

# CATHODIC PROTECTION RECTIFIER SPECIFICATION

## C.P. SENTINEL AUTOMATIC TYPE



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**C.P. SENTINEL AUTOMATIC CATHODIC PROTECTION RECTIFIER SPECIFICATION**

This specification shall outline the features of the Integrated Rectifier Technologies, Inc. C.P. Sentinel Automatic type of Cathodic Protection Rectifiers.

## **1.0 GENERAL**

- 1.1 The C.P. Sentinel Automatic rectifiers are manufactured in accordance with the following applicable standards:
  - a) Canadian Standards Association (CSA) Specifications:
    - C 22.2 / No. 0 – General Requirements
    - C 22.2 / No. 66 – Specialty Transformers
    - C 22.2 / No. 94 – Special Purpose Enclosures
    - C 22.2 / No. 107 – General Use Power Supplies
  - b) National Electrical Manufacturers Association (NEMA) Standard No. 250.
  - c) Canadian Electrical Code (CEC) & National Electrical Code (NEC).
- 1.2 The rectifiers are designed to meet or exceed the National Association of Corrosion Engineers (NACE) criterion for Cathodic Protection use.
- 1.3 The C.P. Sentinel Automatic rectifiers are available with a 115, 208, 230, 460, 600 or dual 115/230, 230/460 Volt AC input at an input frequency of 60 Hz. Other input voltages and/or a 50 Hz input frequency may be optionally available. Both single and three-phase inputs are available. The rectifiers are designed to provide rated DC output with an AC input at 5% below the nominal level specified and to accept an AC input of 10% above nominal AC input voltage without damage to any rectifier components.
- 1.4 The rectifiers are designed to operate in an ambient range of –40°C (-40°F) to +45°C (113°F). An extended temperature range is optionally available.

## **2.0 ENCLOSURE**

- 2.1 The C.P. Sentinel Automatic rectifiers are constructed in the IRT Advantage line of enclosures with either air-cooled or oil-cooled type construction.
- 2.2 Advantage air-cooled line construction.
  - 2.2.1 The Advantage air-cooled line enclosures are constructed in accordance with CSA requirements for outdoor weatherproof, “Type 3R” enclosures. This shall be equivalent to NEMA 3R standards.
  - 2.2.2 The Advantage air-cooled line enclosures are constructed from 12 gauge wiped coat, mill galvanized steel and finished with 3-5 mils of white, fusion bond, polyester powder paint. The enclosures are vented to allow for natural air convection and all openings shall be screened against insects and debris with perforated, 18-gauge stainless steel plate. The enclosures are supplied with suitably sized wall / pole mounting channel brackets and also, suitably sized conduit knockouts (on the bottom front and rear) to allow for connection of AC and DC field cabling. The front door of the enclosure is hinged on the left side, easily removable without tools, and has a heavy duty, lockable draw latch on

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the right side that will accept a maximum 3/8" (9.5mm) padlock. The draw latch is constructed of Series 300 stainless steel. The A-4 size enclosure is supplied with two front doors with two draw latches. For improved accessibility, the enclosure is supplied with left and right side access doors that are hinged at the rear and also easily removable without tools. The enclosures are designed to allow for a single, easily removable inner rectifier frame assembly. All enclosure fasteners, hinges and latches are fabricated from Series 300 stainless steel.

- 2.2.3 All Advantage air-cooled line enclosures are available with optional base (floor) mounting stands. Base mounting stands are required for size A-4 and larger enclosures. Standard base mounting stand height is 12" with other heights available on special request.
  - 2.2.4 The Advantage air-cooled line enclosures are optionally available with 11 gauge steel construction. These enclosures are supplied with a hot-dipped galvanized finish only. This hot-dipped galvanized finish is in accordance with ASTM 123 requirements.
- 2.3 Advantage line oil-cooled construction.
- 2.3.1 Advantage oil-cooled line enclosures are constructed in accordance with CSA requirements for outdoor weatherproof, "Type 4" enclosures. This shall be equivalent to NEMA 4 standards. Enclosures constructed in accordance with "Type 4X" or "Type 8" (NEMA 4X or NEMA 8) are optionally available.
  - 2.3.2 The Advantage oil-cooled line enclosures (tanks) are constructed from 11 gauge steel and finished with 2-3 mils of protective primer and 3-5 mils of white, fusion bond, polyester powder paint. The enclosures are constructed with 4.0" (101.6mm) channels welded to the bottom of the tank for floor or pad mounting and four lifting eyes, with provision for 1.25" (31.75mm) lifting hooks, to allow for balanced lifting of the enclosure. A 1" NPT hole is supplied on the bottom of the right side of the tank for draining of the rectifier cooling oil. Suitably sized conduit knockouts are supplied on the upper left side of the tank to allow for connection of AC and DC field cabling. The lid of the oil-cooled tank is hinged and secured by a minimum of two heavy duty, lockable draw latches that will accept a maximum 3/8" (9.5mm) padlock. The draw latches are constructed of Series 300 stainless steel. All enclosure fasteners and hinges are fabricated from Series 300 stainless steel. The enclosures are designed to allow for an inner rectifier / transformer frame assembly, which is also supplied with a minimum of four lifting eyes to allow for balanced removal. A separately removable diode bridge assembly is optionally available to allow for maintenance without the need to lift the rectifier / transformer frame out of the oil compartment.
  - 2.3.3 For areas where it is not preferred or practical to open the oil compartment for rectifier meter checks, an instrument end-housing, mounted to the left side of the tank, is optionally available. If an instrument end-housing is supplied, the AC & DC conduit knockouts are supplied in the bottom of the end-housing. Other optional features are available with the Advantage oil-cooled line such as

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upgraded tank lid gasket (to provide an improved dust seal), oil filler spout, oil drain valve, oil level gauge, oil temperature gauge, and desiccant breather.

- 2.3.4 The oil-cooled line enclosures are also optionally available with a hot-dipped galvanized finish or marine grade aluminum construction. Enclosures with a hot-dipped galvanized finish are completed in accordance with ASTM 123 requirements
- 2.3.5 The client or CP system installer is responsible for the filling of the rectifier tank with suitable cooling oil prior to being placed into service. Only high quality insulating oil specified for use with electrical transformers should be used. Preference should be given to biodegradable oils such as Cooper Power Systems *Envirotemp FR3* or the equivalent.
- 2.4 The C.P. Sentinel Automatic rectifiers are also optionally available in the IRT Benchmark line enclosures or other non-standard air-cooled type enclosures.

### **3.0 CONTROL METHOD**

- 3.1 The C.P. Sentinel Automatic rectifiers utilize the IRT **VI-ENTRY™** for Current and Voltage control or the **SENTRY CONTROLLER™** for Current, Voltage, and Reference Electrode automatic modes of operation.
- 3.2 The C.P. Sentinel Automatic rectifiers are designed for operation in the following modes:
  - 3.2.1 **CONSTANT VOLTAGE MODE:** In this mode, the rectifier control circuitry automatically adjusts the rectifier output to maintain the DC output voltage at the operator-adjusted level. In this mode, the current setting determines the current limit.
  - 3.2.2 **CONSTANT CURRENT MODE:** In this mode, the rectifier control circuitry automatically adjusts the rectifier output to maintain the DC output current at the operator-adjusted level. In this mode, the voltage setting determines the voltage limit.
  - 3.2.3 **IR-DROP FREE POTENTIAL MODE (optional mode):** In this mode, the rectifier control circuitry automatically adjusts the rectifier output to maintain the Structure-to-Reference Electrode potential at the operator-adjusted level. The Structure-to-Reference Electrode potential is maintained free of error as the control circuit monitors the potential when there is no current flow in the anode-cathode circuit. IR-Drop Free Potential mode is available on non-filtered, single-phase rectifiers only. In this mode, the current setting determines the current limit and the voltage setting determines the voltage limit.
  - 3.2.4 **“ON” POTENTIAL MODE (optional mode):** In this mode, the rectifier control circuitry automatically adjusts the rectifier output to maintain the Structure-to-Reference Electrode potential at the operator-adjusted level. However, the Structure-to-Reference Electrode potential is maintained while there is current

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flow in the anode-cathode circuit. In this mode, the current setting determines the current limit and the voltage setting determines the voltage limit.

- 3.2.5 **MANUAL MODE (optional mode):** In this mode, the Silicon Controlled Rectifier (SCR) devices in the rectifier bridge are gated “ON” to allow them to operate as conventional diode devices. This permits the operator to manually control the rectifier output by adjusting the secondary taps on the transformer.
- 3.3 C.P. Sentinel Automatic rectifiers supplied with the IR-Drop Free or “ON” Potential control modes provide full galvanic isolation of the Reference Electrode and Structure Sense inputs.
- 3.4 C.P. Sentinel Automatic rectifiers incorporate the IRT **VI-ENTRY™** or **SENTRY CONTROLLER™** innovative “anti-spiking” output current interrupt technology to minimize or eliminate current over-shoot during field interrupting of the rectifier.

#### **4.0 C.P. SENTINEL CONTROL ACCURACY**

- 4.1 The C.P. Sentinel Automatic rectifiers maintain the DC output controlled parameters as follows:
  - 4.1.1 **CONSTANT VOLTAGE MODE:** Voltage is maintained within  $\pm 2\%$  of the operator setting from zero to rated rectifier output current and with AC input voltage variations of  $-5\%$  to  $+10\%$  of nominal.
  - 4.1.2 **CONSTANT CURRENT MODE:** Current is maintained within  $\pm 2\%$  of the operator setting from zero to rated rectifier output voltage and with AC input voltage variations of  $-5\%$  to  $+10\%$  of nominal.
  - 4.1.3 **IR-DROP FREE POTENTIAL MODE (optional mode):** The Structure-to-Reference Electrode potential is maintained within  $\pm 5$  millivolts of the operator setting from zero to rated rectifier output and with AC input voltage variations of  $-5\%$  to  $+10\%$  of nominal.
  - 4.1.4 **“ON” POTENTIAL MODE (optional mode):** The Structure-to-Reference Electrode potential is maintained within  $\pm 5$  millivolts of the operator setting from zero to rated rectifier output and with AC input voltage variations of  $-5\%$  to  $+10\%$  of nominal.

#### **5.0 MAIN TRANSFORMER**

- 5.1 The C.P. Sentinel Automatic rectifiers are equipped with a full isolation type transformer.
- 5.2 The transformer is designed to operate properly at 115% of the specified rated output to allow for reserve capacity.
- 5.3 The main transformer is equipped with separate, isolated primary and secondary windings. The transformer windings are constructed from heavy polythermaleze (HPTZ) insulated magnetic wire with a minimum cross sectional area of 800 circular-

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mils per ampere of rated current. The transformer core is constructed from interleaved, "E-I" type, grain-oriented steel laminations for maximum permeability. For transformers utilizing 29 gauge laminations, a design calculation for a maximum flux density of 13,000 gauss is used. For transformers utilizing 26 gauge laminations, a design calculation for a maximum flux density of 11,000 gauss is used. Maximum core losses are limited to 0.7 watts per pound or less. The transformer efficiency shall be no less than 94% and voltage regulation from a "no load" to a "full rated load" condition shall not exceed 5%. The transformer core and coil are constructed from materials with a Class "H" (180°C) operation rating. The transformer lead wires are sized for a minimum cross sectional area of 500 circular-mils per ampere of rated current. The transformer lead wires are silver brazed to the coil magnet wire, taped, and covered with Class "H" silicon impregnated sleeving.

- 5.4 After fabrication, the transformer shall successfully pass a dielectric strength test, as per CSA Standard requirements, between the primary and secondary windings and between each winding and the lamination core.
- 5.5 The transformer dielectric and thermal properties are further enhanced by dipping in a thermo-setting varnish (Class "H") until the entire body of the transformer is saturated. The transformer is then oven baked for a suitable period until such time that the varnish coating has hardened to provide a suitable environmental seal.

## **6.0 INSTRUMENT PANEL**

- 6.1 The instrument panel for the C.P. Sentinel Automatic rectifiers with a rated DC output of 100 amperes and less is constructed from a minimum of 0.25" NEMA Grade "XX" laminated phenolic, rated for Class "B" (105°C) operation. Minimum 0.187" phenolic may be used for instrument panels in C.P. Sentinel Automatic rectifiers constructed in Benchmark or non-standard type enclosures. For rectifiers with a rated DC output in excess of 100 amperes, the instrument panel is constructed from a minimum of 0.25" Spaulding Grade "UTR" (or equivalent) fiberglass reinforced laminate, rated for Class "F" (155°C) operation.

## **7.0 RECTIFYING DEVICES**

- 7.1 The rectifier circuit consists of Silicon Controlled Rectifier (SCR) and silicon diode devices arranged into a full wave bridge configuration. The rectifier bridge devices are sized for approximately 200% of the nominal current through each device at rated rectifier output. All bridge devices are sized for a minimum Peak Inverse Voltage (PIV) rating of 300% of the voltage impressed on each device, or 600 volts, whichever is greater. Bridge devices with a higher PIV rating are available on request.
- 7.2 The rectifier bridge device(s) are mounted to a suitable sized heatsink(s). The heatsinks are fabricated from aluminum, finished in RoHS (Restriction of Hazardous Substances) compliant, clear chromate finish to enhance the thermal transfer of the heat generated by the diode to the ambient air. All heatsinks are sized to ensure that the case temperatures of the diodes do not exceed 100°C at rated ambient and rated rectifier DC output. The heatsink assemblies are constructed to allow for proper diode cooling via natural air convection. Fan cooling is not permitted.

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- 7.3 The rectifying devices are constructed into a modular assembly to allow for ease of any possible field maintenance.
- 7.4 For ambient temperatures above 45°C, all bridge devices are oversized as required and in accordance with manufacturers design recommendations.

## **8.0 MONITORING COMPONENTS**

- 8.1 The C.P. Sentinel Automatic rectifiers are constructed with two continuously reading analog meters for monitoring of the rectifier DC output voltage and current. The meters are typically a 3.5" rectangular type with a scale length of 2.875". Meter scales are of a metallic or plastic type and are mechanically affixed to the meter (adhesive paper type scales are not acceptable). The standard metering utilized is the Yokogawa Model 260 Series (or equivalent) with a 50mV full-scale-deflection (FSD) utilizing a taut-band type movement with "four-to-one swamping". This means that the internal meter resistance is comprised of 25% coil winding resistance and 75% fully temperature compensated dropping resistor resistance, which provides for superior temperature range performance. The taut-band type movement allows for greater meter sensitivity and improved shock resistance. The metering accuracy shall be  $\pm 2\%$  of FSD, in accordance with ANSI C39.1, with a maximum variation of 0.5% over a range from -20 to 65°C. The metering scales are selected such that the rated output indicator (red-line or shading) is within a range of 70% – 95% of the FSD of the meter scale.
- 8.2 C.P. Sentinel Automatic rectifiers with the optional Potential Mode of control are also equipped with an additional meter, as described above, for monitoring the Structure-to-Reference Electrode potential and the desired set-point potential. This Potential Meter is scaled for -100 to -2600 millivolts and is typically referenced to a Copper/Copper-Sulfate (CuSO<sub>4</sub>) Reference Electrode.
- 8.3 Optional digital metering is available for certain applications requiring improved accuracy and resolution. The digital meters utilized are KNS Model "DMO"-series (or equivalent) with a meter accuracy of 0.1%  $\pm 2$  digits with a sample rate of 3.4 per second. These meters shall provide a 3.5 digit display and 0.56" high intensity LED (light emitting diode), daylight readable numerals.
- 8.4 For applications where the rectifier is required to have multiple DC output circuits, metering switches are utilized. The switches are of the "toggle" or "rotary" type, as required, and are environmentally enclosed against dust. The switches are designed to allow for a duty life in excess of 25,000 operations. For areas where the rectifier will be subject to a particularly corrosive or gaseous atmosphere, it is not recommended to use meter switches unless all connections are soldered and optional, completely sealed switches are utilized.
- 8.5 The rectifier ammeter receives a millivolt input from a "block" style shunt resistor located on the front of the instrument panel. The standard shunt utilized is a Holloway "SW" type with an accuracy of 0.25%. The shunt is clearly marked with the current and millivolt rating.

## **9.0 PROTECTIVE DEVICES**

- 9.1 C.P. Sentinel Automatic rectifiers are constructed with a fully magnetic AC input circuit breaker to provide "OFF-ON" control, short-circuit protection, and input overload protection. The circuit breaker is of the manually reset type and is supplied with 1 pole per line of AC power input. The circuit breaker has a time delay rating sufficient to avoid false tripping due to transformer in-rush current or other minor transients. The circuit breaker is sized for the next industry standard current rating above the maximum AC input current rating of the rectifier. For dual input type rectifiers, preference will be given to the highest input load condition (i.e. lowest input voltage).
- 9.2 The C.P. Sentinel Automatic rectifiers are typically constructed with dual time-lag type fusing located in the AC secondary of the transformer. This fusing provides protection for the rectifier components against output short circuit or overload conditions. The fusing is sized to allow for proper rectifier operation up to 110% of rated output. For single-phase input rectifiers, a fuse is installed in one line of the AC secondary and for three-phase AC input rectifiers; fuses are installed in two lines of the AC secondary. In all instances, a spare fuse shall be supplied for each fuse utilized in the rectifier.
- 9.3 The C.P. Sentinel Automatic rectifiers are protected against lightning and other surges by Metal Oxide Varistor (MOV) devices. The rectifier AC input is protected by a high energy MOV arrestor with a minimum extreme surge duty rating of 13 KA, based on a 8x20 $\mu$ Sec. wave, and an AC voltage rating that corresponds to the nominal AC input rating of the rectifier shall be used. The rectifier DC output is protected by a high energy MOV arrestor with a minimum extreme surge duty rating of 13 KA, based on a 8x20 $\mu$ Sec. wave, and a DC voltage rating as close as practical to the maximum peak voltage output rating of the rectifier. The DC surge arrestor is sized such that it conducts the surge current and clamps the transient voltage at a level below the PIV rating of the diodes. Optional 3-terminal DC arrestors are available to provide protection against rectifier DC(+) to Ground and DC(-) to Ground surges as well. The bridge diodes are protected from surges by a disk style MOV with a minimum extreme surge duty rating of 6.5 KA, based on a 8x20 $\mu$ Sec. wave, across the AC input to the bridge.

## **10.0 ELECTRICAL CONNECTIONS**

- 10.1 The AC input terminals for the C.P. Sentinel Automatic rectifiers are suitably sized studs or a terminal block typically located on a phenolic panel on the lower right side of the unit frame. The AC input terminals are clearly labeled to indicate the location for the input wire connection and the rating of the AC input for the rectifier. Additional terminals are provided for dual AC input type units to allow for proper configuration of the AC input. A suitably sized electrical barrier is installed over the AC input terminals to prevent accidental contact with AC line voltages and is fitted with a warning label.
- 10.2 The DC output terminals for the C.P. Sentinel Automatic rectifiers are compression type lug terminals suitably sized for the rated DC output current of the rectifier. Non-standard size lug terminals may be optionally requested. The DC terminals are located on the lower front of the instrument panel and typically labeled as "ANODE DC(+)" and "STRUCTURE DC(-)".



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- 10.3 The rectifier is equipped with a compression type lug terminal for electrical grounding purposes located on the rectifier inner frame near the AC input terminals. The lug terminal is typically sized for #4 - 14 AWG cable.
- 10.4 All electrical wiring within the rectifier is CSA Type TEW wire with a temperature rating of 105°C or Type Exane cable with a temperature rating of 110°C, as the application warrants. The wire is sized as per the manufacturers recommendations for the maximum current through the wire.
- 10.5 All electrical hardware used within the C.P. Sentinel Automatic rectifiers is copper or brass with an electroless nickel-plating for superior atmospheric corrosion protection. All electrical connections utilize the "double-nut" method of fastening resulting in all electrical connection points being compressed between two nut / lock washer assemblies. No electrical connections will rely on the compression properties of the panel material to maintain a secure connection. All electrical studs and connection bars are suitably sized for the maximum rated current through them.

## **11.0 DOCUMENTATION & LABELING**

- 11.1 The rectifier shall be provided with a permanently imprinted nameplate with the following information:
  - a) Manufacturer Name
  - b) Model Designation
  - c) Serial Number
  - d) AC Input Voltage
  - e) AC Input Current
  - f) AC Input Frequency / Phase
  - g) Rated DC Output Voltage
  - h) Rated DC Output Current
  - i) Maximum Operating Ambient (°C)
  - j) Enclosure Type
- 11.2 The components on the front of the instrument panel are identified via silk-screening or by 1/16" lamicoïd (plastic laminate), adhesive type labels with white lettering on a black background. For rectifiers that are to be installed in a high humidity or high temperature environment, lamicoïd labels are mechanically affixed via stainless steel screws or drive screws.
- 11.3 Each rectifier is supplied with a comprehensive data package, enclosed in a waterproof envelope and placed in a document holder pocket on the inside of the enclosure door. The data package includes a manual with details on installation, general operation, maintenance, and troubleshooting tips. A detailed electrical schematic and a parts / data page are also provided. Formalized rectifier test results (detailed below) may be optionally requested for inclusion in the data package.

## **12.0 TESTING AND QUALITY CONTROL**

- 12.1 The main transformer in each C.P. Sentinel Automatic rectifier is subject to and has successfully passed the following electrical performance tests prior to installation into the rectifier unit.
- a) Excitation current and no-load secondary voltage.
  - b) Voltage, current, and conversion efficiency at rated load.
  - c) Voltage, current, and conversion efficiency at 115% of rated load.
- 12.2 Each rectifier is thoroughly mechanically inspected; both during and after the manufacturing process, to ensure that the specification parameters indicated previously have been adhered to. Any discrepancies are documented, reviewed and corrected prior to electrical testing. Overall workmanship quality is also reviewed.
- 12.3 Each rectifier is subject to dielectric strength testing as per CSA Standard requirements and successfully passes this testing prior to further electrical testing.
- 12.4 Each rectifier is subject to and successfully passes the following electrical performance tests at rated DC output prior to release for final packaging.
- a) AC input voltage and current.
  - b) Apparent power, effective power, & power factor.
  - c) DC output voltage, current, wattage, and ripple voltage.
  - d) Overall conversion efficiency.
  - e) Rectifier output control meets or exceeds the performance characteristics indicated in Section 4: C.P. SENTINEL CONTROL ACCURACY.
- 12.5 Each rectifier meter is checked for calibration accuracy to ensure the specifications indicated previously have been met.
- 12.6 After installation into the required enclosure, the rectifier is subject to a final overall inspection including:
- a) Documentation and labeling.
  - b) Overall construction.
  - c) Protective barriers.
  - d) Adherence to the general specification and customer specific requirements.