



**Sandia
National
Laboratories**



**U.S. DEPARTMENT OF
ENERGY**

SPECIFICATION

FOR

Pulsed High Power Calibration System

Prepared by: Eddie O'Brien and Joshua Stanford 06/17/2019

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1.0 PURPOSE

This specification defines the minimum requirements for the manufacture, performance, and acceptance of a 10 kA Pulsed High Power Calibration System capable of output pulsed current with durations ranging from 1 μ s to 100 μ s and currents ranging from 0.1 Amperes to 10,000 Amperes.

2.0 GENERAL REQUIREMENTS, STANDARDS, AND CODES

Sections 2.1 through 2.13 define the minimum requirements for compliance to Environmental, Safety, and Health (ES&H) issues, regarding system design and construction.

- 2.1 All electrical components and connections must comply with DOE orders CPR400.1.1.28 and SNL ES&H Electrical Safety Manual MN471004, Issue T, Revision Date: January 3, 2017 (ESH100.2.ELC.1). All high voltage hardware must also be consistent with modern high voltage practices. The final negotiated system design shall be reviewed and approved by the appropriate Sandia electrical safety Subject Matter Expert before final design acceptance. Both personnel and measuring equipment must be protected.
- 2.2 The system must include a high voltage and high current monitor to verify when high voltage or high current is applied internally or externally. This includes a warning light/beacon to indicate when high voltages or high currents are present in the system. An audible warning, with mute option, is required.
- 2.3 The system shall meet National Fire Protection Association (NFPA) Codes and Standards; NFPA-30 Flammable and Combustible Liquids Code, NFPA-70 National Electrical Code, NFPA-79 Electrical Standard for Industrial Machinery and Appendices, and any control panel(s) shall be designed and fabricated in accordance with UL508A, Underwriters Laboratories Standard for Safety and Industrial Control Panels.
- 2.4 All Seller supplied non-conductive insulating oil shall have flash points of a Class III B liquid, at or above 200° Fahrenheit (F), per National Fire Protection Association (NFPA) 30.
- 2.5 The system/equipment shall be Listed, Labeled, or field inspected by an Occupational Safety and Health Administration (OSHA) recognized Nationally Recognized Testing Laboratory (NRTL) such as Underwriters Laboratory (UL) and /or Factory Mutual (FM), preferably at the Seller's facility. The Seller shall furnish a copy of the NRTL report to the Buyer. A complete listing of the current NRTL's are available at the OSHA website at www.osha.gov/dts/otpca/nrtl/. The Seller shall supply to the Buyer the NRTL certificate of compliance showing the model number of the equipment being procured. If the equipment is not Listed or Labeled, then the Seller shall have a Field Inspection performed by either an NRTL or an inspection company approved by the Buyer's Electrical Safety Committee. The Field Inspection shall result in the equipment being certified and labeled. After completion of

the Field Inspection, the Seller shall supply the final report from either the NRTL or the inspection company to the Buyer.

- 2.6 All electrical and electronic components and wiring shall be guarded against accidental contact by the operator, and all switches and controls accessible to the operator shall not exceed 120 volts potential across the contacts or the equipment ground.
- 2.7 All energy service controls shall have a means to be locked and tagged to comply with 29 CFR 1910.147, The Control of Hazardous Energy (Lockout/Tagout).
- 2.8 All packaged assemblies and subassemblies of the system having internal voltages exceeding 50 volts shall be affixed with a label which states, "DANGER - ELECTRICAL SHOCK HAZARD", and/or, shall be identified with a label with the internationally recognized symbol for high voltage.
- 2.9 Inter-connecting electrical lines from the system to the control shall be routed through protective overhead hardware, a minimum of eight (8) feet above the finished floor, in accordance with the National Electrical Code, in any areas where the inter-connect cables may become a tripping or safety egress hazard. Any mounting hardware required shall be provided by the Seller.
- 2.10 The equipment shall be supplied with a red Emergency Power Off (EPO) button at the operator station. Activation of the EPO shall return clamped components to the least hazardous condition and shall cause a braked shutdown of rotational components. When activated, the EPO shall require a manual reset, and shall not cause any damage to the equipment. Where appropriate, other portions of the equipment shall have an additional EPO.
 - 2.10.1 The equipment shall have a power on/off button that removes all power from the equipment, including the control system. Exceptions include Programmable Logic Controller's (PLC's) and other control devices that rely on a battery to maintain programs and system parameters.
- 2.11 The equipment shall comply with 29 CFR 1910 Subpart O and shall be equipped with the following minimum guards and interlocks:
 - 2.11.1 Guards, shields, or other protective covers shall be required to cover injurious high or low temperature parts and hazardous moving parts, e.g., pulleys, belts, drive shafts, drive screws, sharp edges, pinch points, or other potential hazards.
 - 2.11.2 All guards and shields shall be constructed to provide access to the guarded parts for maintenance and shall not interfere with operation of the system.
 - 2.11.3 All guards and shields shall require the use of a tool for removal.
 - 2.11.4 Switches and levers that actuate moving parts of the system shall be designed or guarded to prevent inadvertent activation.
 - 2.11.5 Interlocks shall be required whenever access can be gained, without the use of a tool, to an area which would allow inadvertent contact with electrical voltages of 50 V or greater and mechanical hazards.

Examples of such include, as a minimum, remote or programmed system starts, moving and rotating mechanical parts, hazardous electrical potentials, hazardous energy levels, including microwave and radio frequency energy, laser beams, ionizing and other non-ionizing radiation, capacitor discharge, or operation of the system without shields and covers in place.

- 2.11.6 Interlocks shall be required whenever access can be gained, without the use of a tool, to an area where a rotational hazard exists. Actuation of the interlock shall cause an immediate and braked rotational shutdown with an alarm actuated. Additionally, no rotational activities shall begin with the interlock actuated.
- 2.12 The system and associated equipment shall not emit noise levels more than 80 decibels ("A" scale) continuous or 137 decibels ("C" scale) for impulse (<0.5 seconds) except as follows: The noise levels shall not exceed 75 decibels ("A" scale) in the areas attended by operators. Test acceptance shall be based on an 8-hour time weighted average (TWA) measured in accordance with procedures and conditions specified in Section 10 of the publication, "Noise Measurement Techniques", January 1976, or latest edition issued by the AMT (formerly the NMTBA). These measurements shall be performed only under the operating conditions (unloaded mode) specified in Section 10.1.3.b of the publication.
- 2.13 The system shall be lead free, shall contain no asbestos or asbestos containing materials, and shall be free of polychlorinated biphenyls (PCBs). Sections 2.14 through 2.19 define the minimum requirements that must be met or provided, for installation in the Buyer's facility.
- 2.14 The system shall be arranged to operate from a maximum 480 volts (V), three-phase, 60 hertz (Hz) power supply and shall contain step down transformers as an integral part of the electrical system for components requiring other than 480 V service. The equipment may be wired to operate from a 120/208 V, single-phase, 60 Hz power supply provided the service size does not exceed 30 amps. The equipment shall not be affected by line voltage variations of $\pm 10\%$ from nominal or transient voltages of 2500 volts maximum. The Seller shall be responsible for providing AC line conditioning devices for equipment not compatible with the voltage variation and transient parameters specified above. All transformers and capacitors supplied shall be of the "dry type" and shall not contain Polychlorinated Biphenyls (PCBs).
- 2.15 All power and control circuits shall be provided with overload and under voltage protection.
- 2.16 The system shall be arranged to provide a minimum SCCR rating of 10 kA (10,000A Short Circuit Current Rating).
- 2.17 All fuses, external to the system, used for voltages greater than 250 VAC shall be Class RK1.

- 2.18 The system and all ancillary equipment, including access doors, shall be designed and constructed to be installed in an area no larger than 100 sq. ft. (10 ft. by 10 ft.)
- 2.19 The system shall be delivered in components that are sized to facilitate rigging from the Buyer's receiving dock to the installation site. Each component shall be no larger than 5 ft. wide by 5 ft. long by 7 ft. tall. and shall weigh less than 3800 lbs.

Sections 2.20 through 2.26 define the minimum requirements for facilitating routine maintenance and for conducting diagnostic testing by the Buyer's maintenance personnel on the equipment.

- 2.20 The system's direct equipment control shall be of solid state, modular construction. Plug-in circuit boards shall be functionally coded for identification and to facilitate location in the control. All circuit diagrams and schematics shall be current, describe accurately the electrical systems actually furnished with the system, shall be detailed to provide basis for analysis of defects in performance by the Buyer's maintenance personnel, and shall be written in English.
 - 2.20.1 If a Programmable Logic Controller (PLC) is used, then the PLC shall be manufactured by Allen Bradley, Automation Direct, or Siemens.
- 2.21 All wiring to components and controls shall be color-coded or labeled at each terminal point.
- 2.22 All associated non-conductive insulating oil system reservoirs or tanks will have overfill protection (e.g., overflow drain, float, interlock), and shall be provided with secondary containment (e.g., primary tank contained within a secondary tank or catch troughs in the machine) sufficient to completely contain the contents of the reservoir or tank in the event of a leak or sudden release.
- 2.23 All bearings exposed to chips, water, or non-conductive insulating oil shall be sealed.
- 2.24 All instruction plates shall be in the English language.
- 2.25 All gages, scales and dials shall be calibrated in the metric system of measurement.
- 2.26 The system shall be provided with limit switches or equivalent controls in all directions of travel to prevent over travel.

Sections 2.27 through 2.29 define requirements that must be met for Environment, Safety, and Health (ES&H) purposes, regarding Seller personnel working on the Buyer's property during installation, acceptance, and servicing:

- 2.27 The Seller will coordinate with the Buyer's ES&H coordinator to determine the hazard mitigation and safety precautions will be utilized during installation, acceptance, and servicing.
- 2.28 The Seller will provide the Buyer's ES&H coordinator with the Seller's personnel training, work authorization, and utilized Personal Protective Equipment.

2.29 The Seller will provide the Buyer's ES&H coordinator with a list of work that the Seller's personnel will perform while on the Buyer's property and ensure that no deviation from the list will occur.

Sections 2.30 through 2.32 define requirements that must be met for security purposes:

2.30 The system, equipment, computer system, or any ancillary device shall not contain wireless or Bluetooth communication capability.

2.31 Unless specifically requested as part of the proposal, there shall not be any camera(s) installed.

2.32 If the equipment computer system requires a license fob, the fob shall be read-only, shall have no writable memory, and shall contain no virus, spyware, or subversive code.

3.0 SPECIFIC SYSTEM REQUIREMENTS

Sections 3.1 through 3.4 define specific Pulsed Current system requirements:

3.1 The System Output Pulse requirements are as follows:

- 3.1.1 Square pulse, selectable polarity with respect to ground.
- 3.1.2 Pulse amplitude of 0.1 A – 10 kA.
- 3.1.3 Pulse width of 0.5 μ s – 100 μ s (FWHM), variable.
- 3.1.4 Maximum droop of flat top region of pulse is \leq 8.5% (for 100 μ s FWHM pulse) (i.e. 0.085%/ μ s).
- 3.1.5 Rise Time (10-90%) \leq 2 μ s at 10kA output for step function.
- 3.1.6 Fall Time (10-90%) \leq 2 μ s at 10kA output for step function.
- 3.1.7 Overshoot \leq 4.2% for 10kA output.
- 3.1.8 Ripple \leq 1% for all pulse width.
- 3.1.9 Output pulse reproducibility \leq 0.005%.
- 3.1.10 Temperature Operation 21 °C – 25 °C.
- 3.1.11 High frequency noise suppression.
- 3.1.12 Minimum expected pulses over system lifetime 10^6 pulses.

3.2 System Control requirements are as follows:

- 3.2.1 The system must have a front panel for manual control.
- 3.2.2 Front panel will allow for the setting of pulse parameters (polarity, width, amplitude, and delay).
- 3.2.3 Front panel will have trigger for single pulse.
- 3.2.4 The system must have capabilities to communicate with, and be controlled by, a Buyer provided personal computer. This must be done via network connection such as IEEE 488, RS232, Ethernet, or USB.
- 3.2.5 The network control must allow the same functionality as the front panel including setting pulse parameters and triggering single pulse.

4.0 OTHER CONTRACTUAL REQUIREMENTS

Sections 4.1 through 4.5 outline other contractual requirements:

4.1 The Training Requirements are as follows:

- 4.1.1 Training will be provided to a maximum of 5 individuals at delivery of system. This includes manual system operation, system safety precautions, and any required system servicing.
- 4.2 The Inspection and Acceptance Requirements are as follows:
 - 4.2.1 All equipment will be visually inspected by Buyer to ensure good conditions and that all minimum requirements are met.
 - 4.2.2 All documentation will be inspected by Buyer to confirm all minimum requirements are met.
 - 4.2.3 Manual system operation will be verified by Buyer during delivery of system to confirm all minimum requirements are met.
 - 4.2.4 Network system operation will be verified by Buyer during delivery of system to confirm all minimum requirements are met.
- 4.3 The Drawings and Manuals Requirements are as follows:
 - 4.3.1 All calculations relevant to system performance, circuit schematics, mechanical drawings, and equipment manuals will be provided to the Buyer upon delivery of the system.
 - 4.3.2 System maintenance procedures and software operation manual(s) will be provided to the Buyer upon delivery of the system.
 - 4.3.3 System tests that verify conformance to design requirements will be provided to the Buyer upon delivery of the system.
 - 4.3.4 System safety precautions will be documented and provided to the Buyer upon delivery of the system.
- 4.4 The Installation Requirements are as follows:
 - 4.4.1 Seller will ship and/or deliver all system equipment, documentation, and deliverables to the Buyer's facility prior to or during installation.
 - 4.4.2 Seller will install all system equipment and deliverables at the Buyer's facility subject to ES&H requirements being met.
- 4.5 The Warranty Requirements are as follows:
 - 4.5.1 Seller will provide Buyer with technical assistance for 2 years after system acceptance.
 - 4.5.2 Seller will provide any required system troubleshooting and maintenance for 2 years after system acceptance.
 - 4.5.3 Seller will perform any required system maintenance for 2 years after system acceptance.