

# LOAD BANK TECHNICAL MANUAL

Customer: XXXXXX

Work Order: XXXXX-XX-XX

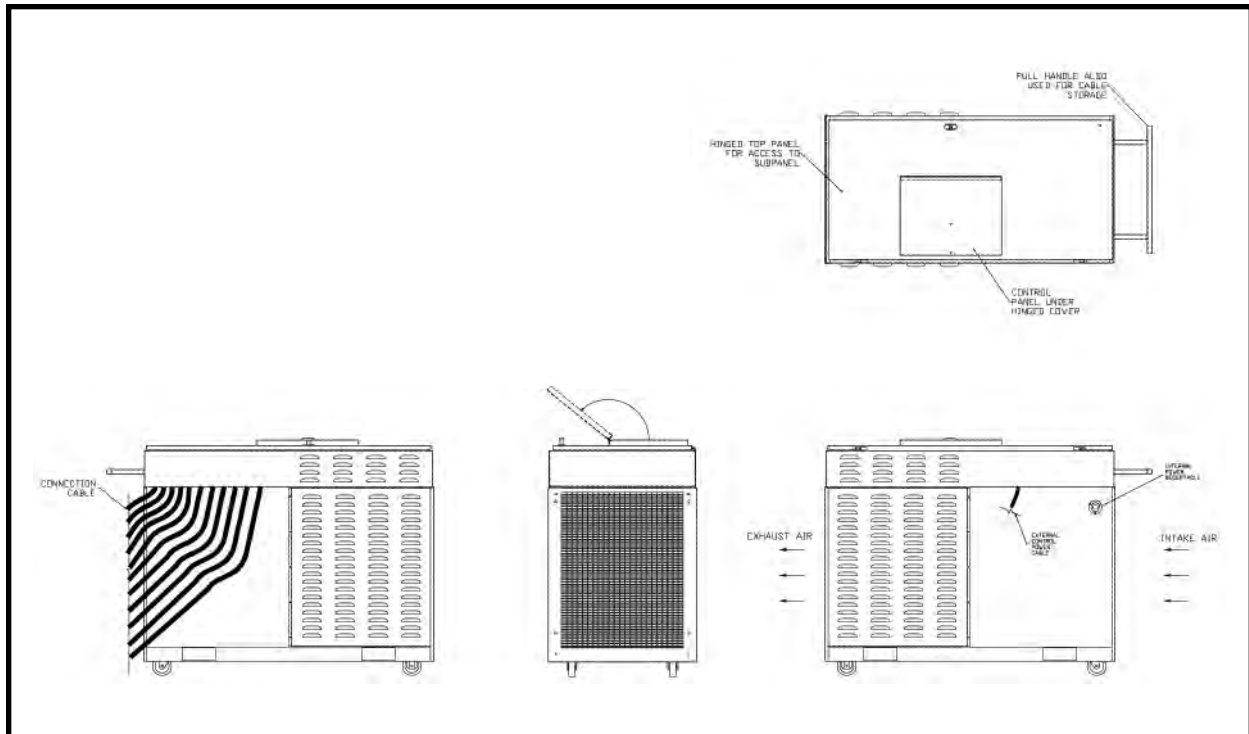
Model: Merlin-II King Load Bank

March 2011

The information herein is the property of Simplex, Inc. and/or its subsidiaries.  
Without written permission, any copying, transmitting to others, and other use  
except that for which it is loaned, is prohibited.  
(File: Merlin-II-Kc.indd)

## Contents

DESCRIPTION .....	2
PRIMARY INSPECTION .....	4
LOAD BANK LOCATION.....	4
OPERATION.....	5
Shutdown.....	6
COOLING FAILURE SUBSYSTEM .....	6
LOAD OVER VOLTAGE DETECTION SUBSYSTEM .....	7
CONTROL OVER VOLTAGE DETECTION SUBSYSTEM .....	7
LOAD ELEMENTS .....	8
MAINTENANCE .....	8
Each Operation .....	8
Every 50 Hours or 6 Months .....	8
TROUBLESHOOTING .....	8
Cooling Fan Motor Will Not Operate .....	8
Load Over Voltage Indicated .....	9
Control Over Voltage Indicated .....	9
Cooling Failure Indicated .....	9
Some Load Steps Cannot Be Energized.....	9
Test Meters Do Not Operate Properly .....	9
DRAWINGS AND PARTS LIST .....	9
APPENDIX A - ABBREVIATIONS USED IN THIS MANUAL.....	10
APPENDIX B - CALCULATIONS & FORMULAS .....	11
APPENDIX C - TORQUE VALUES.....	14



Part of Typical Pictorial Drawing (load cable shown, load cam-locks are optional)

## DESCRIPTION

Simplex Load Banks are precision test instruments 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. They also provide 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.

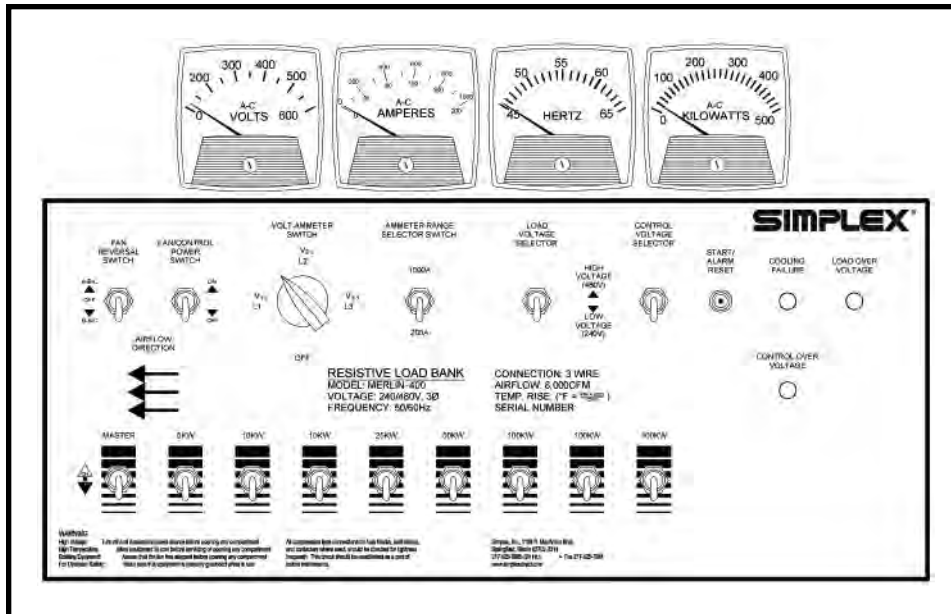
This fully self-contained Load Bank includes test instrumentation, cooling system, rugged load elements, load-application control devices and automatic system protection devices. Operating controls are located on a Local Control Panel.

## **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.**

*See the Load Bank Specifications Sheet in the front of this manual for the specifications of your Load Bank.*

*The illustrations in this manual are examples only and may differ from your Load Bank.*



Part of Typical Merlin 400 Local Control Detail Drawing


The Local Control Panel is comprised of the following components:

1. Voltmeter, Ammeter, and Frequency Meter optional KW meter
2. Control Power switch
3. Volt-Ammeter, Ammeter Range Selector, Load Voltage Selector, Control Voltage Selector switches
4. Start/Alarm Reset pushbutton
5. Cooling Failure, Load Over Voltage, and Control Over Voltage lamps
6. Master Load and load step switches
7. Fan Reversal switch


The resistive load elements in this Load Bank are cooled by a horizontal forced air system. The load system is connected to the test source via the load cables.

This Load Bank is equipped with the following automatic safety systems which de-energize all load steps when any condition is present which could damage the Load Bank or present a safety hazard to the operator:

1. The Cooling Failure Subsystem de-energizes any load applied when cooling of the load elements becomes inadequate due to fan failure, high intake air temperature, or high exhaust temperature.
2. The Load Power Over Voltage Failure System removes all load from the test source in the event the Load voltage selector switch is in the low voltage position (less than 240V), and a high test source voltage (greater than 480V) is applied.



## WARNING



**Never operate or service a Load Bank that is not properly connected to an earthground.**

## **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 Nine 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. Operate all hinged panels and doors for smooth and safe operation, try all latches and knobs.
4. Rotate and push all switches through all positions to ensure smooth operation.
5. Check cooling system by inspecting fan motor and blade. Slowly rotate blade by hand and note clearance of blade tip through its rotation near the housing. Observe free rotation of motor shaft.
6. 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.

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

7. Examine all accessible internal electrical components such as fuses, contactors and transformers. Check lugged wires at these components.
8. Inspect bottom of crate/enclosure for any components that may have jarred loose during shipment such as indicator light lenses, switch knobs, etc.
9. Visually inspect element chamber for foreign objects, broken ceramic insulators, mechanical damage.

## **LOAD BANK LOCATION**

The load elements in this Load Bank are cooled by a horizontal forced air system which discharges through the rear of the cabinet. Location of the Load Bank is of prime importance and should be done by trained personnel. It is one of the most critical factors involved in safe operation. The Load Bank must be positioned and installed according to large airflow requirements. Never point the exhaust at a nearby surface or object which may be adversely affected by high temperature. Never operate the Load Bank in a confined space without regard for adequate intake of air and provision for exit of high temperature exhaust. Consider that the Load Bank and a nearby generator set may have to compete for cooling air. Never bounce hot exhaust air off nearby objects and allow it to recirculate through the cooling system. Never operate the Load Bank in proximity to a sprinkler system.

## OPERATION

1. Confirm the test source is properly grounded and ground the Load Bank to its own independent ground.

2. Confirm the Control Power, Master Load and all load step switches are in the "Off" position.

3. See *Control Section Drawing*:

a. Using the cables provided, connect the load source to the Load Bank as shown.

b. If internal control power is desired, place the Fan/Control Power Plug into the Power Receptacle on the Load Bank.

**Warning: This receptacle is for Fan/Control Power Plug only. It is not current protected.**

c. If external control power is desired, place the Fan/Control Power Plug into an appropriate external receptacle.

4. Confirm the "Fan Reversal Switch" is in the appropriate position, if known. If unknown, leave the "Fan Reversal Switch" in the "Off" position.

5. Confirm the Fan Circuit Breaker, located on the component subpanel, is closed.

6. Confirm the "Volt-Ammeter Switch", the "Ammeter Range Selector Switch", and the "Load Voltage Selector Switch" are in the appropriate positions.

7. Start-up generator set or bring other test source on line.

*If external control power is used energize the cooling fan before starting the generator for proper fan operation.*

8. Adjust power source voltage and frequency.

9. Place the "Control Power Switch" in the "On" position.

If the Fan Reversal Switch is in the "Off" position, place it in the desired position.

**If the Load Bank airflow direction is reversed stop the fan motor immediately by placing the Fan Reversal switch in the "Off" position. After the motor has stopped completely, place the Fan Reversal switch in the correct position. Load Bank operation with the airflow direction reversed will damage the Load Bank.**

*A false "Cooling Failure" lamp indication will be present until the "Start/Alarm Reset" pushbutton is pressed and the cooling fan creates sufficient airflow to close the Fan Pressure Switch.*

10. Press the "Start/Alarm Reset" pushbutton.

11. Visually observe correct fan operation and investigate any unusual fan related noises.

12. Check air intake for obstructions and confirm positive air flow.

### **WARNING**

**If the Load Bank airflow direction is reversed stop the fan motor immediately by placing the Fan Reversal switch in the "Unit Off" position. After the motor has stopped completely place the Fan Reversal switch in the correct position. Load Bank operation with the airflow direction reversed will damage the Load Bank.**

13. Verify the “Cooling Failure” lamp is extinguished before proceeding.

*When the “Cooling Failure” lamp extinguishes, control power is supplied to the “Master Load” switch.*

14. Select the desired load steps by placing them in the “On” position.
15. Place the “Master Load” switch in the “On” position.

*This simultaneously applies all of the load steps which are in the “On” position.*

*Trim is achieved by flipping the load steps “On” and “Off” while the “Master Load” is in the “On” position.*

16. Adjust source voltage and load. Monitor as needed.

## **SHUTDOWN**

1. De-energize the load.
2. Run the cooling fan for 5 minutes to assure a thorough cool down of all load elements (optional).
3. Place the “Control Power” circuit breaker in the “Off” position.

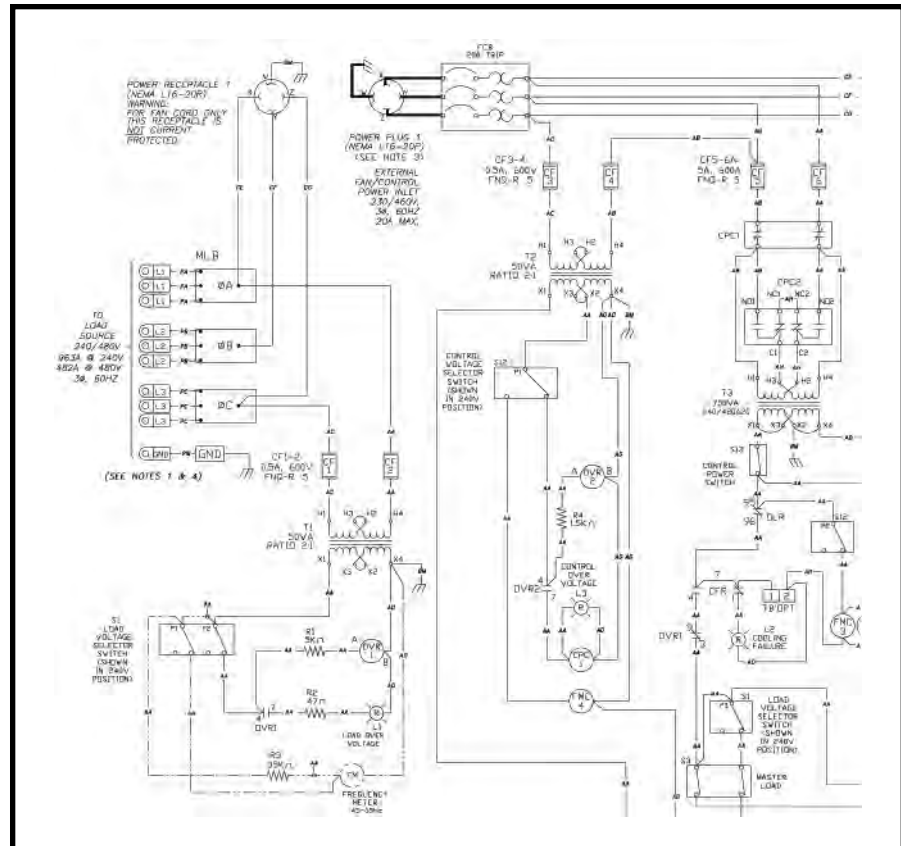
## **COOLING FAILURE SUBSYSTEM**

Excessive intake or exhaust temperatures or any reduction in cooling air flow for any reason is indicated by the illumination of the “Cooling Failure” lamp. All load steps are locked out until the problem is corrected and failure related relays are reset. The Cooling Failure Subsystem consists of the Start/Alarm Reset pushbutton, Intake Temperature Switch, the Fan Pressure Switch, the Exhaust Temperature Switch, and the Cooling Failure Relay. The Cooling Failure Relay must be energized to enable load application. When the cooling fan creates sufficient airflow the PS closes. The operator presses the Start/Alarm Reset pushbutton to complete the circuit to the Cooling Failure Relay. The Cooling Failure Relay energizes, closing contacts 8–5, opening contacts 7–1, and closing contacts 7–4. Closed Cooling Failure Relay contacts 8–5 lock in the circuit to the Cooling Failure Relay, open Cooling Failure Relay contacts 7–1 extinguishes the Cooling Failure lamp, and closed Cooling Failure Relay contacts 7–4 complete the circuit to the Master Load switch.

An exhaust temperature above 295° F or a substantial reduction in air flow pressure will result in the Load Bank entering a failure state. The “Cooling Failure” lamp is illuminated and the load is de-energized. Until the failure is investigated and the control system is reset the load cannot be reapplied.

## LOAD OVER VOLTAGE DETECTION SUBSYSTEM

The load over voltage detection network is activated only when a high voltage (greater than 380V) test source is applied and the “Load Voltage Selector” switch is incorrectly placed in the “Low Voltage” position. When the switch is in the “Low Voltage” position load bus voltage is supplied to Over Voltage Relay 1 via Transformer 1. When load voltage becomes great enough Over Voltage Relay 1 energizes. Over Voltage Relay 1 contacts 4–7 close and illuminate the “Over Voltage” lamp. Over Voltage Relay 1 contacts 9–3 open and interrupt the circuit to the master load switch. The load cannot be re-applied until the control power system is reset and the load voltage selector switch is placed in the high voltage position.



Part of Typical Merlin 400 Control Section Drawing

## CONTROL OVER VOLTAGE DETECTION SUBSYSTEM

The control over voltage detection network is activated only when a high voltage (greater than 380V) control source is applied and the “Control Voltage Selector” switch is incorrectly placed in the “240V” position. When the switch is in the “240V” position control voltage is supplied to Over Voltage Relay 2 via Transformer 2. When control voltage becomes great enough Over Voltage Relay 2 energizes. Over Voltage Relay 2 contacts 4–7 close and illuminate the “Control Over Voltage”

lamp and energize the Control Power Contactor. The Control Power Contactor opens interrupting the Load Bank control circuit. The load cannot be re-applied until the control power system is reset and the control voltage selector switch is placed in the “480V” position.

**⚠ WARNING ⚠**

**If a failure occurs the corresponding status indicator will be present and the load will be de-energized. Before reapplying a load, the failure must be corrected and the system must be reset by turning the Load Bank “Off” then “On”.**



## **LOAD ELEMENTS**

The Merlin Load Bank utilizes specially designed, "Powr-Web" resistive elements. The elements are rigidly supported by high-temperature, ceramic-clad, stainless-steel rods. Element-to-element short circuits are virtually eliminated. The load elements are protected by 200KAIC, 600VAC fuses.

## **MAINTENANCE**

The Load Bank has been designed to require minimum maintenance. All components have been chosen for a long, reliable life. Two basic intervals of maintenance are required: each operation and every 50 hours or 6 months (whichever comes first).

## **EACH OPERATION**

The air intake screens and louvers, fan and cooling chamber, and exhaust openings must be checked for any obstructions or foreign objects. Due to the high volume of air circulated, paper and other items can be drawn into the air intakes. During Load Bank operation insure that air is exiting from the exhaust vent.

The load branches should be checked for blown fuses or opened load resistors. To check the fuses or load resistors, operate the Load Bank from a balanced 3-phase source and check the three line currents. The three current readings should be essentially the same. If a sizeable difference is noted one or more load fuses or load resistors may have malfunctioned.

## **EVERY 50 HOURS OR 6 MONTHS**

Check the tightness of the electrical connections. The expansion and contraction caused by Load Bank operation may result in loose connections. The vibrations caused by the cooling fan may also loosen electrical connections. If the Load Bank is transported "over the road", the electrical connections should be checked for tightness at a shorter-than-normal time interval. See "Primary Inspection".

## **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.

## **COOLING FAN MOTOR WILL NOT OPERATE**

1. Inoperative Fan Circuit Breaker (FCB)
2. Inoperative Unit / Off Fan Reversal switch
3. Fan/Control Power not available/incorrect
4. Inoperative Fan Motor (MOT)



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

## LOAD OVER VOLTAGE INDICATED

1. Load Voltage Selector switch incorrectly positioned

## CONTROL OVER VOLTAGE INDICATED

1. Control Voltage Selector switch incorrectly positioned

## COOLING FAILURE INDICATED

1. Restriction of air (intake or exhaust)
2. Fan pressure switch inoperative
3. Overtemperature sensor failure
4. Alarm Reset pushbutton not engaged
5. Excessive intake temperature
6. Relay failure

## SOME LOAD STEPS CANNOT BE ENERGIZED

1. Inoperative load step switches
2. Inoperative load step contactors

## TEST METERS DO NOT OPERATE PROPERLY

1. Meter voltage switch failure
2. Meter multiplier resistor inoperative
3. Improper positioning of meter voltage selector switch
4. Current transformer or current transformer wiring failure
5. Test meter failure

## 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 Legend on the right hand side of the applicable drawing. When contacting the Simplex Service Department always have your work order and drawing number ready for reference. The Load Bank Specifications Sheet in the front of this manual lists all of the drawings included in this manual. The Work Order Number and the Drawing Numbers are also located on each drawing legend. *A typical drawing legend and parts list is illustrated below.*

<b>SIMPLEX™</b>		SPRINGFIELD, ILLINOIS
SCALE :	APPROVED BY :	DRAWN BY : RER
DATE : 01/12/11		REVISED : 0
RESISTIVE LOAD BANK		MERLIN 400
400KW,240/480V,3 $\phi$ ,60Hz		CONTROL SECTION
STANDARD		DRAWING NUMBER 218202

ITEM	QTY	PART#	DESIG	DESCRIPTION
1	6	24299170	LR1-LR6	LOAD RESISTORS 833W @ 240V HELICAL COIL (STD LOAD RESOLUTION)
2	12	24299260	LR7-LR18	LOAD RESISTORS 1667W @ 240V POWER WEB (STD LOAD RESOLUTION)
3	6	24299510	LR19-LR24	LOAD RESISTORS 4167W @ 240V POWER WEB
4	84	24299515	LR25-LR108	LOAD RESISTORS 4167W @ 120V POWER-WEB
5	13	13011040	C1A-C4A C1B-C4B FMC1-5	CONTACTOR, 3-POLE 40A-RESISTIVE, 600VAC 120VAC, 50/60Hz, 5VA COIL
6	14	13011065	C5A-C11A C5B-C11B	CONTACTOR, 3-POLE 65A-RESISTIVE, 600VAC 120VAC, 50/60Hz, 14VA COIL

## **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.

<b>AC</b> -Alternating current	<b>GFB</b> -Ground fault breaker	<b>OVR</b> -Overvoltage relay-relay used in overvoltage failure system, located on relay sub-panel
<b>AIC</b> -Ampere interrupting current-maximum short circuit fault current a component can safely interrupt	<b>GBTR</b> -Ground breaker tripped relay	<b>OLR</b> -Overload relay-used for motor protection
<b>AM</b> -Ammeter	<b>HMI</b> -Operator Interface	<b>OTR</b> -Overtemperature relay-used in failure system
<b>AMSW</b> - Ammeter selector switch-selects any phase for current reading	<b>HVR</b> -High voltage relay	<b>PF</b> -Power factor-in resistive only loads expressed as unity (1.0), in inductive loads expressed as lagging, in capacitive loads expressed as leading
<b>CF</b> -Control fuse	<b>Hz</b> -Hertz-cycles per second, measurement of frequency	<b>PAR</b> -Control power available relay-relay energized when control power is available
<b>CFM</b> -Cubic feet per minute-used to rate fan air flow capacity and load bank cooling requirement	<b>IFCV</b> -Incorrect fan/control voltage	<b>PFM</b> -Power factor meter
<b>CFR</b> -Cooling failure relay-normally energized relay in cooling failure subsystem	<b>INTS</b> -Intake air temperature switch	<b>PS</b> -Pressure switch-switch used to detect fan failure
<b>CPC</b> -Control power contactor	<b>K</b> -Relay coil/contact designation	<b>RR</b> -Reset relay
<b>CPF</b> -Control power fuse	<b>KVA</b> -Kilovolt amperes	<b>RTM</b> -Running time meter-keeps time log of equipment use.
<b>CT</b> -Current transformer- used in metering circuits	<b>KVAR</b> -Kilovolt amperes-reactive	<b>TB</b> -Terminal block
<b>DC</b> -Direct current	<b>KW</b> -Kilowatts	<b>TDR</b> -Time delay relay-relay which times out before contacts change state
<b>EXTS</b> -Exhaust air temperature switch	<b>KWM</b> -Kilowatt meter	<b>TEFC</b> -Totally enclosed, fan cooled-refers to motor enclosure
<b>FCB</b> -Fan circuit breaker-circuit breaker in series with fan control power	<b>KWT</b> -Kilowatt meter transducer	<b>TEAO</b> -Totally enclosed, air-over-refers to motor enclosure
<b>FCVR</b> -Fan control voltage relay-normally energized relay on relay sub-panel	<b>LM</b> -Louver motor	<b>UPS</b> -Uninterruptable power source
<b>FM</b> -Frequency meter-monitors frequency of test source	<b>LMC</b> -Louver motor contactor	<b>V</b> -Voltage
<b>FMC</b> -Fan motor contactor-controls power to fan motor	<b>LR</b> -Load resistive element	<b>VSR</b> -Voltage sensing relay
<b>FMSW</b> -Frequency meter switch	<b>LX</b> -Load reactive element	<b>XCB</b> -Reactive load controlling circuit breaker
<b>FPS</b> -Fan power switch-used to energize cooling system	<b>L1</b> -Line 1	
	<b>L2</b> -Line 2	
	<b>L3</b> -Line 3	
	<b>MCB</b> -Main circuit breaker	
	<b>MDS</b> -Main Disconnect Switch	
	<b>MF</b> -Meter fuse	
	<b>MLB</b> -Main Load Bus	
	<b>MOT</b> -Motor	
	<b>NEMA</b> -National electrical manufacturer's association	
	<b>ODP</b> -Open, drip-proof-refers to motor enclosure	

## 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 <sub>1</sub> = 249A	V <sub>1-2</sub> = 481V
A <sub>2</sub> = 250A	V <sub>2-3</sub> = 479V
A <sub>3</sub> = 254A	V <sub>3-1</sub> = 483V

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

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

$$\begin{aligned} \text{Kilowatts} &= \frac{\text{Volts} \times \text{Amps} \times 1.732}{1000} \\ &= \frac{481 \times 251 \times 1.732}{1000} \\ &= 209.1\text{KW} \end{aligned}$$

### Single Phase

Current Reading: 150A      Voltage Reading: 240V

$$\begin{aligned} \text{Kilowatts} &= \frac{\text{Volts} \times \text{Amps}}{1000} \\ &= \frac{150 \times 240}{1000} \\ &= 36.1\text{KW} \end{aligned}$$

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

$$\begin{aligned}
 \text{Amperage} &= \frac{\text{KW} \times 1000}{\text{Volts} \times 1.732} \\
 &= \frac{50 \times 1000}{480 \times 1.732} \\
 &= \frac{50,000}{831.36} \\
 &= 60.1
 \end{aligned}$$

### Single Phase

Applied: 25KW      Operating Voltage: 240V

$$\begin{aligned}
 \text{Amperage} &= \frac{\text{KW} \times 1000}{\text{Volts}} \\
 &= \frac{25 \times 1000}{240} \\
 &= \frac{25,000}{240} \\
 &= 104.2
 \end{aligned}$$

**Determining step KW at other than rated voltage:**

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

$$\begin{aligned}
 \text{Step KW} &= (\text{Oper. Volt.} \div \text{Rated Volt.})^2 \times \text{Applied KW} \\
 &= (450 \div 480)^2 \times 80 \\
 &= .9375^2 \times 80 \\
 &= 70.3
 \end{aligned}$$

**FORMULAS**

		<b><u>Alternating Current</u></b>	<b><u>Direct Current</u></b>
<b>Kilowatts</b>	1 phase	$\frac{\text{Volts} \times \text{Amps} \times \text{PF}^*}{1000}$	$\frac{\text{Volts} \times \text{Amps}}{1000}$
	3 phase	$\frac{1.732 \times \text{Volts} \times \text{Amps} \times \text{PF}^*}{1000}$	
*Power Factor, expressed as decimal. (Resistive Load Bank PF is 1.0)			
<b>Amperes</b> (KW known)	1 phase	$\frac{\text{KW} \times 1000}{\text{Volts} \times \text{PF}}$	$\frac{\text{KW} \times 1000}{\text{Volts}}$
	3 phase	$\frac{\text{KW} \times 1000}{1.732 \times \text{Volts} \times \text{PF}}$	
<b>KVA</b>	1 phase	$\frac{\text{Volts} \times \text{Amps}}{1000}$	
	3 phase	$\frac{1.732 \times \text{Volts} \times \text{Amps}}{1000}$	
<b>Amperes</b> (KVA known)	1 phase	$\frac{\text{KVA} \times 1000}{\text{Volts}}$	
	3 phase	$\frac{\text{KVA} \times 1000}{1.732 \times \text{Volts}}$	
<b>KVAR</b>	1 phase	$\frac{\text{Volts} \times \text{Amps} \times \sqrt{1-\text{PF}^2}}{1000}$	
	3 phase	$\frac{1.732 \times \text{Volts} \times \text{Amps} \times \sqrt{1-\text{PF}^2}}{1000}$	

## 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**

<b>FUSEBLOCKS</b>		
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

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

<b>TAPER-LOCK BUSHINGS</b>	
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

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