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System Engineering Document

Q-6 Fireset Requirements

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LIST OF ACRONYMS

BNC	Bayonet Neill-Concelman
CDU	Capacitive Discharge Unit
CVR	Current-Viewing Resistor
CVT	Current-Viewing Transformer
DARHT	Dual-Axis Radiographic Hydrodynamic Test
DCA	Detonator Cable Assembly
DCO	Detonator Continuity Ohmmeter
DOE	Department of Energy
EIRC	Electrical Instrument Review Committee
EMI	Electromagnetic Interference
EMP	Electromagnetic Pulse
ESO	Electrical Safety Officer
HE	High Explosive
HV	High Voltage
LANL	Los Alamos National Laboratory
NNSS	Nevada National Security Site
PIC	Person in Charge
pRad	Proton Radiography
Q-6	Detonation Science and Technology Group
SME	Subject Matter Expert
ST	Straight Tip
TA	Technical Area
TTL	Transistor-Transistor Logic

1.0 INTRODUCTION

1.1 Purpose

Firesets used to fire detonators and detonator cable assemblies (DCAs) at the Detonation Science and Technology Group (Q-6) firing sites are capacitive discharge units (CDUs) capable of storing potentially dangerous amounts of electrical energy and initiating high explosives (HEs) resulting in detonation. Therefore, the firesets should only charge and discharge when intentionally directed by firing site leaders [i.e., persons in charge (PICs)] to maintain a safe work environment. The purpose of this document is to establish requirements and recommendations that ensure this intended behavior for safe operation of CDUs at the Q-6 firing sites.

All fireset designs used at the Los Alamos National Laboratory (LANL) must also pass review by the LANL Electrical Instrument Review Committee (EIRC). Fireset designs that meet the Q-6 requirements in this document can be expected to also meet EIRC requirements. However, formal review by the EIRC is still required before fireset implementation at the Q-6 firing sites.

In addition, each physical fireset will be reviewed and approved by a LANL electrical safety officer (ESO) to ensure adherence to National Electric Safety requirements before the fireset is placed into a Q-6 firing site. It is expected that firesets that meet the requirements in this document and have had designs approved by the ESO are ready for the Q-6 firing site, but review and approval is still required for each fireset built for use at Q-6.

1.2 Scope

This document provides requirements for all CDU designs to be used at the Q-6 firing sites [i.e., Technical Area 22, Building 34 (TA-22-00340; TA-40-0005; and TA-40-0015], including LANL-designed CDUs, firesets from other Department of Energy (DOE) sites, and commercial firesets. CDUs for other, non-Q-6 sites [e.g., Dual-Axis Radiographic Hydrodynamic Test (DARHT) Facility, Proton Radiography (pRad) Facility, Nevada National Security Site (NNSS), etc.] may have additional requirements that are not reflected here.

While this document provides recommendations and examples for some aspects of fireset design, it is not intended to be a design guide. This document is intended for use by subject matter experts (SMEs) in fireset design. Those new to fireset design should consult SMEs before submitting a fireset for Q-6 approval.

2.0 REQUIREMENTS

The fireset **shall have** the following.

R 1. An associated current and released electrical schematic

R 2. Redundant bleed paths to ensure that no electrical energy can be stored in the unpowered CDU

R 3. The ability to discharge stored voltage from maximum to <50 V in a reasonable amount of time (<5 min) that is specified and/or can be calculated from the schematic

R 4. No internal power sources (e.g., batteries)

R 5. A high-voltage monitor connector that reads the main capacitor for monitoring the high-voltage (HV) charge rate and HV safe status of the CDU

R 6. An auditable configuration (i.e., firesets that are calibrated off-site and delivered to Q-6 in a sealed box are acceptable with a provided benchtop test configuration procedure that can be performed in Q-6's non-HE electronics laboratories)

R 7. An established and provided acceptance criteria based on electrical waveforms (e.g., peak current and dI/dt) for discharge into defined loads (i.e., "ringdowns")

R 8. All requirements based on waveform measurements be capable of measurement within the limits of a Tektronix DPO7104C oscilloscope (i.e., 1 GHz, 10 GS/s, 6.7-bit vertical resolution, and max 50-V input)

R 9. Specified output impedance

R 10. A semi-permanent label listing the CDU model name, maximum stored energy, and serial number

R 11. A temporary label that specifies the current calibration and due date

R 12. Labeling of capacitance and current-viewing transformers (CVT)/current-viewing resistor (CVR) values (This labeling can be nominal values on the semi-permanent label, measured values on the calibration label, or both.)

R 13. Specified operating voltage and temperature ranges

R 14. An output port for detonator continuity ohmmeter (DCO) measurements that is accessible while DCAs and/or loads are connected to the fireset

R 15. Isolation between the HE circuit and case with between 100-Ω and 200-Ω resistance (This is only applicable if the case material is conductive.)

R 16. Isolation for preventing ground loop issues [This requirement may be satisfied by isolating the HV connectors from the case and/or by installing dielectric feet (e.g., rubber) on the case bottom.]

R 17. Inputs and outputs clearly and permanently labeled on the CDU case

R 18. Inputs and outputs compatible with Q-6 firing site input/output connections

R 19. Specified trigger connectors compatible with LANL firing systems (Compatible triggers include the following.)

- Transistor-transistor logic (TTL)
- Optical with a 830 nm–850 nm wavelength, >50-mW power, and >1-µs pulse width
- HV trigger at 2 kV (not available in TA-40-0015)

Others triggers may be available but must be confirmed with Q-6.

R 20. HV externally supplied at 15 KV at a 5-mA maximum (10 kV at an 8-mA maximum for TA-40-0015)

3.0 RECOMMENDATIONS

The fireset **<u>should</u> have** the following.

N 1. The ability to discharge the stored voltage from maximum to <50 V in 1 min

N 2. Two each 25-MΩ bleed resistors in parallel

N 3. A series resistor between the HV charge connector and main capacitor and a series resistor between the HV monitor connector and main charge capacitor

N 4. Reynolds 310 (or compatible) connectors on HV charge and monitor connections

N 5. A steel enclosure

N 6. A product specification document that is provided to Q-6 if it exists

N 7. A label listing the operating voltage and temperature ranges

N 8. BNC (Bayonet Neill-Concelman) connectors for the low-voltage coaxial inputs and outputs

N 9. ST (straight tip) connectors for optical inputs

N 10. 50-Ω output termination

N 11. Reynolds 310 (or compatible) connector for DCO

N 12. A specification for trigger to start-of-current jitter with a mean and standard deviation

N 13. No reasonable probability of unintentional discharge as a result of noise or dV/dt triggering while charging

Variations from these recommendations are acceptable as long as proof is given that all requirements (in Section 2.0) are still met and with the understanding that deviations could make implementation of the fireset more time-consuming and costly.

4.0 EXAMPLES

X 1. Figure 1 shows an example of HV input connectors and CVR output. All HV connectors are Reynolds 310 with Condition 1 polarization.

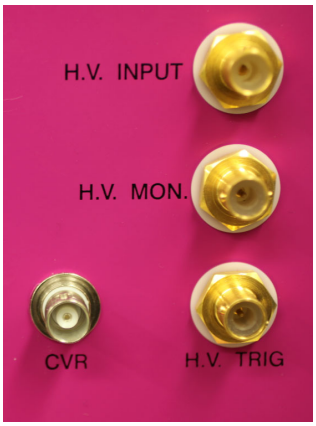

Figure1. Sample of acceptable fireset charge, monitor, trigger, and CVR panel.

X 2. For series resistors between the HV connectors and main capacitor, LANL has found 10 kΩ to work well. Larger values can affect the CDU charge monitor and interfere with the programmed CDU charge rate in LANL firing systems. Smaller resistor values may also work acceptably.

X 3. LANL typically uses Hoffman electrical enclosures (or similar) as the CDU case to shield the electronics from electromagnetic interference (EMI) and electromagnetic pulse (EMP) sources found at firing sites.

X 4. LANL uses a common single-point ground to the CDU electronics at the charge and monitor connector. The load ring output of the CDU can be tied to the CDU enclosure through an isolation 100-Ω to 200-Ω resistor. This design minimizes ground loop effects during CDU discharge.

5.0 RECORDS

Electronic copies of finalized documents will be stored in PDMLink. In accordance with P1020-1, *Laboratory Records Management*; PD1020, *Document Control and Records Management*; and W-AD-0055U, *W-Division Records Management Plan*, the Document Configuration Management Team will maintain official records.[1–3]

6.0 REFERENCES

1. *Laboratory Records Management*, Los Alamos National Laboratory procedure P1020-1, Rev. 11 (November 1, 2018).

2. *Document Control and Records Management*, Los Alamos National Laboratory procedure PD1020, Rev. 4 (November 1, 2018).

3. C. Scully, *W-Division Records Management Plan*, Los Alamos National Laboratory document W-AD-0055U, Rev. C (March 10, 2014).

7.0 APPENDICIES

Appendix A: Q-6 Fireset Requirements Compliance Form

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APPENDIX A – Q-6 FIRESET REQUIREMENTS COMPLIANCE FORM

Fireset Name: _____ **Design Site:** _____

Design Contact: _____ **Phone Number:** _____

Table A-1. Documentation List

Document	Found in Document Number
Fireset schematic	
Ringdown acceptance criteria	
Test configuration (for sealed box only)	

Table A-2. Requirements Checklist

No.	Description	Status
1	Electrical Schematic?	
2	Redundant bleed resistors?	
3	Discharges in reasonable time?	
4	No internal power sources?	
5	HV monitor connection?	
6	Open case and/or published test configuration?	
7-9	Has ringdown acceptance criteria that can be measured on a Q-6 scope with a specified impedance?	
10	Semi-permanent label with name, S/N, and stored energy?	
11	Calibration label?	
12	Capacitance and CVT/CVR value label?	
13	Specified voltage and temperature ranges?	
14	DCO output port present?	
15	Isolation between HV circuit and case 100 Ω–200 Ω? (N/A if non-conducting case material)	
16	Ground loop isolation? (At connectors and/or with feet)	
17	I/O labeled on case?	
18	I/O compatible with Q-6 firing system?	
19	Trigger compatible with Q-6 firing system?	
20	HV supply requirements compatible with Q-6 power supplies?	

Table A-3. Additional Information

Item	Value
Number of bleed paths	
Time to discharge from maximum to <50 V	
HV charge and monitor resistor size	
Main capacitor size	
Trigger type	
Case material	
Isolation resistor value	
Connector types present	
Output impedance	
HV input requirements	
DCO port type	

Additional Comments and/or Document Numbers:

Requirements Compliance Confirmed by: _____

Z Number: _____ Date: _____ Signature: _____