LOAD BANK TECHNICAL MANUAL

Customer: XXXX

Job: XXXX

Model: Nautilus 250

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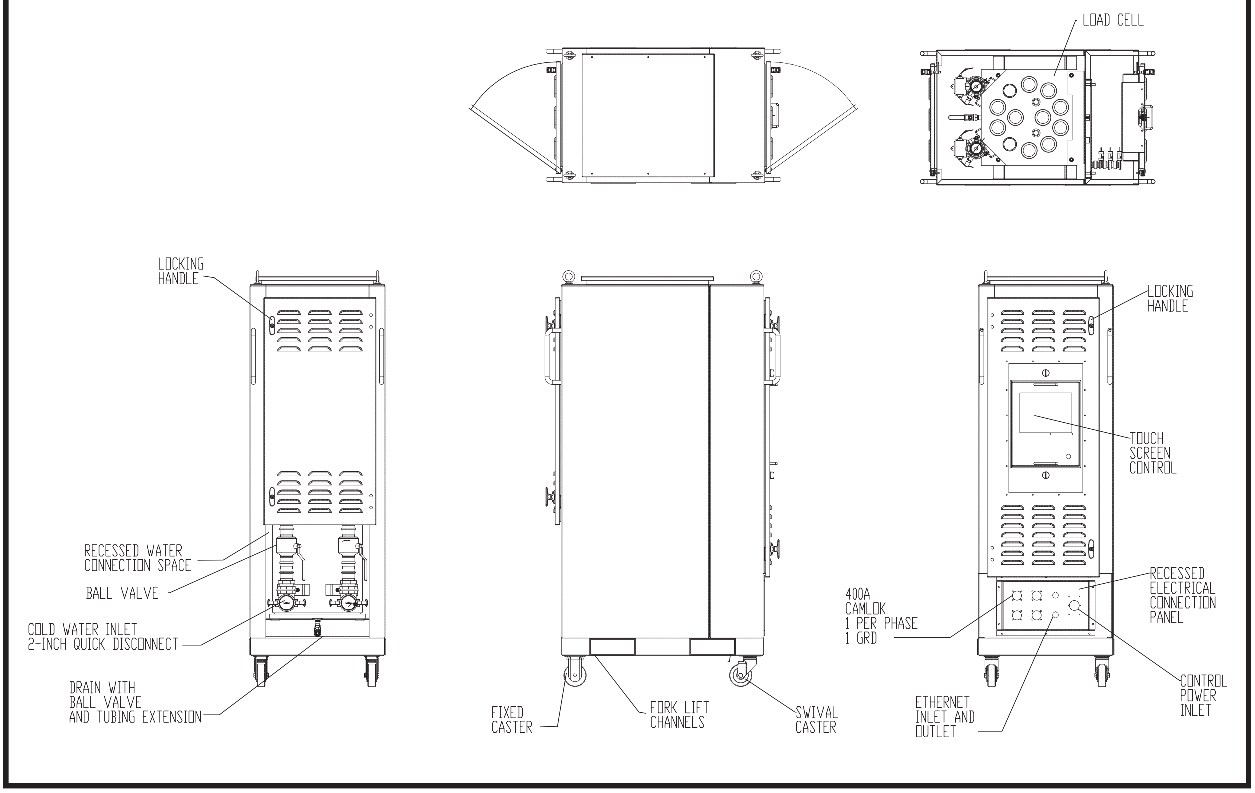


Part of Pictorial Drawing

DESCRIPTION

A Simplex Load Bank is a precision test instrument specifically designed to apply a discrete, selectable resistive electrical load to a power source while measuring the response of the generator to the applied load. It also provides a means for routine maintenance exercise to assure long term reliability and readiness of the standby generator. Exercise Load Banks eliminate the detrimental effects of unloaded operation of diesel engine generators.

Power source testing is accomplished by applying resistive load steps at specific power factor.

Load application is by magnetic contactor. All load branch circuits are protected by 200KAIC fuses.

Operating controls are located on the touchscreen control panel. Common serviceable components include a Control Fuse (CF Series), Metering Fuses (MF Series) and Load Application Fuses (F Series).

> ⚠ **WARNING** ⚠
>
> **Always remove all power from the load bus and all fan/control power before servicing the Load Bank.**

The Load Bank consists of three principal systems:

1. Control System
2. Cooling System
3. Load System

CONTROL SYSTEM

The Load Bank control system is a Programmable Logic Controller (PLC) based system with a touchscreen operator interface. Multiple units may be connected to increase system capacity.

The control system automatically connects control contactors for applied voltage and detects cooling water flow activity.

COOLING SYSTEM

The load elements in this Load Bank are cooled by an open loop fresh water system. Sensors monitor water flow (WFS), water temperature (WTS), water pressure (WPS), and water leak in sump (FSW). If a failure occurs all load is automatically dumped and the operator is alerted by the touchscreen alarm. The failure must be corrected and the system must be reset before a load can be re-applied.

See Load Bank drawings and nameplates for the approximate temperature rise, minimum coolant water flow rate, and working pressure values.

If any problems are observed during Primary Inspection call the Simplex Service Manager at 217-483-1600 (24hrs.)

PRIMARY INSPECTION

Preventative visual inspections of the shipping crate and Load Bank is advised. Physical or electrical problems due to handling and vibration may occur. Never apply power to a Load Bank before performing this procedure. The following Six Point/30 Minute Inspection is recommended before installation, as part of the 50 hour / 6 month maintenance schedule and whenever a Load Bank is relocated:

1. If crate shows any signs of damage examine the Load Bank in the corresponding areas for signs of initial problems.
2. Check the entire outside of the cabinet for any visual damage which could cause internal electrical or mechanical problems due to reduced clearance.
3. Rotate and push all switches through all positions to ensure smooth operation.
4. Inspect all relays, timers, and control modules by opening all accessible panels. Make sure all components are secure in their bases and safety bails are in place. Spot check electrical connections for tightness. If any loose connections are found inspect and tighten all remaining connections.
5. Examine all accessible internal electrical components such as fuses, contactors and transformers. Check lugged wires at these components.
6. Inspect bottom of crate/enclosure for any components that may have jarred loose during shipment such as indicator light lenses, switch knobs, etc.

INSTALLATION

Unless specified on the drawing or in this manual consult NEC for proper wire size for all connections.

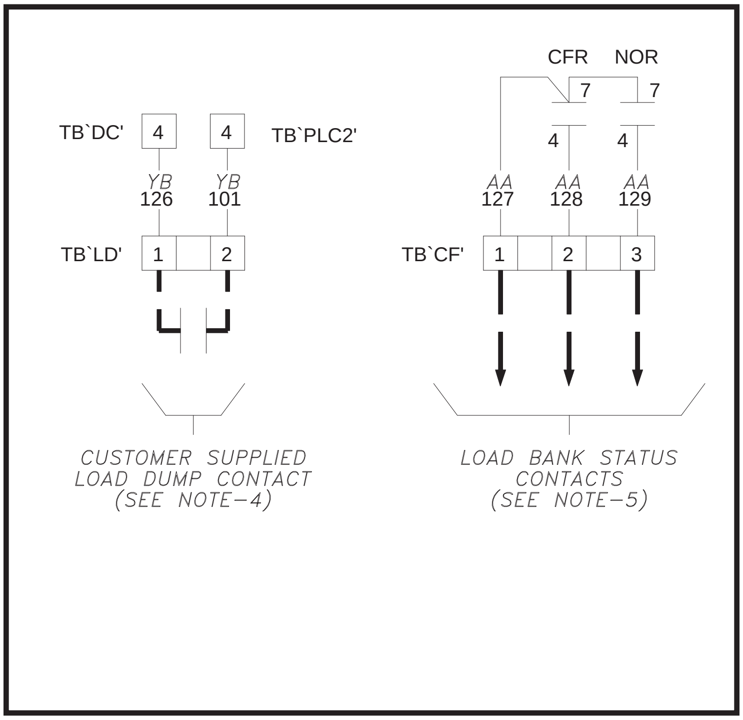
1. Position the Load Bank in the desired area of operation and ground it to its own independent ground.
2. Confirm the test source is properly grounded.
3. *See Control Interconnect Drawing.* Using customer supplied CAT-5, 5E or 6 ethernet cable connect Load Bank(s) to controller(s) as shown for the desired system configuration.
4. *See Pictorial Drawing.* Connect the coolant water piping to the Load Bank Outlet and Inlet connections.
5. *See Load Section Drawing.* Cable the load source to the Cam-Loks on the Load Bank as shown.
6. *See Control Power Distribution Drawing*.
   a. If the Load Dump feature is desired, connect TB'LD' 1–2 to customer supplied Load Dump contacts or jumper if not used.

   Close contacts to enable Load Bank and open contacts to dump load.

   b. Connect customer supplied Load Bank failure contacts to TB'CFR' 1-3 as shown.

   Continuity between TB'CFR' 1 and 3 indicates Normal Operation.

   Continuity between TB'CFR' 1 and 2 indicates Load Bank Failure or Load Bank De-Energized.



Part of Control Power Distribution Drawing

> **⚠ WARNING ⚠**
>
> **Do Not allow the Load Bank to operate unattended for extended periods.**

OPERATION

The screens shown in this manual are examples only. The screens for your Load Bank may differ.

The coolant for this Load Bank is fresh water. See Load Bank drawings and nameplates for minimum coolant water flow rate and working pressure values.

1. Start coolant flow via customer supplied devices.
2. Start generator set or bring other test source on line.
3. Purge air from load cell chambers.
4. Press the "Control Power" "On" button on the Main Screen.

   If multiple units are connected to form one system the Main Screen is only available via the Master Load Bank.

5. Verify normal operation indication in the "System" area of the screen before proceeding.

   Total units available and total KW availabe will be indicated.

   System and individual unit status condition will be indicated.

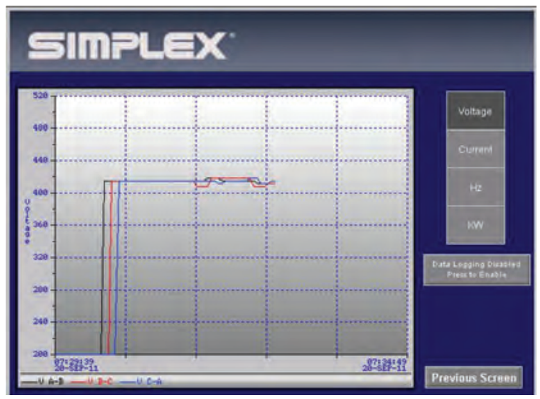
6. Adjust the voltage and frequency of the generator.
7. Press the "KW to Apply" button and enter the desired load.
8. Press the "Apply" button.

   Pressing the "Remove" button will remove all load.

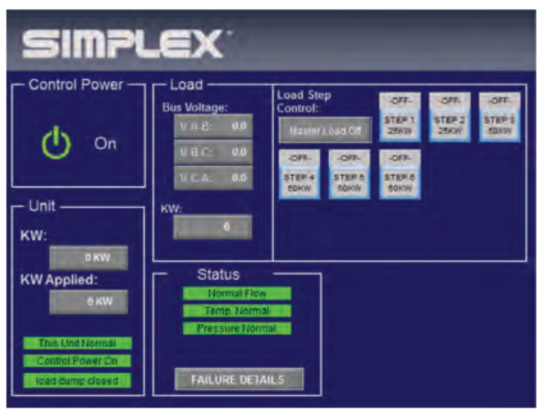
9. If desired the operator may access the Metering Line Trends, Single Unit Monitoring or Maintenance Mode screens from the Main Screen.

   Data logging is available from the Metering Line Trends Screen by pressing the Data Logging button while a customer supplied USB flash drive is inserted into the USB port.

Main Screen Example



Metering Line Trends Screen Example



Single Unit Monitoring Screen Example

The Single Unit Monitoring Screen, without a "Previous Screen" button, is the default screen on slave units.

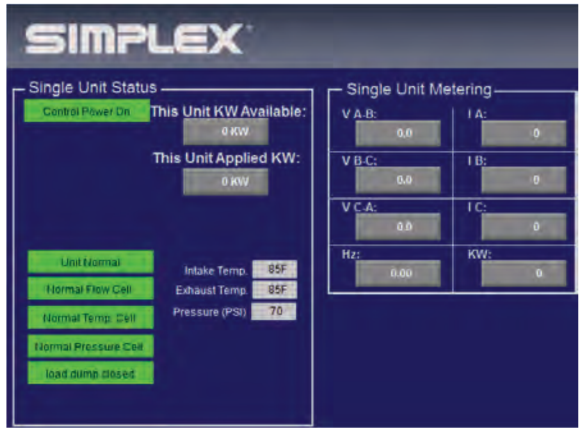
10. Monitor and adjust load steps as needed.

SHUTDOWN

1. Remove all load.
2. Press the "Control" button to the "Off" position.
3. Turn off the test source. Disconnect the cables. Disconnect the controller(s) and ethernet cable(s) and store them appropriately.

DIAGNOSTICS SCREEN

The Diagnostic Screen is used to check the status and settings of the Programmable Logic Controller (PLC) along with unit KW, KW applied, status conditions, and temperatures.



Diagnostics Screen Example

LOAD DUMP

This Load Bank contains a Load Dump feature which de-energizes all applied load when customer supplied contacts open. Normally closed to run, they should be rated at 10A @ 120VAC minimum and should be wired to TB'LD' 1–2. When these contacts open all applied load will be de-energized and the load section will be disabled. If desired, the customer may install automatic transfer switch contacts, a manual pushbutton or circuit breaker for this use. If the Load Dump feature is not used TB'LD' 1–2 must be jumpered. *See Installation.*

WARNING

Always remove all power from the load bus and all fan/control power before servicing the Load Bank. Never operate or service a Load Bank that is not properly connected to an earthground.

FAILURE DETECTION SYSTEM

This is a permissive/energize-to-run circuit in which all safety sensor contacts must be closed before load can be applied. This system includes the following component:

1. Water Flow Switches and Relay (WFS and WFR Series)
2. Water Temperature Switches and Relay (WTS and WTR Series)
3. Water Pressure Switches and Relay (WPS and WPR Series)
4. Coolant Leak Switch and Relay (FSW and WSR Series)
5. Normal Operation Relay (NOR)

The failure detection switches are factory set. WTS and WPS can be field adjusted via the transducer setscrew.

If a failure occurs all load is automatically dumped and the operator is alerted by the touchscreen indicators. The failure must be corrected and the system must be reset by turning the Load Bank Off then On before load can be re-applied. One failure may be the cause of a subsequent, separate failure: a Loss of Flow failure may cause an Over Temperature failure, etc.

MAINTENANCE

Depending upon the ambient operating temperature and the length and KW load of the testing, the maintenance of the load bank will vary. Vibration experienced by the load bank during transportation also affects the maintenance schedule of the load bank. An understanding of the load bank's electrical connections will facilitate a maintenance program suited to your particular testing criteria. All electrical connections should be re-torqued with regularity based upon the weekly usage and the amount of transportation.

Each of the load cell cells includes immersion heaters. The elements are of different wattage ratings and are electrically protected by Class J fuses of different amperage ratings. These fuses are bolted to the main electrical bus bars. If the KW output rating of the load bank is outside of a 7% KW tolerance then it is possible that one or more of the Class J fuses have expired. A continuity tester across the fuse will determine the replacement of the fuse. The fuse is connected to the definite purpose contactors via a wiring harness with compression ring terminals. The wiring harness consist of tin plated copper 150°C color coded conductors. These conductors are inserted into aluminum mechanical screw down connectors rated for either copper or aluminum conductors. The torque rating of the mechanical screw down connector is listed on the label of the contactor. The electrical connections are accessed through the two front doors of the load bank.

The torque rating of the immersion heater's terminal studs, their nickel plated flat washers, and nuts is 25 in lbs. These connections can be accessed by removing the top plates of the load bank.

After the replacement of any blown fuses and the torquing of all electrical connections, if the KW tolerances is greater than 7%, then an ohm measurement across the individual immersion heating elements must be made. These electrical connections are accessed on the top of the load bank as described above. There are three different KW ratings of the immersion heaters in the load bank. Each immersion heater has six terminals for the three elements within each immersion heater. The ohm value across terminals A-B should equal the ohm value across terminals C-D, which should equal the ohm value across the terminals E-F. A variation of more than 15% would indicate the need to replace the entire immersion heater.

While there is a water source to the load bank, if it is necessary to service or repair the immersion elements, the load cell may be isolated from the others by utilizing the isolation hand valves in the rear of the load bank.

⚠ WARNING ⚠

For continued safety and for maximum equipment protection, always replace fuses with one of equal rating only.

TROUBLESHOOTING

This section is designed to aid the electrical technician in basic Load Bank system troubleshooting. All of the problems listed can be verified with a basic test meter and/or continuity tester. For safety reasons, when troubleshooting a Load Bank systems always remove all test source power, fan/control power, anti-condensation heater power, etc.

OVER TEMPERATURE WITH WATER CIRCULATING

1. KW rating of load steps is greater than the water flow to cool the immersion heaters.
2. Defective over temperature switch.
3. Loose electrical connection on the over temperature switch.
4. Intake water temperature above maximum indicated on nameplate.

FALSE COOLING FAILURE INDICATION

1. Inoperative Water Flow Switch.
2. Inoperative Failure Relay.
3. Reversed coolant flow.

NO COOLING WATER CIRCULATION

1. Intake valve turned in the off position.

LOAD CELL OVERPRESSURE FAILURE

1. Electrical connection to pressure sensor disconnected.
2. Pressure of incoming water above 95 PSI.
3. Isolation valves in rear of load bank turned off in three of the four load cells.

⚠ WARNING ⚠

When troubleshooting Load Bank systems always remove all test source power, fan/control power, anti-condensation heater power, etc.

SOME LOAD STEP(S) CANNOT BE ENERGIZED (NO FAILURES INDICATED)

1. Contactor of that load step does not have its 120 VAC coil activated by the control power transformer circuit.
2. Inoperative failure sensor.
3. Load step immersion heater element or Class J fuses bolted to the bus bar opened.

NO LOAD STEPS CAN BE ENERGIZED (NO FAILURES INDICATED)

1. Control Power not available and therefore the touch screen is not illuminated.
2. Control Power Class CC fuse blown in the control circuit.

DRAWINGS AND PARTS LIST

The drawings included in this manual are the most accurate source of part numbers for your Load Bank. When ordering replacement parts for Simplex Load Banks, always consult the Parts Drawing. When contacting the Simplex Service Department always have your work order and drawing number ready for reference. The Job Number and the Drawing Numbers are also located on each drawing legend.

APPENDIX A - ABBREVIATIONS USED IN THIS MANUAL

Listed below are abbreviations of terms found on Simplex Load Bank Systems. When following a load bank drawing utilize this guide to define abbreviated system and component names. As this is a master list, drawings and text pertaining to your equipment may not contain all these terms.

AC-Alternating current

AIC-Ampere interrupting current-maximum short circuit fault current a component can safely interrupt

AM-Ammeter

AMSW- Ammeter selector switch-selects any phase for current reading

CF-Control fuse

CFM-Cubic feet per minute-used to rate fan air flow capacity and load bank cooling requirement

CFR-Cooling failure relay-normally energized relay in cooling failure subsystem

CPC-Control power contactor

CPF-Control power fuse

CT-Current transformer- used in metering circuits

DC-Direct current

EXTS-Exhaust air temperature switch

FCB-Fan circuit breaker-circuit breaker in series with fan control power

FCVR-Fan control voltage relay-normally energized relay on relay sub-panel

FM-Frequency meter-monitors frequency of test source

FMC-Fan motor contactor-controls power to fan motor

FMSW-Frequency meter switch

FPS-Fan power switch-used to energize cooling system

GFB-Ground fault breaker

GBTR-Ground breaker tripped relay

HMI-Operator Interface

HVR-High voltage relay

Hz-Hertz-cycles per second, measurement of frequency

IFCV-Incorrect fan/control voltage

INTS-Intake air temperature switch

K-Relay coil/contact designation

KVA-Kilovolt amperes

KVAR-Kilovolt amperes-reactive

KW-Kilowatts

KWM-Kilowatt meter

KWT-Kilowatt meter transducer

LM-Louver motor

LMC-Louver motor contactor

LR-Load resistive element

LX-Load reactive element

L1-Line 1

L2-Line 2

L3-Line 3

MCB-Main circuit breaker

MDS-Main Disconnect Switch

MF-Meter fuse

MLB-Main Load Bus

MOT-Motor

NEMA-National electrical manufacturer's association

ODP-Open, drip-proof-refers to motor enclosure

OVR-Overvoltage relay-relay used in overvoltage failure system, located on relay sub-panel

OLR-Overload relay-used for motor protection

OTR-Overtemperature relay-used in failure system

PF-Power factor-in resistive only loads expressed as unity (1.0), in inductive loads expressed as lagging, in capacitive loads expressed as leading

PAR-Control power available relay-relay energized when control power is available

PFM-Power factor meter

PS-Pressure switch-switch used to detect fan failure

RR-Reset relay

RTM-Running time meter-keeps time log of equipment use.

TB-Terminal block

TDR-Time delay relay-relay which times out before contacts change state

TEFC-Totally enclosed, fan cooled-refers to motor enclosure

TEAO-Totally enclosed, air-over-refers to motor enclosure

UPS-Uninterruptable power source

V-Voltage

VSR-Voltage sensing relay

XCB-Reactive load controlling circuit breaker

APPENDIX B - CALCULATIONS & FORMULAS

The following calculations are used to determine the actual kilowatt load being applied by the Load Bank, when line voltages and currents are known (at 1.0 power factor).

3 Phase

1. Read all three line currents and find the average reading.
2. Read all three line-to-line voltages and find the average reading.
3. Multiply the average current times the average voltage.
4. Multiply the answer of step #3 times the square root of 3 (1.732).
5. Divide the answer of step #4 by 1000. The answer is the actual kilowatts of load being applied by the Load Bank.

Single Phase

1. Determine the line current.
2. Determine the line-to-line voltage.
3. Multiply the line current times the line-to-line voltage.
4. Divide the answer of step #3 by 1000.
5. The answer of step #4 is the actual kilowatts being applied by the load bank.

EXAMPLES

Using line voltages and currents:

3 Phase

Current Readings	Voltage Readings
A_1 = 249A	$V_{1\text{-}2}$ = 481V
A_2 = 250A	$V_{2\text{-}3}$ = 479V
A_3 = 254A	$V_{3\text{-}1}$ = 483V

$$\text{Average Current} = \frac{A_1 + A_2 + A_3}{3} = \frac{249+250+254}{3} = 251\text{A}$$

$$\text{Average Voltage} = \frac{V_{1\text{-}2} + V_{2\text{-}3} + V_{3\text{-}1}}{3} = \frac{481 + 479 + 483}{3} = 481\text{V}$$

$$\text{Kilowatts} = \frac{\text{Volts x Amps x } 1.732}{1000} = \frac{481 \text{ x } 251 \text{ x } 1.732}{1000} = 209.1\text{KW}$$

Single Phase

Current Reading: 150A Voltage Reading: 240V

$$\text{Kilowatts} = \frac{\text{Volts x Amps}}{1000} = \frac{150 \text{ x } 240}{1000} = 36.1\text{KW}$$

The following calculations are used to determine the amount of current when the desired amount of kilowatts is applied at 1.0 power factor.

3 Phase

1. Multiply the desired amount of kilowatts to be applied by 1000.
2. Multiply the operating voltage times the square root of 3 (1.732)
3. Divide the answer of step #1 by the answer of step #2.
4. The answer of step #3 is the average line current with the desired kilowatts applied at 1.0 power factor.

Single phase

1. Multiply the desired amount of kilowatts to be applied by 1000.
2. Divide the answer of step #1 by the operating voltage.
3. The answer of step #2 is the average line current with the desired amount of kilowatts applied at 1.0 power factor.

The following calculations are used to determine a step kilowatt rating at other than a rated voltage. This is accomplished by referencing the load step to a KW value at a known voltage.

1. Determine the new unrated operating voltage.
2. Divide the new operating voltage by the reference voltage.
3. Square the answer of step #2.
4. Multiply the answer of step #3 times the reference kilowatt value of the load step which the new kilowatt rating is desired.
5. The answer of step #4 is the kilowatt rating of the load step at the new voltage.

EXAMPLES

When desired amount of kilowatts is applied at 1.0 PF:

3 Phase

Applied: 50KW   Operating Voltage: 480V

$$\text{Amperage} = \frac{\text{KW x 1000}}{\text{Volts x 1.732}}$$

$$= \frac{50 \times 1000}{480 \times 1.732}$$

$$= \frac{50,000}{831.36}$$

$$= 60.1$$

Single Phase

Applied: 25KW   Operating Voltage: 240V

$$\text{Amperage} = \frac{\text{KW x 1000}}{\text{Volts}}$$

$$= \frac{25 \times 1000}{240}$$

$$= \frac{25,000}{240}$$

$$= 104.2$$

Determining step KW at other than rated voltage:

Applied: 80KW   Operating Voltage: 450V
Rated Voltage: 480V

$$\text{Step KW} = (\text{Oper. Volt.} \div \text{Rated Volt.})^2 \text{ x Applied KW}$$

$$= (450 \div 480)^2 \times 80$$

$$= .9375^2 \times 80$$

$$= 70.3$$

FORMULAS

		Alternating Current	Direct Current
Kilowatts	1 phase	$\frac{\text{Volts x Amps x PF*}}{1000}$	$\frac{\text{Volts x Amps}}{1000}$
	3 phase	$\frac{\text{1.732 x Volts x Amps x PF*}}{1000}$	

*Power Factor, expressed as decimal.
(Resistive Load Bank PF is 1.0)

		Alternating Current	Direct Current
Amperes (KW known)	1 phase	$\frac{\text{KW x 1000}}{\text{Volts x PF}}$	$\frac{\text{KW x 1000}}{\text{Volts}}$
	3 phase	$\frac{\text{KW x 1000}}{\text{1.732 x Volts x PF}}$	
KVA	1 phase	$\frac{\text{Volts x Amps}}{1000}$	
	3 phase	$\frac{\text{1.732 x Volts x Amps}}{1000}$	
Amperes (KVA known)	1 phase	$\frac{\text{KVA x 1000}}{\text{Volts}}$	
	3 phase	$\frac{\text{KVA x 1000}}{\text{1.732 x Volts}}$	
KVAR	1 phase	$\frac{\text{Volts x Amps x }\sqrt{1-PF^2}}{1000}$	
	3 phase	$\frac{\text{1.732 x Volts x Amps x }\sqrt{1-PF^2}}{1000}$	

APPENDIX C - TORQUE VALUES

FAN BLADES		
FAN PART NO.	BOLT SIZE	TORQUE FT LBS // IN LBS
13820000	SET SCREW	11.7 // 140
13820500	SET SCREW	11.7 // 140
13821000	SET SCREW	8.3 // 100
13822000	1/4 — 20	7.5 // 90
13823000	1/4 — 20	7.5 // 90
13824000	1/4 — 20	7.5 // 90
13825100	1/4 — 20	7.5 // 90
13826000	1/4 — 20	7.5 // 90
13827500	5/16”	13 // 156
13827600	5/16”	13 // 156
13828000	3/8”	24 // 288

MOTORS, BRACKETS, BUS BAR CONNECTIONS		
BOLT/NUT SIZE	GRADE	TORQUE FT LBS // IN LBS
.250 (1/4-20)	Grade 5, dry	8 // 96
.250 (1/4-20)	Grade 2, dry	5.5 // 66
.312 (5/16)	Grade 5, dry	17 // 204
.312 (5/16)	Grade 2, dry	11 // 132
.375 (3/8)	Grade 5, dry	30 // 360
.375 (3/8)	Grade 2, dry	20 // 240
.437 (7/16)	Grade 5, dry	50 // 600
.437 (7/16)	Grade 2, dry	30 // 360
.500 (1/2)	Grade 5, dry	75 // 900
.500 (1/2)	Grade 2, dry	50 // 600
.562 (9/16) & up	Grade 5, dry	110 // 1320
.562 (9/16) & up	Grade 2, dry	70 // 840

CONTACTORS
See torque values on the front of the contactor.

ELEMENTS/TRAYS		
TERM/NUT SIZE		TORQUE INCH LBS
#6	Rod ends	4
#10	Element Conn.	20
1/4-20	High Voltage	Contact Simplex

MAIN LOAD BLOCKS- ALL SIZES		
CONNECTION	WIRE SIZE	TORQUE FT LBS // IN LBS
LOAD SIDE	4-14AWG	2.9 // 35
LINE SIDE	500MCM-4/0	31 // 375
	3/0-4/0	20 // 240
	2/0-6AWG	10 // 120
	8AWG	3.3 // 40

CIRCUIT BREAKERS		
STYLE	WIRE SIZE	TORQUE INCH LBS
Cutler-Hammer 1-Phase	14-10 AWG	20
	8 AWG	25
	6-4 AWG	27
	3-1/0 AWG	45
Merlin Gerin 3-Phase	14-1/0	50

APPENDIX C - TORQUE VALUES CONT'D

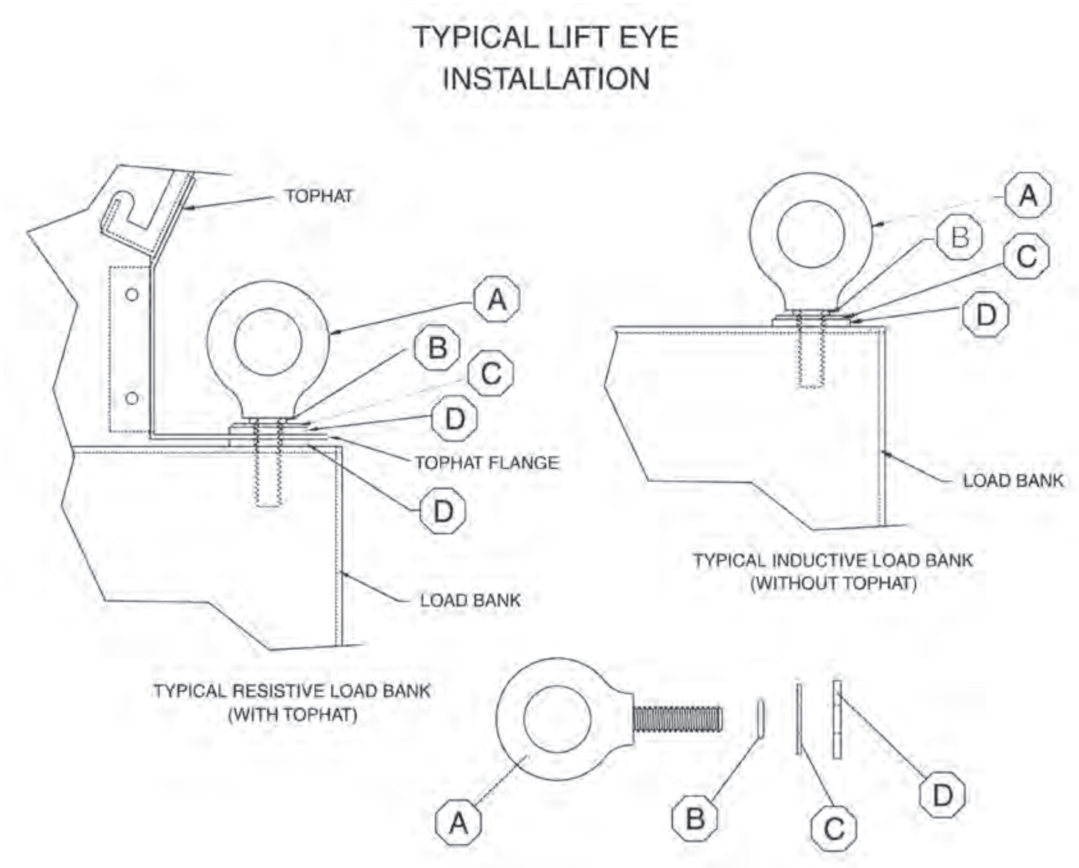
FUSEBLOCKS		
MANUF. PART NO.	WIRE SIZE	TORQUE INCH LBS
BM6031SQ, BM6032SQ, BM6033SQ; 600V, 30A	10-18 AWG	20
T60060-2SR 600V, 60A	10-18 AWG	20
T60030-3CR, 600V, 30A T60060-3CR, 600V, 60A 60100-3CR, 600V, 100A	10-14 AWG	35
	8 AWG	40
	4-6 AWG	45
	2-3 AWG	50

MISCELLANEOUS-TERMINALS, METERS, SWITCHES, COILS, RELAYS, XFORMERS	
CONNECTION SIZE	TORQUE INCH LBS
4	5
6	10
8	19
10	31
1/4-20"	66

TAPER-LOCK BUSHINGS	
BUSHING NUMBER	TORQUE
1008, 1108	55 IN LBS
1210, 1215, 1310, 1610, 1615	15 FT LBS
2012	23 FT LBS
2517, 2525	36 FT LBS
3020, 3030	67 FT LBS
3535	83 FT LBS
4040	142 FT LBS
4545	204 FT LBS
5050	258 FT LBS
6050, 7060, 8065	652 FT LBS
10085, 12010	1142 FT LBS

CAM-LOK STUDS	
THREADED STUD	MAXIMUM TORQUE
5/16" – 18	15 FT LBS
1/2" – 13	40 FT LBS

APPENDIX D - TYPICAL LIFT EYE INSTALLATION



ITEM	DESCRIPTION	1/2"	5/8"	3/4"	7/8"
A	LIFT EYE	15465000	15470000	15471000	15472000
B	O-RING	16750500	16750600	16750610	16750620
C	FLAT WASHER	20424200	20427000	20427100	20427200
D	RUBBER WASHER	20431000	20431001	20431002	20431003