LOAD BANK
TECHNICAL MANUAL
(LBD Series)

Customer: XXXXXX

Work Order: XXXXX-XX-XX

Model: LBD XXX

April 2011

Contents

Simplex, Inc., 5300 Rising Moon Road, Springfield, IL 62711-6228 • 217-483-1600 • Fax 217-483-1616

DESCRIPTION

Simplex LBD Series Load Banks are a special form of stationary, resistive, forced air-cooled Load Bank which utilizes the air outflow of an engine radiator for cooling of the load elements. They are specifically designed to apply discrete, selectable 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.

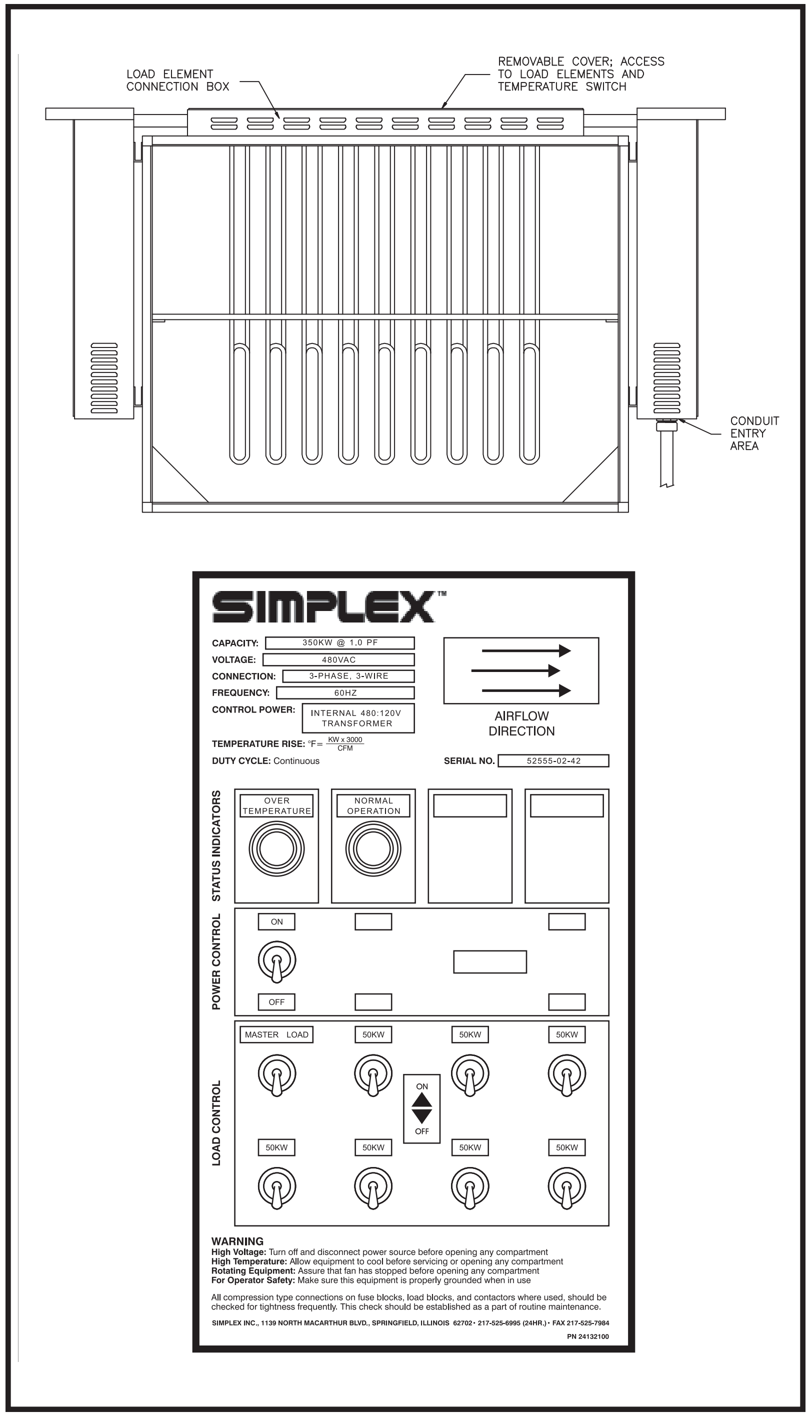
Simplex LBD Series Load Banks are intended for use with water cooled engine generator sets equipped with unit mounted radiators. These Load Banks are built per customer specifications and can be installed in numerous ways, including direct bolted attachment to the radiator, mounting within an air duct, wall mounting over the air outflow opening, indoors or outdoors.

Power source testing is accomplished by applying resistive load steps at unity (1.0) power factor. *See the Load Bank Specifications Sheet in the front of this manual for the rating of your Load Bank.*

Load application is by magnetic contactor. All load branch circuits are protected by 200,000AIC class-T fuses.

The Control Panel contains the following controls and indicator lamps:

1. Over Temperature and Normal Operation lamps,
2. Control Power switch and/or pushbutton and



Part of Typical Pictorial Drawing

3. Master Load and load step switches.

This Load Bank is protected against cooling failures (high exhaust air temperature which could damage the Load Bank or present a safety hazard to the operator). The "Normal Operation" lamp illuminates when Control Power is available and the Cooling System is operating properly. When a cooling failure occurs the automatic safety features in the Control System immediately remove the load from the test source and illuminates the "Over Temperature" lamp. The malfunction must be corrected and the Load Bank must be reset by turning the Load Bank "Off" then "On" before the load can be re-applied.

The Load Bank consists of two principal systems:

1. Control System
2. Load System

CONTROL SYSTEM

The Control System allows the operator to apply a desired load to the test source and measure the response of the test source to the load. This system also contains the circuitry utilized to disconnect the Load Bank from the test source in the event of cooling failures and/or improperly positioned operating controls. The Control System consists of switches and lamps located on the Control Panel and logic circuitry located in the Control Section.

Control power (120V) is supplied to the Load Bank by one of the following methods:

1. test source via a control power transformer,
2. test source line to neutral, or
3. external source.

LOAD SYSTEM

Simplex LBD Series Load Banks are built up in fused branch circuits of not more than 70A each and protected by 600V, 200,000AIC class-T fuses. All wiring and devices within the branch circuit are rated in accordance with the fuse rating. Branch circuit fusing of the elements virtually eliminates the danger of short circuit of the load elements and consequent catastrophic damage to the Load Bank.

These Load Banks utilize either the Simplex Pow'r Rod or the Simplex Pow'r Web load elements. See Parts Legend Drawing for specific elements used.

Pow'r Rod Load Elements

Simlpex Pow'r Rod Load Elements are UL recognized. These elements are totally enclosed, sealed and weatherproof. Pow'r Rod elements consist of nickel-chromium resistance wire electrically insulated and sealed within a metallic sheath. The hazard of electric shock to personnel and the danger of short circuit by foreign object penetration are reduced since the elements are electrically dead on the outside. They will not fatigue from engine or air-blast vibrations and will not sag or stretch if overheated. The sheath material is "incolloy", a rustproof nickel alloy with a very high temperature rating (1600°F). These elements do not require a cool down period.

References to Automatic Operation in this manual should be ignored if the Load Bank you are using is equipped with Manual Load Step Application only.

Powr-Web Load Elements

Simplex "Powr-Web" load elements are UL recognized. These elements conservatively operate at approximately half the maximum temperature rating of the alloy (1080°F vs. 1920°F). For example:

Alloy: FeCrAl

Ratings: 3333W@120V
4170W@139V

Connections: 120V wye (208V),
139V wye (240V, 3ø),
277V wye (480V, 3ø),
240 delta (240V, 3ø), or
480 delta (480V, 3ø).

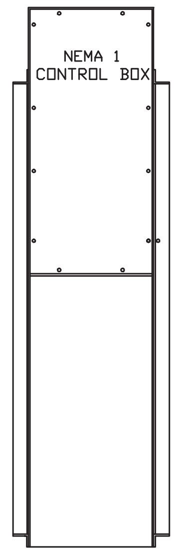
These elements are rigidly supported by high-temperature, ceramic-clad, stainless-steel supports. Element-to-element short circuits are virtually eliminated.

PRIMARY INSPECTION

Preventative visual inspection of the shipping crate and Load Bank must be performed before installation. Physical or electrical problems due to handling and vibration may occur during shipment.

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 the bottom of crate/enclosure for any components that may have jarred loose during shipment such as indicator light lenses, switch knobs, etc.
5. Visually inspect element chamber for foreign objects and mechanical damage.

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



Part of Typical Pictorial Drawing

INSTALLATION

1. Using the flanges provided attach the Load Bank with bolts per specifications. Bottom support for the load element enclosure is recommended.
2. Confirm the test source is properly grounded and ground the Load Bank to its own independent ground.
3. Confirm all load command switches are in the "Off" position.
4. Per load connection drawings cable the load source to the Load Bank. Consult NEC for proper wire size.

   When cabling the Load Bank to the test source pull Load Bank access holes, install conduit connectors and conduits as needed.

5. Connect customer supplied contacts to load dump terminals shown on electrical drawing or jumper if not used.
6. Per drawings connect customer supplied alarm contacts.

References to Remote Control in this manual should be ignored if the Load Bank you are using is equipped with a Local Control Panel only.

⚠ **WARNING** ⚠

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

OPERATION

1. Start-up generator or bring other test source on line.
2. Adjust power source voltage and frequency.
3. Place the "Control Power" switch in the "On" position or press the "On" pushbutton.
4. Verify the illumination of the "Normal Operation" lamp before proceeding.

MANUAL

5. Select the desired load steps by placing them in the "On" position.

   LBD Load Banks equipped with only Manual Control have two-position load step switches: "On" and "Off".

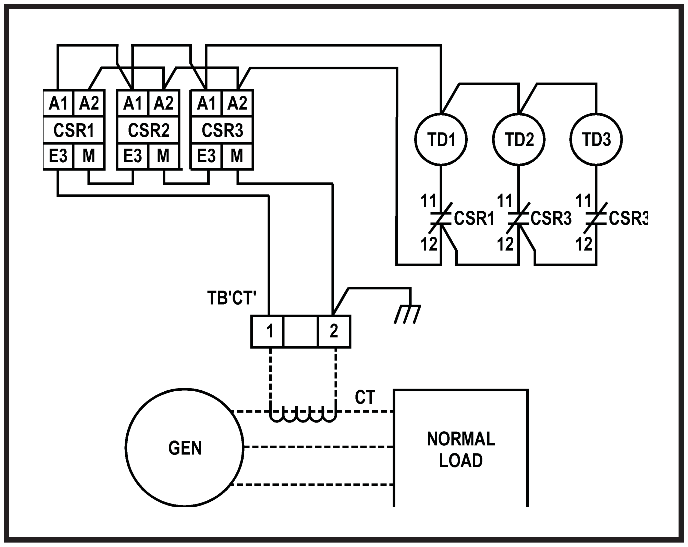
   LBD Load Banks equipped with Manual and Automatic Control have three-position load step switches: "Auto", "Off" and "Manual" – or – a Mode Selector switch with the following positions: "Auto", "Off", and "Manual"; and load step switches with "On" and "Off" positions.

6. Place the "Master Load" switch, if equipped, 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.

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



AUTOMATIC

Place all of the load step switches in the "Auto" position, or the Mode Selector Switch in the "Auto" position. In Automatic Mode, the Current Sensing Relays and Time Delay Relays (CSRs and TDRs), or a Programmable Logic Controller (PLC) in conjunction with (2) CSRs, automatically apply load as needed. These devices are factory set to maintain a minimum net load on the generator equal to approximately 60% of the generator's full load capability. Time delays between applying load steps are adjustable; see the specific prints supplied for your Load Bank.

CSR and TDR Example

60kW Load Bank with (3) 20kW Load Steps Serving a 100kW Generator:

While normal load (building load) is approximately 50kW or greater, the Load Bank will remain off-line, and add no load onto the generator.

When normal load drops below 50kW, the Load Bank will apply load step #1 (20kW) to the generator following a time delay determined by the setting of TDR1.

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When normal load drops below 30kW, the Load Bank will apply load step #2 (20kW) to the generator following a time delay, bringing a total of 40kW of Load Bank load being applied to the generator.

Finally, as normal load drops below 10kW, the last step (20kW) is applied to the generator in the same manner as before, bringing total generator load to a minimum of 60kW.

Upon an increase in normal load, the reverse procedure is followed. The points at which the Load Bank steps drop out will be slightly higher than the pick-up points due to the built in hysteresis of the CSR relay. When calculating the operational points for a Load Bank with Automatic operation, Simplex assumes the normal load of the building will cause the generator to be operating at a 0.8 power factor, and adjusts the CSR pick-up points accordingly.

PLC and CSR Example

60kW Load Bank with 5kW Step Resolution Serving a 100kW Generator:

In this example, the (2) CSRs will be set so that CSR1 drops out (opens it's contacts) when *total* (including the Load Bank load) generator load increases above 50kW. CSR2 will be set to pick up (close it's contacts) when *total* generator load increases above 70kW. This establishes a "window" between 50kW and 70kW, inside of which the PLC takes no action to change Load Bank Load.

When total generator load is below 50kW, the PLC receives a signal from CSR1 to increase Load Bank load. The Load Bank will increase load in 5kW step increments, following time delays set according to Load Bank Control prints, until total load is greater than 50kW. Note that if there is no normal load on the generator, the entire 60kW of Load Bank load may be applied due to the setpoints being calculated for a 0.8 power factor.

When total generator load is above 70kW, the PLC receives a signal from CSR2 to decrease Load Bank load. In the same fashion as above, the Load Bank will remove it's load until total generator load is below 70kW, or all Load Bank load is removed.

Adjusting the CSR and TDR

On the top of each Current Sensing Relay (CSR) dust cover there is a black adjustment knob (3/4 turn potentiometer) with an arbitrary 0.5-1.0 scale. Turn the knob clockwise for a higher current pick-up point and counterclockwise for a lower current pick-up point.

On the top of each Time Delay Relay (TDR) there is an adjustment knob (one turn potentiometer). These relays are adjustable from .1 to 30 seconds. Follow the directions on the white stickers for each potentiometer to adjust the set points.

⚠ WARNING ⚠

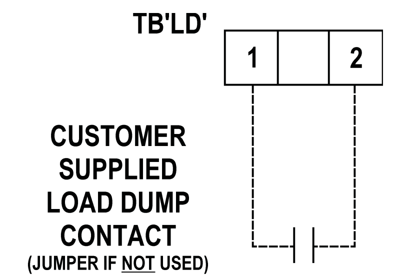
Do Not allow the Load Bank to operate unattended for extended periods.

⚠ WARNING ⚠

If an automatic test is interrupted by a Load Bank failure, do not reset the Load Bank until the source of the failure has been determined.

LOAD DUMP

Most Load Banks contain 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. 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 push-button or circuit breaker for this use. If Load Dump is not desired, the installer must jumper the contacts.



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".

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.

WARNING

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

COOLING FAILURE SUBSYSTEM

Excessive exhaust temperature is indicated by the illumination of the "Over Temperature" 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 the Exhaust Temperature Switch (EXTS) and the Over Temperature Relay (OTR). An exhaust temperature above 295° F will close the EXTS and energize the OTR. OTR contacts 7–4 will close and 7–1 will open. Closed OTR contacts 7–4 will illuminate the "Over Temperature" lamp. Open OTR contacts 7–1 will interrupt the power path to the "Normal Operation" lamp and the Master Load switch. The failure must be corrected and the system must be reset by turning the Load Bank "Off" then "On" before load can be reapplied.

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 openings, cooling chamber, and exhaust screens and louvers must be checked for any obstructions or foreign objects. Due to the high volume of air circulated, paper and other items

⚠ WARNING ⚠

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

can be drawn into the air intakes. During Load Bank operation insure that air is exiting from the exhaust side.

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 generator set 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 Load Bank systems always remove all test source power, control power, anti-condensation heater power, etc.

COOLING FAILURE INDICATED

1. Over temperature sensor failure
2. Loss of genset exhaust
3. Air restriction (intake or exhaust)

TEST METERS DO NOT OPERATE PROPERLY

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

SOME LOAD STEPS CANNOT BE ENERGIZED

1. Inoperative load step switches
2. Open load step resistor(s)
3. Inoperative load step relays
4. Inoperative load step contactors
5. Open load step fuses

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 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 Number are located on each drawing. *A typical drawing legend and parts list is illustrated at right.*

SIMPLEX™ SPRINGFIELD, ILLINOIS

SCALE :	APPROVED BY :	DRAWN BY : amn
DATE : 5/6/11		REVISED :

RESISTIVE LOAD BANK
50KW,480V,3Ø,60HZ

LBD-50
CONTROL SECTION

W.O. # 76149-11-42

DRAWING NUMBER 223723

ITEM	QTY	PART #	DESIG.	DESCRIPTION
1	18	24309540	LR1-18	LOAD ELEMENTS, 3333W@277V OPERATING AT 3333W @ 277V 22", INCOLLOY SHEATH
2	2	13017100	C1,2	CONTACTOR 50A, 600V, 3POLE 120VAC COIL
3	2	13906000	CF1,2	FUSE, TIME DELAY 0.5A, 600V, 200KAIC
4	6	14075000	F1-6	FUSE, FAST ACTING 40A, 600V, 200KAIC
5	1	15011500	[CF1,2]	FUSEBLOCK 30A, 600V, 2 POLE
6	2	15015500	[F1-6]	FUSEBLOCK 60A, 600V, 3 POLE
7	1	25649500	MLB	MAIN LOAD BLOCK, 175A 600V, 3-POLE, LINE CONS: 2/0-#14AWG, 1 CONN./Ø
8	1	25665000	TB'CT'	TERMINAL BLOCK 30A, 600V, 4 LINE
9	1	25671000	TB'A'	TERMINAL BLOCK 30A, 600V, 15 LINE
10	1	25450000 UL	T1	TRANSFORMER, 150VA 480/240V: 240/120V MACHINE TOOL CLASS
11	2	24771000	CPR OTR	GENERAL PURPOSE RELAY 10A, 240VAC, 3PDT 120VAC COIL
12	2	24891000	[CPR OTR]	RELAY BASE 11 PIN SCREW TRM
13	2	25301000	S1,2	SWITCH DPDT, TOGGLE 6A @ 125VAC
14	2	25305100	S3,4	SWITCH 3PDT, CENTER-OFF, TOGGLE 15A @ 125VAC
15	1	25309790	EXTS	EXHAUST TEMP SWITCH NO, CLOSE @ TEMP >295°F
16	2	24261500	L1-2	LIGHT-BASE 125V, NEON, FOR B2A BULB

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 sub-system

CPC - Pilot contactor-Contactor that must be energized before load is applied.

CPF - Control power fuse

CT - Current transformer-Transformer used in metering circuits

DC - Direct current

DHF - De-humidity control fuse

DHR - De-humidity control relay

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

GPM - Gallons per Minute

HCF - Humidity Control Fuse

HCR - Humidity Control Relay

HMD - Humidistat

HTR - Heater Strips

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

LBA - Load Bank Available Relay

LFR - Loss of Flow Relay

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

MF - Meter fuse

MLB - Main line bus

MOT - Motor

NEMA - National Electrical Manufacturer's Association

NSR - Normal Source Relay

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

OPR - Over Pressure Relay

OTR - Over Temperature Relay-Used in overtemperature 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

PLC - Programmable Logic Controller

PT - Potential Transformer

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

PFM - Power factor meter

PS - Pressure switch-Normally closed switch used to detect fan failure

PSI - Pounds per square inch

PSR - Pump Start Relay

RML - Remote Master Load Relay

RR - Run relay

RS - Remote Load Step Relay

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

TB - Terminal block

TD-0 - Time Delay Timer-Delay on operate

TD-R - Time Delay Timer-Delay on release

TDR-0 - Time Delay Relay-Delay on operate

TDR-R - Time Delay Relay-Delay on release

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

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

UPS - Uninterruptable power source

V - Voltage

VO - Valve Operator

VOR - Valve Operator Relay

VSR - Voltage sensing relay

WFS - Water Flow Switch

WPS - Water Pressure Switch

WTS - Water Temperature Switch

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

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

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

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

Single Phase

Current Reading: 150A   Voltage Reading: 240V

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

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

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

Single Phase

Applied: 25KW Operating Voltage: 240V

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

Determining step KW at other than rated voltage:

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

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

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

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

$$= 70.3$$

FORMULAS

		Alternating Current	Direct Current
Kilowatts	1 phase	$\frac{\text{Volts} \times \text{Amps} \times \text{PF*}}{1000}$	$\frac{\text{Volts} \times \text{Amps}}{1000}$
	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)

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

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