

Load Banks Fundamentals

ASCO Power Technologies™



Course Code: CEU301
CEU Value: 0.1 CEU

Learning Objectives

At the end of this class you will be able to determine:

- What is a Load Bank?
- Why do you need a Load Bank?
- Basic types of Load Banks
- How to Recognize a Load Bank
- Load Bank Applications
- Load Bank Control Platforms
- Load Bank Markets
- Load Bank Safety

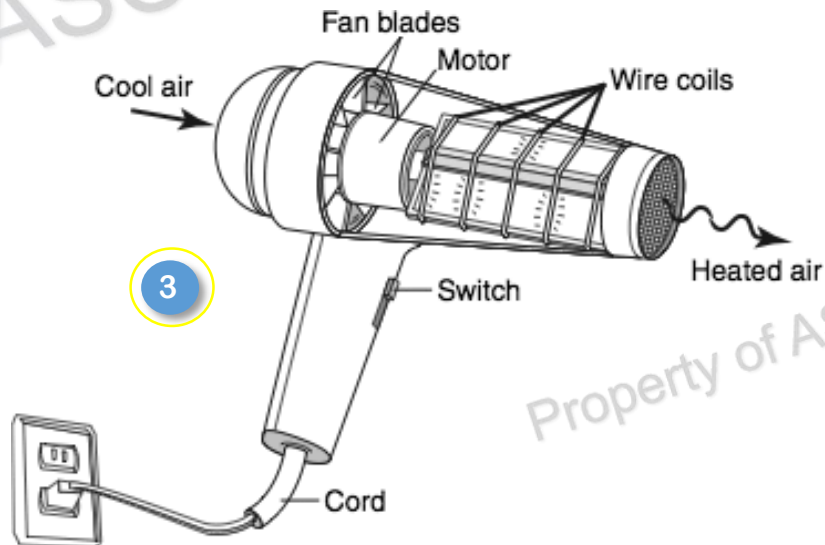
What is a Load Bank?

A load bank provides an electrical load on a power source.

Load banks typically use resistive load elements.

Common examples of simple “load banks” are:

1. Toasters
2. Light Bulbs
3. Hair Dryers

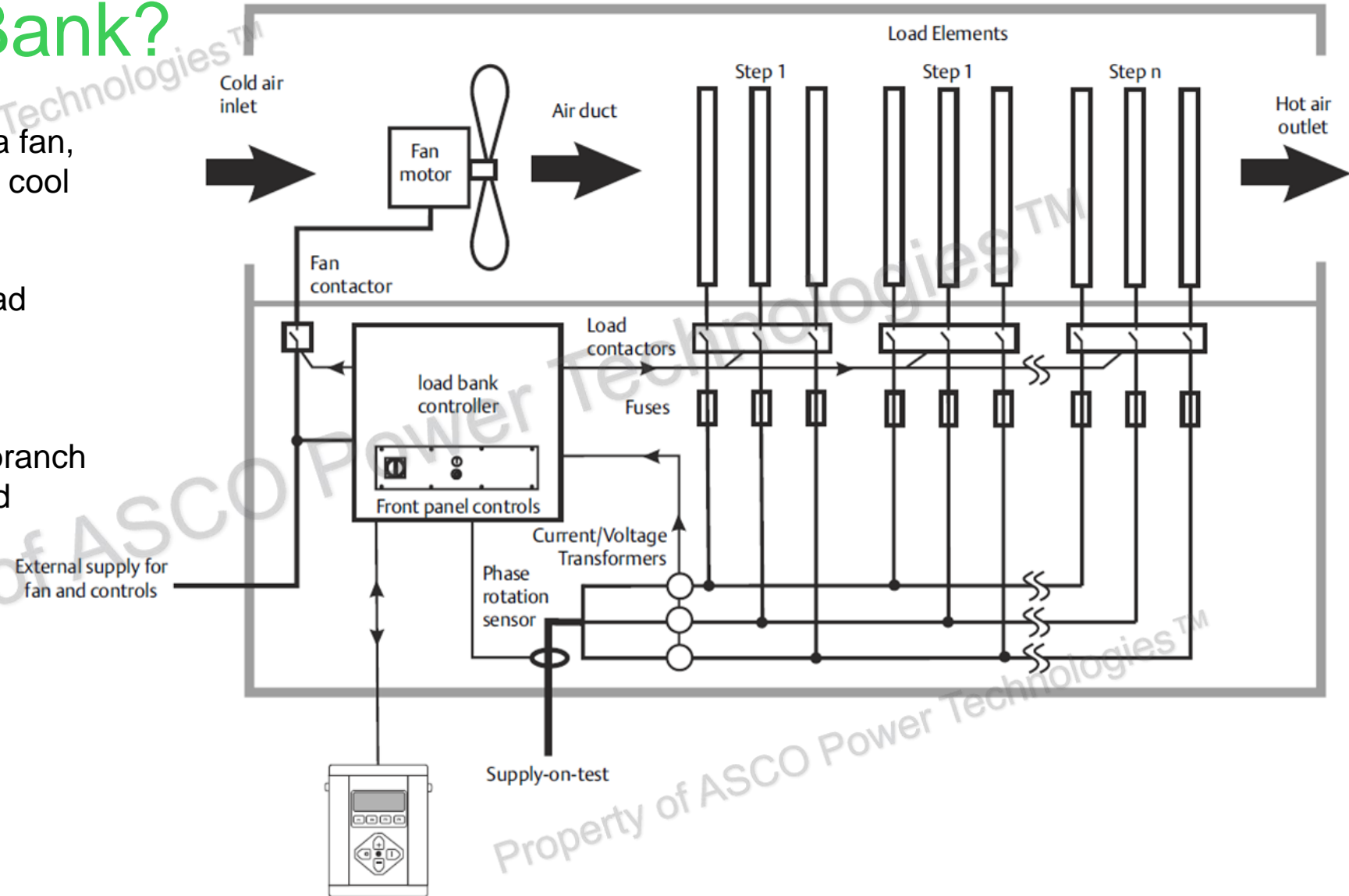


What is a Load Bank?

Modern industrial load banks utilize a fan, and use the corresponding airflow to cool the resistive elements.

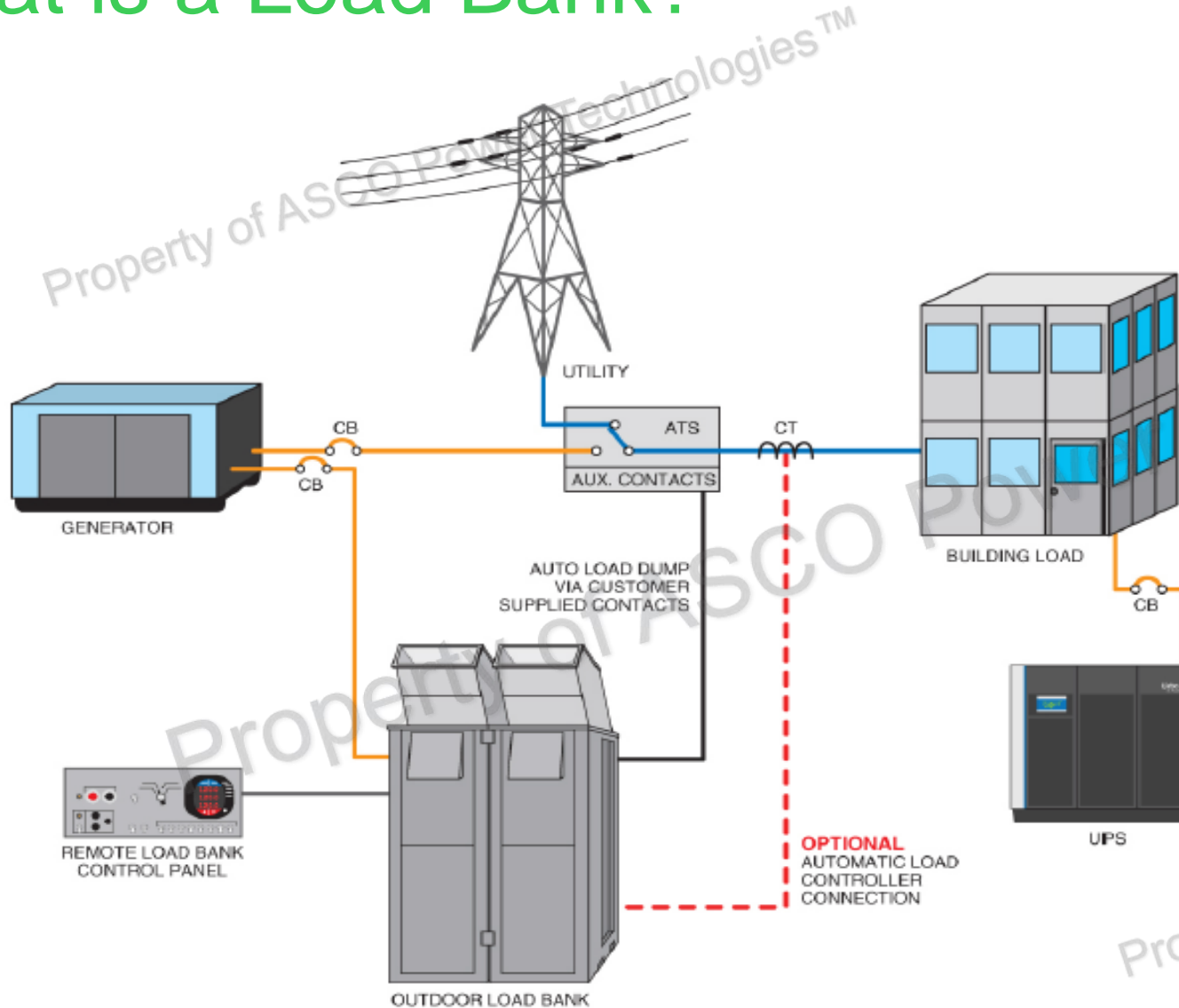
Modern units also have individual load steps which allow for precise and repeatable loading.

Properly rated load contactors with branch fuse protection are used to apply and remove load steps.



What is a Load Bank?

Typical one line of a load bank in a emergency backup power application



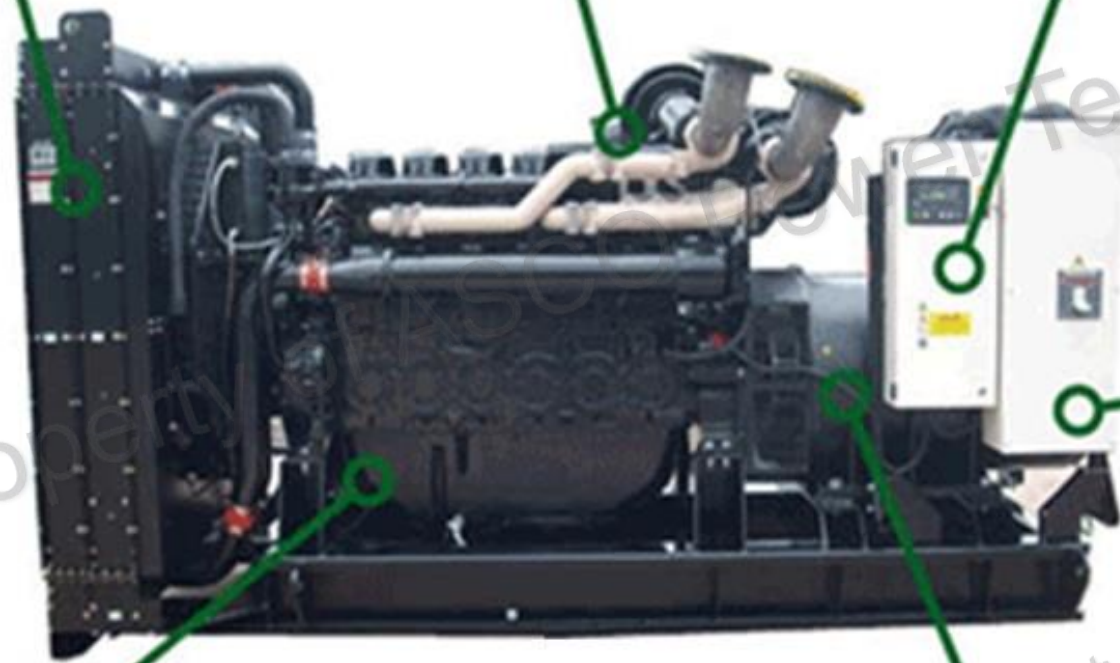
Why do you need a Load Bank?

A load bank test will affect the following systems on a genset:

Radiator & Cooling System

Exhaust System

Control Panel



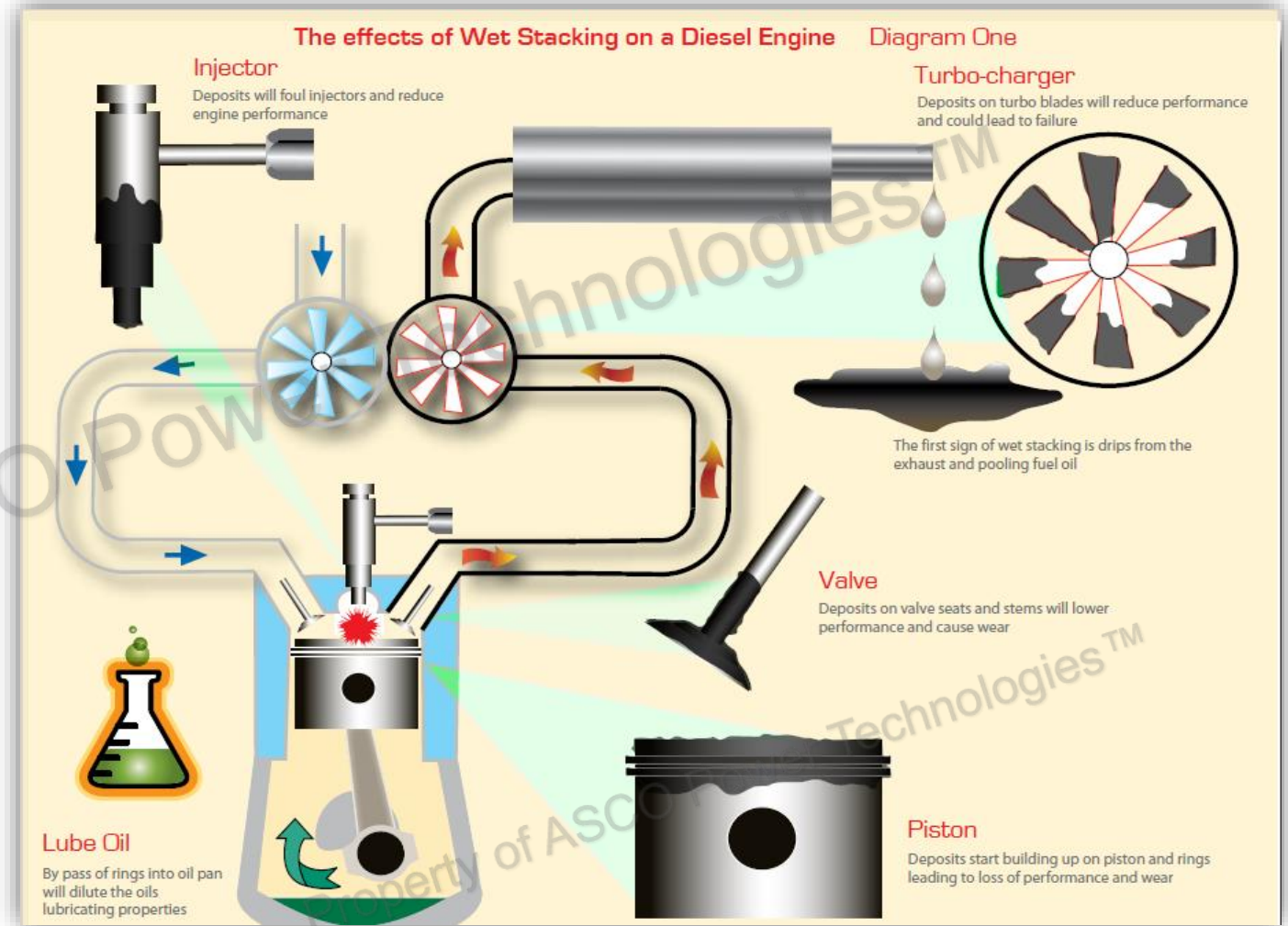
Diesel Engine

Alternator

Circuit Breaker

Why do you need a Load Bank? Wet Stacking

- Wet stacking is an industry term for the accumulation of unburned fuel in the exhaust system of a diesel engine.
- Wet stacking commonly occurs when engines are under loaded.
- Wet stacking commonly occurs when engines do not reach their operating temperature.
- If uncorrected, wet stacking can reduce engine output and efficiency and result in premature failure.
- In general, operating a diesel generator between 30-50% of the nameplate rating allows the engine to reach its recommended operating temperature and burn off any fuel deposits.



Why do you need a Load Bank? Emissions

Using a Load Bank on a diesel generator set helps the engine run at proper temperatures. This prevents fuel build up and promotes cleaner emissions.

Load Banks test power sources so they run efficiently. This efficiency helps with lower emissions and to reduce energy waste.

Load Banks can also test other power sources to help determine if their carbon footprint is as small as it can be.

Load Banks help ensure the proper running of emergency backup power equipment in the event of power outages.

the carbon footprint



Why do you need a Load Bank? NFPA Code Compliance

The **National Fire Protection Association (NFPA)** is a United States trade association, albeit with some international members, that creates and maintains private, copyrighted standards and codes for usage and adoption by local governments.

NFPA 99 - Healthcare Facilities Code - Healthcare facilities must exercise Emergency and Standby Power Systems under load and operating temperature conditions for at least 30 minutes at intervals of not more than 30 days

NFPA 110 - Standard for Emergency Generator Systems - Monthly testing is performed on generators whose failure could result in injury or death. If a generator fails a monthly test, it should be tested annually for two continuous hours using a load bank. Under the continuous test, the generator should be operated at 25 percent of the nameplate kilowatt rating for 30 minutes, at 50 percent of the kilowatt rating for 30 minutes and at 75 percent of the kilowatt rating for 60 minutes.

Why do you need a Load Bank? NEC Code Compliance

The National Electrical Code (NEC) is a regionally adoptable standard for the safe installation of electrical wiring and equipment in the United States.

NEC Article 700 - Emergency Systems – Emergency systems are required to receive an operating permit as determined by the local code enforcement authority. This requirement is a lifeline for occupants, ensuring that lighting and life safety loads take priority over other building loads. Should the main electrical power supply fail, backup emergency power for life safety systems must be available within 10 seconds.

NEC Article 701 - Legally Required Standby Systems – It requires standby power to be available to legally required systems within 60 seconds of power loss. While NEC 700 is designed to ensure that people can exit a building, NEC 701 responds to the needs of firefighters and other personnel responding to an emergency.

NEC Article 702 - Optional Standby Systems – This applies to situations where standby generators are optional. In these cases, the systems may be put in place to protect against economic loss or business interruptions. For instance, data centers may elect to install backup power because an outage could result in large revenue losses.

NEC Article 708 - Critical Operations Power Systems – This article was developed following the 9/11 World Trade Center, Hurricane Katrina, and Hurricane Rita disasters in the United States. It requires a commissioning plan for on-site backup generation, baseline testing, and periodic witness testing, as well as a documented preventive maintenance program, written test records, and a method for testing all critical power systems for maximum anticipated load conditions.

Why do you need a Load Bank? Joint Commission Accreditation

The **Joint Commission** is a United States based nonprofit organization that accredits more than 21,000 US healthcare organizations and programs. Their standards for emergency power testing are summarized in the table below.

Emergency Power Testing Standards		
Standard	Description	Interval
EC 02.05.07 EP 4	Generators tested 12 x year (not <20 days or >40 days apart) for 30 continuous minutes under load.	Monthly
EC 02.05.07 EP 5	Generator test performed with 30% or greater of nameplate rating dynamic load or the exhaust gas temperature during test meets manufacturer's recommendations. If not, a test is performed every 12 months using a supplemental load bank as per EC 02.05.07 EP 5.	Annual if required
EC 02.05.07 EP 6	Transfer switches 12 x year (not <20 days or >40 days apart).	Monthly
EC 02.05.07 EP 7	Test generator for 4 continuous hours every 36 months.	36 Months
EC 02.05.07 EP 8	36 month tests performed with a dynamic or static load of at least 30% of nameplate rating or the exhaust gas temperature during test meets manufacturer's recommendations.	See EC 02.05.07 EP 7
EC 02.05.07 EP 9	If a required emergency power system test failed, measures were implemented to protect patients, visitors and staff until repair or corrections are completed	As applicable
EC 02.05.07 EP 10	If a required emergency power system test failed, a retest was performed after repairs are made	As applicable

Types of Load Banks

Resistive: Most common type of load bank. It uses resistors to load the power source. Resistors have a unity (1.0 Power Factor).

Reactive: These load banks are used anytime an AC power source requires testing at a lagging power factor. (OEM Factory Testing, Military)

DC: This type of load bank is used to test DC power sources such as batteries, inverters and Ground Power Units (GPU's).

Capacitive: It is used anytime an AC power source requires testing at a leading power factor. (UPS OEMS, Crest Factor Loads)

Types of Load Banks



Portable: Defined by dual voltage capability, digital metering, casters and proper dimensions required to fit thru man doors and freight elevators.



Permanent: Defined by single voltage capability and stationary (pad mounted) installation.



Trailer Mounted: Defined by outdoor rated, high capacity, factory mounted on a properly balanced DOT trailer.



Radiator Mounted: Defined by single voltage capability, and either indoor or outdoor rated construction. Load Bank dimensions are based on gen-set radiator core opening.



Container: Defined by single voltage capability, remote Hand-Held control packaged in a 10' or 20' ISO style container.

How to Recognize a Load Bank

1. Mounted on the radiator of a genset
2. Mounted on a concrete pad
3. Portable on casters
4. Mounted on a trailer
5. Container



Types of Load Banks- Common Formulas

Power Information

kW- kilowatts

kVA- kilo volts-amperes

kVAR-kilo volt-amperes reactive

Pf-power factor

Formulas

$kW = kVA \times pf$

$kVA = kW / pf$

$pf = kW / kVA$

Voltage Derating

$\frac{\text{Applied Voltage}^2}{\text{Rated Voltage}^2} = D$

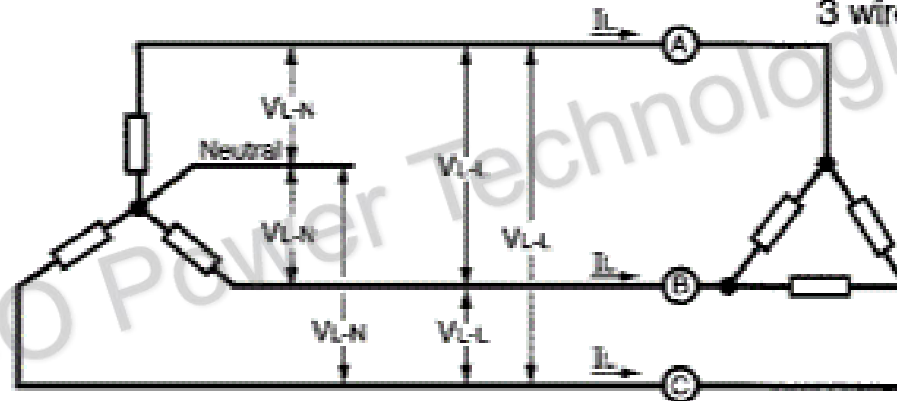
Rated Voltage²

$D \times \text{Rated Capacity} = \text{Derated kW capacity}$

CONNECTION DIAGRAM

4 wire Wye Generator

Load Bank
3 wire Delta



$$V_{L-L} = V_{L-N} \times \sqrt{3}$$

$$I_L = \frac{KW \times 577}{V_{L-L}}$$

V_{L-L} = Voltage measured Line to Line

V_{L-N} = Voltage measured Line to Neutral

I_L = Current in Amps

Types of Load Banks | Typical Voltages

VOLTAGE	PHASE	FREQUENCY
120	Single	60
208	Single or Three	60
240	Single or Three	60
400	Three	50
415	Three	60
480	Three	60
600	Three	60
690+ (Medium Voltage)	Three	60

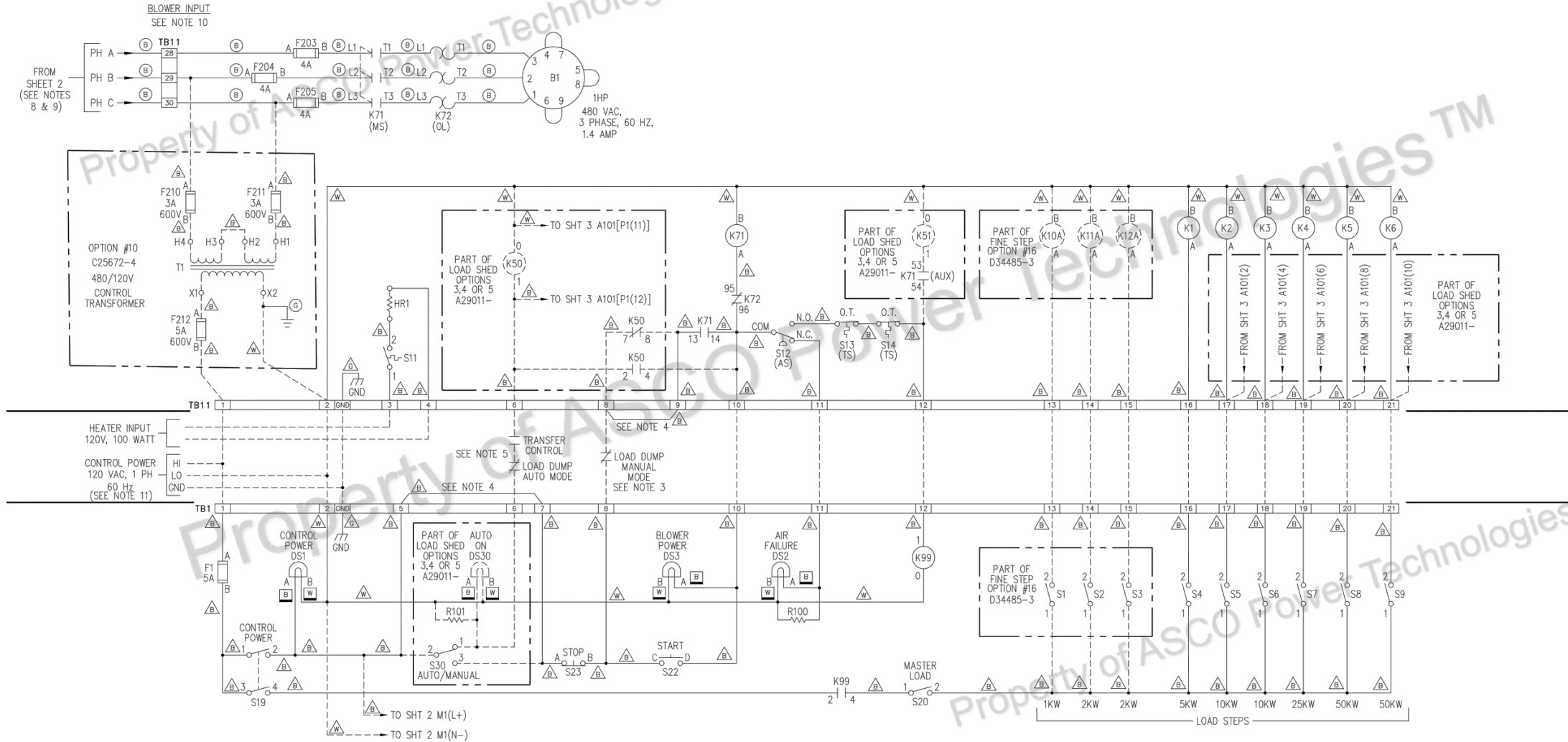
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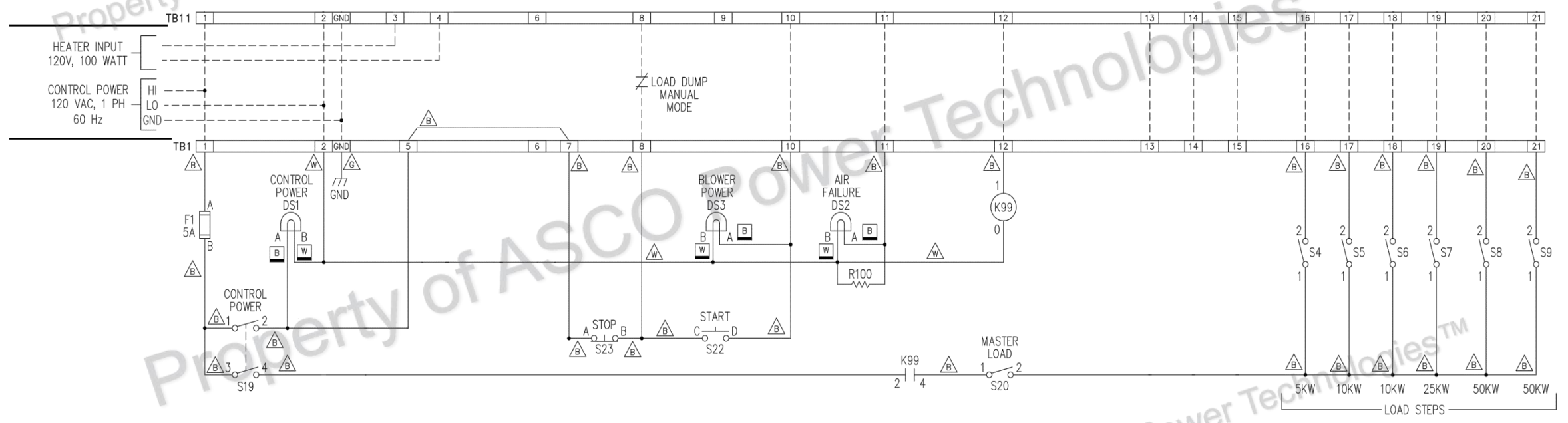
Schematics

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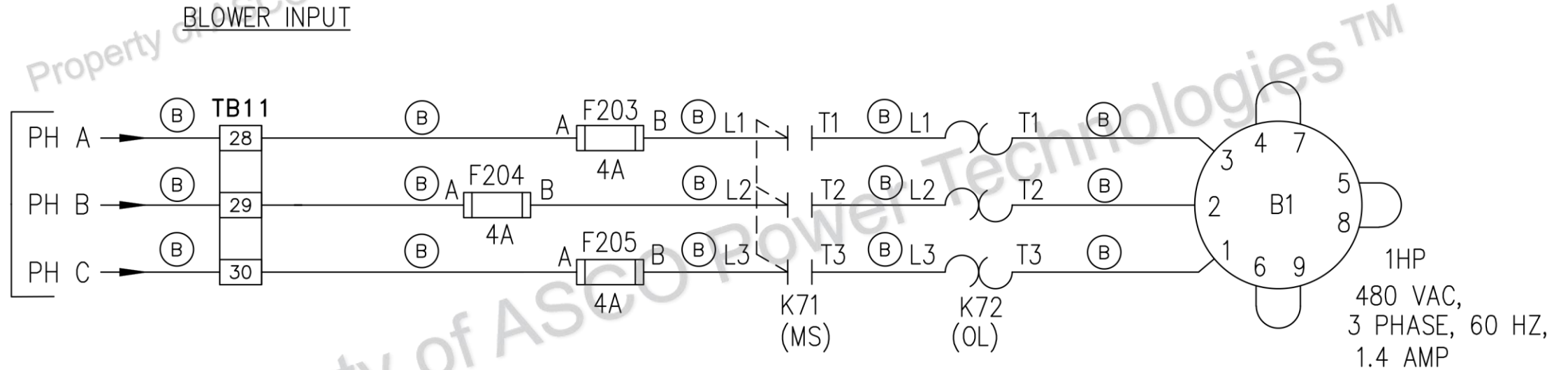
What is a Load Bank? Schematic



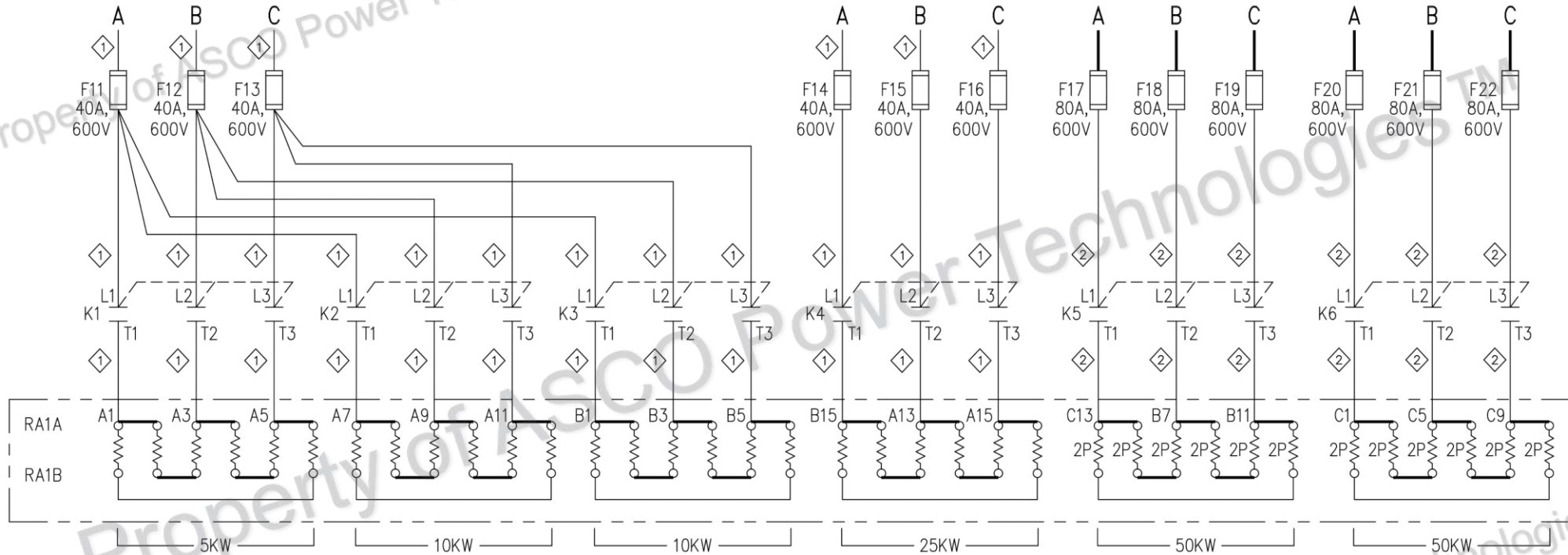
What is a Load Bank? Control Circuit



What is a Load Bank? Blower Circuit



What is a Load Bank? Load Circuit



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Control Platforms

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Load Bank Controls | Simple to Sophisticated

Cost

Comprehensive Control Options from Simple Toggle Switches to Sophisticated PLC

- Standard Toggle
- Digital Controls
- Software Control
- Auto Load Control
- Site Load Control
- Modbus
- Remote I/O
- PLC

Standard Toggles



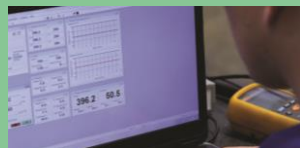
- Manual Load Application

Digital Control



- Digital Toggles
- Hand-Held
- Networking

Digital/Software/Modbus



- Software Control
- Remote Hand Held Control
- Modbus Interface
- Site Load Control
- Networking Multiple Load Banks

Remote I/O



- Critical Power Management Systems
- Load Banks have Remote I/O option for Interface

PLC



- Programmable Logic Control
- Typically used for Large System Integration

Features

Load Bank Controls | Manual Toggle

Key Features

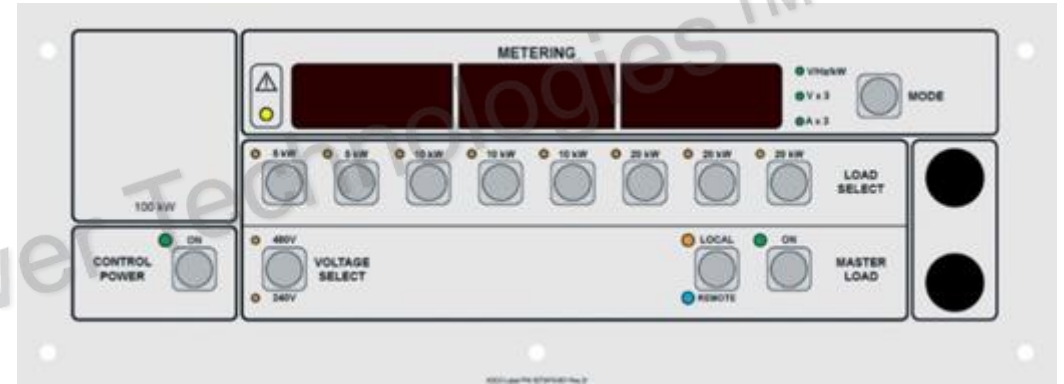
- Simple easy to use, straight forward operation
- Toggle switch design ensures reliability
- Basic, resistive load testing
- Ideal for remote and extreme locations
- Offers automatic load control: allows permanently installed or radiator mounted load banks to provide load levelling
- Digital metering is often included for indication of applied load in amps and kW



Load Bank Controls | Digital Toggle Switches

Key Features

- Takes conventional manual control to next level with SYNCHRONOUS load steps
- Automatic blower operation with fail safe directional sensing
- True single phase load control and instrumentation
- Digital Toggles have a 10x longer life span than standard toggle switches
 - 100,000 vs 10,000 actuations
- Standard In-Out port allows for networking and use in remote control
- LED instrumentation for high visibility



Load Bank Control | Hand-Held

Key Features

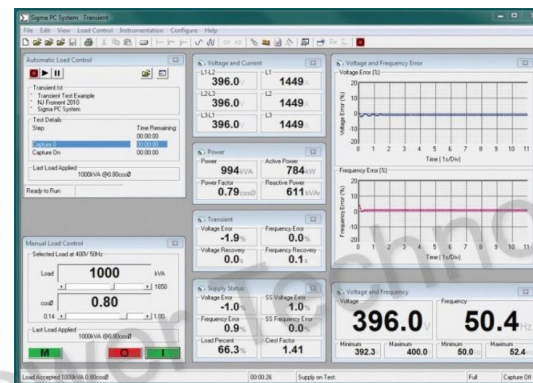
- Robust light weight aluminium construction with a long life touch screen
- Color display – with intuitive and simple user interface
- Instrumentation and control screens
- Data logging and easy firmware updates via USB port
- Single or Three phase load control and instrumentation
- No Manual Calculations needed
- Individual load bank control optimized for data center testing



PC Software Control

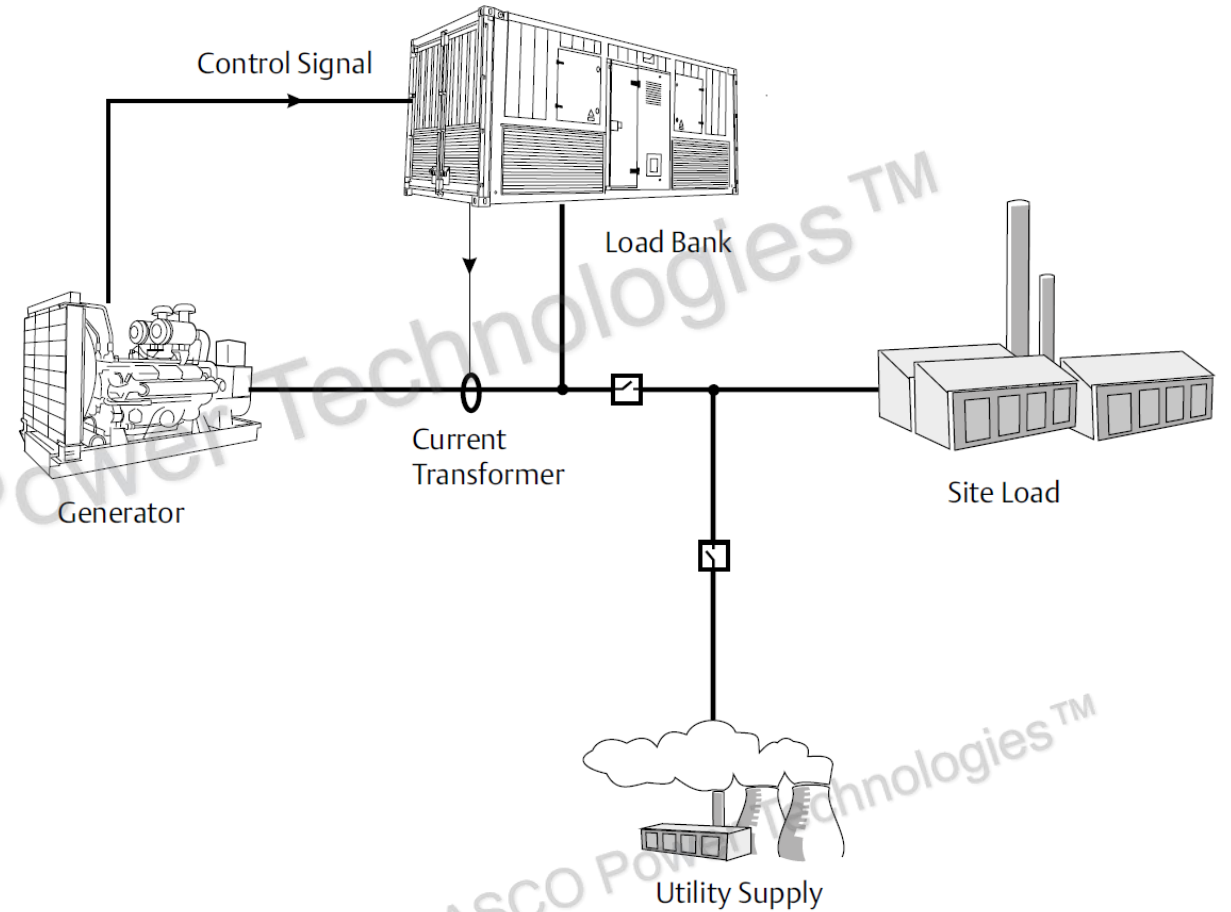
Key Features

- Load Bank Control Software
 - Designed for sophisticated control of multiple load banks
 - Scripting load control
 - Data acquisition
 - Comprehensive reporting and connectivity to customer MRP
 - Data analysis to ISO 8528
 - Dedicated pass/fail to International Testing Standard
 - Allows for user-defined test configuration
 - Personalized names for load banks
 - Customized grouping based on user test layout
 - Allows for system, user defined group, and individual load bank monitor and control
 - Monitoring and data logging of full 3 phase instrumentation for each load bank
 - Time stamped status, alarm, and error logs



Site Load Correction

- Automatically maintains set load level
- Prevents Wet Stacking
- Local Set-Point switch to set load level
- Remote control via Modbus



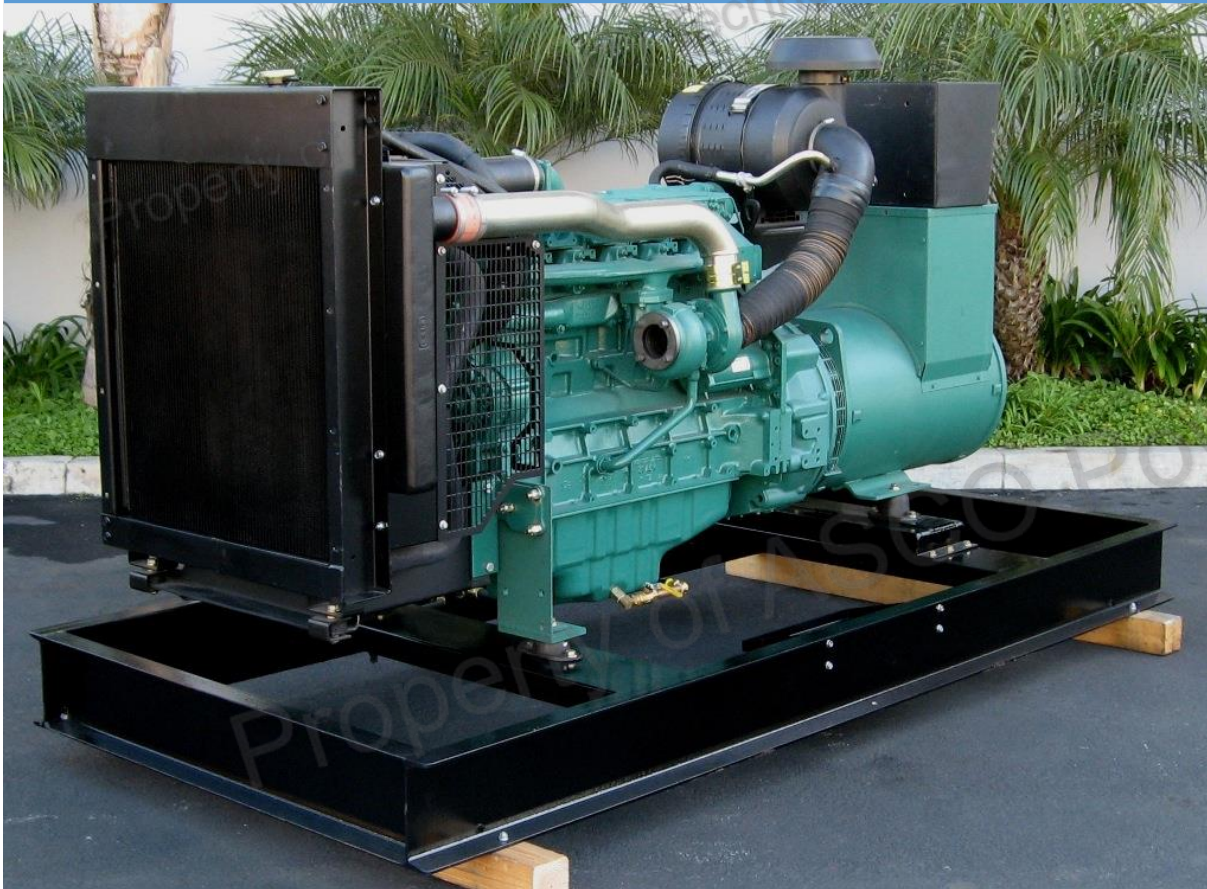
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Markets

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Load Bank Markets | Power Generation



Diesel Generator Sets for Backup (Emergency) Power.

Load banks used for testing:

- Generator OEMs
- Tier 4 Emission Compliance
- Resale/bid specification projects at distributors/dealers.
- In house generator testing at service dept.
- In the field for generator service contracts
- Rental department for start-up/commissioning

Load Bank Markets | Data Centers



Uninterruptable Power Supply (UPS) Systems, Generator(s) for Backup (Emergency) Power, Battery Strings, and Rack Servers for 24/7 Critical Data Storage.

Load banks used for testing:

- Generator
- UPS Systems
- Back up Battery String
- Commissioning

Load Bank Markets | Healthcare



Backup Power Generators for Emergency Power.

Reliable power is critical for all life saving equipment, but also for HVAC systems.

Load banks used for testing:

- Generator
- UPS Systems
- Compliance
 - National Fire Protection Association (NFPA)
 - American Society for Hospital Engineers (ASHE)
 - Joint Commission Accreditation of Healthcare Organizations
- Back up Battery String

Load Bank Markets | OEMs/Test Cells



Custom Engineered Load Banks for Specific Product Requirements.

Load banks used for Research & Development, Production and Quality Control testing:

- Generators
- Turbines
- Fuel Cells
- Inverters
- Batteries
- UPS
- Automotive
- Rotary UPS
- Welding

Load Bank Markets | Utilities



Substations and Transformers for Utility (Prime) Power Generation.

Load banks used for testing:

- Medium Voltage Load banks for off Grid Testing
- Harmonic Filters (tuned grid resistors)
- Code Compliance
- Utility Substations
- Water Treatment Facilities

Also an opportunity for **Neutral Grounding Resistors**

Load Bank Markets | Oil and Gas



Generators for Prime Power Applications for Offshore Platforms. Backup Generators for Onshore Pipeline Pumps.

Load banks used for testing:

- Generators 600V up to 15kV
- Supplemental Loading
- UPS Systems
- Back up Battery String

Load Bank Markets | Wind, Solar, Hydro



Load Banks Help Maintain Power to Desired Level.

These types of power generation produce unsteady output due to the uncontrollable nature of wind, the sun, and water.

Load banks used for testing:

- Turbines
- Commissioning
- Collection System (at full load)
- Steady and Unsteady Load Inputs
- Battery Capacity

Load Bank Safety

A Load Bank is an industrial test unit designed and manufactured with the latest safety features.

However, because the function of the Load Bank is to dissipate electrical energy, there are inherent dangers to operators and equipment.

Electrical energy is transformed into heat by the resistors. This heat must be removed from the Load Bank by the cooling fans/blowers.

- The Load Bank should never be used without the fan motor(s) operating. Inadequate cooling airflow will result in resistor elements causing overheating and a definite fire hazard.
- Do not bypass the airflow safety switch or exhaust over-temperature switch to prevent nuisance tripping.
- Never exceed the rated voltage as this will cause the Load Bank to overheat.
- DO NOT touch the top exhaust hood/duct or cover panel during operation.
- If the AIR FAILURE indicator light stays on for more than a few seconds, shut down the Load Bank, and do not operate the unit until the problem is corrected.
- It is always recommended to use PPE when installing and operating a load bank.



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Life Is On



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