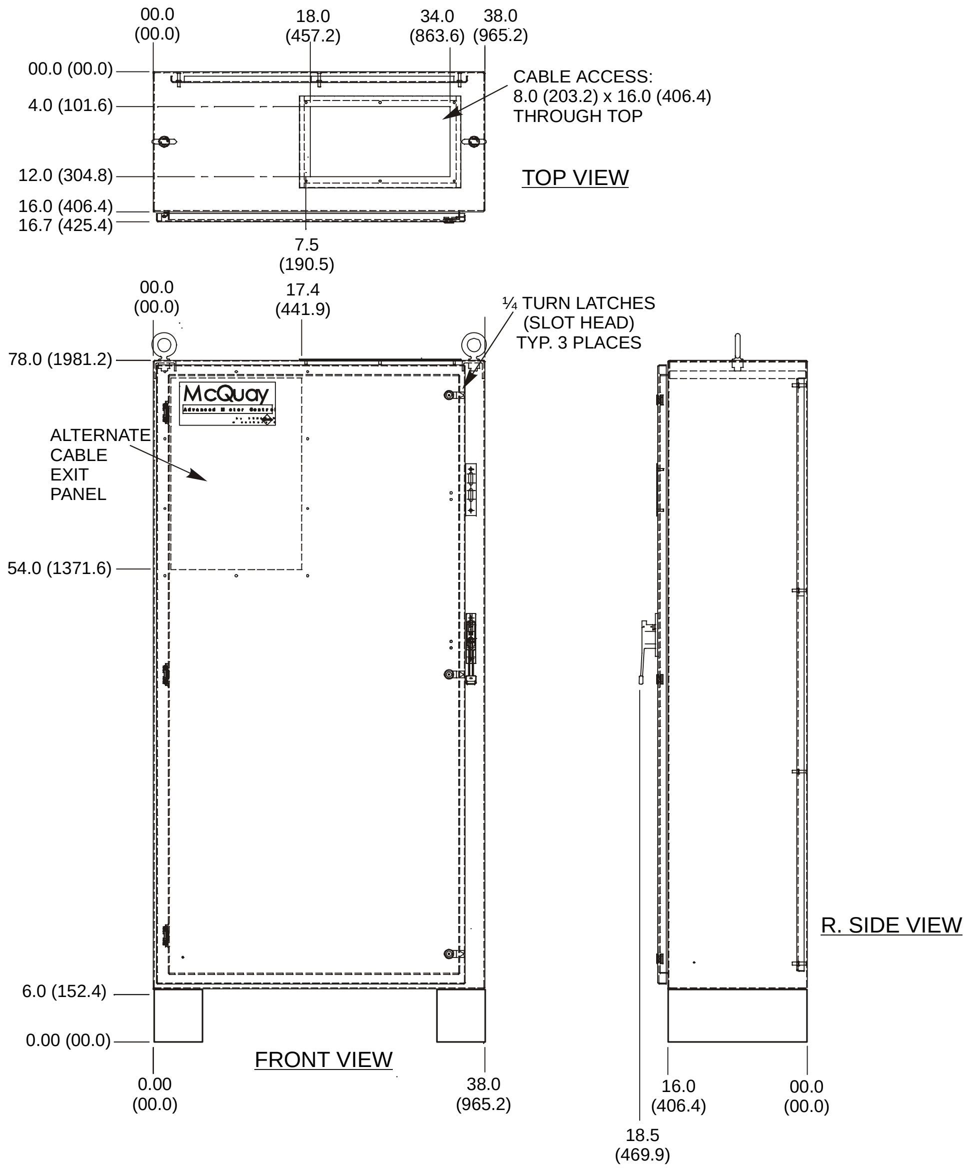
Figure 6, Wye-Delta Starter, Free-Standing or Unit-Mounted Models D3WD11 to D3WD43, D3WT11 to D3WT43



NOTES:

1. All dimensions are in inches (mm).
2. Free-standing YD models have optional 18-inch legs as shown in front view.
3. Power factor correction capacitors cannot be mounted in this size enclosure.
4. Weight of free-standing model is 450 lbs (204 kg).

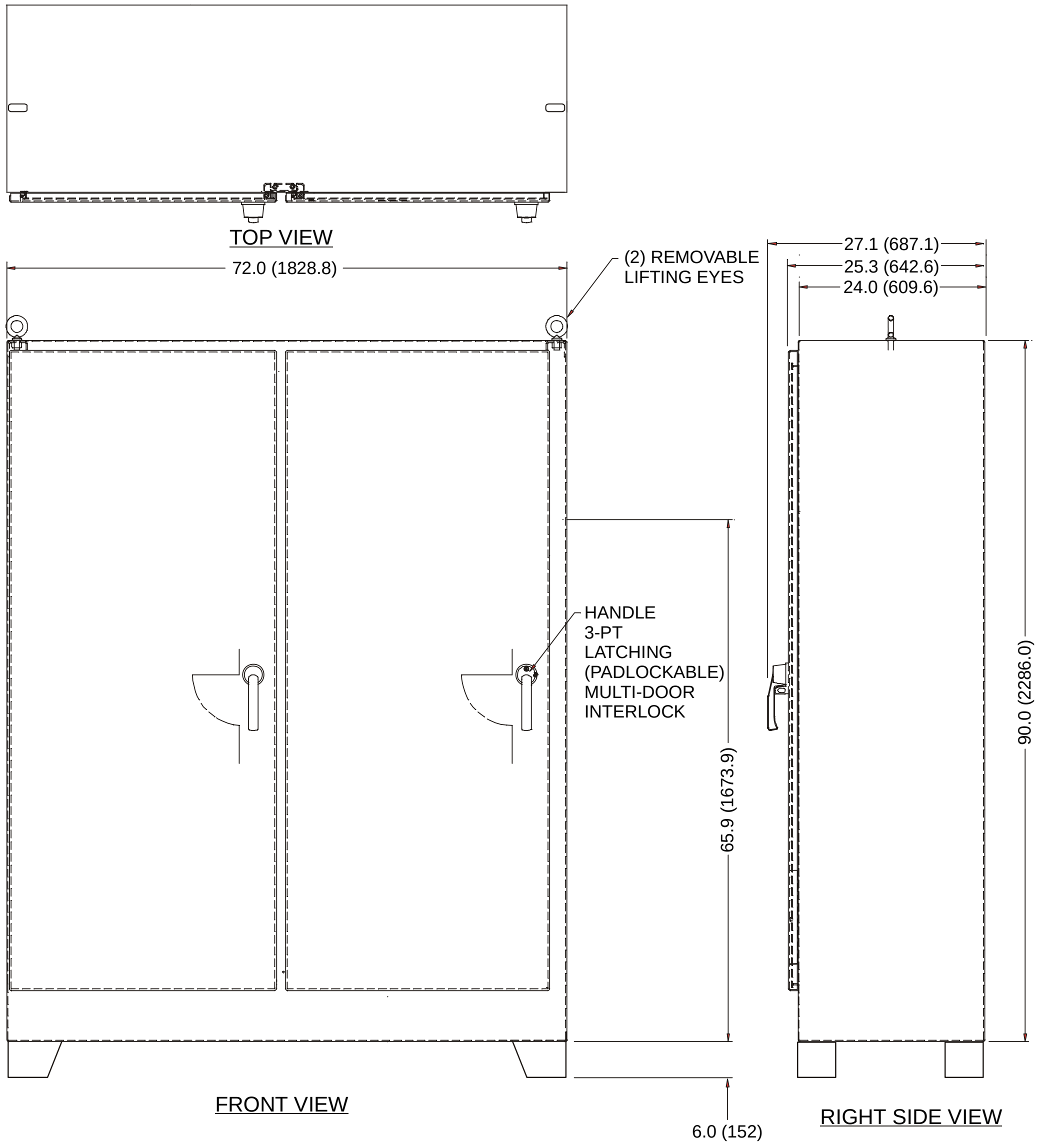
Figure 7, Wye-Delta Starter, Free-Standing or Unit-Mounted Models D3WD62 to D3WD65, D3WT62 to D3WT65



NOTES:

1. The location of factory-mounted starters is shown on the chiller unit dimension drawing.
2. The optional 6-inch feet are for free-standing starters only.
3. Weight of free-standing unit is 600 lbs (272 kg).
4. Power factor correction capacitors up to 50 KVAR can be mounted internally.
5. Incoming connections can be made through the removable plate on the top of the enclosure. If drilling is to be performed, the plate should be removed to avoid drill chips entering the enclosure.
6. For free-standing starters, the outgoing connections can be made through the top of the enclosure or through the upper-left rear area.

Figure 8, Wye-Delta Starter, Free-Standing Only Models D3WD86 to D3WD2K



NOTES:

1. All dimensions in inches (mm)
2. Cable entry and exit through the enclosure top.

Medium Voltage Starters (2300 to 7200 Volts)

Agency Approvals

All controllers are for continuous duty, constructed in accordance with National Electric Manufacturers Associations (NEMA) Standard for Industrial Controls and Systems (ICS). Medium voltage starters are rated as NEMA Class E2. They have UL and cUL labels available as an option and can be modified to meet most federal, state and local codes.

Contactor Duty

Contactors are capable of carrying the specified current on a continuous basis and also handle locked rotor amps on a temporary basis without damage.

Storage and Operating Environment

Starters can be stored at temperatures from -40°F to 140°F (-40°C to 60°C). Operating range is from 32°F to 104°F (0°C to 40°C) with a maximum relative humidity of 95%.

Enclosure and Cable Penetrations

Unless stated otherwise, the starter enclosures for medium and high voltage starters are NEMA 1 with gaskets. Standard construction for free -standing starters allows main power to enter the top of the starter and load side connections through the bottom, lower sides, or back near the floor.
Adequate separation of high and low voltage sections and proper mechanical and electrical interlocks are provided to meet all safety and operating codes.

Starter Types

Available medium/high voltage starters are solid state, across-the-line, reduced voltage auto transformer, and reduced voltage primary reactor.

Mounting

All medium voltage starters are only available as free-standing.

Solid State

The solid state starter includes a load break switch as standard, and is described on page 26. They are fast becoming the starter of choice for centrifugal compressors.

Across-the-Line Starter

Across-the-line starters are very simple and consist of a primary contactor that allows locked rotor amps to reach the motor when energized. These starters are low cost, provide the highest starting torque, highest inrush current, and can be used with any standard medium voltage motor. A complete description begins on page 33.

Auto transformer Starter

This starter type uses a transformer winding per phase with 50%, 65%, and 80% taps. The taps determine the initial voltage and resulting inrush amps that will reach the motor.   For centrifugal compressors, the 65% tap is used allowing 42% of normal inrush current and produces 42% of starting torque. The 50% tap will usually not produce enough starting torque and the 80% tap allows unnecessary inrush (64% of LRA).

Once the starting sequence begins, the motor is not disconnected from the line, which prevents a second inrush “spike” from occurring. A bypass contactor is provided for across-the-line operation after the start-up cycle is completed. Auto transformer starters are a good choice because of their efficiency and smooth starting characteristics. A complete description begins on page 36.

Primary Reactor Starter

Primary reactor starters are medium voltage starters that use a reactor in series with the motor to reduce inrush current. These starters have a higher inrush current for the same starting torque as an auto transformer starter. The starters are factory wired at the 65% tap which produces 42% starting torque and 65% inrush current. A bypass contactor is provided for across-the-line operation after the start-up cycle is completed. A complete description begins on page 36.

Description, Solid State Starters

Solid state starters are an excellent type of starter for centrifugal compressors. McQuay is able to offer these superior starters at a price competitive with the traditional wye-delta starters. Solid state starters have become the starters-of-choice for most applications. These starters use solid state switching devices called SCRs (silicon controlled rectifiers) to control the flow of current to the motor during start-up.

During starting, SCRs control the amount of voltage that reaches the motor, which in turn, controls the motor's acceleration and current inrush. Eventually, full voltage is applied and a bypass contactor is energized. The contactor bypasses the SCRs and allows full current direct to the motor. This reduces heat build-up to prolong the life of solid-state circuit boards, SCRs, and other starter components. The compressor size and motor characteristics determine the starter operational setpoints. Motor starting torque is reduced to the minimum required by the compressor/motor load.

Features

McQuay solid state starters afford the most precise form of motor and compressor acceleration: McQuay solid state starters have adjustable starting current and acceleration settings. This feature provides precise motor control that cannot be accomplished utilizing the fixed 33% starting torque available from a wye delta starter, or other fixed level electro-mechanical starters. These adjustments are extremely important in assuring that the starter delivers exactly the amount of current and torque necessary to perform the smoothest start possible. In addition, if conditions change, i.e., temperature, bearing condition, unloading operation, to the point where the fixed level starter cannot support the acceleration torque needed, the motor will simply hang up or worse, skip the first step of wye delta starting and proceed directly to a full voltage start. With the McQuay solid state starters, the motor will always ramp up to meet the torque level required in a smooth linear predictable time period-with no transition surge. McQuay solid state starters are defaulted to set levels that have been predetermined to provide the best start possible. Wye-delta starters are not capable of being programmed in such a manner; they are what they are.

McQuay solid state starters provide a smoother, softer start. Wye-delta starters and other electro-mechanical starters produce fixed amounts of torque that are generally in excess of that required by the compressor load. The McQuay solid state starter tapers accelerating current to just what is required by the compressor. No initial surges or transitional surges are experienced with a solid state starter. This fact translates directly to less mechanical stress on the motor/compressor drive train, extending the life of the compressor.

McQuay solid state starters provide better control of the motor inrush current. By controlling both voltage and current going to the motor, the solid state starter lowers the nominal inrush current to a desired level and also eliminates any transitional currents. The beneficial effects of this are extended motor life and less strain on the user's power distribution system.

McQuay solid state starters are extremely reliable. The McQuay solid state starters have an integral bypass contactor that takes the SCRs out of the system once the motor has been brought up to full speed. In addition, the McQuay solid state starters have embedded self-diagnostic features, not available in competitive wye delta starters, which protect both the starter and the motor.

McQuay solid state starters are extremely price competitive. McQuay International has been able to bring the price of solid state starters below the price of electro-mechanical controls such as wye delta starters, giving the customer more control and better protection for less money. In addition, parts replacement of solid state starters is minimal compared to wye delta starters. The solid state starter is designed to protect itself from component failure.

McQuay solid state starters are simple to use. Care is taken to provide solid state starters that default to the most efficient settings. The starters have been tested in our lab to determine the best setpoints for maximum performance of the compressor. They are literally plug and play devices. In addition, the self-diagnostics of the solid state starter do their own trouble shooting and take the proper steps (notification/shutdown) to correct a fault.

Motor Control Features

The starter provides closed-loop, current controlled, soft-starting, utilizing silicon controlled rectifiers (SCR). The current ramp, start profile is based on programmable motor FLA, initial current, final current and ramp time.

Enclosures

The basic structure is welded type construction utilizing minimum 11-gauge sheet metal.

Doors are minimum 12-gauge sheet metal, pan type with flanges formed to provide a sturdy, rigid structure.

Doors with circuit breakers or disconnect switches are interlocked to prevent the doors from being opened with power applied.

Doors are hinged to allow 120^o swing.

The standard starter enclosures are gasketed NEMA 1.

The starter cabinet contains the following:

- Main load break and fault make isolating switch.
- Vacuum inline and bypass contactors.
- Current limiting power fuses
- Low voltage control panel.

The enclosure finish is as follows:

- Metal parts are given a thorough rust-resistant treatment.
- Primer is a recoatable epoxy primer B-67 Series.
- Finish is a high solid polyurethane Polate T plus F63 series.

Disconnects

A load break disconnect switch for isolating the starter is standard on medium and high voltage starters.

Motor Protection Features

The starter monitors the motor with current and voltage feedback. If any condition occurs that could damage the compressor motor, the starter declares a fault condition, the run relays are de-energized, the fault contactors close, and the motor is immediately shut down. The starter is latched off until a reset command is received.

Overload

The starter monitors motor current through the current transformers (CTs) and performs an I^2t (current and time) thermal overload calculation. If the calculated overload exceeds the maximum allowed, a fault condition is declared.

Overcurrent

The starter monitors motor current through the CTs after the motor is up to speed. If the current rises above a programmed trip level (in % of RLA) for a programmed length of time, a fault condition is declared.

Ground Fault

The starter monitors the motor current for residual ground fault currents. If the measured residual ground fault exceeds a programmed trip level for more than 3 seconds, a fault condition is declared.

No Current at Run

The starter monitors the phase-one current through a CT. If the current is less than 10% rated for one second, a fault is declared.

Over/Under Voltage

The starter monitors the line voltages. If the voltage drops below, or rises above, programmed trip levels, a fault condition is declared.

Current Unbalance

The starter monitors individual phase currents. If the unbalance exceeds a programmed trip level for more than 10 seconds, a fault condition is declared.

Phase Rotation

The starter monitors the three-phase voltage rotation. If C-B-A phase sequence is detected (A-B-C is standard) while the motor is stopped, an alarm condition is declared. If a start command is subsequently received while the sequence is C-B-A, a fault condition is declared and an attempt to start will not be made.

Shorted/Open SCR

The starter monitors individual phase currents and stack voltages and can determine when an SCR is shorted or opened. If either condition exists for 300 milliseconds, a fault condition is declared.

Standard Metering

The percent of rated load amps is displayed on the chiller interface touch screen.

Table 14, Solid State Starter Models

2300 V		3300 V		4160 V		5.1 kV – 7.2 kV	
Model No.	**Max. RLA**	**Model No.**	**Max. RLA**	**Model No.**	**Max. RLA**	**Model No.**	**Max. RLA**
MVSS36	36	MVSS50	50	MVSS40	40	HVSS42	42
MVSS12	120	MVSS13	127	MVSS99	99	HVSS63	63
MVSS18	180	MVSS16	169	MVSS33	133	HVSS84	84
MVSS24	240	MVSS21	211	MVSS68	168	HVSS05	105
MVSS30	300			MVSS20	200		

Options

Metering

Metering for the following is displayed in color on the chiller VGA interface touchscreen.

Standard Amp Display; displays the percent of unit rated load full amps, an approximation of chiller load.

Lightning Arrestors

Provide a safe path to ground for a lightning surge.

Ground Fault Protection

Protects equipment from damage from line-to-ground fault currents too small to trip overcurrent or short circuit protection devices.

Pilot Lights

Red and green pilot lights on the front of the enclosure to indicate status.

NEMA Modifications

The standard enclosure is NEMA 1 with additional gasketing.

- NEMA 3R -- Rain resistant construction (consult McQuay sales office)
- NEMA 4 -- Dust tight/rain tight construction (consult McQuay sales office)
- NEMA 12 -- Dust tight construction (consult McQuay sales office)

Extended Warranty for Parts Only, or Parts & Labor

The duration and type of the starter warranty is determined by the chiller warranty.

Power Factor Correction Capacitors

The McQuay chiller selection program prints out the unit power factor and will also calculate capacitor size if power factor correction is required. See page 60 for details.

California Code

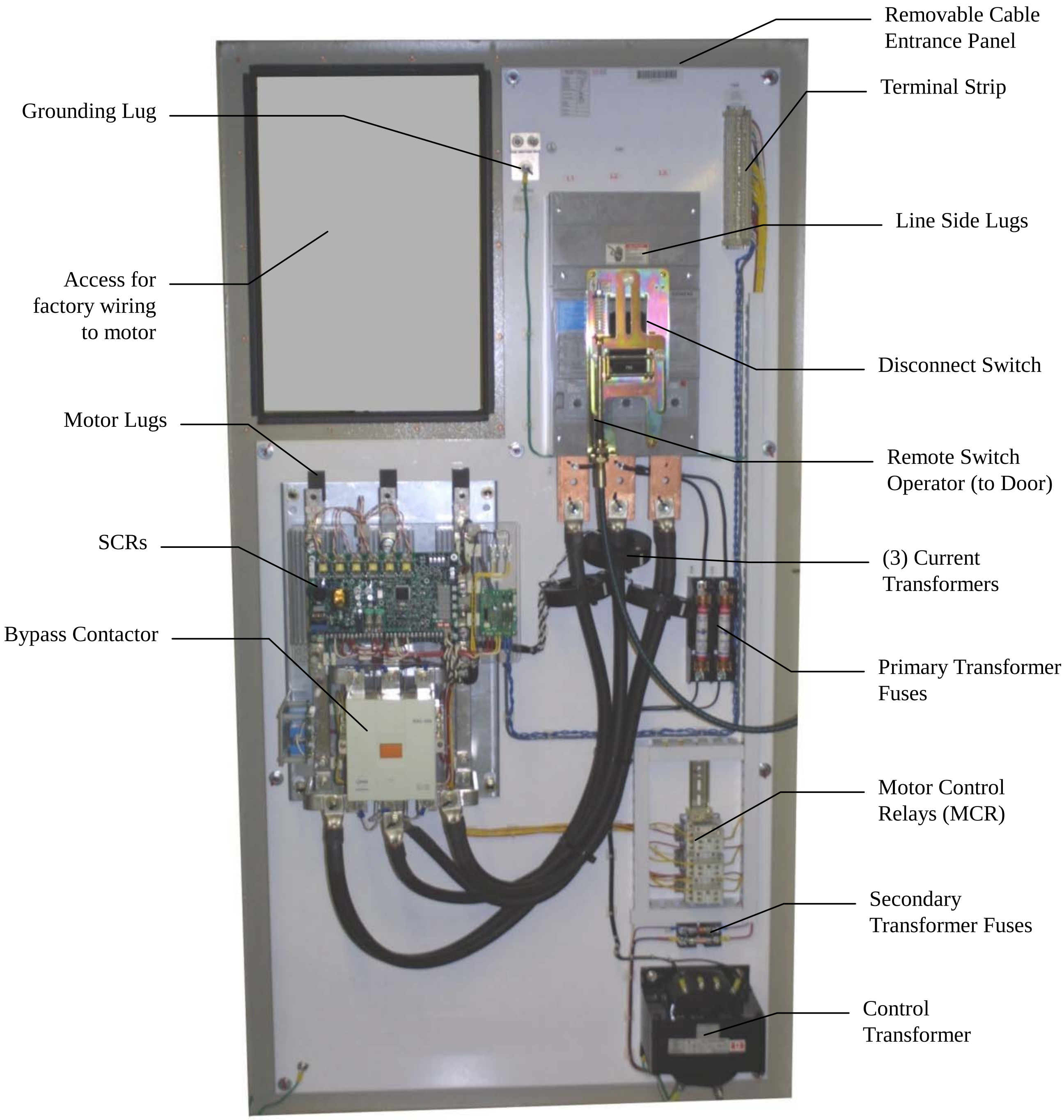
Modifications are made to the starter to comply with California Code requirements.

Terminal Sizes

Incoming and outgoing connections are crimp-type connectors, standard bus tabs are NEMA 2.

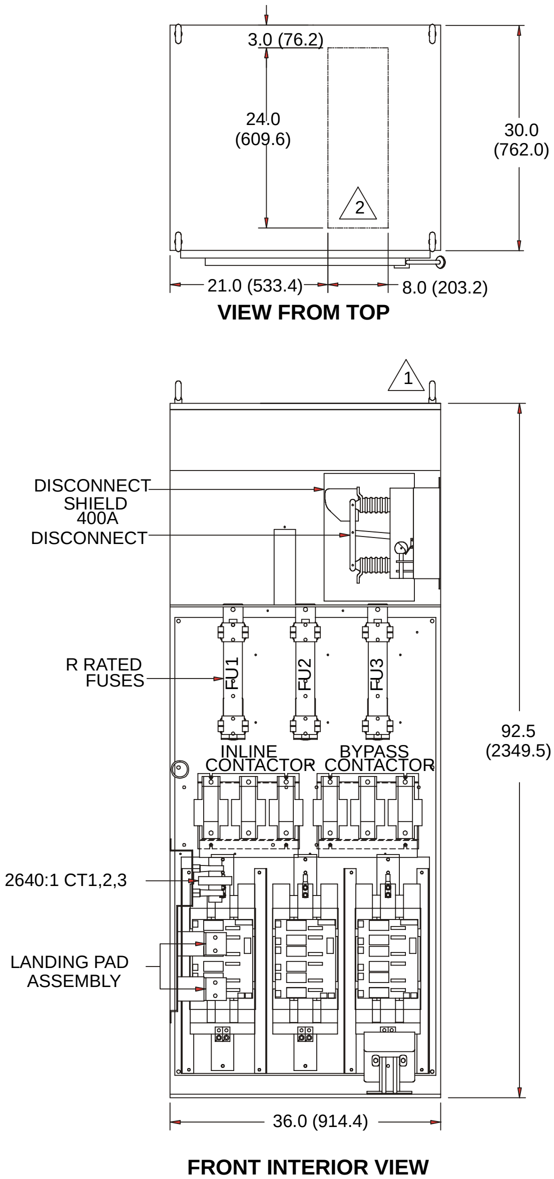
Component Location

Figure 9, Solid State Starter w/ Disconnect, Free-standing Only



Dimensions

Figure 10, Solid State Starter, Free-Standing Only
Medium Voltage, 2300V to 4160V
All Models MVSS



NOTES:

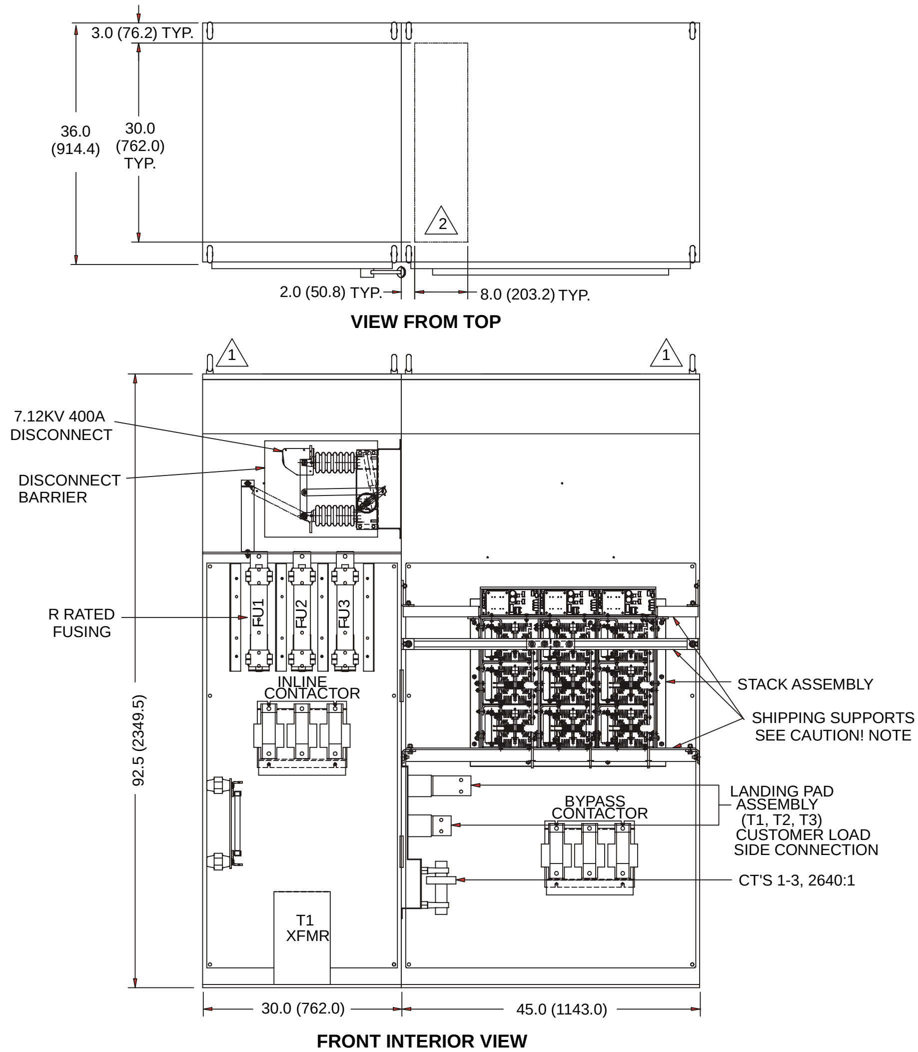
1. REMOVABLE LIFTING EYEBOLTS, PLUG HOLES IF REMOVED.
2. CABLE ENTRY/EXIT AREA. NO CUTOUT SUPPLIED. CUSTOMER TO CUT AS REQUIRED.
3. ENCLOSURE COLOR: ANSI 61 GREY
4. TIGHTEN BOLTS PER CHART BELOW

STEEL BOLT TORQUE IN FOOT-POUNDS				
1/4-20	5/16-18	3/8-16	1/2-13	5/8-11
5	12	20	50	95

5. STARTER WEIGHT: APPOXIMATELY 1800LBS

NOTE: Dimensions shown are for standard starters without options that can affect unit dimensions and weight. Consult the local McQuay sales office for information.

Figure 11, Solid State Starter, Free-Standing Only
Medium Voltage, 5100V to 7200V
All Models HVSS



NOTES:
1. REMOVABLE LIFTING EYEBOLTS, PLUG HOLES IF REMOVED.
2. CABLE EXIT AREA. NO CUTOUT SUPPLIED. CUSTOMER TO CUT AS REQUIRED.
3. ENCLOSURE COLOR: ANSI 61 GREY.
4. TOTAL WEIGHT IS APPROXIMATELY 2400LBS.
5. TYPICAL LAYOUT FOR EACH STARTER.
6. TIGHTEN BOLTS PER CHART AT RIGHT.

STEEL BOLT TORQUE IN FOOT-POUNDS				
1/4-20	5/16-18	3/8-16	1/2-13	5/8-11
5	12	20	50	95

NOTE: Dimensions shown are for standard starters without options that can affect unit dimensions and weight. Consult the local McQuay sales office for information.

Medium Voltage, Across-the Line

Description

Across-the-line starters contain the standard components listed below.

Main Control Relays

Starters are equipped with redundant motor control relays, with coils in parallel and contacts in series, to interlock the starter with the chiller. These two relays constitute the only means of energizing the motor contactors. No other devices (manual or automatic) with the capability of energizing the starter can be used. The starter must be controlled by the chiller microprocessor.

Motor Protection and Overloads

Starters include devices to provide monitoring and protection functions. These controls include:

- Solid state overload (overcurrent) protection
- Phase unbalance protection
- Phase reversal and phase loss protection
- Under/over voltage protection
- Adjustable overload to closely match motor performance
- Three current transformers to measure motor current and a fourth current transformer for input to the chiller microprocessor.

Control Voltage Transformer

The starter is provided with a 3 KVA control transformer with both secondary and primary fuses to supply control power to the chiller.

Terminals

Solderless mechanical connectors are provided to handle wire sizes indicated by the NEC.

Load-Break Disconnect Switch

Fuses

Three vertically mounted, current limiting power fuse blocks (Class "R" fuses included).

Table 15, Across-the-Line Starter Models

2300 V		3300 V		4160 V		6600 V	
Model No.	**Max RLA**	**Model No.**	**Max RLA**	**Model No.**	**Max RLA**	**Model No.**	**Max RLA**
MVAT12	120	MVAT16	169	MVAT13	133	HVAT27	127
MVAT24	240	MVAT21	211	MVAT26	267		
MVAT36	360	MVAT25	254				

Options

Surge Capacitors

Surge capacitors to protect the compressor motor from voltage spikes can be provided as an option.

Auxiliary Relay

Four-pole relay, two normally open and two normally closed contacts.

Lightning Arrestors

Provide a safe path to ground for a lightning surge.

Ground Fault Protection

Protects equipment from damage from line-to-ground fault currents too small to trip overcurrent or short circuit protection devices.

Pilot Lights

Red and Green pilots on the front of the enclosure to indicate status.

NEMA Modifications

The standard enclosure is NEMA 1 with additional gasketing.

- NEMA 3R -- Rain resistant construction (consult McQuay sales office)
- NEMA 4 -- Dust tight/rain tight construction (consult McQuay sales office)
- NEMA 12 -- Dust tight construction (consult McQuay sales office)

Extended Warranty for Parts Only, or Parts & Labor

The duration and type of the starter warranty is determined by the chiller warranty.

Power Factor Correction Capacitors

The McQuay chiller selection program provides the unit power factor and will also calculate capacitor size for power factor correction, if required. See page 60 for details.

California Code

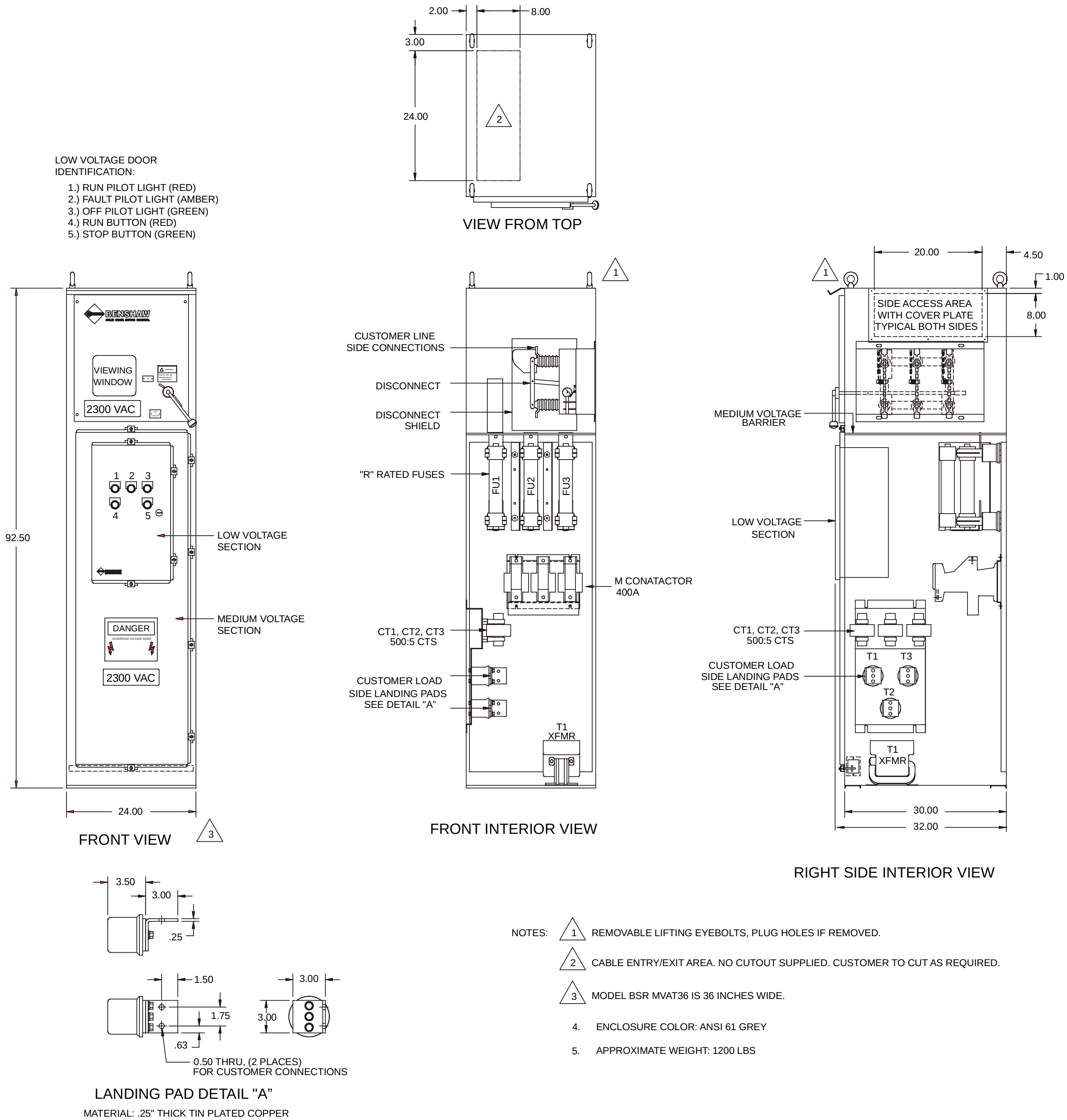
Modifications to the starter to comply with California Code requirements.

Terminal Sizes

Incoming and outgoing connections are crimp-type connectors, standard bus tabs are NEMA 2 hole.

Dimensions, Across-the-Line

Figure 12, Across-the-Line, Medium Voltage Free-Standing Only
Models MVAT12-24, MVAT 16-25, MVAT13-26, HVAT27
Model MVAT 36, See Note 3 Below.



NOTE: Dimensions shown are for standard starters without options that can affect unit dimensions and weight. Consult the local McQuay sales office for information.

Medium Voltage, Auto Transformer & Primary Reactor

Description

Reduced Voltage Primary Reactor

In addition to the standard components listed below, these starters also contain:

- Drawout magnetic, three-pole, vacuum break shorting assembly
- Three-phase starting reactor, factory set at the 65% tap

Reduced Voltage Auto Transformer

In addition to the standard components listed below, these starters also contain:

- Drawout magnetic, three-pole, vacuum break shorting contactor
- Drawout magnetic, two-pole, vacuum break starting contactor
- Open delta starting auto transformer factory set at 65%

Standard Components

Main Control Relays

Starters are equipped with redundant motor control relays, with coils in parallel and contacts in series, to interlock the starter with the chiller. These two relays constitute the only means of energizing the motor contractors. No other devices (manual or automatic) with the capability of energizing the starter can be used. The starter must be controlled by the chiller microprocessor.

Motor Protection and Overloads

The starter includes overload protection functions. These controls include:

- Solid state overload (overcurrent) protection
- Phase unbalance protection
- Phase reversal and phase loss protection
- Adjustable overload to closely match motor performance
- Three current transformers to measure motor current and a fourth current transformer for input to the chiller microprocessor

Undervoltage (UV) Relay

The undervoltage relay is an adjustable three-phase protection system that is activated when the voltage falls below a predetermined safe value and is factory set at 90% of nominal.

Control Voltage Transformer

The starter is provided with a 3KVA control transformer with both secondary and primary fuses to supply control power to the chiller.

Additional Standard Components

- Mechanical type solderless connectors are provided to handle wire sizes indicated by the NEC
- Three isolated vertical line contactors
- Three-pole, gang operated, non-load-break isolating safety switch
- Three vertically mounted, current limiting, power fuse blocks (fuses included)
- Magnetic three-pole, vacuum break contactor
- Three KVA control circuit transformer
- Vertically mounted control circuit primary current limiting fuses
- Current transformers
- Load terminals
- Control circuit terminal blocks and secondary fuses

Certifications and Approvals

- UL (USA and Canadian) certification is standard for all type medium voltage starters.

Table 16, Primary Reactor & Auto Transformer Starter Models, 2300V – 4800V

Auto Transformer			Primary Reactor		
Model No.	**Max RLA**	**Max LRA**	**Model No.**	**Max RLA**	**Max LRA**
602M01	18	325	502M01	18	325
602M02	27	325	502M02	27	325
602M03	32	325	502M03	32	325
602M04	46	325	502M04	46	325
602M05	55	750	502M05	55	750
602M06	65	750	502M06	65	750
602M07	88	750	502M07	88	750
602M08	107	1000	502M08	107	1000
602M09	125	1000	502M09	125	1000
602M10	148	1000	502M10	148	1000
602M11	172	1500	502M11	172	1500
602M12	204	2000	502M12	204	2000
602M13	255	2000	502M13	255	2000

Table 17, Primary Reactor & Auto Transformer Starter Models, 5000V – 6900V

Auto Transformer			Primary Reactor		
Model No.	**Max RLA**	**Max LRA**	**Model No.**	**Max RLA**	**Max LRA**
602H01	18	325	502H01	18	325
602H02	27	325	502H02	27	325
602H03	32	325	502H03	32	325
602H04	46	325	502H04	46	325
602H05	55	750	502H05	55	750
602H06	65	750	502H06	65	750
602H07	88	750	502H07	88	750
602H08	107	1000	502H08	107	1000
602H09	125	1000	502H09	125	1000
602H10	148	1000	502H10	148	1000
602H11	172	1500	502H11	172	1500
602H12	204	2000	502H12	204	2000
602H13	255	2000	502H13	255	2000

Options

Metering Devices (Displayed on Starter)

- Reduced voltage primary reactor and auto transformer:
  - Analog ammeters and voltmeters with 3-phase selector switches.
  - Full metering system, IQ 310, which includes digital readouts of 3-phase amps, 3-phase volts, watt-hours, watts, volt-amps, volt-amp reactive (VAR)-hours, power factor, and frequency; all in a single device.

Lightning Arrestors

Provide a safe path to ground for a lightning surge.

Ground Fault Protection

Protects equipment from damage from line-to-ground fault currents too small to trip overcurrent or short circuit protection devices.

Surge Capacitors

Starters can be provided with surge capacitors to protect the compressor motor from voltage spikes. Surge capacitors are not used with solid state starters.

Pilot Devices

Indicating lights, additional electrical interlocks and control relays.

NEMA Modifications

NEMA modifications for the NEMA 1-gasketed standard enclosure include:

- NEMA 3R -- Rain resistant construction (contact McQuay sales office)
- NEMA 12 -- Dust tight construction (contact McQuay sales office)

Power Factor Correction Capacitors

The McQuay chiller selection program prints out the unit power factor and will also calculate capacitor size for power factor correction, if required. See page 60 for details.

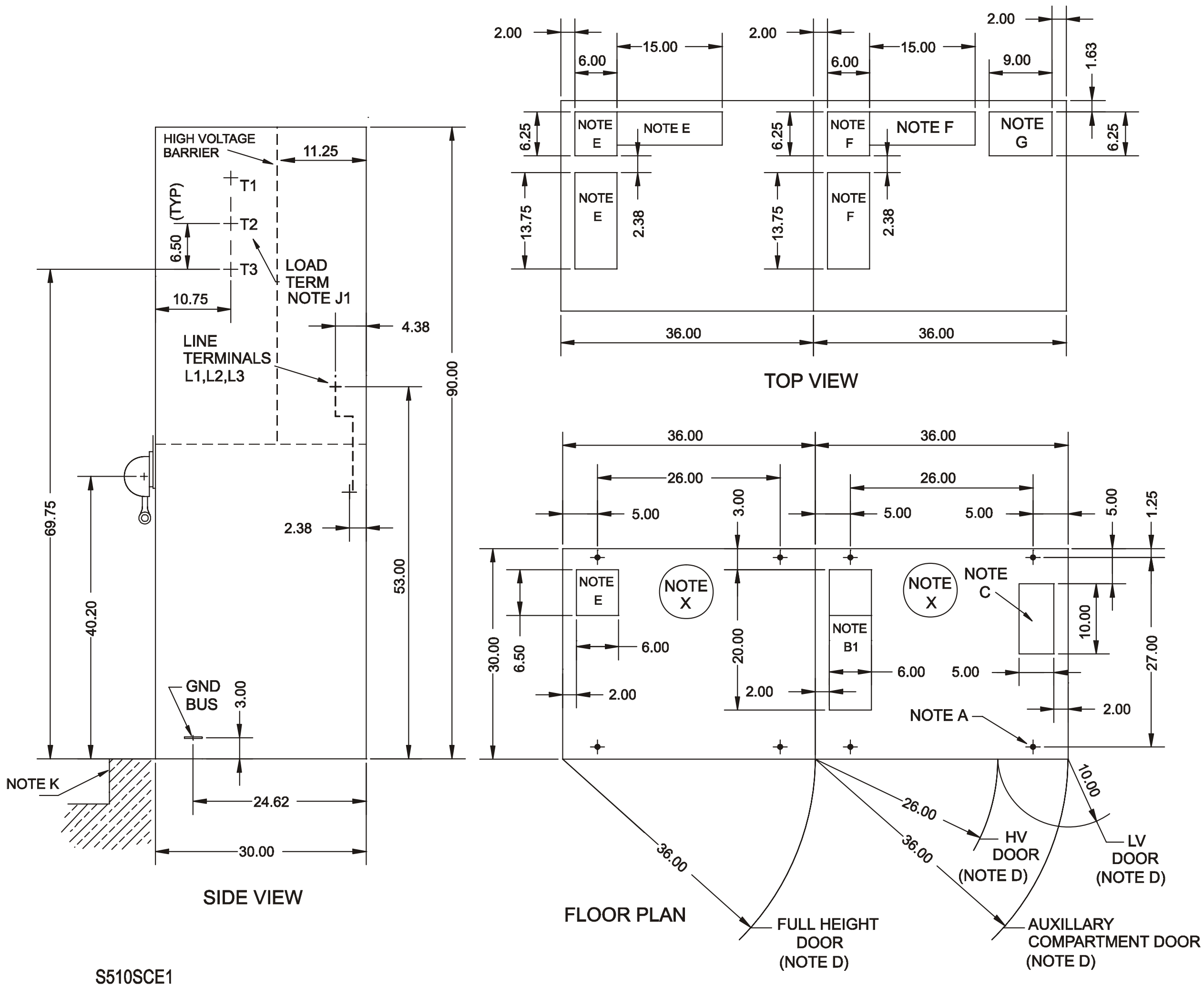
Notes for Medium Voltage Starters

- Reduced voltage enclosures are 90" tall, 72" wide and 30" deep.
- Add 10" to height if main horizontal bus is required for interconnecting adjacent starters.
- **IMPORTANT --- ISOLATION SWITCH** Medium voltage starters are constructed to allow components to slide out of the cabinet for servicing and repair. The disconnect switch on medium voltage starters isolates the power from electrical components within the starter for safety of service personnel.
- The standard enclosure is designed for the vacuum contactors to slide out. Contact the factory if optional roll out construction is desired.
- Medium voltage starters have a wide range of special options and application flexibility that is not available with low voltage starters. Contact the factory for special needs.

Dimensions, Auto transformer & Primary Reactor

Figure 13, Free Standing, Reduced Voltage Auto transformer and Primary Reactor

(See notes on page 40)



Detail Drawing Notes:

A - .75 diameter, typical of 4 holes. Mounting studs must extend a minimum of 2.50" above grade.

B - High voltage conduit space, line and load for two high starters, upper starter cable should enter in rear half of conduit space and lower starter should enter in front half of conduit space (line connection w/o main bus).

B1 - High voltage conduit space (line w/o main bus).

B2 - High voltage conduit space (incoming line connection).

C - Low voltage conduit space. For two high starters control wiring for upper starter should enter in rear half of conduit space and lower starter control wiring should enter in front half of conduit space.

D - Door dimensions to open doors 90°. Not applicable for two high starters.

E - High voltage conduit space, load.

F - High voltage conduit space, line only.

G - Low voltage conduit space only.

H - For top entry, load terminals located 32.50" from bottom of enclosure. For bottom entry, load term located 18.00" from bottom of enclosure.

H1 - For top entry, load terminals located 76.00" from bottom of enclosure. For bottom entry, 61.00" from bottom of enclosure.

H2 - For top entry, load terminals located 53.00" from bottom of enclosure. For bottom entry, load terminals located 40.50" from bottom of enclosure.

H3 - For top entry, load terminals located 62.50" from bottom of enclosure. For bottom entry, load terminals located 48.00" from bottom of enclosure.

J - Load terminals located on left-hand side of enclosure.

J1 - Load terminals located in reduced voltage enclosure on left-hand side.

K - Maximum sill height 6.00" and maximum sill extension 3.00" for removal of contactor without lifting device.

L - Line terminal for top cable entry.

M - Line terminal for bottom cable entry.

X - Steel bottom with removable lead plates.

Y - Tolerances -0.0" + .25" per structure.

Z - Conduits to extend a maximum of 2" into structure.

High Voltage, 10kV

Introduction

Electrical service at 10kV and 50 Hz is used in some parts of the world (not North America) and McQuay can supply selected chiller sizes with motors and starters at this voltage, primarily chillers with compressors CE 100 through CE154. This would generally include models WSC/WDC 100 through 126. Contact the local McQuay sales office for specific availability.

Agency Approvals

All controllers are for continuous duty, constructed in accordance with National Electric Manufacturers Associations (NEMA) Standard for Industrial Controls and Systems (ICS). They comply with UL 508 Standard for Industrial Control Equipment, IEC, CSA, and UL.

Contactor Duty

Contactors are capable of carrying the specified current on a continuous basis and also handle locked rotor amps on a temporary basis without damage.

Storage and Operating Environment

Starters can be stored at temperatures from -40°F to 140°F (-40°C to 60°C). Operating range is from 32°F to 104°F (0°C to 40°C) with a maximum relative humidity of 95%non-condensing.

Enclosure and Cable Penetrations

The standard starter enclosures for high voltage starters are NEMA 1 with gaskets. Standard construction has power entrance and exit and control connections through the bottom of the enclosure.

Adequate separation of high and low voltage sections and proper mechanical and electrical interlocks are provided to meet all safety and operating codes.

Mounting

All high voltage starters are only available as free-standing.

Starter Types

Available high voltage starters are solid state and across-the-line.

Solid State

The solid state starter includes a load break switch as standard, and has the features and options as described for medium voltage starters described on page 26. They are fast becoming the starter of choice for centrifugal compressors.

Across-the-Line

Across-the-line starters are very simple and consist of a primary contactor that allows locked rotor amps to reach the motor when energized. These starters are low cost, provide the highest starting torque and highest inrush current. They have the features and options described for medium voltage starters on page 33.

Options

Surge Capacitors

Surge capacitors to protect the compressor motor from voltage spikes can be provided as an option.

Auxiliary Relay

Four-pole relay, two normally open and two normally closed contacts.

Lightning Arrestors

Provide a safe path to ground for a lightning surge.

Ground Fault Protection

Protects equipment from damage from line-to-ground fault currents too small to trip overcurrent or short circuit protection devices.

Pilot Lights

Red and Green pilots on the front of the enclosure to indicate status.

NEMA Modifications

The standard enclosure is NEMA 1 with additional gasketing.

- NEMA 3R -- Rain resistant construction (consult McQuay sales office)
- NEMA 4 -- Dust tight/rain tight construction (consult McQuay sales office)
- NEMA 12 -- Dust tight construction (consult McQuay sales office)

Extended Warranty for Parts Only, or Parts & Labor

The duration and type of the starter warranty is determined by the chiller warranty.

Power Factor Correction Capacitors

The McQuay chiller selection program provides the unit power factor and will also calculate capacitor size for power factor correction, if required. See page 60 for details.

California Code

Modifications to the starter to comply with California Code requirements.

Specials

A variety of special construction and equipment options are available for this class of equipment. Contact the local McQuay sales office with special requests.

Terminal Sizes

Incoming and outgoing connections are standard bus tabs, NEMA 2 hole.

Analyses

McQuay can perform either of the following system analyses at no cost. Contact you local McQuay sales office for an electronic form to fill in with particulars of the electrical system being considered.

- A motor starting analysis to determine the motor starting current required as well as the motor acceleration time.
- A system voltage drop analysis to determine the voltage drop at various points in the power system.

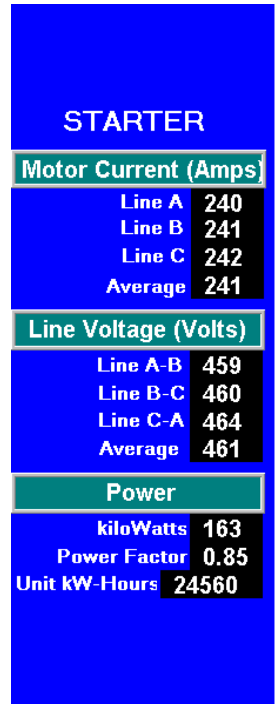
Metering Availability

Low Voltage Standard

Percent of unit rated load amps (RLA) is displayed as a bar graph on the home screen of the chiller touchscreen.

Low Voltage Option

Figure 14, Full Metering Option Screen



Low voltage solid state and wye-delta starters have a Full Metering Option that displays certain electrical parameters on the chiller MicroTech II operator interface touchscreen (12 inch Super VGA screen). The display provides very useful operating parameters and is a valuable analytic tool and is extremely easy to access right on the chiller's interface color monitor. The data is available to a BAS if the optional BAS communication module is ordered. The display is depicted in Figure 14. The following data is displayed:

- Phase and average amps
- Phase and average volts
- Compressor kilowatts
- Power Factor
- Unit kilowatt-hours

Medium and High Voltage Standard

Medium and high voltage starters have full metering as standard, but is located in the starter enclosure. It is not available on the chiller touchscreen and not available for reading by a BAS. The following data is available:

- Phase and average amps
- Phase and average volts
- Frequency
- Compressor kilowatts
- Power factor
- kVAR
- Unit kilowatt-hours
- Elapsed time
- Motor thermal capacity (I^2T)

Variable Frequency Drives

General

Single and dual compressor units can be equipped with a variable frequency drive (VFD). A VFD modulates the compressor speed in response to load and evaporator and condenser pressures, as sensed by the compressor controller. Due to the outstanding part load efficiency, and despite the minor power penalty attributed to the VFD, the chiller can achieve outstanding overall efficiency. VFDs really prove their worth when there is reduced load combined with low compressor lift (lower condenser water temperatures) dominating the operating hours.

VFDs for large capacity compressors over 1200 tons are disproportionally expensive. McQuay's dual compressor units (Model WDC and WCC) with two *half size* compressors allow VFDs to become a reasonable cost alternative on large chillers compared to the very expensive large capacity drives required for competitors' large single compressor chillers.

The traditional method of controlling centrifugal compressor capacity is by variable inlet guide vanes. Capacity can also be reduced by slowing the compressor speed, reducing the impeller tip speed, *providing* sufficient tip speed is retained to meet the discharge pressure (lift) requirements. This method is more efficient than guide vanes by themselves.

In actual practice, a combination of the two techniques is used. The microprocessor slows the compressor (to a fixed minimum percent of full load speed) as much as possible, considering the need for sufficient tip speed to make the required compressor lift. Guide vanes take over to make up the difference in required capacity reduction. This methodology provides the optimum efficiency under any operating condition.

VFDs and Distortion

Despite their many benefits, care must be taken when applying VFDs due to the effect of line harmonics on the building electric system. VFDs cause distortion of the AC line because they are nonlinear loads; that is, they don't draw sinusoidal current from the line. They draw their current from only the peaks of the AC line, thereby flattening the top of the voltage waveform. Some other nonlinear loads are electronic ballasts and uninterruptible power supplies.

Line harmonics and their distortion can be critical to ac-drives for three reasons:

1. Current harmonics can cause additional heating to transformers, conductors, and switchgear.
2. Voltage harmonics upset the smooth voltage sinusoidal waveform.
3. High-frequency components of voltage distortion can interfere with signals transmitted on the AC line for some control systems.

The harmonics of concern are the 5^{th}, 7^{th}, 11^{th}, and 13^{th}. Even harmonics, harmonics divisible by three, and high magnitude harmonics are usually not a problem.

Harmonic Distortion Analysis

A simple distortion analysis program is available form the local McQuay sales office. It can easily be e-mailed and provides the user with a basic look at voltage and current harmonics or voltage harmonics only.

Current Harmonics

An increase in reactive impedance in front of the VFD helps reduce the harmonic currents. Reactive impedance can be added in the following ways:

1. Mount the drive far from the source transformer.
2. Add line reactors. They are standard equipment on WMC chillers.
3. Use an isolation transformer.
4. Use a harmonic filter.

Voltage Harmonics

Voltage distortion is caused by the flow of harmonic currents through a source impedance. A reduction in source impedance to the point of common coupling (PCC) will result in a reduction in voltage harmonics. This can be done in the following ways:

1. Keep the PCC as far from the drives (close to the power source) as possible.
2. Increase the size (decrease the impedance) of the source transformer.
3. Increase the capacity (decrease the impedance) of the busway or cables from the source to the PCC.
4. Make sure that added reactance is "downstream" (closer to the VFD than the source) from the PCC.

The IEEE 519-1991 Standard

The Institute of Electrical and Electronics Engineers (IEEE) has developed a standard that defines acceptable limits of system current and voltage distortion.

An electronic calculation worksheet is available from McQuay that is intended to be used as an estimating tool for air-cooled or LiquiFlo VFDs only. It is not a replacement for an on-site harmonic survey, or modeling service that considers detailed drive and distribution system information.

An accurate determination of compliance can be fairly complicated, depending on the complexity of the electrical network, and is best performed by personnel experienced and trained in the procedure.

Air-Cooled/LiquiFlo™ (LF) vs. LiquiFlo 2.0™ (LF 2.0)

McQuay has two types of VFDs, along with available options, to provide the lowest cost solution to meet IEEE 519-1991 acceptable distortion limits for a given application. The level of distortion is a function of the electrical distribution system and system's electrical apparatus. Each of the following types of VFD is described in subsequent sections of this catalog.

Table 18, VFD MODELS

<table>
<tr><th colspan="3">LESS RIGOROUS APPLICATIONS</th></tr>
<tr><th>COOLING</th><th>MOUNTING</th><th>VFD MODEL</th></tr>
<tr><td>AIR-COOLED</td><td rowspan="2">UNIT-MOUNT or FREE-STANDING</td><td>AIR-COOLED VFD009 ⇓ VFD028</td></tr>
<tr><td>FLUID-COOLED
SELF-CONTAINED COOLING</td><td>FLUID-COOLED LF
VFD047 ⇓ VFD072</td></tr>
<tr><td>FLUID-COOLED
REMOTE COOLING MODULE</td><td>FREE-STANDING ONLY</td><td>FLUID-COOLED LF
VFD090 ⇓ VFD120</td></tr>
</table>

<table>
<tr><th colspan="3">MORE RIGOROUS APPLICATIONS</th></tr>
<tr><th>COOLING</th><th>MOUNTING</th><th>VFD MODEL</th></tr>
<tr><td>FLUID-COOLED
REMOTE COOLING MODULE</td><td>FREE-STANDING ONLY</td><td>FLUID-COOLED LF 2.0
VF2037 ⇓ VF2110</td></tr>
</table>

Air-Cooled/LiquiFlo

Applications with less rigorous requirements can use the air-cooled models or the fluid-cooled, LiquiFlo models. They are the base VFDs and have no harmonic attenuation as standard, and as such, are considered unmitigated. However, adding optional components such as 3-percent line reactors and/or harmonic filters can reduce their harmonic distortion. Five-percent reactors are available as a special option.

LiquiFlo 2.0

Applications with more rigorous requirements may need the LiquiFlo 2.0 models. They use a separate synchronous rectifier and inverter section to reduce higher levels of harmonic distortion (THD) on the incoming power grid.

Due to the higher cost of this drive, it should be used only if a harmonics survey has concluded that a standard Air-Cooled/LiquiFlo VFD cannot meet the job site specifications for total harmonic distortion (THD) levels. These LiquiFlo 2.0 VFDs have the capability of meeting IEEE-519 limits for harmonic distortion in nearly every installation.

Air-Cooled/LiquiFlo

Specifications

1) Incoming and outgoing power terminals (landing pads).
2) Transformer to supply power to the control circuit, oil heaters, and oil pump.
3) Redundant motor control relays with coils in series.
4) The VFD is current rated and uses a 2 kHz carrier frequency for all drives 219 RLA and larger. The drive is capable of running at 110% of nameplate current continuously and provides a minimum of 150% of this rated current for 5 seconds.
5) The VFD will not generate damaging voltage pulses at the motor terminals when applied within 500 feet of each other. Both Drive and Motor comply with NEMA MG1 section 30.40.4.2 which specifies these limits at a maximum peak voltage of 1600 Volts and a minimum rise time of .1 microseconds.
6) Units drawing 273 amps or less are air-cooled and use a 4 kHz carrier frequency. All others are water-cooled. Factory-mounted water-cooled VFDs are factory piped to the chiller's oil cooler circuit. Free standing water-cooled units (models VFD 047LW – 072LW) require chilled water supply and return piping for the VFD cooling. They have a liquid-cooled heat sink assembly enabling liquid cooling of the drive through a single inlet and outlet connection point on the VFD. The two largest VFDs (models VFD 090 and 120) have a separate cooling module interposed between the chilled water source and the VFD. See page 50 for details. The cooling circuit maintains water temperature between 60°F and 104°F (15°C to 40°C).
7) The VFD and options are UL™ 508 listed. The drive and options are designed to comply with the applicable requirement of the latest standards of ANSI, NEMA, National Electric Code NEC, NEPU-70, IEEE 519-1992, FCC Part 15 Subpart J, CE 96.
8) The VFD is functionally tested under motor load. During this load test the VFD is monitored for correct phase current, phase voltages, and motor speed. Correct current limit operation is verified by simulating a motor overload. Verification of proper factory presets by scrolling through all parameters is performed to check proper microprocessor settings. The computer port also verifies that the proper factory settings are loaded correctly in the drive.

9) The VFD has the following basic features:

a) An overload circuit to protect an AC motor operated by the VFD output from extended overload operation on an inverse time basis. This electronic overload is UL™ and NEC recognized as adequate motor protection. No additional hardware such as motor overload relays or motor thermostats are required.

b) An LED display that digitally indicates:

Frequency output	Voltage output	Current output
Motor RPM	Output kW	Elapsed time
DC bus volts	Time-stamped fault indication	

c) The capability of riding though power dips up to 10 seconds without a controller trip, depending on load and operating condition.

d) RS232 port and Windows™ based software for configuration, control, and monitoring.

e) An isolated 0-10 V or 4-20 mA output signal proportional to speed or load.

f) Standard input/output (I/O) Expansion Interface Card with the following features:

Four Isolated 24 VDC programmable digital inputs

One frequency input (0 to 200 Hz) for digital control of current limit

Four programmable isolated digital outputs (24 VDC rated)

One form A output relay rated at 250 VAC or 24 VDC

Two NO/NC programmable output relays rated at 250 VAC or 24 VDC

10) The VFD includes the following protective circuits and features:

a) Motor current exceeds 200% of drive continuous current rating.

b) Output phase-to-phase short circuit condition.

c) Total ground fault under any operating condition.

d) High input line voltage.

e) Low input line voltage.

f) Loss of input or output phase.

g) External fault. (This protective circuit shall permit wiring of remote a NC safety contact to shut down the drive).

h) Metal oxide varistors for surge suppression are provided at the VFD input terminals.

Options

3-Percent Line Reactor

Used for control of line harmonics in some installations. See page 52 for details.

Incoming Line Termination Options

- Terminal block
- Non-fused disconnect with through-the-door handle
- High interrupting circuit breaker with through-the-door handle
- Ultra high circuit breaker with through-the-door handle

Volts/Amps Meter with 3-phase Switch

Mounting

VFD 009 through VFD 072 can be factory-mounted on the same chiller models as conventional starters or they can be free-standing, as shown in the table below. Sizes VFD 090 through 120 and VF 2037 through 2110 are free-standing only. Dimensions begin on page 55.

Chiller Model	Mounted at Factory (1)	Unit Mounted in Field	Free Standing (2)
WSC, WDC 050-087	X		X
WSC 100-126		X (3)	X
WDC/WCC 100-126			X

Notes:

1. Optional reactor is field-mounted and wired to unit mounted VFDs.
2. Optional reactor is factory-mounted in the VFD enclosure on free-standing VFDs.
3. Brackets and interconnecting cables shipped with unit.

Operating/Storage Conditions

Operating Temperature (inside NEMA 1 enclosure)…..0° C to +55° C (1) (32° to 131° F)

Ambient Temperature (outside NEMA 1 enclosure)…..0°C to +40° C (32° to 104° F)

Humidity ……………………………………………5% to 95% (non-condensing)

Table 19, Model Sizes, Air-Cooled/LiquiFlo

L=Shipped loose, **M**=Mounted, **A**=Air-cooled, **W**=Water-cooled

VFD Model	VFD Family Designation	Page Location	Max. Amps	Cooling	Optional Line Reactor (Note 1)	
					Size	Amp Rating
VFD 009LA	SP 600	Page 46	87	Air	RC	100
VFD 009MA			87	Air	RC	100
VFD 012LA			114	Air	R1	130
VFD 012MA			114	Air	R1	130
VFD 015LA			142	Air	R2	160
VFD 015MA			142	Air	R2	160
VFD 017LA			164	Air	R3	200
VFD 017MA			164	Air	R3	200
VFD 023LA			225	Air	R4	250
VFD 023MA			225	Air	R4	250
VFD 024LA	PF700H	Page 46	237	Air	RY	STD.
VFD 024MA			237	Air	RY	STD.
VFD 028LA			273	Air	RY	STD.
VFD 028MA			273	Air	RY	STD.
VFD 047LW	LF	Page 46	414	Water	RD	500
VFD 047MW			414	Water	RD	500
VFD 060LW			500	Water	R7	600
VFD 060MW			500	Water	R7	600
VFD 072LW			643	Water	R8	750
VFD 072MW			643	Water	R8	750
VFD 090LW			890	Water	RM	900
VFD120LW			1157	Water	R9	1200

NOTES

1. Line reactors are optional on all sizes except Models VFD 024 and 028, where they are included as standard.
2. Electrical characteristics: 380/460 VAC ±10%, 3 phase, 50/60 Hertz, ±5 Hz.
3. Optional line reactors are 3% impedance.

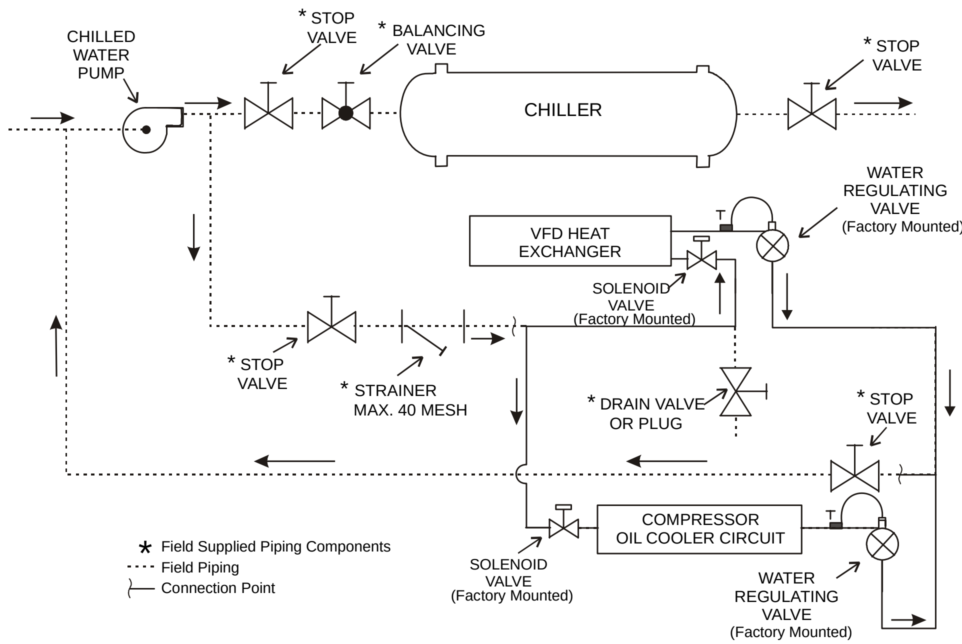
Table 20, Model Sizes, LiquiFlo 2.0

VFD Model	VFD Family Designation	Page Location	Max. Amps	Cooling
VF 2037	LF 2.0, Frame 3	Page **Error! Bookmark not defined.**	368	Water
VF 2055			553	Water
VF 2080	LF 2.0, Frame 4		809	Water
VF 2110			1105	Water

Cooling Requirements

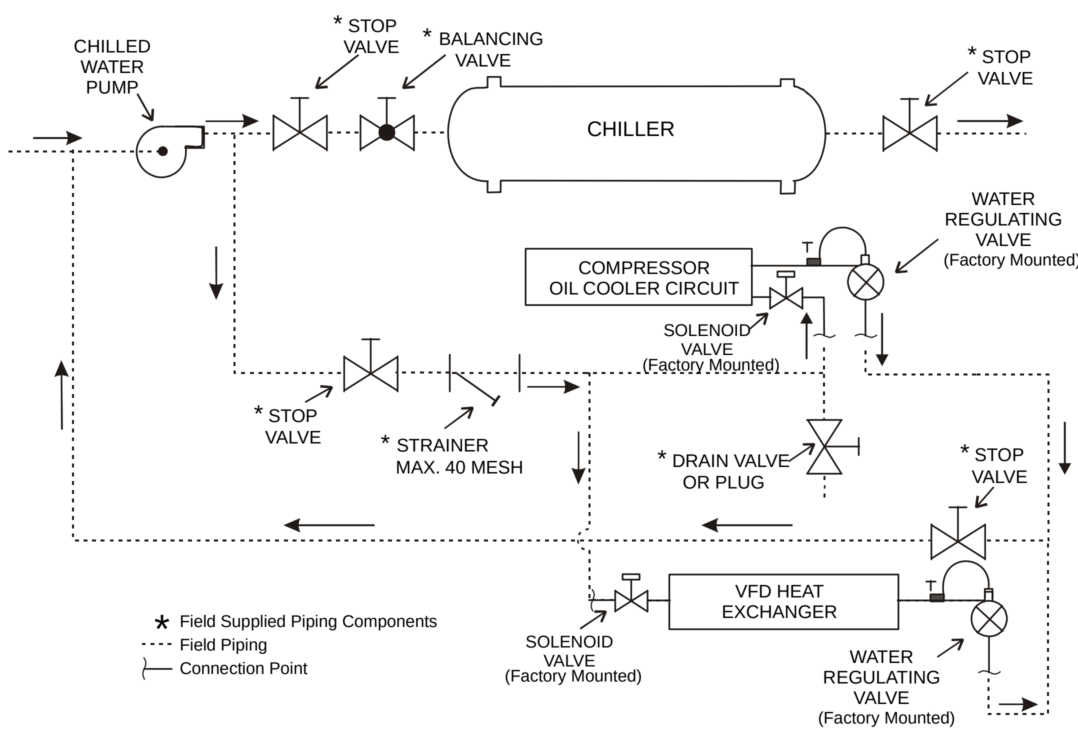
Models VFD 047 through 072 are self-contained water-cooled. The larger units, models VFD 090 and 120, have a remote cooling module interposed between the cooling source water and the VFD. Details are contained later in this section.

Figure 15, VFD (047 through 072) Cooling Water Piping for Factory-Mount



See notes on next page under Table 21.

Figure 16, VFD (LF and LF 2.0) Cooling Water Piping for Free-Standing VFD



See notes on next page following Table 21.

Table 21, Cooling Requirements

McQuay Drive Model Number	Combined Compressor Oil and VFD Cooling Copper Tube Size Type K or L	VFD Cooling Only Copper Tube Size Type K or L	Coolant Method	Coolant Flow gpm	Max. Entering Coolant Temp. (°F)	Min. Entering Coolant Temp. (°F)	Required Pressure Drop (feet)	Maximum Pressure Water Side (psi)
VFD 009-028	N/A	N/A	Air	N.A.	104	40	NA	N/A
VFD 047	1.0	7/8 in.	Water (1)	2.0	90	40	10 (2)	300
VFD 060	1.0	7/8 in.	Water (1)	2.0	90	40	30 (2)	300
VFD 072	1.0	7/8 in.	Water (1)	2.5	90	40	30 (2)	300
VFD 090	1 1/4	1.0 in.	Water (1) (3)	7.0	90	40	30 (2)	300
VFD 120	1 1/4	1.0 in.	Water (1) (3)	7.0	90	40	30 (2)	300

Notes:

1. Cooling water must be from the closed, chilled water circuit with corrosion inhibitors for steel and copper, and must be piped across the chilled water pump.
2. The required pressure drop is given for the maximum coolant temperature. The water regulating valve will reduce the flow when the coolant temperature is below the maximum in the table. The pressure drop includes the drop across the solenoid valve, heat exchanger and water regulating valve.
3. Models VFD 090 and 120 have a separate self-contained cooling loop with a recirculating water pump and heat exchanger, but are piped to the cooling water source the same as all water-cooled VFDs.

Table 22, Chiller Cooling Water Connection Sizes

Chiller Unit	Free-Standing VFD		Factory-Mounted VFD
	Oil Cooler	VFD	Combined
WDC/WCC 100/126	1 1/2 in. FPT	3/4 in. MPT	1 1/2 in. FPT
WSC/WDC 050	Not Required	Air-Cooled	Not Required
All Others	1 in. FPT	3/4 in MPT	1 in. FPT

Separate Cooling Module

VFD models 090 and 120 and all LF 2.0 models have a separate, remote-mounted cooling module interposed between the cooling water source and the VFD. All other water-cooled units have self-contained cooling.

Water Quality:

Water must be compatible with components supplied in the cooling loop; brass, copper, stainless steel and neoprene rubber seals. Supply water circulates through a copper brazed stainless steel, plate type heat exchanger by way of a stainless steel and brass ball valve and associated stainless steel, brass and copper piping.

Water Source:

Clean and non-corrosive chilled water must be used for the coolant to the module.

Flow Rate:

Approximately 7 gpm maximum of chilled source water cooling will be used. Source water (chilled water) flow is regulated by a control valve and will fluctuate depending on load and water temperature.. Supply side pressure difference at minimum flow is less than 10 psi

Maximum Static Pressure:

300 psi nominal limited by ball valve and piping pressure ratings

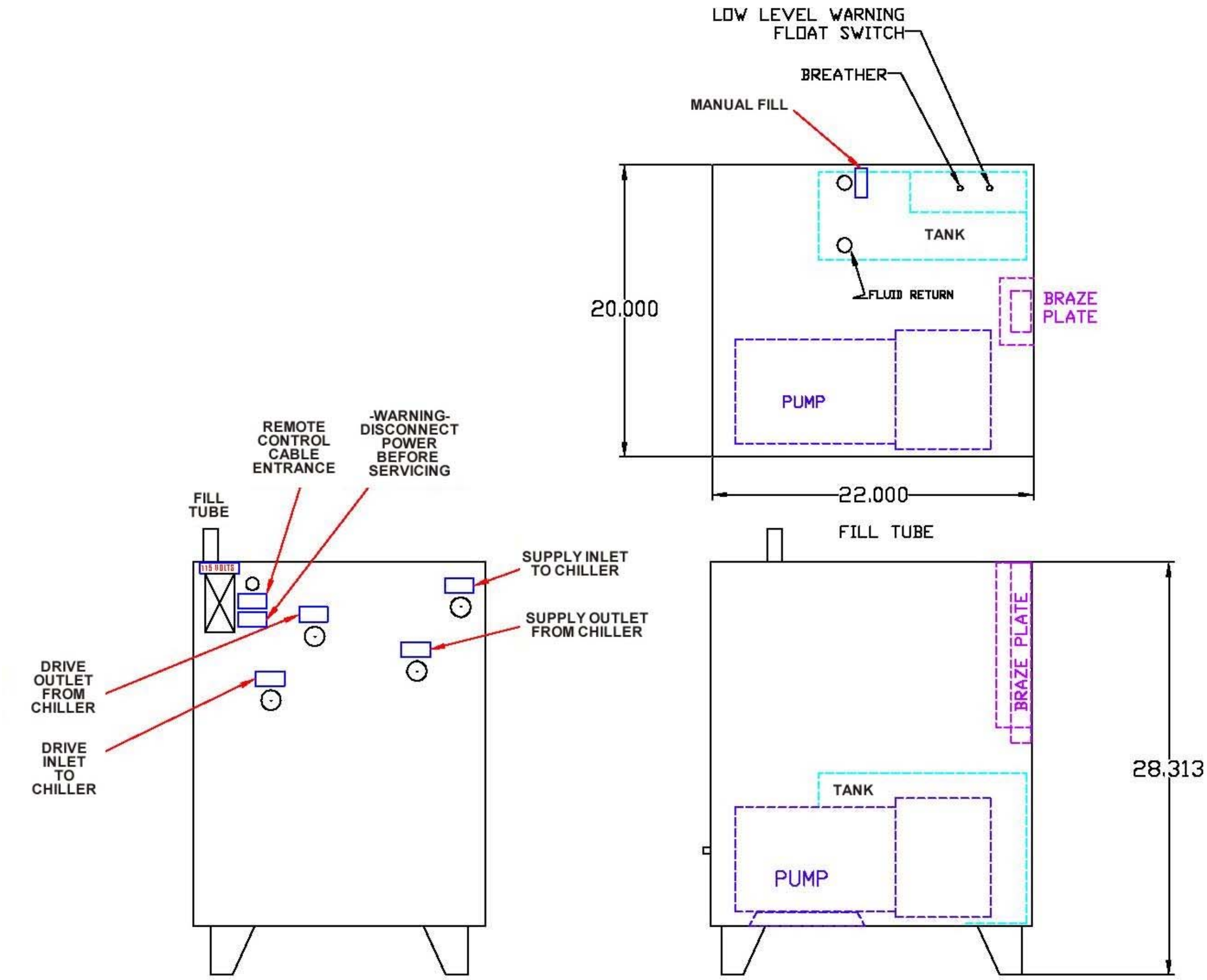
Cooling Module Installation

The module must be located within 20 feet (6 meters) of the VFD and the interconnecting piping from the cooling module to the VFD can be hose if supplied with the unit.

Wiring

Power and control wiring for the module come from the VFD as show in **Error! Reference source not found.**.

Figure 17, Cooling Module Dimensions



Weights

Shipping weight: 300 lbs (136 kg)
Dry weight: 250 lbs (114 kg)
Operating weight: 270 lbs. (123 kg)

Optional Line Reactors

See page 44 for an explanation of VFD distortion and system requirements.

Mounting Options

Optional line reactors can be mounted in the VFD enclosure on free-standing units and must be field-mounted and wired when the VFD is factory-mounted. This is caused by the fact that when the reactor is installed in the VFD enclosure, a larger enclosure is required and it is too large to mount on the chiller.

Figure 18, Line Reactor Dimensions, Models

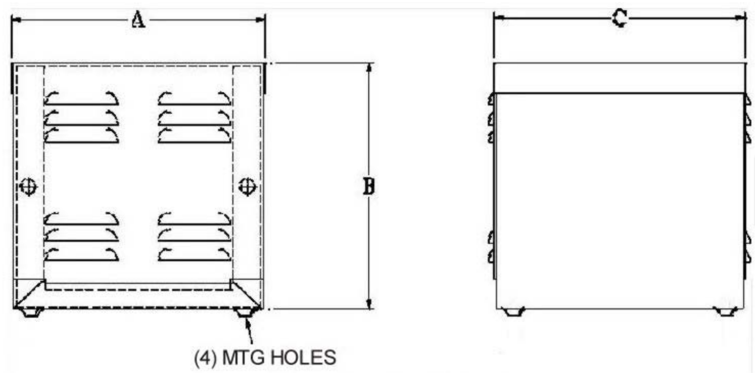


Figure 19, Line Reactor Dimensions, Models

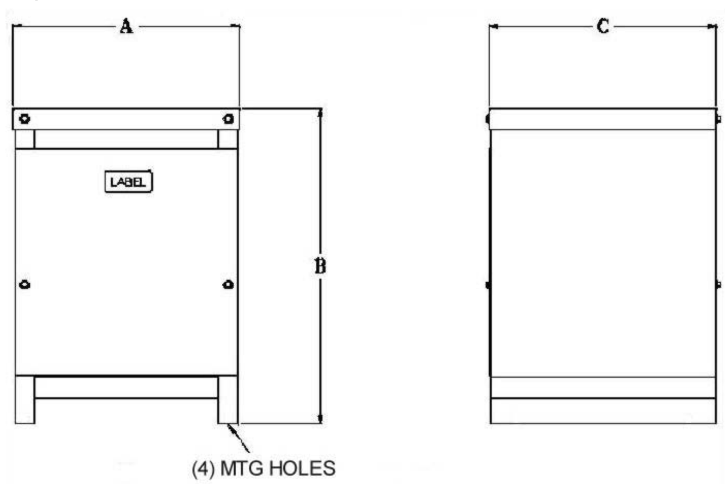


Table 23, Line Reactor Physical Data

VFD Model	Width "A" in. (mm)	Height "B" in. (mm)	Depth "C" in. (mm)	Weight lbs (kg)
009MA	13.2 (335)	13.2 (335)	13.2 (335)	86 (39)
012MA–017MA	13.2 (335)	13.2 (335)	13.2 (335)	98 (44)
023MA	17.0 (432)	24.0 (610)	17.0 (432)	151 (69)
024-028	See Note 3			
047MW-060MW	17.0 (432)	24.0 (610)	17.0 (432)	225 (102)
072MW	24 (610)	30 (762)	24 (610)	393 (178)
090LW-120LW	See Note 4			

NOTES:

1. Models 012MA through 023MA have box lugs, one wire per lug.
2. Models 047MW through 072MW have copper tabs with (1) 0.656 hole.
3. Models 024LA/MA through 028LA/MA have a reactor as standard and it is mounted in the VFD. Wiring required to incoming reactor terminals.
4. Models 090LW through 120LW have (2) 0.656 holes, and are always shipped loose with optional reactors factory-mounted in VFD if ordered. Wiring required to incoming terminals.

Mounting

NEMA 1 enclosures designed for floor mounting must be mounted with the enclosure base horizontal for proper ventilation. Wall mounting a floor mounted enclosure with the base against the wall will cause the reactor to over heat resulting in equipment damage.
Allow a minimum side, front, and back clearances of 12 inches (305 mm) and vertical clearances of 18 inches (457 mm) for proper heat dissipation and access. Do not locate the enclosure next to resistors or any other component with operating surface temperatures above 260°F (125°C).

Allow a minimum side, front, and back clearances of 12 inches (305 mm) and vertical clearances of 18 inches (457 mm) for proper heat dissipation and access. Do not locate the enclosure next to any component with operating surface temperatures above 260°F (125°C).

Select a well-ventilated, dust-free area away from direct sunlight, rain or moisture, where the ambient temperature does not exceed 45°C (113°F).

Do not install in or near a corrosive environment.

Avoid locations where the reactor will be subjected to excessive vibrations.
Where desirable, enclosures may be mounted on vibration isolating pads to reduce audible noise. Standard vibration control pads made from neoprene or natural rubber and selected for the weight of the enclosed reactor are effective.

Reactor Power Wiring

A fused disconnect switch or circuit breaker should be installed between the reactor and its source of power in accordance with the requirements of the NEC and all local electrical codes and regulations.

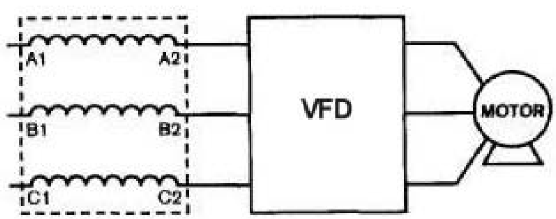
The reactor is suitable for use on a circuit capable of delivering not more than 65,000 rms symmetrical amperes at 480 volts when protected by Bussman type JJS, KTK, KTK-R, PP or T class fuses.

Reactors are designed for use with copper conductors with a minimum temperature rating of 75°C.

Refer to Figure 20 for a typical electrical diagram of a reactor in its proper location, upstream of a VFD.

Where desirable, a flexible conduit connection to the reactor enclosure should be made to reduce audible noise.

Figure 20, Line Reactor Wiring



Grounding

A stud is provided in the reactor enclosure for grounding the enclosure. The enclosure must be grounded.

Power Wiring

Wire size should be determined bases on the size of conduit openings, and the user is responsible for conforming to all applicable local and national codes (e.g. NEC).

Compressor Motor Terminals

Power wiring connections at the motor are “spark plug” type terminals with threaded copper bar, sized per the following table.

Table 24, Chiller Compressor Motor Terminal Sizes

Type/Size	Comp. Size	Terminal Size
Low Voltage to 275 A, to 575 V	CE 050	0.375-16 UNC2A, 0.94 in. long
Low Voltage to 750 A, to 575V	CE 063-126	0.635-11 UNC-2A, 1.88 in. long

VFD Terminals

For field wiring freestanding VFDs, the outgoing terminals and incoming power block terminals are determined by the VFD size listed in Table 25. For factory-mounted VFDs, the outgoing terminals are factory-connected to the compressor motor.

When wiring to a VFD with a disconnect switch or circuit breaker, the incoming lug size is determined by the device size as shown in Table 26.

Table 25, Air-Cooled/LiquiFlo, Outgoing, Incoming Power Block, Terminal Size Range

VFD Size		Incoming Power Block Terminals	Outgoing Terminals
VFD 009	SP600	#14 – 1/00	#14 – 1/00
VFD 012	SP600	#4 – 3/0	#4 – 3/0
VFD 015	SP600	#14 - 250	#14 - 250
VFD 017	SP600	#14 - 250	#14 - 250
VFD 023	SP600	#14 - 250	#14 - 250
VFD 024	PF700H	4/0 - 350	4/0 - 350
VFD 028	PF700H	4/0 - 350	4/0 - 350
VFD 047	LF	(2) #4 - 500	(2) #6 - 300
VFD 060	LF	(2) #4 - 500	(2) #4 - 350
VFD 072	LF	(2) #4 - 500	(2) #4 - 350
VFD 090	LF	(2) #4 - 500	2 in. x 1/4 in. bus (1) 9/16 in. hole
VFD 120	LF	(2) #4 - 500	2 in. x 1/4 in. bus (1) 9/16 in. hole

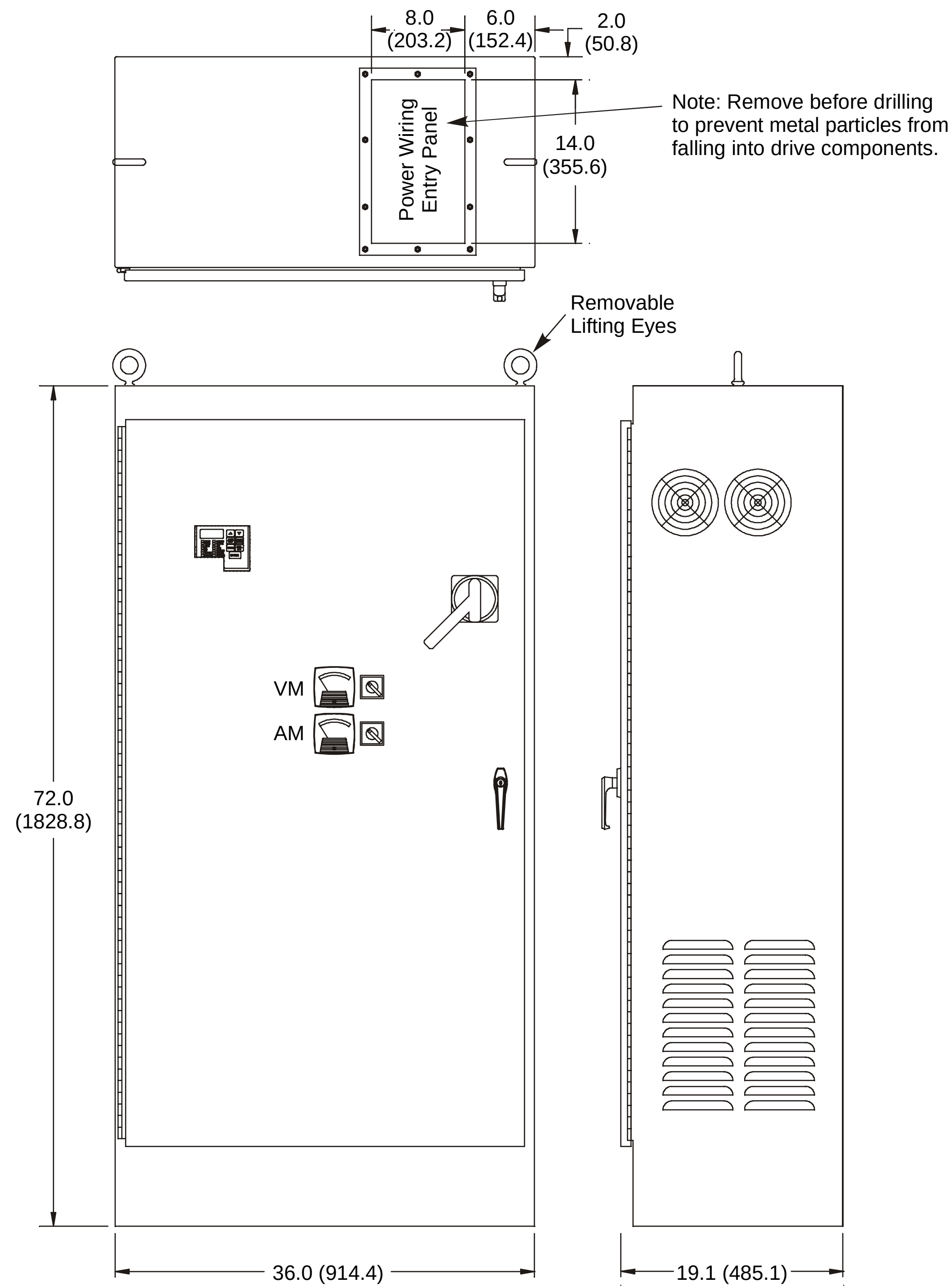
Table 26, Incoming Terminal Size Range, Disconnects & Circuit Breakers

Max RLA	Size	Incoming Terminal, Disconnect Switch or Circuit Breaker
74	100	(1) #6- 300
93	125	(1) #6- 300
148	200	(1) #6- 300
163	220	(1) 4/0 - 500
185	250	(2) 3/0 - 500
296	400	(2) 3/0 - 500
444	600	(3) 1/0 - 500
593	800	(4) 250 – 500
889	1200	(5) 300 – 600
1185	1600	(5) 300 - 600

NOTE: (X) is the number of terminals per phase.

VFD Dimensions

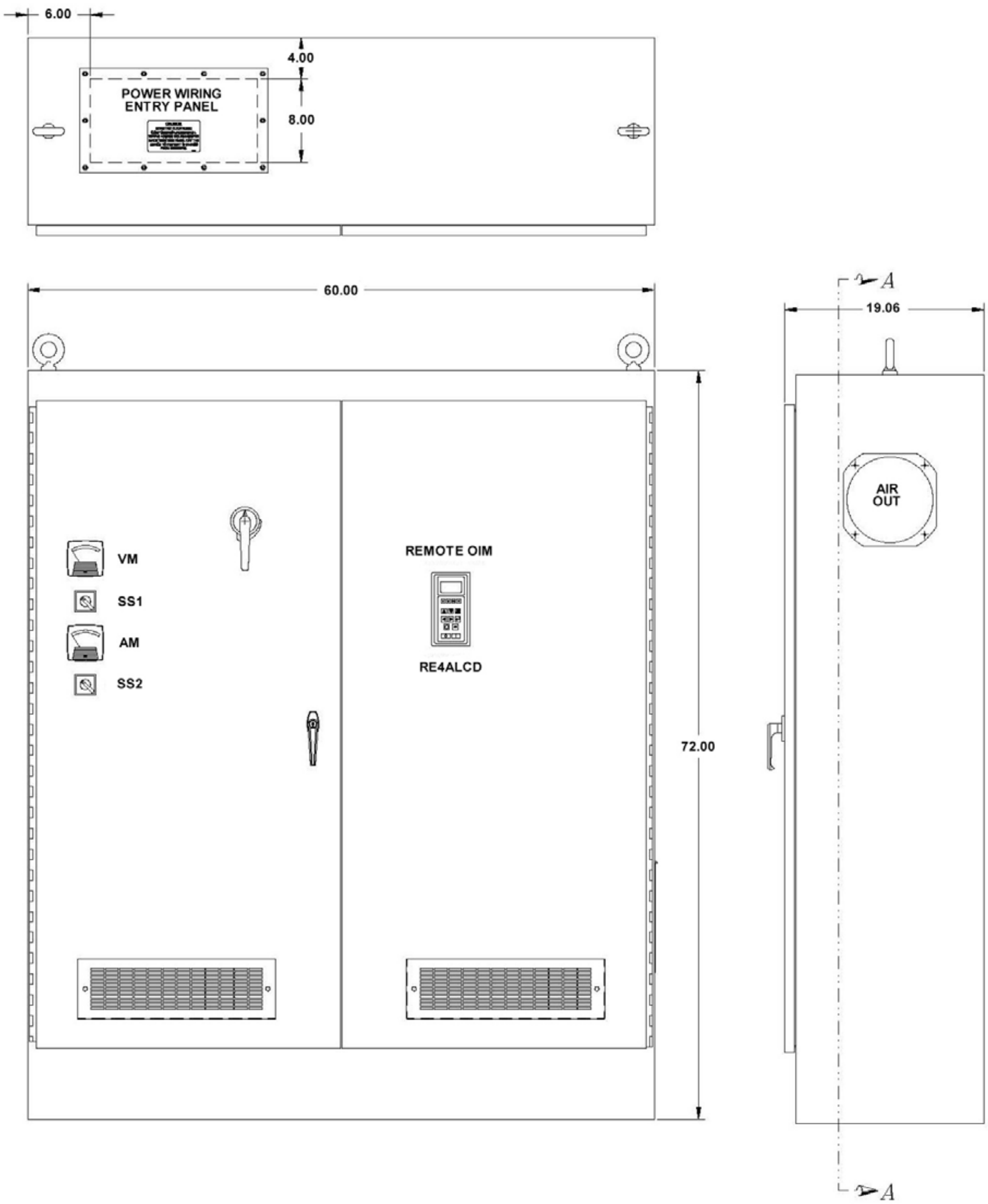
Figure 21, VFD 009LA/023LA, Air-Cooled, Free-Standing



Unit Weights

Model	VFD 009	VFD 012	VFD 015	VFD 017	VFD 023
Operating Weight, lb (kg)	725 (329)	725 (329)	796 (361)	796 (361)	796 (361)
Shipping Weight, lb. (kg)	795 (361)	795 (361)	866 (393)	866 (393)	866 (393)

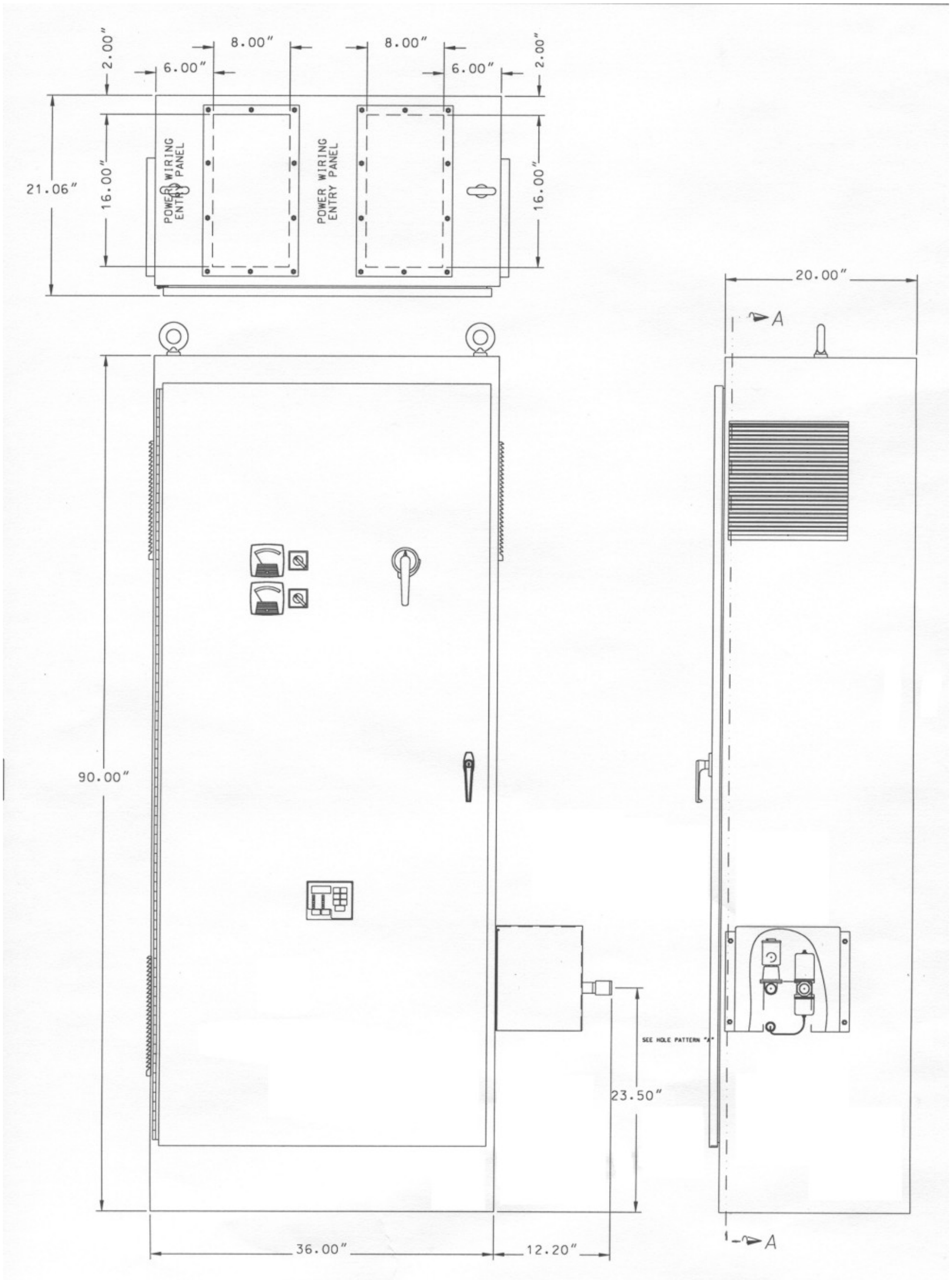
Figure 22, VFD 024LA/028LA, Air-Cooled, Free-Standing



Unit Weights

Model	**VFD 024LA**	**VFD 028LA**
Operating Weight, lb. (kg)	1206 (548)	1206 (548)
Shipping Weight, lb (kg)	1326 (602)	1326 (602)

Figure 23, VFD 047LW, Water-Cooled, Free-Standing

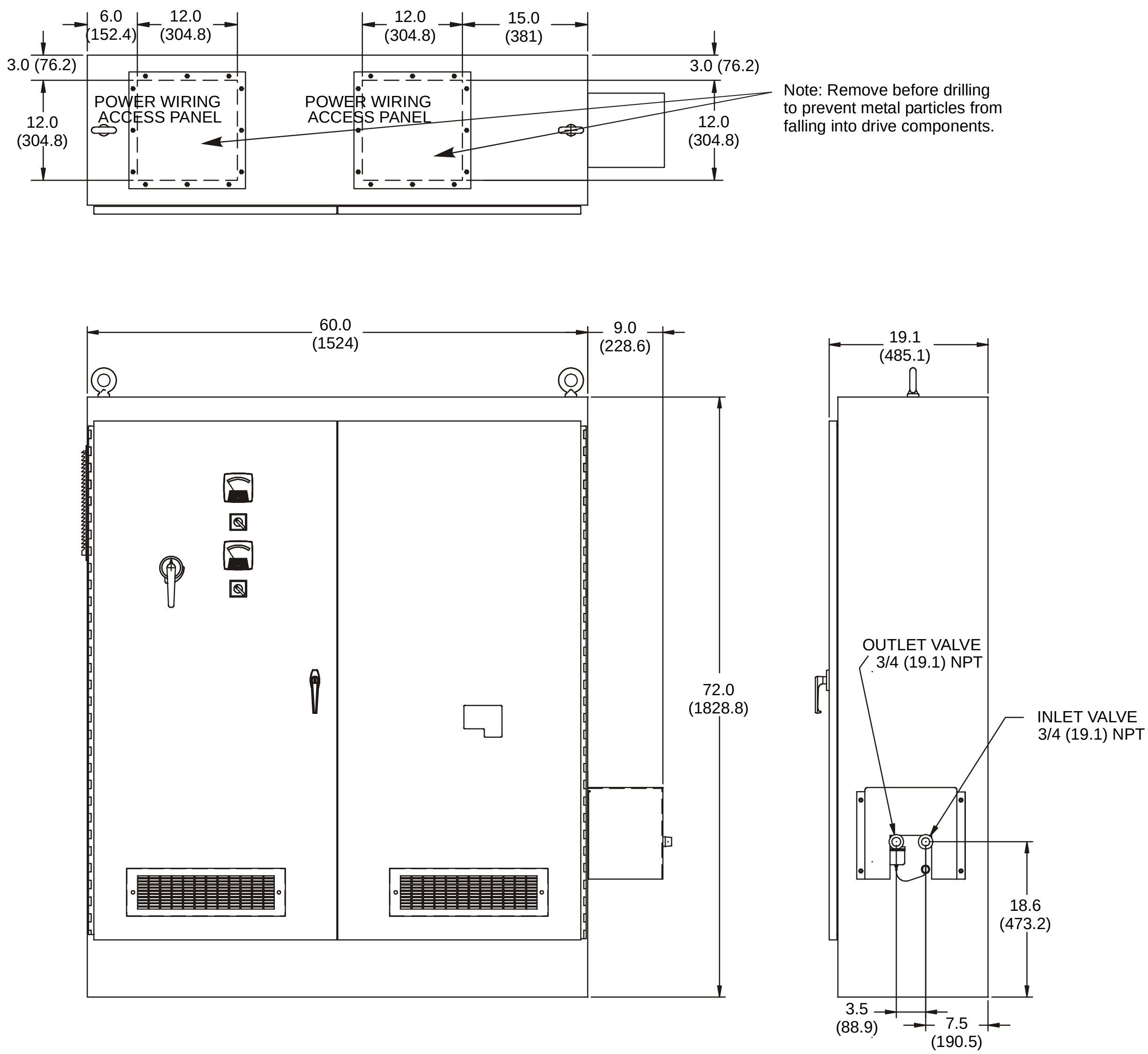


NOTE: Power entry for unit-mounted VFD is on top, left hand.

Unit Weights

Model	VFD 047LW
Operating Weight, lb. (kg)	982 (446)
Shipping Weight, lb (kg)	1070 (486)

Figure 24, VFD 060LW/072LW, Water-Cooled, Free-Standing

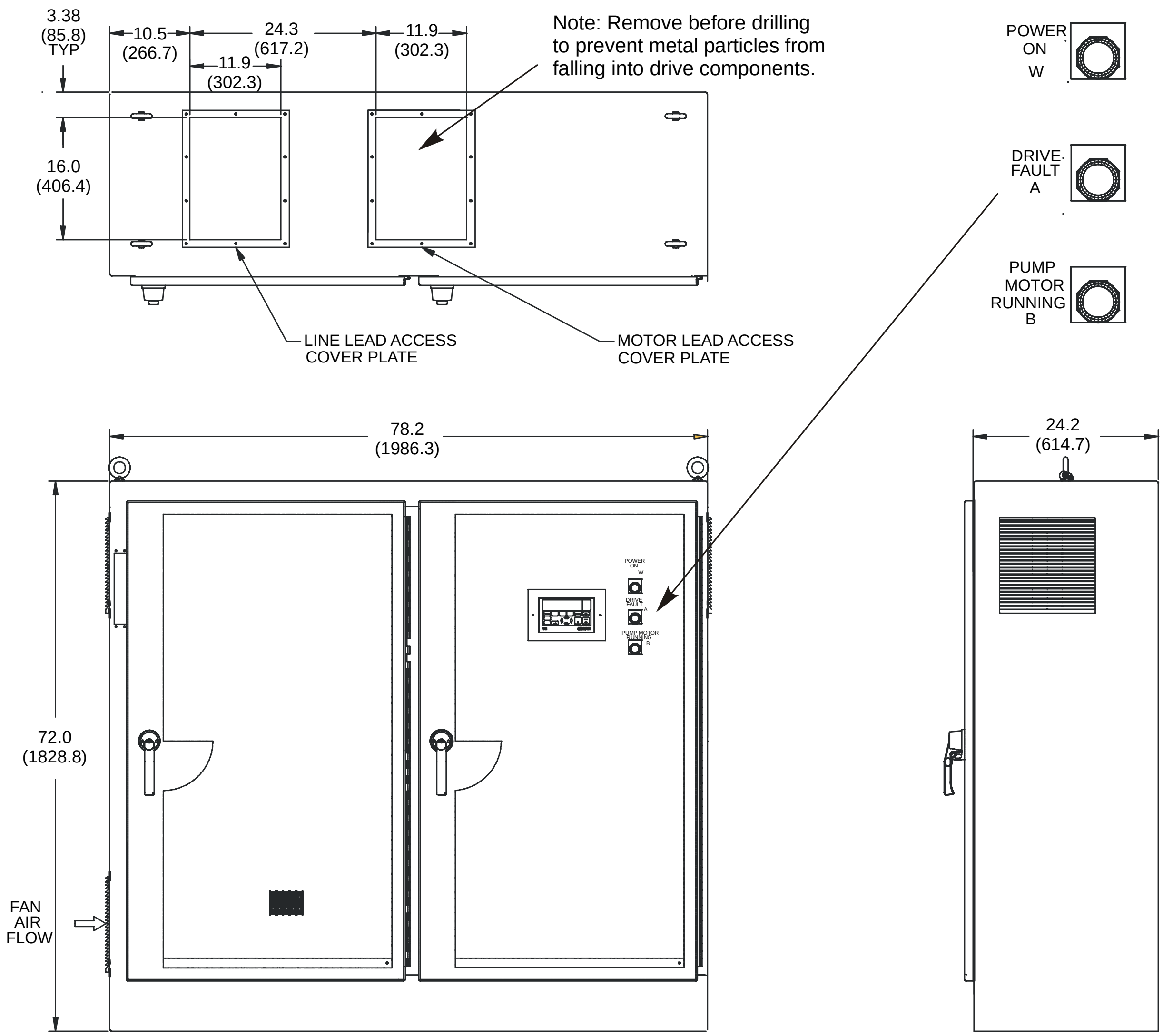


NOTE: Power entry for unit-mounted VFD is on top, left hand.

Unit Weights

Model	VFD 060LW	VFD 072LW
Operating Weigh,t lb. (kg)	1272 (577)	1272 (577)
Shipping Weight, lb (kg)	1410 (640)	1410 (640)

Figure 25, VFD 090LW/120LW, Water-Cooled, Free-Standing Only

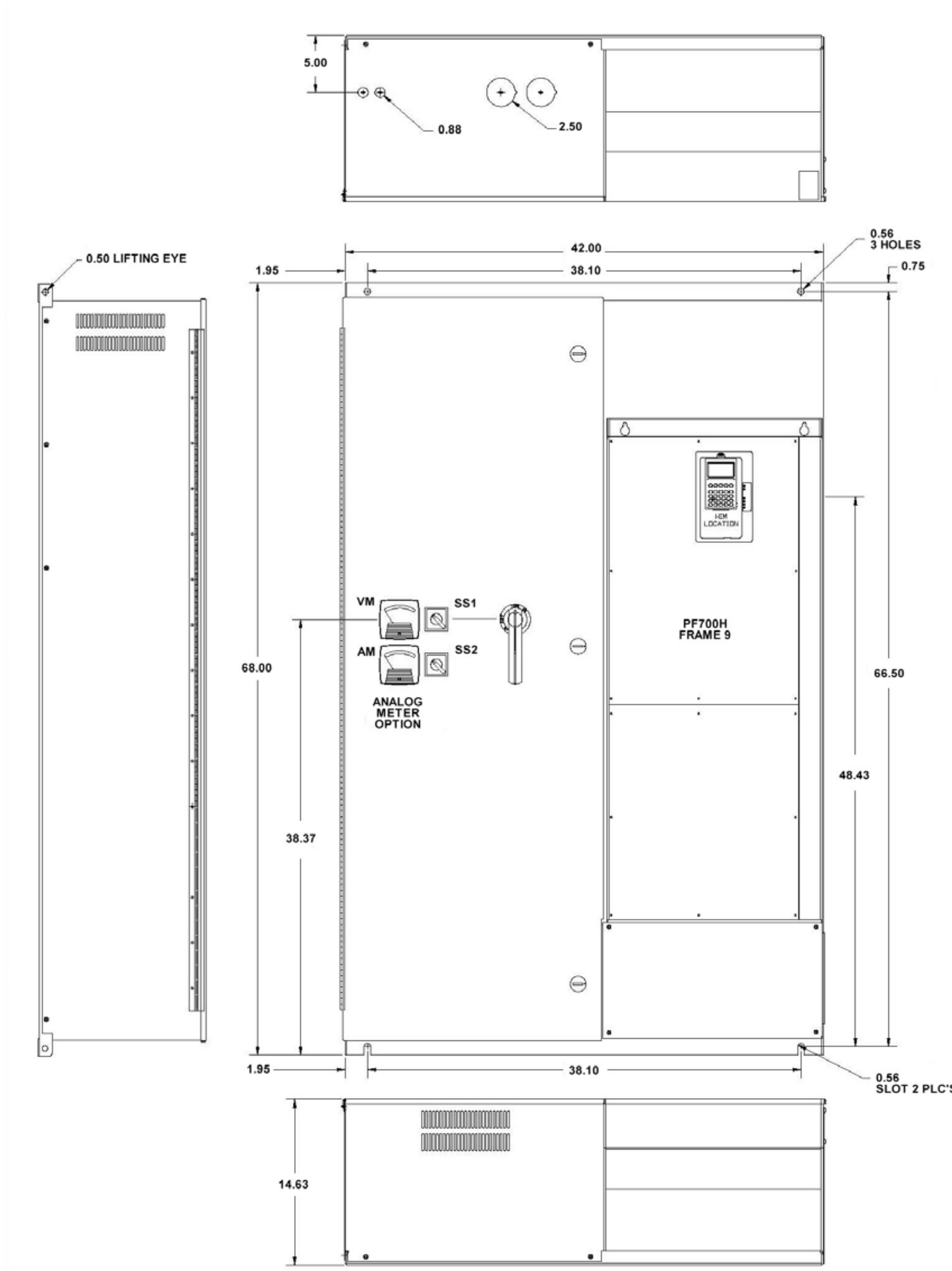


NOTE: The shipped loose, field installed, closed loop cooling module is shown installed adjacent to the VFD. It can also be install separated from it. See page 50 for installation instructions.

Unit Shipping Weights

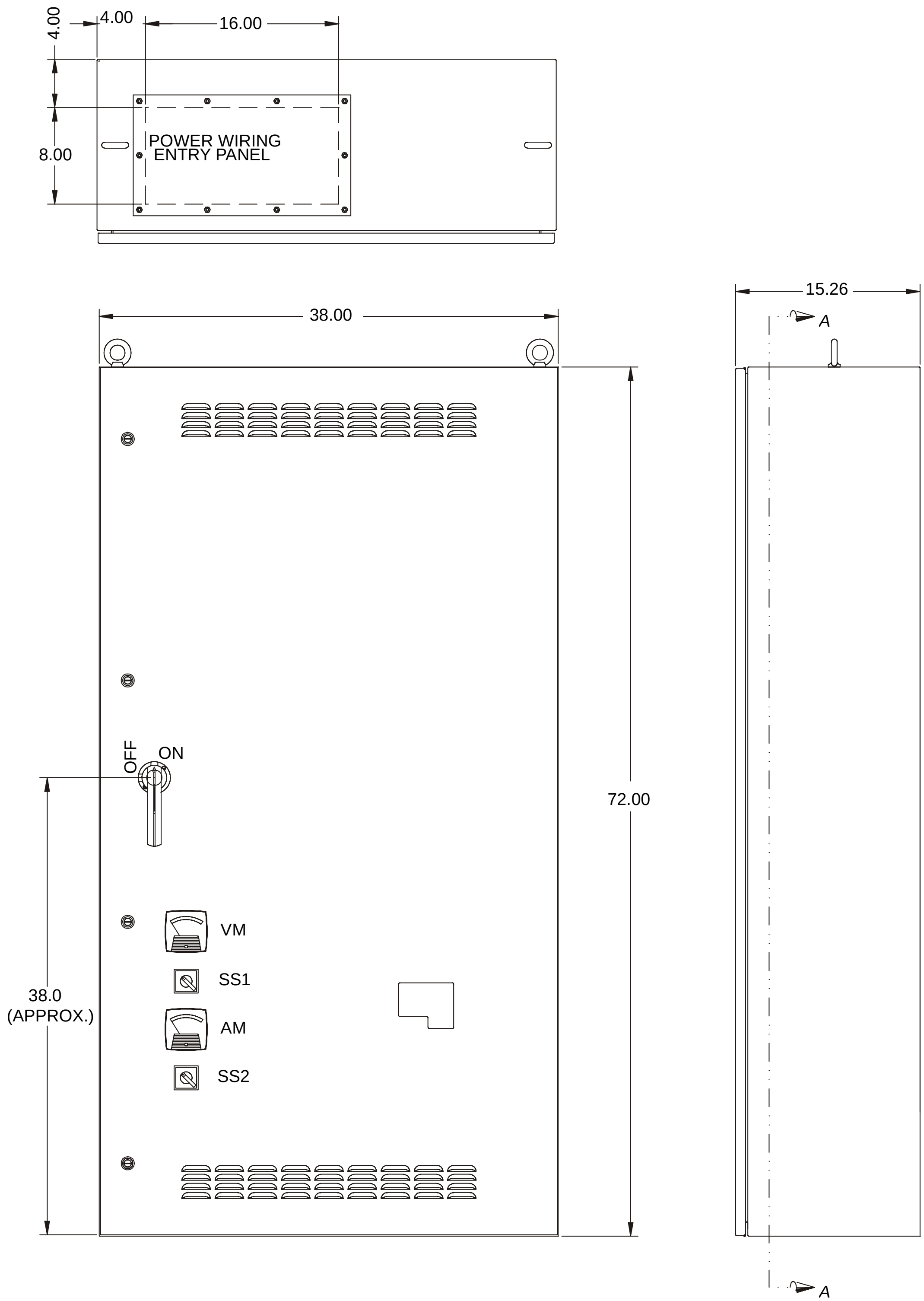
Model	VFD 090LW	VFD 120LW
Operating Weight, lb. (kg)	1800 (817)	1800 (817)
Shipping Weight, lb (kg)	2020 (917)	2020 (917)

Figure 26, VFD 009MA/028MA, Air-Cooled, Unit Mounted



NOTE: Incoming cable entrance is top-left. Outgoing wiring is factory-installed.

Figure 27, VFD 047MW/072MW, Water-Cooled, Unit Mounted



Benefits of the LiquiFlo 2.0 Synchronous Rectifier front end

- **Power Flow**: IGBT devices will allow power to flow into or out of the drives. This is extremely beneficial in that it allows an AC drive to absorb power from the application and put it back on the AC line at relatively the same efficiency level as when motoring. This one feature allows AC drives to be used in almost any application, which was previously solved with a DC drive.
- **Full rated Voltage on the Motor for Wide Input Voltage Ranges**: A synchronous rectifier can regulate the voltage level on the DC bus. The buck boost nature of the topology allows voltage levels on the DC bus to be higher than the peak of the AC line. During line sags, brownouts and other low voltage conditions the synchronous rectifier can maintain the DC bus at its rated voltage and thus provide full output voltage to the motor under almost all low line conditions. One very good example of this benefit is that the same drive and 480V motor can be used on a 380 Volt 50Hz line and a 480V 60Hz line and the motor will still operate at 480V and provide the same torque for both cases.
- **Harmonics:** The current waveforms produced by a synchronous rectifier are regulated to be sine waves. Thus the current harmonics can be regulated to meet IEEE 519 as well as the current CE standards for Europe with no additional modifications. Voltage harmonics in the range of 0.5 to 2% are typical at the drive.
- **Bus Over Voltages:** Just as critical as it is to keep the DC bus above an acceptable voltage level it is also possible to be too high. A synchronous rectifier will regulate the DC bus and lower the voltage if it rises above the desired set point. Repetitive line spikes will increase the DC bus voltage during the spike, however the synchronous rectifier will reduce the level as soon as the spike has passed, thus preventing the ratcheting up of the DC bus voltage level with each spike. The LC filter formed by the rectifier and the DC bus capacitors will also limit the transient voltage excursions.
- **Unity and/or Controlled Power Factor:** The input line currents are regulated by the synchronous rectifier, therefore a pre determined power factor can be set by the controls. This power factor is usually set to unity to maximize the unit's current draw; however it is possible to dynamically change the power factor to meet the user's desire to have an improved plant power factor.

Each of these benefits have varying degrees of importance to a user, but with a good synchronous rectifier the user always has the option to avoid issues and improve performance.

Table 27, LiquiFlo 2.0 Models:

Model	Max RLA	Phase	60 HZ Voltage Range	50 HZ Voltage Range
VF2037	368	3	380-481	380-400
VF2055	553	3	380-482	380-400
VF2080	809	3	380-483	380-400
VF2110	1105	3	380-484	380-400

NOTE: The initial "2' in the model number, such as VF**2**037 indicates that the VFD is a LiquiFlo 2.0 model.

Specifications

- NEMA 1 enclosure with hinged door.
- Package includes a circuit breaker with shunt trip with AIC rating of 65,000 amps.
- The drive is rated for 346-480vac input.
- Full motor voltage is applied regardless of the input voltage.
- Efficiency at rated load and 60 hertz is 97%.
- Drive thermal overload is 110% for 60 seconds in volts per hertz mode and 150% for five seconds in sensorless vector mode.
- Achieves IEEE519 using actively controlled IGBT front-end maximum of 5% THD.
- 0.99 power factor at full load and provides power factor correction at lighter loads.
- IGBT switching: 2kHz carrier frequency.
- The entire drive package is UL/CUL listed.
- Optional multi language LCD keypad.
- Power line dip ride through capability for up to 10 seconds.
- Adjustable auto restart (number of restarts and time delay between attempts are selectable.) Display indicates when controller is attempting to restart.
- Control power transformer for chiller unit controls

Options:

- Contact the local McQuay sales office for special options:
- Analog Metering - Volts and Amps with 3 Phase switch
- Ultra High Interrupt Breaker – 100 KAIC

Mounting

Liquid Flo2 are only available in free-standing configuration and require field mounting, wiring, and installation of a remote cooling module. See page 65 and following, for dimensions and weights.

Cooling Requirements

Liquid Flo2 VFD are fluid cooled and are provided with a closed loop cooling module. This module circulates cooling fluid between the VFD and a heat exchanger within the module.

The cooling module is field installed and requires a customer supplied chilled water source and some field wiring.

See page 50 for details on the separate cooling module.

Table 28, LiquiFlo 2.0, Cooling Requirements

McQuay Drive Model Number	Coolant Flow gpm	Max. Entering Coolant Temp. (°F)	Min. Entering Coolant Temp. (°F)
VF 2037	7	90	40
VF 2055	7	90	40
VF 2080	7	90	40
VF 2110	7	90	40

Power Wiring

Compressor Motor Terminals

For field-mounted VFDs, the power wiring connections at the motor are “spark plug” type terminals with threaded copper bar, sized per the following table.

Table 29, Chiller Compressor Motor Terminal Sizes

Type/Size	Comp. Size	Terminal Size
Low Voltage to 275 A, to 575 V	CE 050	0.375-16 UNC2A, 0.94 in. long
Low Voltage to 750 A, to 575V	CE 063-126	0.635-11 UNC-2A, 1.88 in. long

VFD Terminals

For field wiring freestanding VFDs, the outgoing terminals and incoming power block terminals are determined by the VFD size listed in the following tables. For factory-mounted VFDs, the outgoing terminals are factory-connected to the compressor motor.

When wiring to a VFD with a disconnect switch or circuit breaker, the incoming lug size is determined by the device size as shown in Table 31.

Table 30, LiquiFlo 2.0, Terminal Size Range

VFD Size	Incoming Terminals	Outgoing Terminals
VF2037	Incoming connection is to the standard circuit breaker. See Table 31.	(3) 1.5 inch wide tab w/ 0.472 inch hole
VF2055		
VF2080		(3) 2.25 inch wide tab w/ 0.56 inch hole
VF2110		

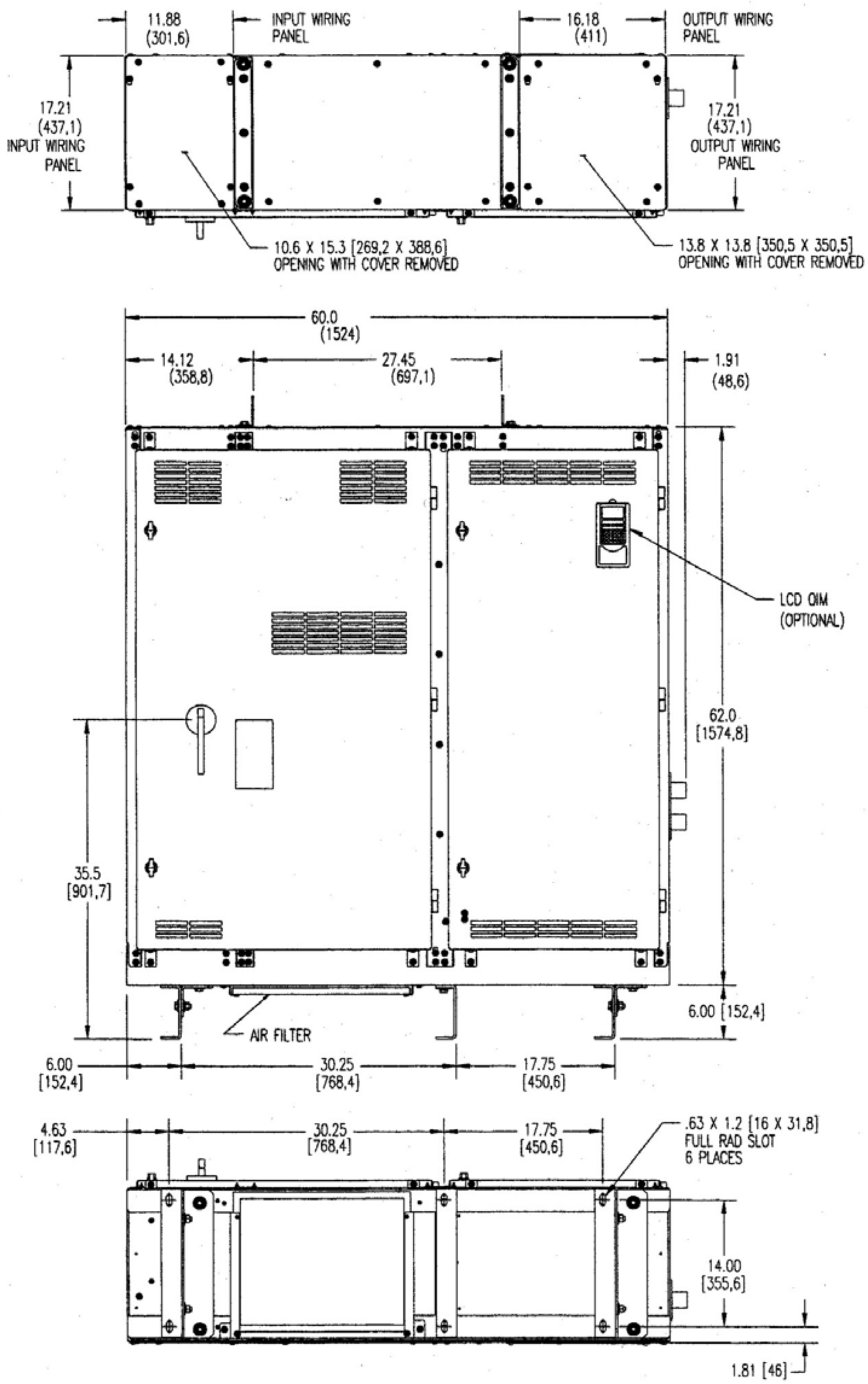
Table 31, Incoming Terminal Size Range, Disconnects & Circuit Breakers

Max RLA	Size	Incoming Terminal, Disconnect Switch or Circuit Breaker
74	100	(1) #6- 300
93	125	(1) #6- 300
148	200	(1) #6- 300
163	220	(1) 4/0 - 500
185	250	(2) 3/0 - 500
296	400	(2) 3/0 - 500
444	600	(3) 1/0 - 500
593	800	(4) 250 – 500
889	1200	(5) 300 – 600
1185	1600	(5) 300 - 600

NOTE: (X) is the number of terminals per phase.

VFD Dimensions

Figure 28, VF 2037-2055;

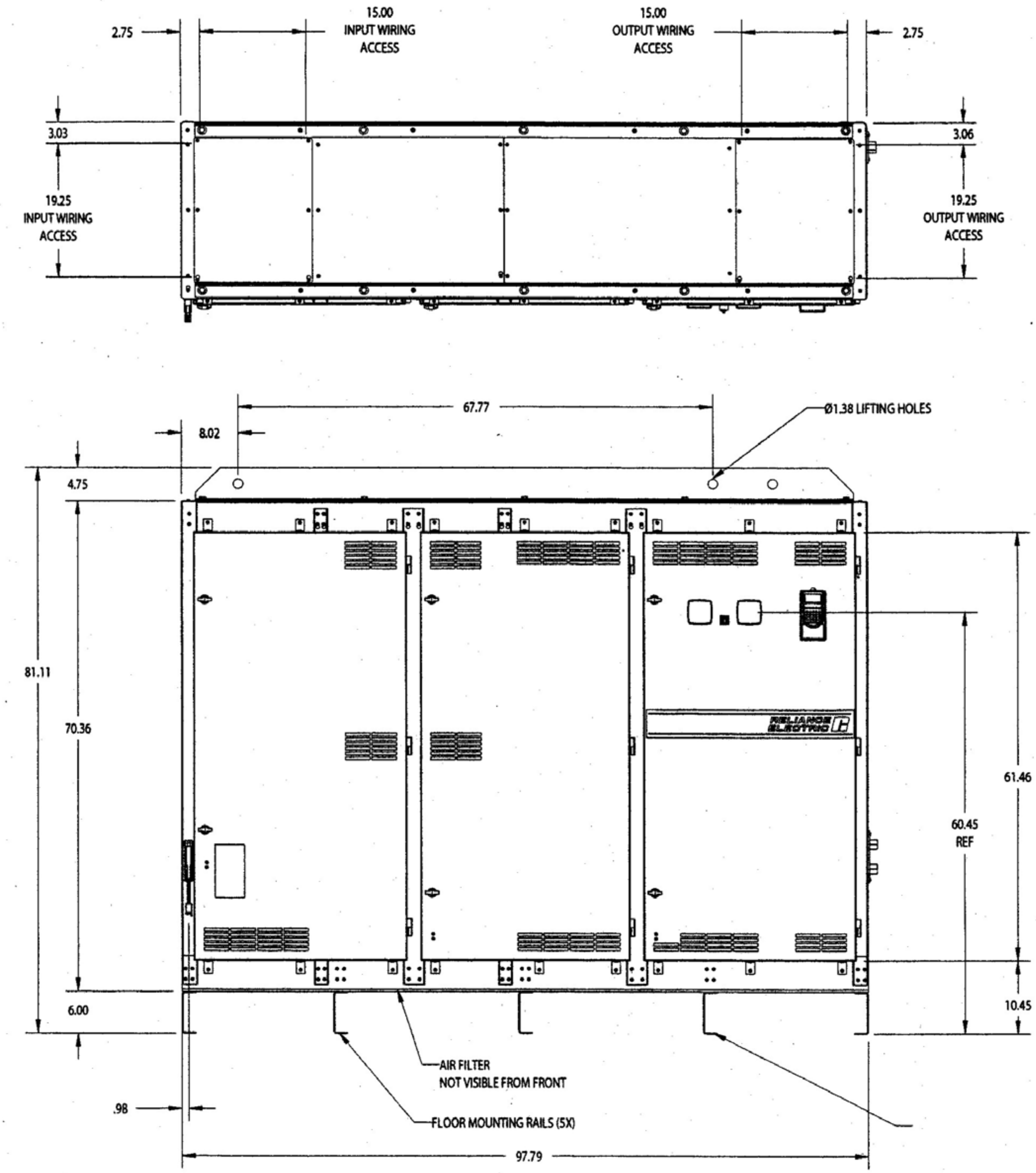


NOTE: Closed loop cooling module is also required.

Unit Shipping Weights

Model	VF 2037	VF 2055
Weight lb. (kg)	1600 (726)	1600 (726)

Figure 29, VF 2080-2110



NOTE: Closed loop cooling module is also required.

Unit Shipping Weights

Model	VF 2080	VF 2110
Weight lb. (kg)	2000 (908)	2000 (908)

Power Factor Correction

Many local codes and utility companies require power factor correction to improve the utilization of power.

Voltage and current in alternating current systems travel through wires in a sine wave pattern developing positive charges and negative charges. The number of sine waves or cycles per second is called frequency. The most common frequencies are 50 Hz and 60 Hz (cycles per second).

Induction devices such as electric motors and solenoid coils use energy to create magnetic fields to perform their tasks. This magnetizing energy does not perform usable work and will cause the current to lag the voltage, traveling in a slightly different sine wave. When electrical measurements are made, only the mean values for voltage and amperage are measured. These measurements do not indicate that the voltage and amperage have "slipped".

This "slippage" can be corrected by applying power factor capacitors. These capacitors have the reverse effect causing voltage to lag current. When capacitors are used with motors, the two devices offset each other allowing voltage and amperage to travel more consistently. It is good practice to select capacitors that will correct to a maximum of 95% of total correction. Capacitors are sized in terms of KVAR (1000 volt-amp reactive). Readily available low voltage sizes are 2.5, 5.0, 7.5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 75 and 100 KVAR. For medium voltage applications, available sizes are 25, 50, 100, 150 and 200 KVAR. Contact the McQuay sales office for larger sizes.

Power factor correction capacitors should be connected to the load side of contactors except for solid state starters. If field supplied capacitors are used with solid state starters, they must be installed upstream of the starter. At least ten feet of wire is required between the capacitors and the starter. A separate isolation contactor must be supplied to disconnect the capacitors during starter ramp-up and ramp-down. When the capacitors for solid state starters are supplied by McQuay, the isolation contactor is furnished and ten feet of wire is coiled within the starter enclosure. Use two sets of capacitors for dual compressor units.

The McQuay chiller selection program can provide the unit power factor and will also calculate capacitor size for power factor correction.

Indices: Figures & Tables

Index of Figures

Index of Tables

This document contains the most current product information as of this printing. For the most up-to-date product information, please go to www .mcquay. com.