LOAD CUBE LOAD BANK SYSTEM TECHNICAL MANUAL

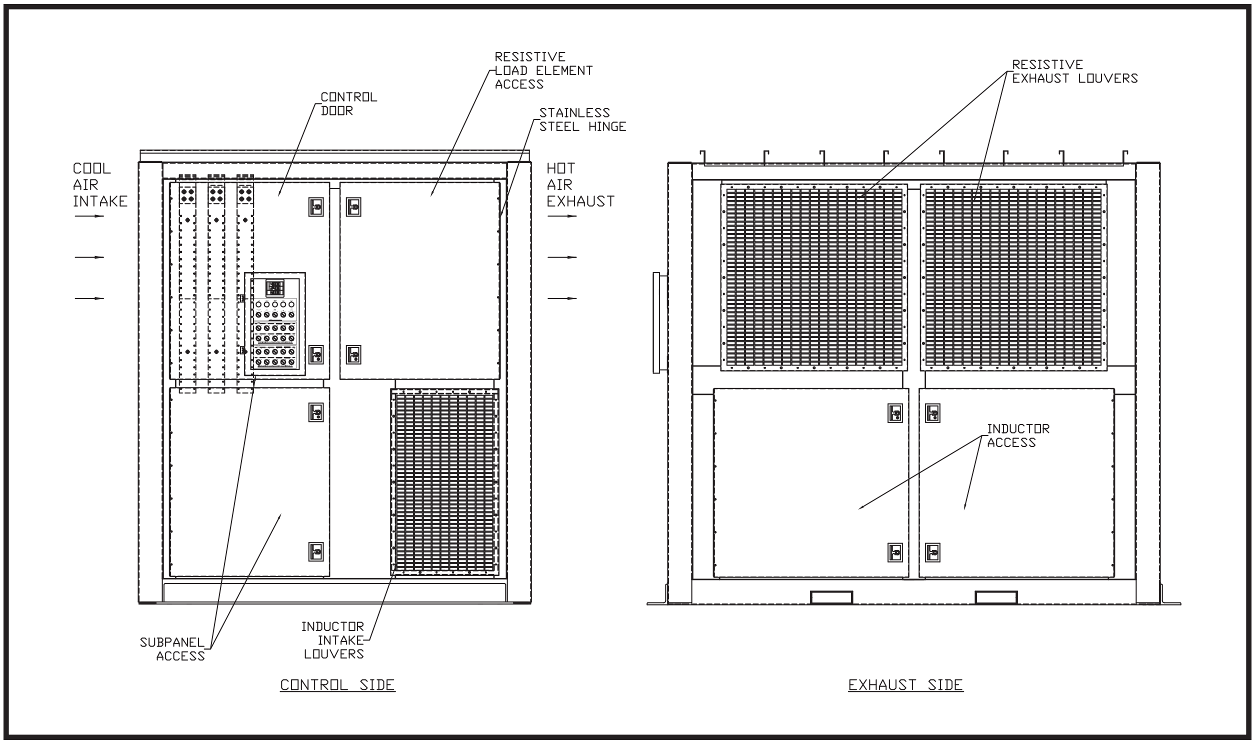
Customer: XXXXX

Work Order: XXXXX-XX-XX

Model: Load Cube Load Bank System

June 2011

Contents



Part of Typical Pictorial Drawing

DESCRIPTION

Simplex Load Cubes are precision test instruments 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 Cubes eliminate the detrimental effects of unloaded operation of diesel engine generators.

The cabinet on this Load Cube is rated Type 3R outdoor weatherproof.

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

Power source testing is accomplished by applying resistive and inductive load steps at unity (0.8) power factor.

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

Operating controls are provided locally via a control panel and remotely via touchscreen housed in a high impact plastic suitcase. The control system is composed of 120V discrete components. Louver motors are powered

⚠ WARNING ⚠

This manual represents a generic configuration. Each Load Cube Load Bank System is engineered per customer specifications therefore each Load Cube is provided with a unique operator's manual.

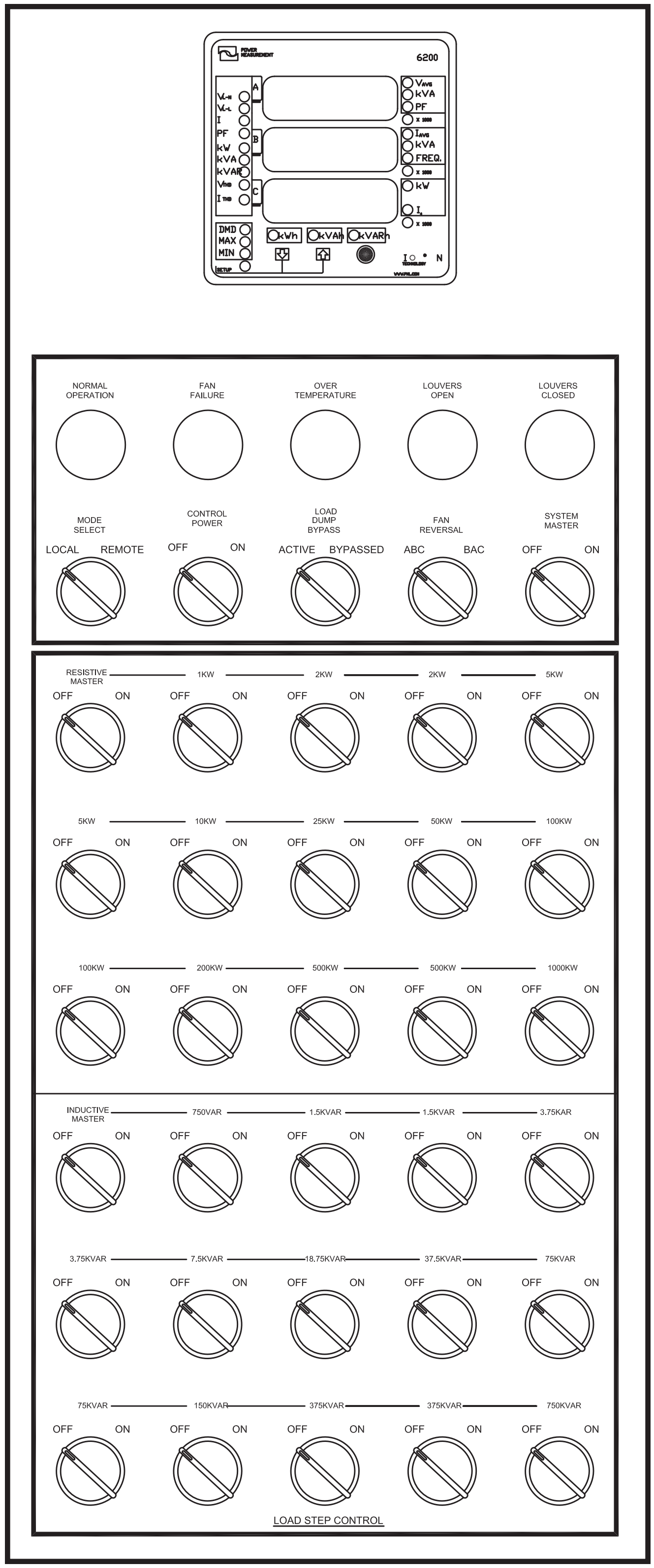
via a 24VDC power supply located in the Load Cube. Common serviceable components include Control Fuses (CF Series), Load Application Fuses (F Series and XF Series), and Metering Fuses (MF Series). Lamps on the local control panel indicate the Load Cube operating status.

The Local Control Panel contains the following components:

1. Digital Meter
2. Normal Operation, Fan Failure, Over Temperature, Louvers Open and Louvers Closed indicator lamps
3. Mode Selector switch
4. Control Power switch
5. Load Dump Bypass switch
6. Fan Reversal switch
7. System Master Load switch
8. Resistive Master Load and load step switches
9. Inductive Master Load and load step switches

The “Normal Operation” lamp illuminates when Control Power is available and the Cooling System is operating properly.

This Load Cube is protected against cooling failures (loss of cooling air flow, high intake or exhaust air temperature which could damage the Load Cube or present a safety hazard to the operator). When a cooling failure occurs the automatic safety features in the Control System immediately remove the load from the load source. The malfunction must be corrected and the system must be reset by turning the Load Cube “Off” then “On” before the load can be re-applied.



The Load Cube consists of three principal systems:

1. Control System
2. Cooling System
3. 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 Cube from the test source in the event of cooling failures and/or improperly positioned operating controls.

Control Power (120V) is supplied internally via the load source and the Control Power Transformer (T1) or externally via an appropriate source. Control power is applied to the coil of the Fan Motor Contactor (FMC1 and FMC3 or FMC2 and FMC4) when Fan Control Relay (FCR) contacts 7–4 close. When the operator places the Fan/Control Power switch (S1) in the "On" position the Fan Control Relay (FCR) energizes. The FCR contacts 7–4 close and energize the Fan Motor Contactors (FMC1 and FMC3 or FMC2 and FMC4). The FMC contacts close and complete the power path to the Fan Motors (MOT-A and MOT-B)

COOLING SYSTEM

The load elements in this Load Cube are cooled by a forced air system consisting of two (2) fan blades belt driven by a TEFC motor. The fan motor is energized by a Fan Motor Contactor (FMC) and protected by a Fan Circuit Breaker (FCB).

LOAD SYSTEM

The Load System consists of independently controlled resistive and/or reactive load elements specifically designed for Load Cube systems. They are protected by 200,000AIC, 600VAC fuses.

Simplex Resistive Load 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).

See Parts Legend Drawing for specific elements used.

These elements are rigidly supported by high-temperature, ceramic-clad, stainless-steel supports. Element-to-element short circuits are virtually eliminated. The elements are assembled in discrete trays which are assembled in a vertical "stack". Each tray is independently serviceable without disturbing adjacent trays.

Reactive Load Elements are iron-core, non-saturable, air gap calibrated and air cooled. Standard elements have a temperature sensor embedded in the windings to detect element overheating and are varnish coated. Epoxy coatings are available for severe environments.

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

PRIMARY INSPECTION

Preventative visual inspections of the shipping crate and Load Cube is advised. Physical or electrical problems due to handling and vibration may occur. Never apply power to a Load Cube 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 the Load Cube is relocated:

1. If crate shows any signs of damage examine the Load Cube 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. Inspect 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. Check fan blades for stress fractures. 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.

INSTALLATION

LOCATION

This Load Cube is installed on a tandem axle flatbed trailer. The load elements in this Load Cube are cooled by a forced air system which discharges through the side of the cabinet. This Load Cube will produce a large quantity of exhaust air. Location of the Load Cube 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 Cube must be positioned and installed according to large airflow requirements.

- There must be a minimum clearance of 25 feet on the discharge side and 6 feet on all other sides of the Load Cube.
- Never position the Load Cube so that any structure or object at any height is above the Load Cube.

- Always locate the Load Cube in a secure area accessible by trained personal only.
- Use forklift channels provided to lift and position the Load Cube.
- Never point the exhaust at a nearby surface or object which may be adversely affected by high temperature.
- Never operate the Load Cube in a confined space without regard for adequate intake of air and provision for exit of high temperature exhaust.
- Consider that the Load Cube 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 Cube in proximity to a sprinkler system.

Failure to properly install this Load Cube may result in substantial damage to or the destruction of the Load Cube, and adjacent equipment.

⚠ WARNING ⚠

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

⚠ 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.

SETUP

Consult NEC for proper wire size for all connections unless stated within this manual or on a drawing.

1. Confirm the test source is properly grounded and ground the Load Cube to its own independent ground.
2. Confirm the Internal/External Circuit Breakers (FCB1 and FCB2) are in the "Off" position.
3. If External Fan/Control Power is desired connect the External Fan/Control Power Inlet to a 480V, 3ø, 60Hz, 30A maximum source.
4. If remote control is desired connect Receptacle 1 on the Load Bank to Receptacle 2 on the Remote Suitcase using the remote cable.
5. Confirm all switches on the Local Control Panel are in the "Off" position.
6. Cable the load source to the Load Cube as shown.
7. Connect customer supplied Load Dump contacts to as shown.

   Load is disengaged when contact is open.
8. Place the appropriate Fan/Control Power Circuit Breaker (FCB1 Internal or FCB2 External) in the "On" position.
9. *See digital meter manufacturer's manual for meter operation.*
10. Place the Mode Selector switch in the "Local" or "Remote" position.
11. Start-up generator set or bring other test source on line.

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

LOCAL CONTROL

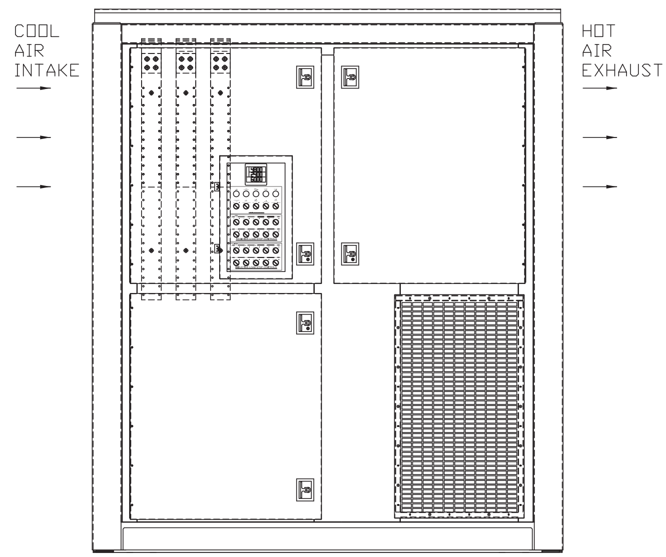
1. Verify the Fan Reversal switch is in the appropriate position.
2. Place the Fan/Control Power switch in the "On" position to open the louvers and energize the cooling fans.

   The louvers will open before the fans energize.
3. Verify the louvers are open.
4. Verify the illumination of the "Normal Operation" lamp before proceeding.
5. Adjust source voltage.
6. Visually observe correct fan operation and investigate any unusual fan related noises.
7. Check air intake for obstructions and confirm positive air flow.

   If the Load Bank airflow direction is reversed stop the fan motor immediately. After the motor has stopped completely change the position of the Fan Reversal switch and energize the fan motor. Load Bank operation with the airflow direction reversed will damage the Load Bank.
8. Select the desired load steps by placing them in the "On" position.

⚠ WARNING ⚠

If the Load Bank airflow direction is reversed stop the fan motor immediately. After the motor has stopped completely change the position of the fan reversal switch and energize the fan motor. Load Bank operation with the airflow direction reversed will damage the Load Bank.



Part of Typical Pictorial Drawing

9. Place the appropriate "Master Load" switch in the "On" position.
10. Place the "System 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 "System Master Load" and the corresponding "Master Load" switches are in the "On" position.
11. Adjust the load and monitor load source as needed.

⚠ WARNING ⚠

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

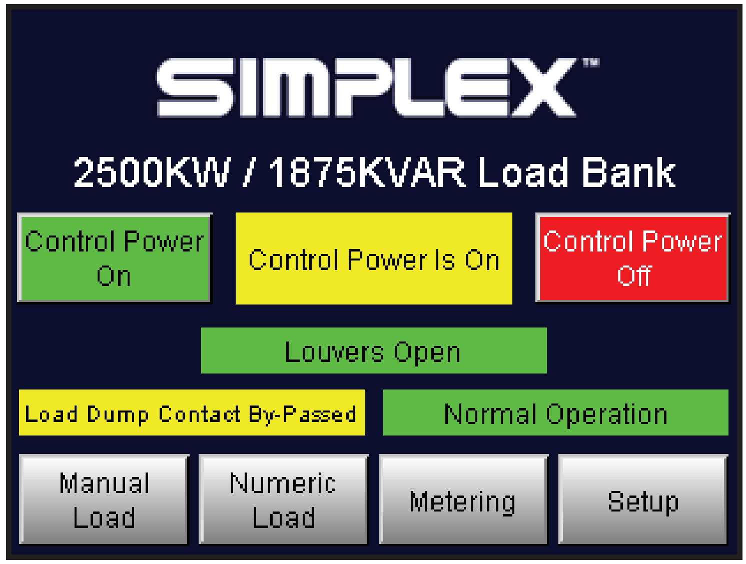
REMOTE CONTROL

The Standard Remote Control panel is comprised of seven (7) touchscreens: Start Up / Status, Load Selection, Resistive Manual, Inductive Manual, Numeric Mode, Metering and Setup.

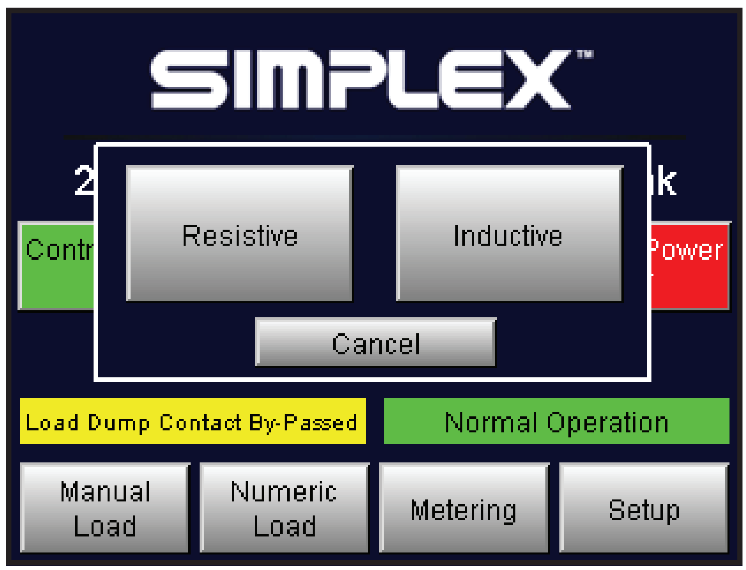
MANUAL OPERATION

1. Start-up generator or bring other test source on line.
2. Adjust power source voltage and frequency.
3. Press the "Control Power On" button to energize the cooling fan.

   "Control Power is On" will be indicated and Load Bank status indicators will appear.
4. Verify normal operation before proceeding.
5. Visually observe correct fan operation and investigate any unusual fan related noises.
6. Check air intake for obstructions and confirm positive air flow.
7. Press the "Manual Load" button to open the Load Selection Screen will appear.
8. Press the "Resistive" or "Inductive" button.



Start Up / Status Screen



Load Selection Screen

9. Select the desired load steps by pressing the appropriate button.
10. Press the corresponding "Master Load" button.
11. If desired, press the "Status" button to go back to the Load Selection Screen and repeat load step selection for Resistive or Inductive load.
12. Press the "System Master Load" button.

    This simultaneously applies all of the load steps which are in the "On" position while the corresponding "Master Load" is in the "On" position.

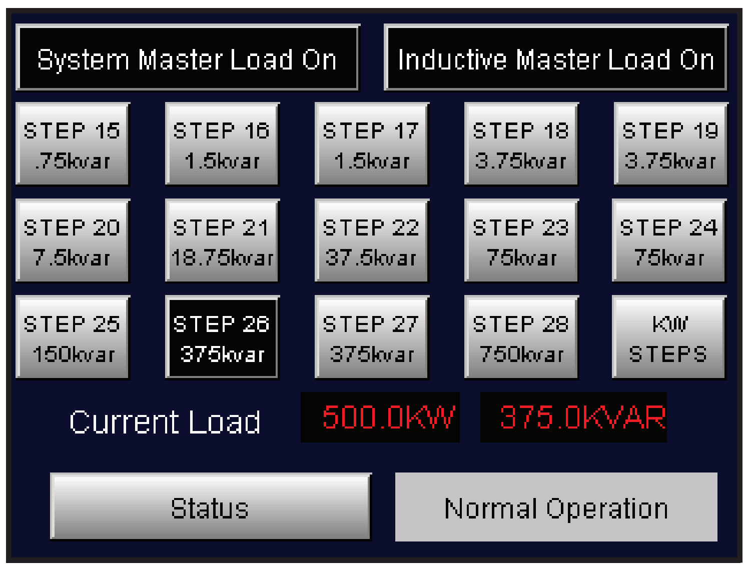
    Trim is achieved by turning the load steps "On" and "Off" while the corresponding "Master Load" and "System Master Load" are in the "On" position.
13. Adjust source voltage and load. Monitor as needed.

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. Press the "Control Power Off" button on the Start Up / Status screen.

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

Resistive Load Step Screen



Inductive Load Step Screen

NUMERIC LOAD APPLICATION

1. Start-up generator or bring other test source on line.
2. Adjust power source voltage and frequency.
3. Press the "Control Power On" button to energize the cooling fan.

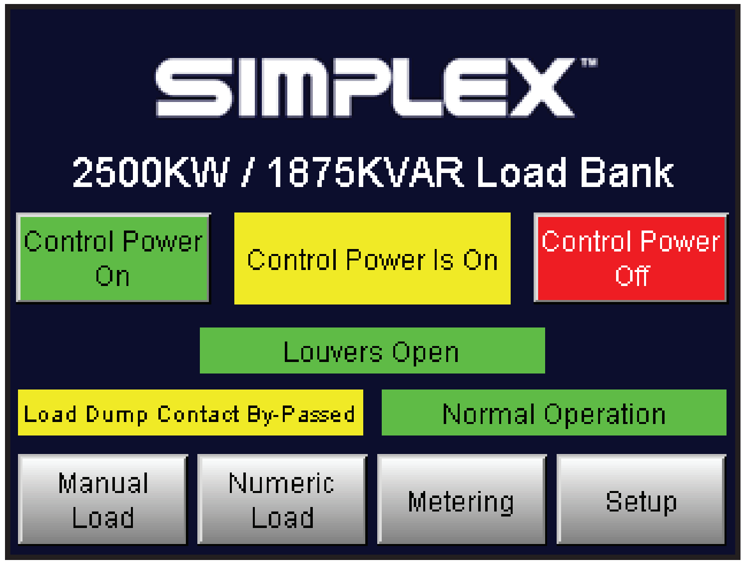
   "Control Power is On" will be indicated and Load Bank status indicators will appear.
4. Verify normal operation before proceeding.
5. Visually observe correct fan operation and investigate any unusual fan related noises.
6. Check air intake for obstructions and confirm positive air flow.
7. Press the "Numeric Load" button.
8. Press the "Enter KW Value to Apply" button and enter the desired value in the numeric pop-up screen.
9. Press the "Apply Numeric Load" button.
10. Adjust source voltage and load via the apply and remove buttons. Monitor as needed.

Shutdown

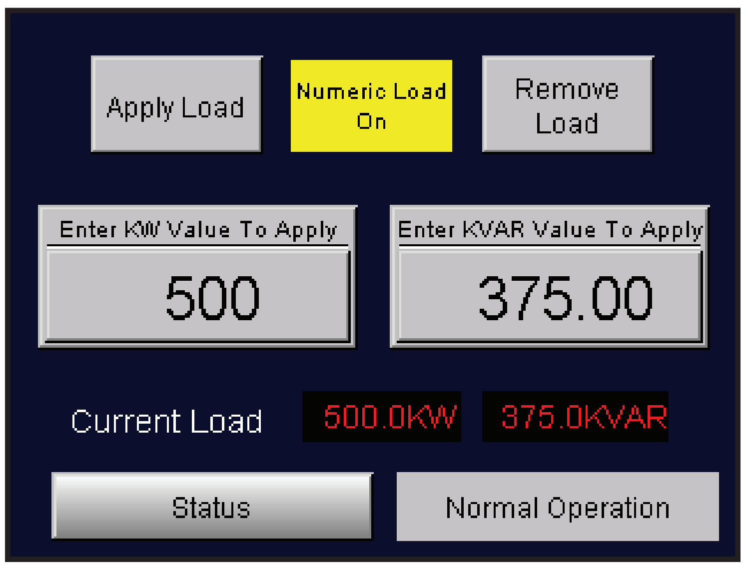
1 De-energize the load.

2. Run the cooling fan for 5 minutes to assure a thorough cool down of all load elements (optional).

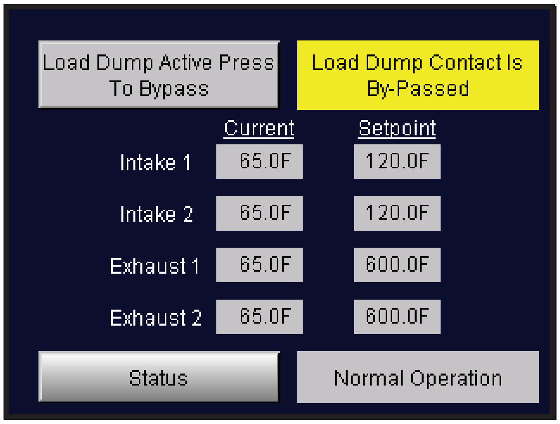
3. Press the "Control Power Off" button on the Start Up / Status screen.



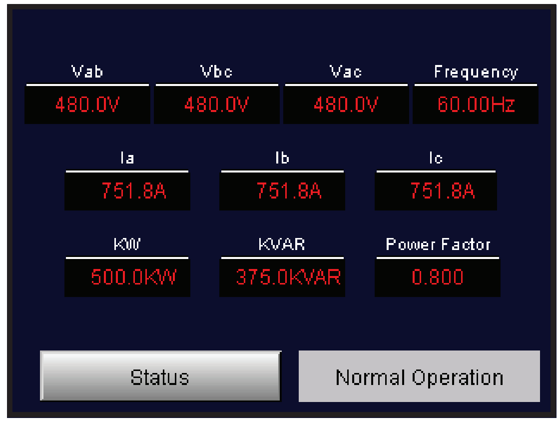
Start Up / Status Screen



Numeric Load Step Screen



Setup Screen



Metering Screen

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 are rated at 2A @ 24VDC and should be wired to TB'A' 4–5. 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.

The operator also has the option of bypassing these contacts and enabling the load section by placing the "Load Dump Bypass" switch on the local control panel in the "Bypassed" position or pressing the "Load Dump Active Press To Bypass" button on the "Status" screen. This disables the load dump feature and illuminates the "Load Dump Bypass" lamp.

SETUP SCREEN

The Setup Screen is accessed via the "Setup" button on the Manual Load Application or Numeric Load Application. The intake and exhaust setpoints are factory set but may be modified *(see Failure Detection section below)*.

FAILURE DETECTION

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".

This is a permissive/energize-to-run circuit in which all safety sensors must energize their control relays on normal operation before load can be applied. This system will include the following components:

1. Thermocouples into Programmable Logic Controller (PLC) for intake and exhaust
2. Pressure Switch (PS)

THERMOCOUPLES

The thermocouples setpoints have been factory adjusted for precise Load Bank over temperature protection under normal operating conditions. Unusual operating conditions may require field adjustment. The setpoints may be changed via the touch panel. Consult the Simplex Service Department (217-483-1600 24hrs) before changing the temperature switch setpoint.

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. Check fan blades for stress fractures. 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”.

⚠ WARNING ⚠

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

⚠ WARNING ⚠

Overgreasing is a major cause of bearing and/or motor failure. The amount of grease added should be carefully controlled. Also make sure dirt and contaminants are not introduced when adding grease.

⚠ WARNING ⚠

If motor is nameplated for hazardous locations, do not run motor without all of the grease or drain plugs installed.

⚠ WARNING ⚠

If lubrication instructions are shown on the motor nameplate, they will supersede this general instruction.

MOTOR LUBRICATION

Motors are properly lubricated at the time of manufacture. It is not necessary to lubricate at the time of installation unless the motor has been in storage for a period of 12 months or longer (refer to lubrication procedure that follows).

Inspect the fan motor supplied with your Load Bank for grease fittings. If the motor contains grease fittings you must lubricate the motor. If lubrication instructions are shown on the motor nameplate, they will supersede this general instruction. Belt driven cooling fans have bearings which should be lubricated. Bearings should be lubricated every 50 hours of operation or 6 months whichever comes first.

RELUBRICATION TIME INTERVAL
for motors with regreasing provisions.

	NEMA Frame Size					
	140 – 180		210 – 360		400 – 510	
	1800 RPM and less	Over 1800 RPM	1800 RPM and less	Over 1800 RPM	1800 RPM and less	Over 1800 RPM
Standard	3 yrs.	8 mo.	2 yrs.	8 mo.	1 yr.	3 mo.
Severe	1 yr.	3 mo.	1 yr.	3 mo.	6 mo.	1 mo.
Seasonal	See Note 2.					

Standard: Up to 16 hours of operation per day, indoors, 100°F maximum ambient.

Severe: Greater than 16 hours of operation per day. Continuous operation under high ambient temperatures (100° to 150°F) and/or any of the following: dirty, moist locations, high vibration (above NEMA standards), heavy shock loading, or where shaft extension end is hot.

Seasonal: The motor remains idle for a period of 6 months or more.

Note:

1. For motors nameplated as "belted duty only" divide the above intervals by 3.
2. Lubricate at the beginning of the season. Then follow service schedule above.

Lubrication Procedure

1. Stop motor. Disconnect and lock out of service.
2. Remove contaminants from grease inlet area.
3. Remove filler and drain plugs.
4. Check filler and drain holes for blockage and clean as necessary.
5. Add proper type and amount of grease. See the **Relubrication Time Intervals** table for service schedule and **Relubrication Amounts** table for volume of grease required.
6. Wipe off excess grease and replace filler and drain plugs.

RELUBRICATION AMOUNTS
for motors with regreasing provisions.

NEMA Frame Size	Volume cu. in. (fluid oz.)
140	.25 (.14)
180	.50 (.28)
210	.75 (.42)
250	1.00 (.55)
280	1.25 (.69)
320	1.50 (.83)
360	1.75 (.97)
400	2.25 (1.2)
440	2.75 (1.5)
500	3.00 (1.7)

7. Motor is ready for operation.

   Warning: If motor is nameplated for hazardous locations, do not run motor without all of the grease or drain plugs installed.

Grease Type

Unless stated otherwise on the motor nameplate, the motors on this Load Bank are pregreased with a polyurea mineral oil NGLI grade 2 type grease. Some compatible brands of polyurea mineral base type grease are:

- Chevron SRI #2
- Rykon Premium #2
- Exxon Polyrex EM
- Texaco Polystar RB

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, fan/control power, anti-condensation heater power, etc.

COOLING FAN MOTOR WILL NOT OPERATE

1. Inoperative Fan Circuit Breaker (FCB)
2. Fan/Control Power not available/ incorrect
3. Inoperative Fan Motor (MOT)
4. Fan Motor Contactor (FMC) de-energized
5. Restriction of air (intake or exhaust)

⚠ WARNING ⚠

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

COOLING FAILURE INDICATED

Exhaust temp above EXTS setpoint:

1. Over temperature sensor failure
2. Fan failure
3. Air restriction (intake or exhaust)
4. Overvoltage condition present

Exhaust temp below EXTS setpoint:

1. Restriction of air (intake or exhaust)
2. Fan pressure switch inoperative
3. Overtemperature sensor failure

METERING SYSTEM DOES NOT OPERATE PROPERLY

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

SOME LOAD STEPS CANNOT BE ENERGIZED

1. Open load step resistor(s)
2. Inoperative load step relays
3. Inoperative load step contactors
4. 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 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 at right.

SIMPLX® SPRINGFIELD, ILLINOIS

SCALE :	APPROVED BY :	DRAWN BY : BAB
DATE : 10/15/09		REVISED :
RESISTIVE/INDUCTIVE LOAD BANK 2500KW/1875KVAR,480V,3ø,60Hz	LOAD CUBE-2500 FAN/CONTROL SECTION	
W.O.# 71784-09-43/-1-2		DRAWING NUMBER 199488A

ITEM	QTY.	PART #	DESIG.	DESCRIPTION
1	3	DRAWING 199502A	LR1-LR3	LOAD ELEMENTS 333W @ 480V HELICAL COIL
2	6	DRAWING 199502A	LR4-LR9	LOAD ELEMENTS 667W @ 480V HELICAL COIL
3	6	DRAWING 199502A	LR10-LR12	LOAD ELEMENTS 1667W @ 480V POWER-WEB
4	3	DRAWING 199502A	LR13-LR15	LOAD ELEMENTS 3333W @ 480V POWER-WEB
5	3	DRAWING 199502A	LR16-LR18	LOAD ELEMENTS 8333W @ 480V POWER-WEB
6	147	DRAWING 199502A	LR22-LR168	LOAD ELEMENTS 16667W @ 480V POWER-WEB
7	1	DRAWING 201658	LX1	LOAD REACTOR, 0. 75KVAR 480V, 3PH. , 60HZ 3-WIRE, DELTA
8	2	DRAWING 201658	LX2-LX3	LOAD REACTOR, 1. 50KVAR 480V, 3PH. , 60HZ 3-WIRE, DELTA
9	2	DRAWING 201658	LX4-LX5	LOAD REACTOR, 3. 75KVAR 480V, 3PH. , 60HZ 3-WIRE, DELTA
10	1	DRAWING 201658	LX6	LOAD REACTOR, 7. 50KVAR 480V, 3PH. , 60HZ 3-WIRE, DELTA
11	1	DRAWING 201659	LX7	LOAD REACTOR, 18. 75KVAR 480V, 3PH. , 60HZ 3-WIRE, DELTA
12	1	DRAWING 201659	LX8	LOAD REACTOR, 37. 5KVAR 480V, 3PH. , 60HZ 6-WIRE, DELTA
13	24	DRAWING 201659	LX9-LX32	LOAD REACTOR, 75KVAR 480V, 3PH. , 60HZ 6-WIRE, DELTA
14	12	13011040	C1-C6 XC1-XC6	CONTACTOR 35A, 600V, 3POLE 120VAC 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.

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

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

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

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

$$= 70.3$$

FORMULAS

		Alternating Current	Direct Current
Kilowatts	1 phase	$\frac{\text{Volts x Amps x PF*}}{1000}$	$\frac{\text{Volts x Amps}}{1000}$
	3 phase	$\frac{\text{1.732 x Volts x Amps x PF*}}{1000}$	
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	$\frac{\text{1.732 x Volts x Amps x }\sqrt{1-PF^2}}{1000}$	

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

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

