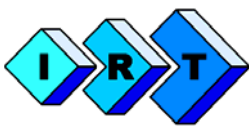


# CATHODIC PROTECTION RECTIFIER SPECIFICATION

## C.P. SENTINEL AQUA-LINE



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This specification shall outline the features of the Integrated Rectifier Technologies, Inc. C.P. SENTINEL Aqua-Line Cathodic Protection Rectifiers.

## **1.0 GENERAL**

- 1.1 The C.P. SENTINEL Aqua-Line 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 Aqua-Line rectifiers are available with a 115, 208, 230 or 115/230 Volt AC input at an input frequency of 60 Hz. 50 Hz input frequency may be optionally 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  $-40^{\circ}\text{C}$  ( $-40^{\circ}\text{F}$ ) to  $+50^{\circ}\text{C}$  ( $122^{\circ}\text{F}$ ). An extended temperature range is optionally available.

## **2.0 ENCLOSURE**

- 2.1 The C.P. SENTINEL Aqua-Line rectifiers are constructed in NEMA 4X, FRP fiberglass enclosure for natural air-cooled construction.
- 2.2 NEMA 4X, FRP fiberglass enclosure construction.
  - 2.2.1 The C.P. SENTINEL Aqua-Line air-cooled enclosures are constructed in accordance with CSA requirements for outdoor sealed, weatherproof, "Type 4X" enclosures. This shall be equivalent to NEMA 4X standards.
  - 2.2.2 The C.P. SENTINEL Aqua-Line enclosures are constructed from hot compression molded fiberglass reinforced polyester material (FRP). Color shall be light grey. Ultraviolet resistant SOLARGUARD™ FRP enclosures are optionally available. Color for the SOLARGUARD™ FRP enclosures shall be white. Enclosures shall meet UL94-5V flammability rating. Enclosures are supplied with top and bottom mounting flanges suitable for wall or pole mounting. The front door of the enclosure is hinged on the left side, and is equipped with two lockable draw latches on the right side that will accept a maximum 5/16" (8.0mm) padlock. All enclosure fasteners are fabricated from Series 300 stainless steel.

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- 2.2.3 All C.P. SENTINEL Aqua-Line enclosures are constructed with "Touch-Safe" hinged instrument panel. Operator controls, instrumentation, alarms and fusing are segregated from chassis mounted components. Instrument panel constructed from 0.125 fusion bond powder coated aluminum, with durable silk-screened labeling. Instrument panel is secured shut by two, captive thumb screws, fabricated from Series 300 stainless steel.
- 2.2.4 All C.P. SENTINEL Aqua-Line enclosures are constructed with lift-out removable chassis, fabricated with 10 gauge formed aluminum. Chassis is finished in 3-5 mils fusion bond polyester powder paint. Chassis is secured to FRP enclosure by four Series 300 stainless steel screws with lock washers.
- 2.2.5 Optionally available NEMA 4X rated enclosures fabricated from 14 gauge satin coat galvanized steel finished in 3-5 mils of fusion bond polyester powder paint; or alternately, Series 300 stainless steel are available.

### **3.0 CONTROL METHOD**

- 3.1 The C.P. SENTINEL Aqua-Line rectifiers utilize the IRT **SENTRY CONTROLLER™** for all automatic modes of operation.
- 3.2 C.P. SENTINEL Aqua-Line rectifiers are designed for the following operational 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:** 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 flow in the anode-cathode circuit. In this mode, the current setting determines the current limit and the voltage setting determines the voltage limit.

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- 3.2.5 **MANUAL 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 Aqua-Line rectifiers supplied with the IR-Drop Free or “ON” Potential control modes provide full galvanic isolation of the Reference Electrode and Structure Sense inputs. Input impedance is greater than 20 megohms.
- 3.4 C.P. SENTINEL Aqua-Line rectifiers incorporate the IRT **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 AQUA-LINE CONTROL ACCURACY**

- 4.1 C.P. SENTINEL Aqua-Line rectifiers maintain the DC output controlled parameters as follows:
- 4.1.1 **CONSTANT VOLTAGE MODE:** Voltage is maintained within  $\pm 1\%$  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  $\pm 1\%$  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:** 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  $\pm 15$  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 C.P. SENTINEL AQUA-LINE CONTROL SETTINGS AND MODE STATUS**

- 5.1 The C.P. SENTINEL Aqua-Line rectifiers are equipped with 20-turn potentiometers for setting the following rectifier output parameters:
- 5.1.1 **RECTIFIER OUTPUT VOLTAGE:** Voltage mode/limit operation is indicated by the red LED indicator located adjacent the Voltage setting potentiometer.
- 5.1.2 **RECTIFIER OUTPUT CURRENT:** Current mode/limit operation is indicated by the green LED indicator located adjacent the Current setting potentiometer.
- 5.1.3 **STRUCTURE-REFERENCE CELL POTENTIAL:** Rectifier Structure-Reference electrode Potential is set by the 20-turn potentiometer in conjunction with the Press-to-Set/Actual” selector switch. Potential mode operation is indicated by the yellow LED indicator located adjacent the Potential setting potentiometer.

## 6.0 MONITORING COMPONENTS

- 6.1 The C.P. SENTINEL Aqua-Line rectifiers are equipped with individual digital meters for monitoring rectifier voltage, current and potential readings.
- 6.2 The C.P. SENTINEL Aqua-Line rectifiers utilize the KNS Instruments "DMO" Series (or equivalent) high intensity LED (Light Emitting Diode) panel meters. Meter accuracy of 0.2%  $\pm$ 2 digits with a sample rate of 3.3 samples per second. Meters are 3.5-digit display and 0.56" (14.2 mm) high intensity numerals. Full scale readings are: Voltage  $\pm$ 199.9 Volts; Current  $\pm$ 19.99 Amperes; Potential  $\pm$ 1999 Millivolts
- 6.3 C.P. SENTINEL Aqua-Line rectifiers are equipped with 0.093 (2.36 mm) meter test jacks for user verification of digital meter readings from the front panel.
- 6.4 For rectifiers equipped with multiple DC output circuits, metering switches are utilized. The switches are of the "toggle" 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.
- 6.5 C.P. SENTINEL Aqua-Line rectifiers are equipped with a momentary, "press-to-read" toggle switch to monitor the desired "set" potential on the potential meter. Upon release of the toggle, the switch will display the "Actual" Structure – Reference Cell potential, free of IR-Drop error.
- 6.6 C.P. SENTINEL Aqua-Line rectifiers are equipped with a toggle switch to select either Reference Cell #1 or Reference Cell #2 for purposes of control and monitoring.
- 6.7 The rectifier ammeter receives a millivolt input from a "block" style shunt resistor located on the rectifier chassis. The rectifier shunt provides an output of 10 Millivolts per ampere of DC current. The shunt is a Holloway type "SW" block shunt with an accuracy of  $\pm$ 0.25%. The shunt is clearly marked with the current and millivolt rating.

## 7.0 MAIN TRANSFORMER

- 7.1 The C.P. SENTINEL Aqua-Line rectifiers are equipped with a full isolation type transformer.
- 7.2 The transformer is designed to operate properly at 115% of the specified rated output to allow for reserve capacity.
- 7.3 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-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 11,500 gauss is used. Maximum core losses are limited to 0.7 watts per pound or less. The transformer efficiency shall be no

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less than 95% 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.

- 7.4 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.
- 7.5 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.

## **8.0 RECTIFICATION & CONTROL DEVICES**

- 8.1 The rectifier circuit consists of Silicon Controlled Rectifier (SCR) and silicon diode devices arranged into a full wave bridge configuration, utilizing AC phase control for regulation. The rectifier bridge devices are constructed into a single molded module, which are sized for approximately 200% of the nominal current through each device at rated rectifier output. All bridge modules 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 modules with a higher PIV rating are available on request.
- 8.2 The rectifier bridge modules 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.
- 8.3 Rectifying modules are constructed to allow for ease of any possible field maintenance.

## **9.0 PROTECTIVE DEVICES**

- 9.1 C.P. SENTINEL Aqua-Line 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 C.P. SENTINEL Aqua-Line 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 bridge components against output short circuit or overload conditions.

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The fusing is sized to allow for proper rectifier operation up to 100% of rated output. For single-phase input rectifiers, a fuse is installed in one line of the AC secondary.

- 9.3 C.P. SENTINEL Aqua-Line rectifiers are also equipped with high speed semiconductor fuses located in the DC output leg of the rectifier. 100% spare fuses are supplied.
- 9.4 C.P. SENTINEL Aqua-Line 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 C.P. SENTINEL Aqua-Line rectifiers is a 85-Ampere, 600 VAC. terminal block located on a the rectifier chassis. The AC input terminals are clearly labeled to indicate the location for the input wire connection and the rating of the AC voltage input for the rectifier. Terminal blocks are designed to prevent accidental contact with AC line voltages and are fitted with a warning label. Terminal block accommodates a wire size range of #4 - #18 AWG.
- 10.2 DC output lugs for the C.P. SENTINEL Aqua-Line rectifiers are compression type terminal blocks, rated at 85 amperes. The DC terminal block is located on a the rectifier chassis and labeled as "ANODE1" and "STRUCT.". Optionally, an extra lug is provided on dual Positive circuit units labeled "ANODE2".Terminal block accommodates wire size range of #4 - #18 AWG.
- 10.3 The rectifier is equipped with a compression type lug terminal for electrical grounding. The electrical grounding lug is part of the AC input terminal block.
- 10.4 The rectifier is equipped with 5-Way binding posts for field hookup of Reference Cell & Structure sensing leads. Provision for two Reference Cell inputs is provided.
- 10.5 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.
- 10.6 All electrical hardware used within C.P. SENTINEL Aqua-Line rectifiers are 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

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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 is equipped 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 Components on the front of the instrument panel and chassis 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 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.

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- 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 outlined in Section 4: *C.P. SENTINEL AQUA-LINE 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.