

Guideform Specification

P40 Agile Enhanced Protection Platform

Directional Feeder Management Relay

Mechanical Specifications

Design

- The device shall be presented in a 4U case height format (177mm height), for ease of integration/standardization in standard protection racks and panels.
- The device shall be housed in a case width of 20TE (4 inch width).
- The device shall protrude into the space behind the mounting panel to a depth no greater than 160mm.
- The relay shall have a draw-out construction to facilitate testing, maintenance and interchange flexibility. The draw-out construction shall ensure that any connected CT circuits are not at risk of open-circuiting at any time during extraction or when the relay's active part is extracted.
- The device shall not include any internal battery, facilitating UN3091 air transit compliance.

Enclosure Protection

The degree of protection offered shall be as per IEC 60529: 2013:

- IP 52 Protection (front panel) against dust and dripping water.
- IP 20 Product safety protection for the rear shall ensure that no live connections remain exposed to inadvertent touching. Any ring terminals shall be shielded with a terminal block cover.
- The device shall be housed in a robust metallic case wrapper.
- The device case shall not include any ventilation louvres or other deliberate holes – it shall be an enclosed unit, in order to prevent dust or other ingress.

General Input / Output Terminals

- All CT, VT and power supply terminals shall be ring-lug screw type for security and robustness.
- CT terminals shall be furnished with an optional commoning bar, to form a convenient star point (wye-connection) for the non-polarity terminal of the phase CTs. This shall avoid the need to terminate two wires on any CT terminal.

- Pin type connectors/terminals shall be supported for digital inputs and outputs, to increase the density of connections supported.
- Pin terminals shall have each individual wire's screw accessible from the rear without needing to detach the entire block.
- Pin terminal blocks shall be detachable and keyed such they cannot be inserted upside down.

Ratings

AC Measurement Range

- The device shall be suitable for power systems operating at 50 and 60Hz.
- The relay shall be suitable for current transformer secondary ratings of 1A and 5A, which shall be software selectable, as required.
- The protection relay shall provide analog input systems that can reproduce up to 40 times CT rating RMS symmetrical. The relay shall execute protection-related main algorithms at 8 times per power system cycle.
- The operating range for the network frequency shall be from 45 to 70Hz.

Auxiliary Voltage (Vx)

The device shall include a universal power supply unit to eliminate multiple ordering options and simplify spares holdings.

- The device shall support all typical battery voltage ratings from 24V up to 250V in a single, universal power supply (no ordering option).
- The device shall operate for a battery voltage deviation from the nominal range of -20% from lowest nominal voltage (24V minus 20%), up to +20% from highest nominal voltage (250V plus 20%).
- Auxiliary power supply interruption ride-through according to IEC 60255-26: 2013, with all communications ports active, all binary I/O energized, and LCD backlight on: 100ms minimum
- With a tolerable ac ripple of <15% for a dc supply, as per IEC 60255-26: 2013.
- The quiescent burden of the energized device shall be less than 10W.
- The DC supply to the relay shall be supervised, with under and over voltage monitoring thresholds being configurable under the control of the user.

Digital (“Opto”) Inputs

The relay shall have the option for up to a maximum of 14 configurable opto inputs, of which minimum 9 shall be general purpose as described below.

- The opto inputs shall be universal range, rated from 24V to 250Vdc nominal, with a withstand up to 300Vdc.

- The opto inputs shall have a software-selectable pick-up setting, without needing an ordering option nor any need to change jumpers.
- The pick-up setting shall be matched at approximately 80% of battery nominal, with reset hysteresis such that drop-off is at approximately 60% of battery nominal. Such operation shall ensure that spurious pickup is avoided for battery earth faults where half-voltage may be falsely experienced by capacitive coupling.
- Opto inputs shall be compliant to ESI 48-4 EB2, presenting a “high burden” to prevent spurious pickup for capacitive discharge, with intelligent switching to reduce the burden to a low quiescent value under genuine operated conditions.
- Opto inputs shall be immune to capacitor discharge and power frequency without the need for external suppression. External resistors shall not be required in regular input applications.
- General purpose opto inputs shall be presented in groupings of no more than three with a common terminal.

The relay shall provide a 1 millisecond time stamp resolution for state changes.

Two of the opto inputs shall feature current pick-up operation (“series flagging”), for use in trip circuit supervision applications. These inputs shall be discrete, with no commoning of terminal connections.

Output Contacts

The relay shall have the option for up to a maximum of 11 configurable output contacts suitable for a mix of trip and signalling purposes. The relay output contacts shall be electromechanical in type. All output contacts shall be discrete, with no commoning of terminals.

Trip Contacts

The rating of the trip contacts shall be as follows, in accordance with IEC 60255-1: 2009:

- Maximum continuous current shall be 10A.
- The short term make and carry rating shall be 30A for 3s.
- The DC break capacity shall be 50W resistive or 62.5W inductive (L/R = 50ms)
- It shall be possible to configure a software latching (lockout) function for output contacts, whose status is memorized for reapplication after a power supply interruption

Signalling Contacts

The rating of the trip contacts shall be as follows, in accordance with IEC 60255-1: 2009:

- Maximum continuous current shall be 5A.
- The short term make and carry rating shall be 10A for 3s.
- The DC break capacity shall be 24W resistive

- It shall be possible to configure a software latching (lockout) function for output contacts, whose status is memorized for reapplication after a power supply interruption

Watchdog Contacts

A relay fail watchdog contact shall be provided. Any error detected by the device self-monitoring, or device de-energisation, shall cause an alarm to be raised, such that hardwiring of an alarm to adjacent devices is possible, if required.

The contact ratings shall be:

- DC breaking capacity 24W resistive

LED Indicators

Eight LED indicators shall be provided, four shall be freely-programmable, in addition four can have a fixed function assignment for Alarm, Trip, Out of Service and Healthy indication.

- It shall be possible to set all the programmable LED's in three different colors - RED / ORANGE / GREEN as per the scheme requirement.
- It shall be possible to configure a software latching function for the LEDs, whose status is memorized for reapplication after a power supply interruption

HMI Display

- A textual LCD display screen shall be provided on the product, capable to display power system measurements, fault summaries and event records, interrogate alarms, implement password access control, initiate commissioning test modes, monitor I/O status, alter protection settings, and change settings groups.
- The user interface shall integrate a 3-line front panel display menu controlled by navigation keys, with a 6-line default display for enhanced visualisation of power system measurements.
- The front panel shall have the provision to control via software "Hotkeys" the breaker, and to display online metering and status information.
- The device menu shall incorporate dependency rules, such that menu cells which are rendered inapplicable as a result of a previous menu selection are removed/hidden. Any whose range of options or settings range is affected shall also be automatically adapted.

Functional Specifications

Protection and Control

Feeder protection shall be provided by a numerical microprocessor-based relay equipped with the following protection, monitoring, control, automation, and reporting functions. Specific requirements are as follows:

The relay shall provide the following current based protection functions:

- Minimum 1 stage of Undercurrent - loss of load (37)
- Minimum 6 stages of Phase Definite Time Overcurrent (50P)
- Minimum 4 stages of Neutral/Ground Definite Time Overcurrent (Derived and Measured) (50N/G)
- Minimum 4 stages of Sensitive Earth Fault Definite Time (50SEF) – with 2mA setting sensitivity possible (for Sensitive Earth CT ordering option)
- Minimum 2 stages of Sensitive Earth Fault IDMT Overcurrent (51SEF) – with 2mA setting sensitivity possible (for Sensitive Earth CT ordering option)
- Minimum 3 stages of Phase IDMT Time Overcurrent (51P)
- Minimum 2 stages of Neutral/Ground IDMT Overcurrent (Derived and Measured) (51N/G)
- Minimum 4 stages of Negative Sequence Instantaneous Definite Overcurrent (50_2)
- Minimum 4 stages of Negative Sequence Timed IDMT Overcurrent (51_2)
- Minimum 6 stages of Phase/Neutral/Ground Directional Overcurrent (67P/N)
- Minimum 4 stages of Neutral/Earth Directional Overcurrent (67N/G)
- Minimum 4 stages of Sensitive Earth Directional Overcurrent (67SEF) – with 2mA setting sensitivity possible (for Sensitive Earth CT ordering option)
- Minimum of 4 stages of Negative Sequence Directional Overcurrent (67_2)
- Restricted Earth Fault (64N)- High & Low Impedance option
- Breaker Failure (50BF)
- Switch On To Fault (SOTF)
- Thermal Overload - current replica (49)
- Cold Load Pickup (CLP)
- Broken Conductor
- Inrush blocking

The relay shall provide the following voltage-based protection functions.

- Minimum 4 stages of Phase Overvoltage and Phase Undervoltage (59P, 27P)
- Minimum 4 stages of Residual Overvoltage (59N)
- Minimum 2 stages of Positive sequence undervoltage/overvoltage (27V/59V)
- Minimum 2 stages of Negative Sequence Overvoltage (47)

- Minimum 4 stages of Directional Power (32)
- Minimum 9 stages of Overfrequency/Underfrequency (81O/81U)
- Minimum 9 stages of Rate of Change of Frequency (81df/dt)
- Undervoltage blocking of frequency protection (81V)
- Synchrocheck (25)

The relay shall provide the following control and monitoring functions.

- 4 Shot Auto Reclose (79)
- Pole Discrepancy (52PD)
- VT Fuse failure (VTFF)
- CT Supervision (CTS)
- H7 compliant Trip Circuit Supervision – providing full supervision of the trip circuit whether the breaker is open (“preclosing supervision”) or closed
- Manual Close Blocking
- Latching output contacts - Lockout relay (86)
- Switch and circuit breaker status control
- Harmonic and THD measurements with setpoints, up to the 21st harmonic.

The time overcurrent and instantaneous overcurrent elements shall be selected to operate either on RMS or Fundamental values.

The relay shall provide Breaker Health Monitoring features including: Breaker close and breaker open times, Trip/Close circuit monitoring, Spring charging time, Per-phase arcing current, and Trip counters.

The relay shall have 4 Programmable curves with graphical manipulation of the individual points.

The relay shall have configurable option to select any protection elements to be used as a trip, alarm or latched alarm function without using programmable logic.

The relay shall support 8 Flex elements that can use any available/calculated analogue parameters within the relay (e.g. comparator, inverter, over/under, etc.)

The relay shall support up to 16 Digital Counters.

It shall be possible to test the Binary Inputs, Outputs and protection functions without the need for an external test kit.

Disturbance Recording

The device shall include on-board disturbance recording:

- The relay shall provide up to 64 digital channels and up to 16 analogue channels of oscillography.
- The sampling rate shall be configurable to 8/16/32/64/128 samples/cycle
- All channels and the trigger source shall be user configurable.
- A recording time of 30 seconds @ 64 samples/cycle shall be supported
- The disturbance records shall be able to be extracted from the relay via the remote communications and saved in the COMTRADE format.
- The record storage shall be maintained even after the device has been powered-down

Data Logger

The relay shall provide a separate data logger function which shall record a maximum of 16 Analog channels with a settable sampling rate of 1 cycle, 1 second, 30 seconds, 1 minute, 15 minutes, 30 minutes, 1 hour, 6 hour, 8 hour, 12 hour or 24 hour including a trigger source of sample, min, max, mean.

Event Recording

The device shall include on-board event recording, suitable to record a minimum of 2048 time-tagged events:

- The time stamp resolution of the records shall be 1ms
- The record storage shall be maintained even after the device has been powered-down
- The menu and PC toolsuite shall provide shortcut access to at least the last 25 fault trip records
- Fault location (21FL distance to fault) shall be provided.

Programmable Logic

The device shall include a graphical programmable logic facility, to enable customizing of the device response to the client's exact requirements:

- The relays shall support 1024 lines of user defined logic to build control schemes supporting logic gates, timers, non-volatile latches.
- The programmable logic in the relay shall be executed at 8 times per power system cycle
- The relay configuration tool shall have graphical user interface to build programmable scheme logic (PSL).
- The relay shall support 128 Virtual Outputs + 128 Virtual Inputs
- The relays shall support Logic designer and Logic Monitor – i.e. graphical logic editing tool and online monitoring of logic states in a graphical way.

- Gate logic shall be provided including OR, AND and majority gate functions, with the ability to invert the inputs and outputs, and provide feedback paths in the logic. A minimum of 100 logic gates shall be available.
- Time delay functions shall be provided, including delay on pick-up (DPU), delay on drop-off (DDO), combined DPU/DDO, pulsed, and minimum dwell time functions. A minimum of 32 timers shall be provided
- The amount of logic programmed shall not in any way affect the deterministic behaviour of the protection, control and communication functions in the relay. Whether the logic is sparsely used, or used up to its maximum capacity, this shall not change the operating time of those functions.
- Vice-versa, the programmable logic shall remain deterministic regardless of the extent of other device functions enabled.
- A license-free graphical PC tool shall be provided, to configure the programmable logic.

Measurements

- The device shall include capabilities for real-time AC measurements, derived power and energy quantities, and demand values.
- The current metering accuracy shall be +/- 0.5% from 0.05 to 2.0 x In
- The voltage metering accuracy shall be +/- 0.5% from 10V to 300V
- The power metering accuracy shall be +/- 1.5% of the reading.
- The frequency metering accuracy shall be typically at 10 millihertz accuracy level.

Setting Groups

The relay shall have 4 switchable setting groups for dynamic reconfiguration of the protection elements according to user-defined conditions.

Simulation & Testing

The relay shall support simulation feature for testing the functionality in response to programmed conditions, without the need of external AC voltage and current inputs. System parameters such as currents, voltages and phase angles can be entered as setpoints. When placed in test mode, the relay shall suspend reading actual AC inputs, generate samples to represent the programmed phasors, and load these samples into the memory to be processed by the relay. It shall be possible to program normal (pre-fault), fault, and post-fault conditions which can simulate a wide variety of system disturbances and test the behaviour of the relay.

PC Toolsuite

The device shall be supported by a license-free Windows®-based toolsuite, with support for operating systems Windows 7 and 10. The toolsuite shall support:

- Creation of offline protection settings, downloading and uploading to the device

- Standard application template creation for protection settings, such that the utility can standardize on a number of global templates, where only local (feeder-specific) thresholds change at each site.
- Settings file export and import in Excel format
- Graphical creation and editing of programmable logic
- Comparison of setting and programmable logic files to identify any differences between versions
- Creation of IEC 61850 configuration and reports
- Retrieval of fault, event and disturbance records
- Display of extracted records, including disturbance record waveform graphics
- Changing of settings groups, control and resetting commands
- Polling of measurement values
- Export of settings files in .xrio format, for compatibility with protection testing equipment
- There shall be only a single relay setting (i.e. CID based XML format) file which can be directly uploaded into the device. This means there is no intermediate conversion of any proprietary setting file formats.
- The entire relay settings (not only communication related but also protection and control functional settings) shall be part of the same single setting file.
- The relay shall be configured through IEC 61850-6 standard based Configured IED Description (CID in XML) format file.

Communications

Station Bus – IEC 61850-8-1

- The relay shall support up to 8 concurrent IEC61850 client connections.
- IEC 61850 Edition 2 support shall be provided.
- The relay shall support GOOSE Analog reception and transmission.
- The relay shall support up to 128 Virtual Outputs and 128 Virtual Inputs over GOOSE
- The relay shall support file transfer protocol TFTP and file transfer through 61850.
- The device shall support the quality bit when set in test mode or when the analog values are out of range.

Time synchronization

The relay shall support multiple time synchronization sources such as IRIG-B, SNTP and PTP (IEEE 1588), with the ability to configure priority for the time sources and dynamically switch based on the availability of each source.

Front Port USB PC Interface

A front panel USB port shall be provided for service access by relay technicians/engineers, communicating with the PC toolsuite software:

- Isolation shall be to PELV level.
- The maximum cable length supported up to the PC connection shall be 5m.

Rear communication

The rear communication port shall support the following:

- Modbus RTU, DNP 3.0, IEC 60870-5-103 protocols over serial
- Modbus TCP, IEC 61850 Ed2 (GOOSE,MMS), DNP3oE protocols over ethernet
- The relay shall offer one Serial and Ethernet port as standard
- There should be option to order Fibre optic or copper Ethernet port
- Standard rear port can be used as demodulated IRIG-B or serial communications port through software configuration
- The relay shall provide an additional rear RS-485 port as an ordering option
- The relay shall provide option to order additional 2 Ethernet ports (Fibre optic or copper) for supporting redundant Ethernet communication. A choice of redundancy protocols such as IEC 62439 PRP, HSR and LLA shall be available as soft selection option in a single ordering option.
- It shall be possible to support up to 50 nodes in HSR ring
- It shall be possible to support up to three Ethernet ports allowing separation of IT and OT networks.
- It shall be possible to run a wired serial protocol and an Ethernet protocol concurrently in the device.

Cyber security

- The relay shall provide an option for RBAC (Role based access control) with three roles such as Observer for accessing operational data, Operator for opening/closing of breakers, and Administrator for configuring the relay.
- The relay shall provide an option for password complexity.
- The relay shall provide an option for local device level authentication and for remote server authentication using RADIUS.
- The relay shall provide optional support for SYSLOG to publish security related events.
- The relay shall support secure file transfer protocol (SFTP).
- The relay shall provide SSH tunnelling connection

Environmental Conditions

The following norms and standards compliance shall be demonstrated. All shall be carried out at an ILAC accredited laboratory:

Ambient Temperature Range

As per IEC 60255-27: 2014

- Operating temperature range: -25°C to +60°C
- Storage and transit: -40°C to +85°C

Tested as per IEC 60068-2-1: 2007:

- -40°C storage (96 hours), -25°C operation (96 hours)

IEC 60068-2-2: 2007: +85°C storage (96 hours)

Ambient Humidity Range

- As per IEC 60068-2-78: 2013: 56 days at 93% relative humidity and +40°C
- As per IEC 60068-2-30: 2005: Damp heat cyclic, six (12 + 12) hour cycles, 93% RH, +25 to +55°C

Corrosive Environments

The device shall provide harsh environmental coating of relevant printed circuit boards as standard for HEC compliance. The coating shall be applied after printed circuit boards have been subjected to a cleaning and drying process.

The device shall employ IPC (Institute for Interconnecting and Packaging Electronic Circuits) Class 2 printed circuit boards (PCB) i.e. IPC Class 610-3.

Type Tests

The following norms and standards compliance shall be demonstrated:

Insulation

As per IEC 60255-27: 2014

- Insulation resistance > 100MΩ at 500Vdc (using only electronic/brushless insulation tester).

Creepage Distances and Clearances

As per IEC 60255-27: 2014

- Pollution degree 2,
- Overvoltage category III,
- Impulse test voltage (non RJ45) 5 kV.

High Voltage (Dielectric) Withstand

(i) As per IEC 60255-27: 2014, 2 kV rms AC, 1 minute:

Between all case terminals connected together, and the case earth.

Also, between all terminals of independent circuits.

- 1kV rms AC for 1 minute, across open watchdog contacts.

- 1kV rms AC for 1 minute, across open contacts of changeover output relays.

(ii) As per ANSI/IEEE C37.90-2005:

- 1.5 kV rms AC for 1 minute, across open contacts of changeover output relays.

Impulse Voltage Withstand Test

As per IEC 60255-27: 2014

- Front time: 1.2 μ s, Time to half-value: 50 μ s,
- Peak value: 5 kV, 0.5J
- Peak value (RJ-45): 1kV
- Between all terminals, and all terminals and case earth.

Electromagnetic Compatibility (EMC)

The following norms and standards compliance shall be demonstrated. All shall be carried out at an ILAC accredited laboratory:

1 MHz Burst High Frequency Disturbance Test

As per IEC 60255-26: 2013

- Common-mode test voltage: 2.5 kV,
- Differential test voltage: 1.0 kV,
- Test duration: 2s, Source impedance: 200 Ω

Damped Oscillatory Test

As per EN61000-4-18: 2011: Level 3, 100 kHz and 1 MHz. Level 4: 3 MHz, 10 MHz and 30 MHz, IEC 60255-26:2013:

- Common mode test voltage:
 - 100kHz & 1MHz 2.5kV
 - 3MHz, 10MHz, 30MHz 4kV
- Differential mode test voltage: 1kV (100kHz & 1MHz)

Immunity to Electrostatic Discharge

As per IEC 60255-26:2013:

- 15 kV discharge in air to user interface, display, and communication port
- 8 kV discharge in contact to exposed metalwork and communication port.

Electrical Fast Transient or Burst Requirements

As per IEC61000-4-4:2012. and IEC 60255-26:2013:

- Applied to communication inputs: Amplitude: 2 kV, burst frequency 5 kHz and 100 KHz

- Applied to power supply and all other inputs except for communication inputs: Amplitude: 4 kV, burst frequency 5 kHz and 100 KHz

Surge Withstand Capability

As per IEEE/ANSI C37.90.1:2012:

- 4kV fast transient and 2.5kV oscillatory applied common mode and differential mode to to all circuits excluding communications ports.
- 4kV fast transient and 2.5kV oscillatory applied common mode to communications.

Surge Immunity Test

As per IEC 61000-4-5: 2014 Level 4, IEC 60255-26:2013,

- Time to half-value: 1.2/50 μ s,
- Amplitude: 4kV between all groups and case earth,
- Amplitude: 2kV between terminals of each group.

Immunity to Radiated Electromagnetic Energy

As per IEC 60255-26:2013:

- Frequency band 80 MHz to 1.0 GHz, 10V/m, AM 1 kHz @ 80%
- Spot tests at 80, 160, 380, 450, 900, 1850, 2150 MHz

As per IEEE/ANSI C37.90.2: 2004:

- Frequency band 80 MHz to 1.0 GHz, 35V/m, AM 1 kHz @ 80%
- Spot tests at 80, 160, 450, 900 MHz

Immunity to Conducted Disturbances Induced by Radio Frequency Fields

As per IEC 61000-4-6: 2014, Level 3 and IEC 60255-26: 2013

- Disturbing test voltage: 10 V rms

Power Frequency Magnetic Field Immunity

As per IEC 61000-4-8: 2009, Level 5,

- 100A/m applied continuously,
- 1000A/m applied for 3s.

As per IEC 61000-4-9: 2016, Level 5,

- 1000A/m applied in all planes.

As per IEC 61000-4-10: 2016, Level 5,

- 100A/m applied in all planes at 100kHz/1MHz with a burst duration of 2s.

Conducted Emissions

As per EN 55016-2-1: 2014: and IEC 60255-26: 2013

- Power supply
 - 0.15 - 0.5MHz, 79dB μ V (quasi peak), 66dB μ V (average)
 - 0.5 - 30MHz, 73dB μ V (quasi peak), 60dB μ V (average).

Radiated Emissions

As per EN 55022: 2010 and IEC 60255-26: 2013

- 30 - 230MHz, 40dB μ V/m at 10m measurement distance
- 230 - 1GHz, 47dB μ V/m at 10m measurement distance
- 1 – 6 GHz, 76 dB μ V/m at 10 m measurement distance

Power Frequency

As per IEC 60255-26:2013:

- 300 V common-mode
- 150 V differential mode

EU Directives

A declaration of conformity shall evidence compliance with EU directives, and each device shall display a



mark.

EMC Compliance

As per 2014/30/EU: Compliance to the European Commission Directive on EMC shall be claimed. Product specific standard EN 60255-26: 2013 shall be used to establish conformity.

Product Safety

As per 2014/35/EU: Compliance to the European Commission Low Voltage Directive (LVD) shall be claimed. Product specific standards shall be used to establish conformity: EN 60255-27: 2014

RoHS

As per 2011/65/EU: Compliance to the European Commission Restrictions on substances hazardous to health (RoHS) shall be claimed, without reliance on any exemption

A product environmental profile (PEP) shall be provided.

Mechanical Robustness

The following norms and standards compliance shall be demonstrated:

Vibration Test

As per IEC 60255-21-1: 1988

- Response Class 2
- Endurance Class 2

Shock and Bump

As per IEC 60255-21-2: 1988

- Shock response Class 2
- Shock withstand Class 1
- Bump Class 1

Seismic Test

As per IEC 60255-21-3: 1993

- Class 2

Transit Packaging Performance

The primary packaging carton shall comply with the international freight standard ISTA 1C specification, to minimize the risk of damage in transit:

- Compression test - 1.4 x Calculated force
- Vibration tests - in 4 Orientations, Random frequency, 22.45mm amplitude, 1.15 G
- Drop tests - 10 drops from 760mm on multiple carton faces, edges and corners

Quality

- The company's quality management system shall be accredited and independently audited to ISO 9001: 2015
- The company's information management system shall be accredited and independently audited to ISO 27001: 2013
- The company's environmental management system shall be accredited and independently audited to ISO 14001: 2015
- The company's occupational health and safety management system shall be accredited and independently audited to OHSAS 18001: 2007
- The company's test laboratories shall be accredited and independently audited to ISO 17025

- Each device shall be subjected to a heat-soak during the manufacturing process, in order to minimize the risk of early-life failures.
- The device shall include a ten-year warranty for material and workmanship defects.
- The vendor shall offer a nominal 10 day turn-around for warranty repairs.