

Rectifiers for Industrial Applications



Spang Power Electronics

Spang heavy-duty DC power supplies are designed to operate within harsh environments. They provide DC power for any industrial application including: mill duty cranes, electromagnets, ladles, plasma arc, synchronous motors, municipal transit, electrochemical and electrowinning applications.



*Cover: Regulated 1500 KW Crane Rectifier with Regeneration
Above: 360 KW Water Cooled Magnet Power Supply*

Unregulated & Regulated Rectifiers

Spang custom engineers rectifiers in both unregulated and regulated versions. Unregulated rectifiers are an economical way to obtain bulk DC power. Each system consists of a transformer and silicon diodes. The transformer converts the incoming voltage to the rectifier utilization voltage. Silicon diodes, located on the secondary of the transformer, convert the AC power to DC.

Spang regulated rectifiers also incorporate a thyristor (SCR) section to control the amount of voltage or current flowing to the load. Spang can design regulated rectifiers with either primary or secondary regulation. In a primary regulated system, thyristors are connected between the incoming voltage source and the transformer to control the amount of voltage to the isolation transformer. To control both the positive and negative half cycles, two thyristors are connected back to back on each phase. In a secondary regulated system, the incoming voltage is fed directly to the transformer. On the secondary side of the transformer, thyristors replace silicon diodes as they perform both rectification and regulation.

Spang unregulated and regulated rectifiers offer many features and options that enable you to precisely meet your DC power requirements.

COMPONENTS

Transformer

Dry Type Transformer

The Spang dry-type transformer converts incoming voltage to the rectifier utilization voltage. A UL approved insulation system allows up to 220°C operation. The primary and secondary coils are wound using electrolytically pure copper or aluminum. Spang transformer coils are vacuum/pressure impregnated with solventless polyester varnish. They are designed and mechanically braced to assure superior short circuit withstand strengths. The core is constructed with low loss, high quality, grain oriented M6 silicon steel laminations. The Spang dry-type isolation transformer has two taps at 2½% full capacity above and below normal taps to exactly match incoming AC line voltage. Water cooled designs are also available.

Transformer — Liquid Filled

Spang liquid filled transformers are filled with mineral oil and provide a 65°C rise insulation system. They are provided with copper or aluminum windings and are available in a range of 1000 KVA through approximately 10 MVA. All conform to applicable ANSI standards. Available options include:

- Stainless Steel Tank
- Lightning Arrestors
- Load Tap Changer
- Oil Preservation System
- Fans with Control Transformer
- Primary/Secondary Electrostatic Shielding
- Primary/Secondary Bushings
- Grounding Resistors
- Liquid Level Gauge
- Liquid Temperature Gauge
- Pressure/Vacuum Regulator
- Pressure Relief Device with Indication
- Silicone Filled
- Drain Valve with Sampling Device

High Voltage Transformers

Spang also manufactures transformers for high voltage applications. These applications typically require an additional step-down transformer to reduce the incoming voltage before feeding it to the rectifier-transformer. Spang's ability to manufacture high voltage transformers enables the user to minimize total investment by eliminating the need to purchase this additional transformer because the high voltage transformer is incorporated into the rectifier system.

Enclosure

A rigid (minimum 12 gauge) sheet steel panel and welded structural steel base protects the entire rectifier. It is a free standing, self-supporting structure. The enclosure is cleaned and primed to guarantee paint adhesion and finished with a corrosion resistant enamel. Available in NEMA 1, NEMA 2, and NEMA 12.

COMPONENTS AND SPECIFICATIONS

Unregulated Rectifiers

Silicon Diodes

Silicon diodes convert AC power to DC. They allow current to flow in one direction while impeding the flow in the opposite direction. Hermetically sealed diodes become completely impervious to external conditions and are able to operate in harsh environments and withstand very high temperatures. Surge suppression networks limit the reverse voltage across the diodes to a value within the peak reverse voltage (PRV) rating of the diode. The PRV protection is a minimum of three times the rated DC voltage.

Diodes can be mounted on either air-cooled or water-cooled heatsinks.

Input Voltage

230/460 Volts AC (high input voltages are also available).

Output Voltage

Up to 600 Volts DC (other output voltages available upon request).

Output Current

Through 30,000 Amperes (other output currents available upon request).

Power Factor

96% or greater from 25% to 100% at rated voltage.

Ripple

4.5% RMS AC ripple maximum at rated voltage and current.

Efficiency

96% at full load with rated input voltage.





Unregulated 500 KW Crane Rectifier with Regeneration



Unregulated 1500 KW 12-Pulse Crane Rectifier with Regeneration

COMPONENTS AND SPECIFICATIONS

Regulated Rectifiers

Thyristors (SCRs)

Thyristors (SCRs) provide regulation of the voltage or current. This section may be located either on the primary or secondary side of the transformer. Thyristors turn on at a point on the positive side of the AC sine wave. This controls the amount of voltage or current applied to the load.

Primary Regulation

In primary regulated systems, the thyristors are connected between the incoming voltage source and the transformer to control the amount of voltage to the isolation transformer. To control both the positive and negative half cycles, two thyristors are connected back to back on each phase. Thyristors are designed to be high voltage, low current devices. The current is lower on the primary side of the transformer and this allows a more compact power supply, greater operating efficiency and lower manufacturing costs. In a primary regulated system, the regulated AC voltage is fed to the isolation transformer which conveys the reduced voltage to diodes for rectification.

Secondary Regulation

The rectifier may also be designed to regulate voltage or current on the secondary side of the transformer. Incoming voltage is fed directly to the transformer. On the secondary side, thyristors replace diodes and perform both rectification and regulation. The secondary side generally has lower voltage and higher current. Secondary regulation is typically used in high voltage applications and provides maximum protection from voltage transients and electrical noise.

Thyristors can be mounted on either air-cooled or water-cooled heatsinks.

Silicon Diodes

In a primary regulated system, silicon diodes perform rectification. Silicon diodes allow current to flow in one direction while impeding the flow in the opposite direction. Hermetically sealed diodes become completely impervious to external conditions and are able to operate in harsh environments and withstand very high temperatures. Surge suppression networks limit the reverse voltage across the diodes to a value within the peak reverse voltage (PRV) rating of the diode. The PRV protection is a minimum of three times the rated DC voltage.

Diodes can be mounted on either air-cooled or water-cooled heatsinks.

Input Voltage

230/460 Volts AC (high input voltages are also available).

Output Voltage

Up to 600 Volts DC (other output voltages available upon request).

Output Current

Through 30,000 Amperes (other output currents available upon request).

Power Factor

Typically better than 90% when operating near full rated output.

Ripple

4.5% RMS AC ripple maximum at rated voltage or current.

Efficiency

Typically better than 95% at full load; with rated input voltage, typically between 96-97%.

Constant Voltage Control

Maintains voltage setpoint to within $\pm 0.5\%$ (of rated voltage) from 0 to 100% of rated voltage. Constant current control also available.



Water Cooled Electrowinning Rectifier, 20,000 ADC

Current Limit

Senses current and limits output to prevent the current from exceeding a preset level. Voltage limit also available.

Short Circuit Detection/Overcurrent Shutdown

Fuseless, fast-acting, solid-state overcurrent shutdown circuit provides load fault protection. The circuitry senses instantaneous peak current and interrupts power by removing the gate signals to the thyristors within 8.3 milliseconds if the adjustable trip point is exceeded. After three (3) seconds, the overcurrent shutdown automatically resets, ramping the thyristors back on. This circuitry continues to trip and reset until the fault is cleared. Manual reset is also available.

Lockout (Shutdown) Circuit

Terminals are provided for a dry contact closure to turn the unit off by removing the gate signals from the thyristors.

Firing Indication

LEDs provide a visual indication that the gate signals to the thyristors are present.

Meters and Controls

Automatic voltage control potentiometer
Automatic current control potentiometer

OPTIONAL FEATURES

6 or 12-Pulse Rectification

Spang industrial rectifiers are designed with either 6 or 12-pulse rectification. In regulated systems, the 6-pulse design may be used with either primary or secondary regulation, while the 12-pulse design requires secondary regulation.

6-Pulse Rectification

The 6-pulse is the most common and most economical design. The six thyristors or diodes can be designed in three different power circuits, depending on load current requirements: the 3-phase bridge, the 6-pulse star and the double wye with inter-phase transformer.

12-Pulse Rectification

Spang also offers the option of 12-pulse rectification. For high current applications, two bridges, connected in parallel, allow twice the current flow. The 12-pulse design is also used in high voltage applications. In this case, two bridges, connected in series, allow the devices to control a higher level of voltage.

The 12-pulse design also has some significant advantages over the 6-pulse design. As the rectification section converts the incoming AC waveform to DC, it creates a wave chopping effect. This effect causes input harmonics which reflect upstream into the power delivery system. When the power system supplying the rectifier also supplies other loads, these harmonics may adversely affect those loads. The 12-pulse configuration minimizes input harmonics.

The 12-pulse design also reduces output ripple. Ripple is the amount of AC sine wave still present in the rectified DC output.

The 12-pulse configuration may be designed with two power circuits: one transformer with a delta-wye secondary and an interphase transformer and; two transformers, each with a double wye secondary, and an interphase transformer.

Interphase Transformer

The Spang interphase transformer forces equal current sharing between both transformer secondaries.

Regeneration Control

In applications where the DC motor can rotate or reverse quickly, excessive back voltage can be generated across the rectifier. Without some means of dissipating the excess energy, the rectifier eventually becomes overloaded and fails. The regeneration package automatically senses this condition and connects a dissipating resistor bank in parallel with the load to absorb this power. When the regeneration ceases, power from the DC supply will automatically be converted to the load and the resistor bank drops out. Due to the substantial heat generated, the circuit is often furnished in its own ventilated cabinet. The regeneration circuit package includes a DC contactor, resistor bank, control relay and time delay relay.

Cooling

Forced Air Cooling

Forced air cooling is often used when the surrounding environment is relatively free of contaminants. Fans draw the air through a series of filtered openings in the rectifier enclosure and force it past the internal power supply components and through an exit typically located on the top of the power supply. If the ambient air contains corrosive vapor or particles, it may accelerate deterioration inside the power supply and reduce the efficiency and useful life of the rectifier.





220 KW Water Cooled Super Conductor Magnet Power Supply

Water Cooled System

The direct water cooling system overcomes the problems of forced air cooling systems. Water passes through the semiconductor heatsinks. A water cooled system is more compact than the forced air cooled system. In addition, multiple rectifiers can be placed closer together. If an adequate coolant source is not available, a closed loop system may be supplied. This ensures that the coolant source is of the proper temperature, conductivity and pH.

AC Circuit Breaker

The molded case circuit breaker provides line disconnect and primary overload and short circuit protection. The circuit breaker is interlocked to the electronics system to provide a three-second delay between breaker closing and thyristor conduction. It is also available with a shunt or undervoltage trip.

AC Contactor

The primary AC contactor provides remote control and isolation of input power in applications where frequent On-Off switching is required. It is supplied with On-Off pushbuttons and indicator lights mounted locally or on a remote panel.

Switchgear Options

- Fused Disconnect Switch
- Unfused Disconnect Switch
- High Voltage Circuit Breaker
- High Voltage Vacuum Breaker
- DC Switchgear

Trigger Fuse System

Trigger fuses are connected across each individual fuse and provide indication that a fuse has failed.

Choke

When operating in phased back condition, the output choke reduces input RMS current and minimizes high current spikes.

Fuse Failure Indicator

Lights located on the door indicate the loss of a fuse.

Load Disconnect

Knife switches or DC circuit breakers provide DC bus isolation. This option is desirable when more than one rectifier feeds a common bus.

L-C Filter

Reduces output ripple to a maximum of 1 to 2%.

Options for System Protection

Overtemperature

Temperature sensing devices are mounted on the semiconductor heatsinks and in the transformer coils. The sensors are interlocked with the input contactor to provide automatic shutdown of the rectifier before the operating temperature ratings of any components are exceeded.

Coolant Flow Switch

The coolant flow switch is interlocked with the control circuitry to inhibit rectifier output if the coolant flow is not present. An optional fault indicator provides visual indication of a blown fuse.

Leak Detector

Provides electronic detection of moisture in liquid cooled designs.

Programmable Logic Controller (PLC)

A PLC enables the user to automatically retrieve and set process profiles, quickly revise process parameters and monitor realtime data. The PC-based system can also centralize control of a number of rectifiers, collect and store process performance information and generate reports for trend analysis and statistical process control.

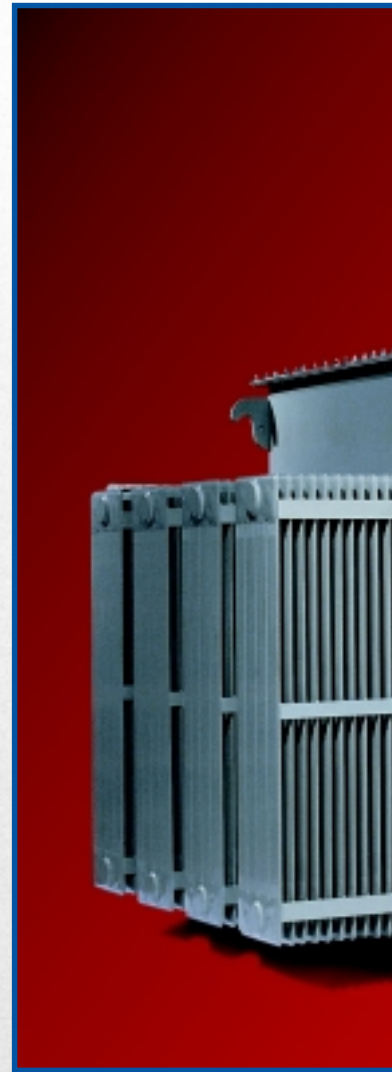
The computer integration can match your process requirements and investment plans. Configurations range from PLCs for control of logic functions and data acquisition of individual or multiple rectifiers to complete process or batch automation using host PC networks.

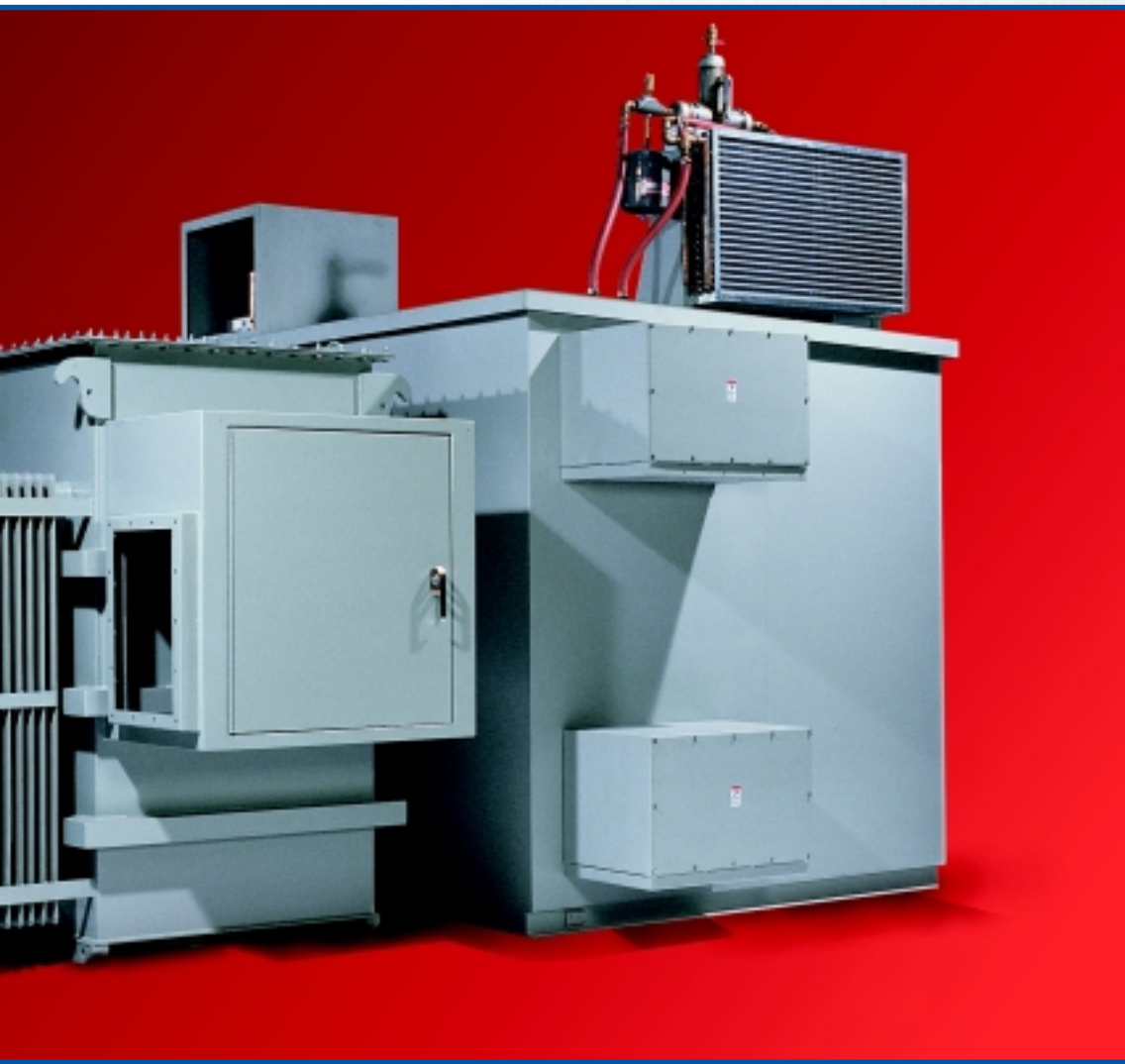
Other Optional Meters and Controls

- Ampere/Hour meters and controls
- Control Transformer with fuses
- Load Ammeter
- Load Voltmeter
- Power on Indicator Light

Remote Panel

Metering and controls may be mounted in or on a remote NEMA 12 panel.





1540 KW 12-Pulse Electrochemical Rectifier with Oil Filled Transformer

OPTIONAL FEATURES

Regulated Rectifiers

Adjustable Ramp

Ensures that the current will be applied to the load in a gradual manner.

Phase Loss Detection

With the loss of any incoming AC power phases, the unit automatically shuts off by inhibiting the gate signals to the thyristors. The unit is connected on the load side of the input fuses and the contact is wired to a terminal strip.

Imbalance Detector

Protects against distortions in the DC output caused by defective thyristors, cleared fuses, firing malfunctions, or loss of a diode bank. Under such a condition, the unit will automatically phase-back output power to a safe level.

Output Inhibit Circuit

I²t trigger fuses, protecting the diodes or secondary SCRs, are interlocked with the control circuitry to inhibit rectifier output if a fuse clears. This feature can be combined with the fuse failure indicator option.

Spang Power Electronics engineers rectifiers for reliability, energy efficiency and extended life. Spang rectifiers incorporate more than 35 years of experience, research and development, and application experience. All manufacturing and engineering, from the component level to final system integration, is performed in our modern 100,000-square-foot plant in Sandy Lake, Pennsylvania and at our headquarters in Mentor, Ohio.

Spang offers a complete range of support services including application engineering, technical assistance and consultation, start-up supervision, operator training, preventative maintenance contracts and fast worldwide field service.

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