TRIDENT TRAILER LOAD BANK TECHNICAL MANUAL

Customer: XXXXXXXX

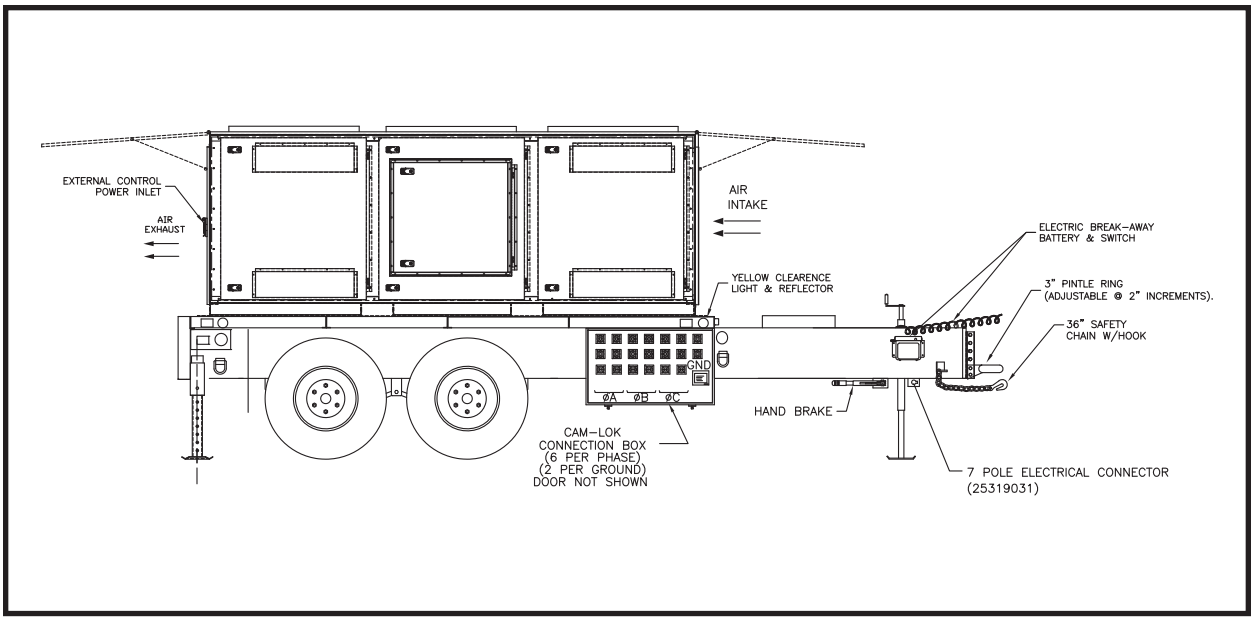
Work Order: XXXXX-XX-XX

Model: Trident Trailer

June 2011

(File: TridentTrailer-110601.indd)

Contents



Part of Pictorial Typical Drawing

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.

The Load Bank System on this work order includes a Trident Load Bank mounted on a dual axle highway trailer which conforms to applicable Federal and DOT standards. The trailer includes ICC 12V electric lights with 7 pole connector, electric brakes with mechanical parking brake, break-away battery and switch safety kit, leaf springs, ICC 36" safety chains with hooks, 3" pintle ring and 7,000 pound lift jack with foot plate.

This fully self-contained Load Bank System includes test instrumentation, cooling system, rugged load elements, local load application control devices and automatic system protection devices. Control Power (120V) is provided internally via transformers or externally via External Control Power Inlet. Common serviceable components include Control Fuses (CF Series) and Load Fuses (F Series). Instrumentation is protected by hinged cover.

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

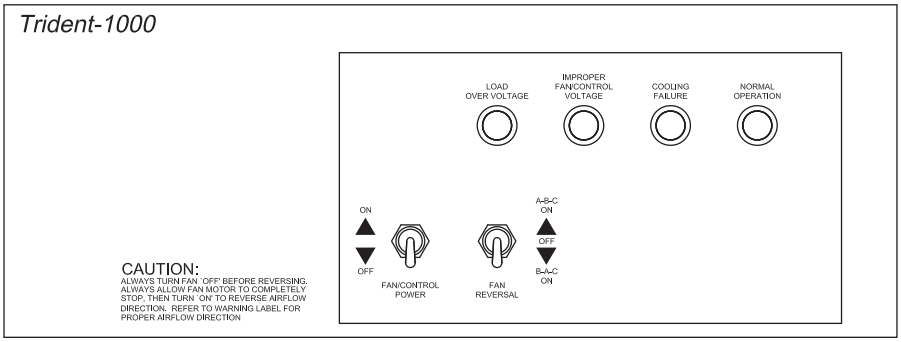
⚠ WARNING ⚠

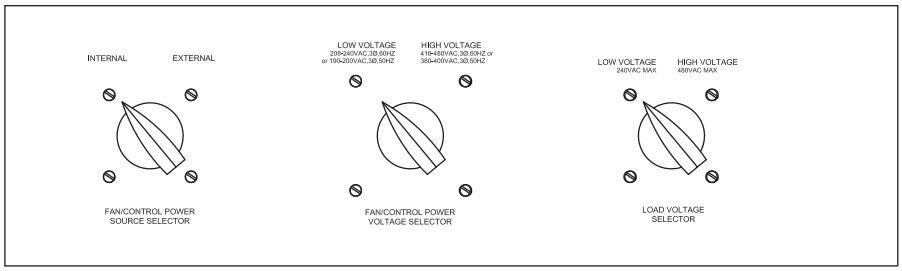
This manual represents a generic configuration. Each Trident Trailer Load Bank is engineered per customer specifications therefore each manual is unique.

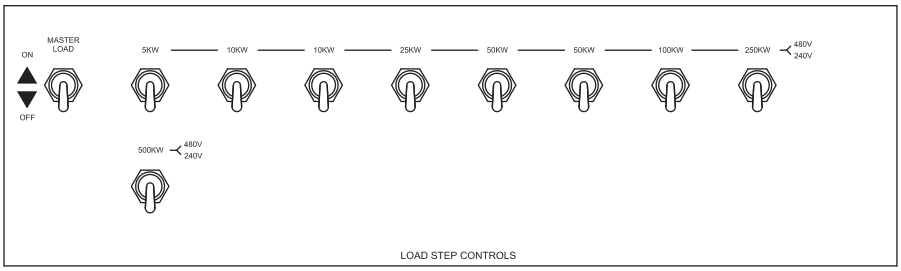
The Control Panel is comprised of the following components:

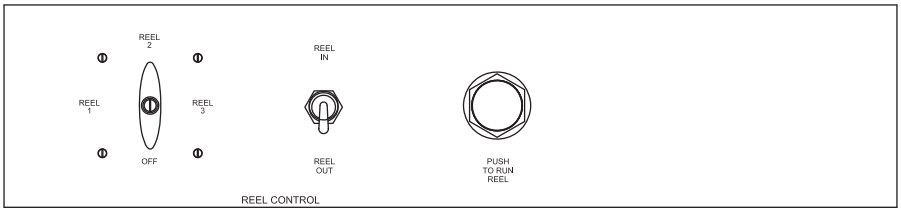
1. Load Over Voltage, Improper Fan/Control Voltage, Cooling Failure, and Normal Operation indicator lamps
2. Fan/Control Power switch
3. Fan Reversal switch
4. Fan/Control Power Source Selector switch
5. Fan/Control Power Power Voltage Selector switch
6. Load Voltage Selector switch
7. Master Load and load step switches
8. Reel Control switches and pushbutton

Trident-1000









The load elements in these Load Banks are cooled by a horizontal forced air systems which discharge at a high velocity through the front. Exhaust temperatures may reach 600°F. Care must be taken to insure personnel safety. Do not allow personnel to walk through exhaust air stream within 50 feet of the Load Bank.

⚠ 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.

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 "Voltage Selector Switch" is in the "Low Voltage" position (less than 240V) and "High Voltage" (greater than 380V) is applied.
3. The Fan/Control Power Over Voltage Failure System removes all load from the test source in the event the "Fan/Control Power Selector Switch" is in the "Low Voltage" position (less than 240V) and "High Voltage" (greater than 380V) is applied.

COOLING FAILURE SUBSYSTEM

A closed intake or exhaust cover, excessive intake or exhaust temperatures or any reduction in cooling airflow for any reason is indicated by the illumination of the "Cooling Failure" lamp on the Control Panel. All load steps are locked out until the problem is corrected and failure related relays are reset by turning the Load Bank "Off" then "On". The Cooling Failure Subsystem consists of the Intake Temperature Switch (INTS), Intake Cover Switch (LS1), Exhaust Cover Switch (LS2), Pressure Switch (PS), the Exhaust Temperature Switch (EXTS), Cooling Failure Relay (CFR), and the Normal Operating Relay (NOR). Since these components are all connected in series an intake temperature above 125° F, an exhaust temperature above the setpoint of the EXTS, a closed intake or exhaust cover, or a substantial reduction in air flow pressure will open the voltage path to the NOR and the "Normal Operation" lamp. The NOR de-energizes, the "Normal Operation" lamp extinguishes and the "Cooling Failure" lamp illuminates. The "Master Load" switch is disabled when NOR contacts 4–7 and 5–8 open. The load is de-energized and load cannot be reapplied until the failure is corrected.

Thermocouple Temperature Switch

The exhaust temperature network consists of a type J thermocouple (TC) and a solid state thermocouple sensor (EXTS). The temperature switch has been factory adjusted for precise Load Bank over temperature protection under normal operating conditions. Unusual operating conditions may require field adjustment. The setpoint of the Exhaust Temperature Switch (EXTS) may be changed by rotating the adjustment knob (see diagram). Consult the Simplex Service Department (217-483-1600 24hrs) before changing the temperature switch setpoint.

LOAD POWER OVER VOLTAGE

The Load Power Over Voltage detection network is activated only when a "High Voltage" test source (greater than 380V) is applied and the "Load Voltage Selector Switch" (S1) is incorrectly placed in the "Low Voltage" position. When voltage from the load source becomes great enough the Voltage Sensing Relay (VSR1) energizes. VSR1 contacts 8–6 close, energizing the Over Voltage Relay (OVR1). The "Load Over Voltage" lamp (L1) is illuminated. Open OVR1 contacts 9–3 de-energize the Normal Operation Relay (NOR). NOR contacts 4–7 and 5–8 –open. The "Master Load" switches and the load step switches are disabled disconnecting the Load Bank from the test source. The operator must place the "Load Voltage Selector Switch" in the "High Voltage" position to apply the load.

FAN/CONTROL OVER VOLTAGE

The Fan/Control Over Voltage detection network is activated only when a "High Voltage" test source (greater than 380V) is applied and the "Fan/Control Power Voltage Selector Switch" (S2) is incorrectly placed in the "Low Voltage" position. When voltage from the load source becomes great enough Voltage Sensing Relay (VSR2) energizes. VSR2 contacts 8–6 close and energize Over Voltage Relay (OVR) and illuminate the "Improper Fan/Control Voltage" lamp (L2) and energize the Control Power Contactor (CPC1). CPC1 opens its contacts. Open CPC1 contacts interrupt the power path to the "Fan/Control Power Switch" and disconnect the Load Bank from the test source. The operator must place the "Fan/Control Power Voltage Selector Switch" in the "High Voltage" position to apply the load.

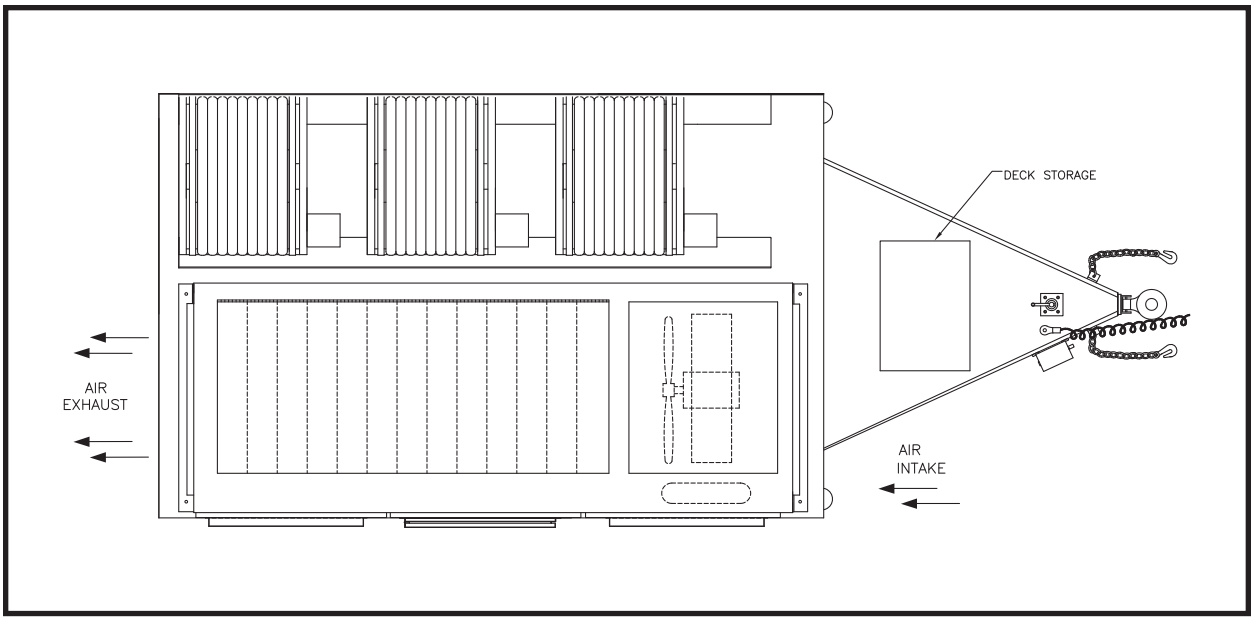
⚠ WARNING ⚠

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

PRIMARY INSPECTION

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

1. Check the entire outside of the Load Bank for any visual damage which could cause internal electrical or mechanical problems due to reduced clearance.
2. Operate all hinged panels and doors for smooth and safe operation, try all latches and knobs.
3. Rotate and push all switches through all positions to ensure smooth operation.
4. Inspect all relays, timers, and control modules by opening all accessible panels. Make sure all components are secure in their bases and safety bails are in place. Spot check electrical connections for tightness. If any loose connections are found inspect and tighten all remaining connections.
5. Examine all accessible internal electrical components such as fuses, contactors and transformers. Check lugged wires at these components.
6. Visually inspect element chamber for foreign objects, broken ceramic insulators, mechanical damage.



Part of Pictorial Typical Drawing

TRAILER INSPECTION

1. Inspect safety chains, ensure solid connection to trailer and chain hooks.
2. Inspect the trailer electrical system, lighting system, bulbs, electrical harness and connector.
3. Inspect brake system, brake shoes, etc.
4. Inspect hitch ring, operate lift jack, tighten all hardware as necessary due to vibration.

Also see Trailer Maintenance section for additional information.

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

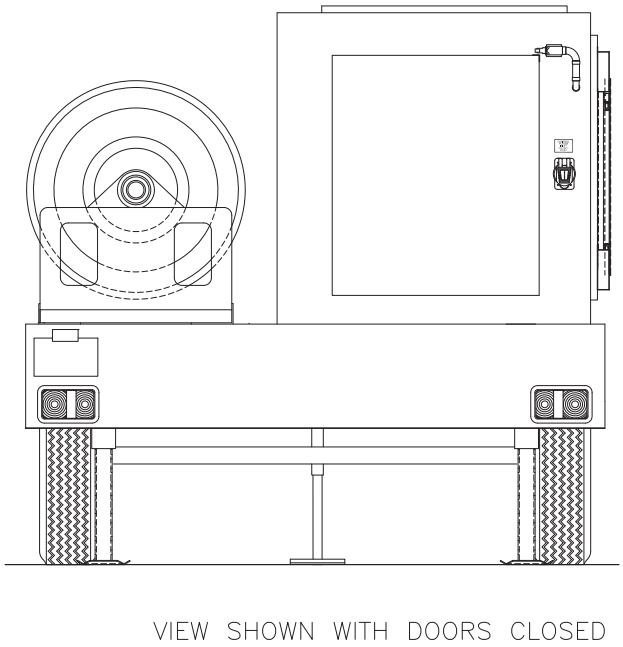
LOAD BANK LOCATION

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, as exhaust temperatures can easily exceed 600°F. 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

Note: Towing vehicles for Simplex trailer mounted Load Banks equipped with electric brakes, must be equipped with a modulated brake controller to synchronize the trailer brakes with the towing vehicle brakes. See Dexter Axle "Operation, Maintenance, Service Manual" and customer supplied modulated brake controller manual for detailed synchronization procedure. Lack of proper synchronization of the towing vehicle brakes with the trailer brakes may result in harsh or unsafe braking of the trailer.

1. Confirm that the test source is properly grounded and ground the Load Bank to its own independent ground.
2. *See Pictorial Drawing.* Open and lock intake and exhaust covers.
3. Confirm FCB1 and FCB2 are in the "Off" positions.
4. Confirm the "Fan/Control Power" and the "Fan Reversal" switches are in the "Off" position.
5. Confirm the "Master Load" switch and load step switches are in the "Off" positions.
6. If needed, place the "Fan/Control Power Source Selector", the "Fan/Control Power Voltage Selector" and the "Load Voltage Selector" switches in the appropriate positions.
7. *See Reel Control Drawing and Pictorial Drawing.*
   a. Connect a 60A, 12VDC source to the Cable Reel Power inlet.
   b. Connect the foot switch to the Foot Switch Receptacle.
8. Unreel the cables via the Reel Controls on the Control Panel and the Foot Switch.



Rear View - Part of Typical Pictorial Drawing

⚠ WARNING ⚠

Towing vehicles for Simplex trailer mounted Load Banks equipped with electric brakes, must be equipped with a modulated brake controller to synchronize the trailer brakes with the towing vehicle brakes. See Dexter Axle "Operation, Maintenance, Service Manual" and customer supplied modulated brake controller manual for detailed synchronization procedure. Lack of proper synchronization of the towing vehicle brakes with the trailer brakes may result in harsh or unsafe braking of the trailer.

9. *See Control Section Drawing.* If External Control Power is desired, connect a 240/480V, 3ø, 60Hz, 30A maximum power source to the External Fan/Control Power Inlet.
10. *See Load Section Drawing.* Using the customer supplied load cables cable the Load Bank Cam-Lok connectors to the load source as shown.
11. Place FCB1 and FCB2 in the "On" positions.
12. 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. (Steps 10–14)
13. Place the "Fan/Control Power" switch in the "On" position.
14. Verify the illumination of the "Normal Operation" lamp before proceeding.
15. Adjust source voltage.
16. Visually observe correct fan operation and investigate any unusual fan related noises.
17. 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.
18. 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.

⚠ WARNING ⚠

The receptacle at the rear of the Load Bank is <u>not</u> current protected.

19. Place the "Master Load" switch to 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.
20. Adjust the load via the "Load Step Controls" and monitor load source 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 "Fan/Control Power" switch in the "Off" position.

LOAD BANK MAINTENANCE

This 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 ⚠

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.

⚠ WARNING ⚠

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

⚠ 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.

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.

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)

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.
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

TRAILER MAINTENANCE

See the chart at right. *For detailed information see the manufacturer's manual.*

Item	Function Required	Weekly	3 Months or 3000 Miles	6 Months or 6000 Miles	12 Months or 12000 Miles
Brakes	Test that they are operational	*At Every Use*			
Brake Adjustment	Adjust to proper operating clearance		●		
Brake Magnets	Inspect for wear and current draw			●	
Brake Linings	Inspect for wear or contamination				●
Brake Controller	Check for correct amperage & modulation			●	
Brake Cylinders	Check for leaks, sticking				●
Brake Lines	Inspect for crakes, leaks, kinks				●
Trailer Brake Wiring	Inspect, wiring for bare spots, fray, etc.				●
Breakaway System	Check battery charge and switch operation	*At Every Use*			
Hub/Drum	Inspect for abnormal wear or scoring				●
Wheel Bearings & Cups	Inspect for corrosion or wear. Clean & repack.				●
Seals	Inspect for leakage. Replace if removed.				●
Springs	Inspect for wear, loss of arch.				●
Suspension Parts	Inspect for bending, loose fasteners, wear.			●	
Hangers	Inspect Welds.				●
Wheel Nuts and Bolts	Tighten to specified torque values.		●		
Wheels	Inspect for cracks, dents or distortion.			●	
Tire Inflation Pressure	Inflate tires to mfg's. specifications.	●			

Trailer Maintenance Schedule

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 (CB)
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)
6. Fan pressure switch inoperative

LOAD OVER VOLTAGE INDICATED

1. Load Voltage Selector switch incorrectly positioned

⚠ 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

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 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.

SIMPLEX™ SPRINGFIELD, ILLINOIS

SCALE :	APPROVED BY :	DRAWN BY : AMN
DATE : 01/15/11		REVISED :

RESISTIVE LOAD BANK 1000KW,240/480V,3ø,60Hz — TRIDENT–1000 CONTROL SECTION

W.O. # 75005–11–41 — DRAWING NUMBER 201230

ITEM	QTY.	PART #	DESIG.	DESCRIPTION
1	12	193535	LR1-LR12	LOAD ELEMENTS 417W @ 120V POWR-WEB
2	24	193535	LR13-LR36	LOAD ELEMENTS 833W @ 120V POWR-WEB
3	12	193535	LR37-LR48	LOAD ELEMENTS 2083W @ 120V POWR-WEB
4	228	193535	LR49-LR276	LOAD ELEMENTS 4167W @ 120V POWR-WEB
5	10	13011040	C1A-C4A C1B-C4B FMC1,2	CONTACTOR 35A, 600V, 3POLE 120VAC COIL
6	38	13011065	C5A-C23A C5B-C23B	CONTACTOR 65A, 600V, 3POLE 120VAC COIL
7	2	13008000	CPC1,2	POWER RELAY 30A-300VAC, 5A-600VAC DPDT, 120V COIL, 1½ Hp
8	4	13906500	CF1-CF4	FUSE, TIME DELAY 0.5A, 600V, 200KAIC CURRENT LIMITING
9	1	14014750	CF10	FUSE, FAST ACTING 2A, 600V, 100KAIC
10	4	14036500	CF5-CF8	FUSE, TIME DELAY 5A, 600V, 200KAIC CURRENT LIMITING
11	2	14044050	CF9,CF11	FUSE, FAST ACTING 10A, 600V, 100KAIC
12	6	14042000	F1-F6	FUSE, FAST ACTING 10A,600VAC,200KAIC
13	12	14051500	F7-F18	FUSE, FAST ACTING 15A,600VAC,200KAIC
14	6	14074000	F19-F24	FUSE, VERY FAST ACTING 35A, 600VAC, 200KAIC
15	114	14087000	F25-F138	FUSE, VERY FAST ACTING 70A, 600VAC, 200KAIC
16	4	15012250	[CF1-12]	FUSEBLOCK 30A, 600V, 3 POLE QUICK-CONNECT

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_{1-2} = 481V
A_2 = 250A	V_{2-3} = 479V
A_3 = 254A	V_{3-1} = 483V

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

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

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

Single Phase

Current Reading: 150A Voltage Reading: 240V

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

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

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

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

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

$$= 60.1$$

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	$\frac{\text{Volts x Amps x PF*}}{1000}$	$\frac{\text{Volts x Amps}}{1000}$
	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