

CATHODIC PROTECTION RECTIFIER SPECIFICATION

ADVANTAGE OIL-COOLED LINE



INTEGRATED RECTIFIER TECHNOLOGIES, INC.

15360 – 116 Avenue, Edmonton, Alberta, Canada T5M 3Z6

Phone: (780) 447-1114 Fax: (780) 454-0004 Email: admin@irtrectifier.com

Website: www.irtrectifier.com

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ADVANTAGE OIL-COOLED LINE CATHODIC PROTECTION RECTIFIER SPECIFICATION

This specification shall outline the features of the Integrated Rectifier Technologies, Inc. Advantage Oil-Cooled line of Cathodic Protection Rectifiers.

1.0 GENERAL

- 1.1 The Advantage 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 Advantage line rectifiers are available with a 115, 230, 460, 115 / 230, 230 / 460, or 600 Volt AC input at an input frequency of 60 Hz. Other inputs may be optionally available. Both single and three-phase inputs are available. The rectifier shall be designed to provide rated DC output with an AC input at 5% below the nominal level specified and such that an AC input of 10% above nominal AC input voltage shall not damage any rectifier components.
- 1.4 The rectifiers are designed to operate in an ambient range of -50°C (-58°F) to $+45^{\circ}\text{C}$ (113°F). An extended temperature range may be optionally requested.

2.0 ENCLOSURE

- 2.1 The 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.
- 2.2 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 zinc dichromate plated steel or optionally, of Series 300 stainless steel. All enclosure fasteners are fabricated from 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.

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- 2.3 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 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.
- 2.4 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.

3.0 CONTROL METHOD

- 3.1 The Advantage oil-cooled rectifiers are designed for manual, Constant Voltage control via 25 steps (5-Coarse & 5-Fine) of transformer secondary tap adjustment. A larger number of tap adjustment steps is optionally available. The tap adjustment method for the Advantage oil-cooled line of rectifiers shall be via tap link bars, normally located inside the oil compartment but above the oil level. For lower amperage units, the tap link bars are secured via thumb knobs that allow for easy adjustment without the need for tools. For rectifiers designed for a NEMA 8 hazardous environment, the tap link bar adjustment shall be located below the oil level. To allow for more convenient adjustment, tap switches are optionally available.

4.0 MAIN TRANSFORMER / ADJUSTMENT

- 4.1 The Advantage oil-cooled rectifiers are equipped with a full isolation type, secondary tap adjusted transformer.
- 4.2 The transformer is designed to operate properly at 115% of the specified rated output to allow for reserve capacity.
- 4.3 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 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.
- 4.4 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.

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- 4.5 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.

5.0 INSTRUMENT PANEL

- 5.1 The instrument panel for Advantage line 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. 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.

6.0 RECTIFYING DEVICES

- 6.1 The rectifier circuit consists of individual silicon diodes arranged into a full wave bridge configuration or a single molded diode bridge module. The diodes are sized for approximately 200% of the nominal current through each device at rated rectifier output. All diodes 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. Diodes with a higher PIV rating are available on request.
- 6.2 The diodes or molded diode bridge module are mounted to a suitable sized heatsink(s). The heatsinks are fabricated from either gold or black anodized aluminum 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 convection.
- 6.3 The rectifying devices are constructed into a modular assembly to allow for ease of any possible field maintenance. The diode bridge assembly can be optionally constructed on a separately removable frame to allow for maintenance without the need to lift the main rectifier / transformer frame out of the oil compartment.
- 6.4 For ambient temperatures above 45°C, all diodes are oversized as required and in accordance with manufacturers design recommendations.

7.0 MONITORING COMPONENTS

- 7.1 The Advantage line rectifiers are constructed with two continuously reading analog meters for monitoring of the rectifier DC output voltage and current. The meters are a minimum of 3.5" rectangular type with a scale length of 2.875" except for hazardous location rectifiers, which have meters of a minimum of 2.5" rectangular type with a scale length of 2.29". 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

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metering accuracy shall be 2% of FSD and shall comply with the requirements of ANSI C39.1. 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.

- 7.2 Optional digital metering is available for certain applications requiring improved accuracy and resolution. The digital meters utilized are Summit Model SI469 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 numerals.
- 7.3 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.
- 7.4 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 Type "SW" shunt with an accuracy of 0.25%. The shunt is clearly marked with the current and millivolt rating.

8.0 PROTECTIVE DEVICES

- 8.1 The Advantage 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).
- 8.2 The Advantage line rectifiers are constructed with semiconductor (rectifier) type fusing in the AC secondary of the transformer. This fusing provides protection for the rectifier components against output short circuit or overload conditions. For certain applications, time delay type fusing may be used to avoid fuse operation caused by minor transients. 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 shall be supplied for each fuse utilized in the rectifier.
- 8.3 The Advantage 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 arrester with a minimum extreme surge duty rating of 15 KA, based on a 8X20us 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 arrester with a minimum extreme surge duty rating of 15 KA, based on a 8X20us wave, and a DC voltage rating as close as practical to the maximum peak voltage output rating of the rectifier. The DC surge arrester is sized such that it conducts the surge

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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 8 KA, based on a 8X20us wave, across the AC input to the bridge.

9.0 ELECTRICAL CONNECTIONS

- 9.1 The AC input connections for the Advantage oil-cooled line rectifiers are made via a terminal block located on the left side instrument panel (bottom rear of the instrument end-housing for units supplied with the end-housing option). 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. The AC input terminal block is shielded or a suitably sized electrical barrier is installed over the AC input terminals to prevent accidental contact with AC line voltages and it is fitted with a warning label.
- 9.2 The DC output terminals for the Advantage line rectifier 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(-)".
- 9.3 The rectifier is equipped with a compression type lug terminal for electrical grounding purposes located on the right side mounting channel of the oil-cooled enclosure. The lug terminal is typically sized for #4-14 AWG cable.
- 9.4 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. The wire is sized as per the manufacturers recommendations for the maximum current through the wire.
- 9.5 All electrical hardware used within the Advantage line 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 / lockwasher 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.

10.0 DOCUMENTATION & LABELING

- 10.1 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

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- i) Maximum Operating Ambient (°C)
 - j) Enclosure Type
- 10.2 The components on the front of the instrument panel are identified via silk-screening or by 1/16" lamicoid (plastic laminate), adhesive type labels with white lettering on a black background affixed via stainless steel screws or drive screws.
- 10.3 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.

11.0 TESTING AND QUALITY CONTROL

- 11.1 Each rectifier main transformer is subject to and has successfully passed the following electrical performance tests prior to installation into a 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.
- 11.2 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.
- 11.3 Each rectifier is subject to dielectric strength testing as per CSA Standard requirements and successfully passes this testing prior to further electrical testing.
- 11.4 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.
- 11.5 Each rectifier meter is checked for calibration accuracy to ensure the specifications indicated previously have been met.
- 11.6 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.