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Title:	ESD Testing of the 8S Actuator (U)
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Intended for:	Tri-Lab Dialog Meeting

Abstract - UNCLASSIFIED

The 8S actuator is a hot-wire initiated explosive component used to drive the W76-1 2X Acorn 1V valve. It is known to be safe from human electrostatic discharge (ESD) pin-to-pin and all pin-to-cup stimuli as well as 1 amp/1 watt safe. However low impedance (furniture) ESD stimuli applied pin-to-pin has not been evaluated.

Components were tested and the results analyzed. The 8S actuator has been shown to be immune to human and severe furniture ESD, whether applied pin-to-pin or pin-to-cup.

Cost Codes: JUBN DCA1 4103

Purpose and place of meeting: The Tri-Lab Dialog meeting is a follow-on meeting to the Nuclear Explosive Safety Workshop which allows additional discussion of important nuclear safety topics. It will be attended by LANL, LLNL, SNL. This first meeting will take place at Livermore.

ESD Testing of the 8S Actuator (U)

Tri-Lab Dialog Meeting

November 30, 2010

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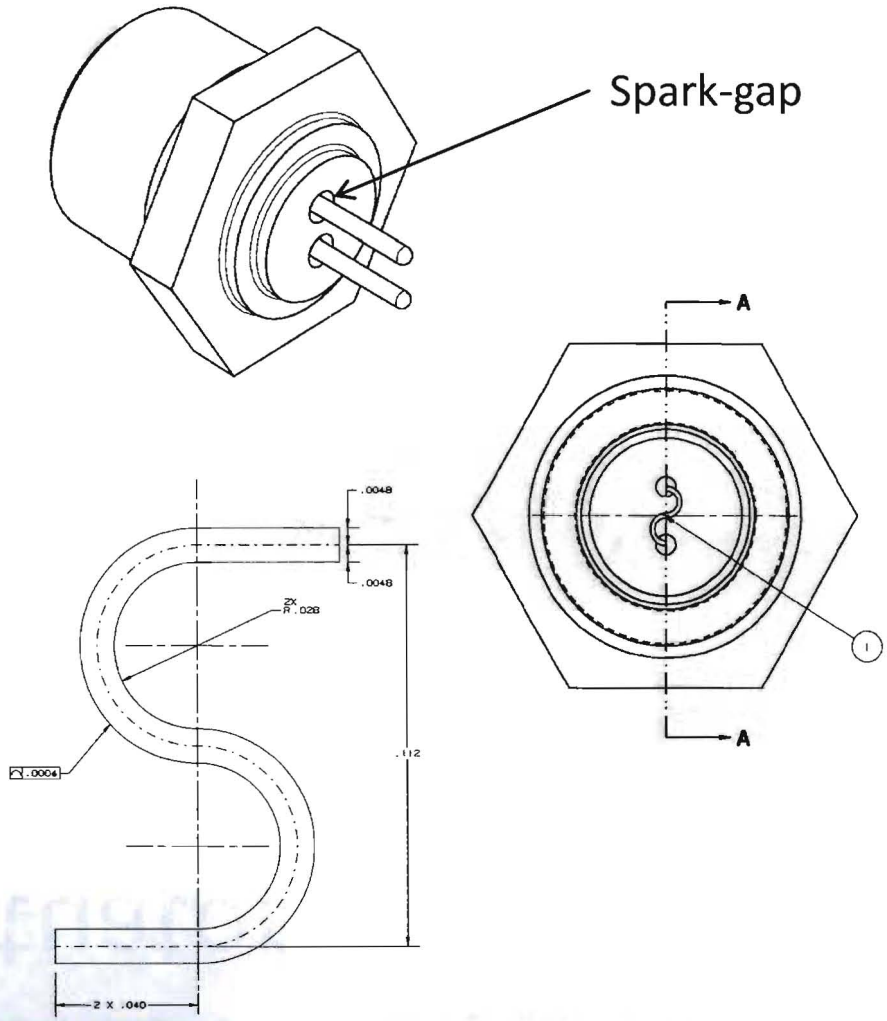
Background

- Hot-wire initiated explosive component that generates high-pressure gas to drive the piston of the W76-1 2X Acorn 1V valve
- ESD safe for human ESD and has an engineered spark gap (0.020-inch) for pin-to-cup ESD scenarios and is 1A/1W safe
- Uncertain whether the device is safe for furniture (low impedance) ESD applied in pin-to-pin mode

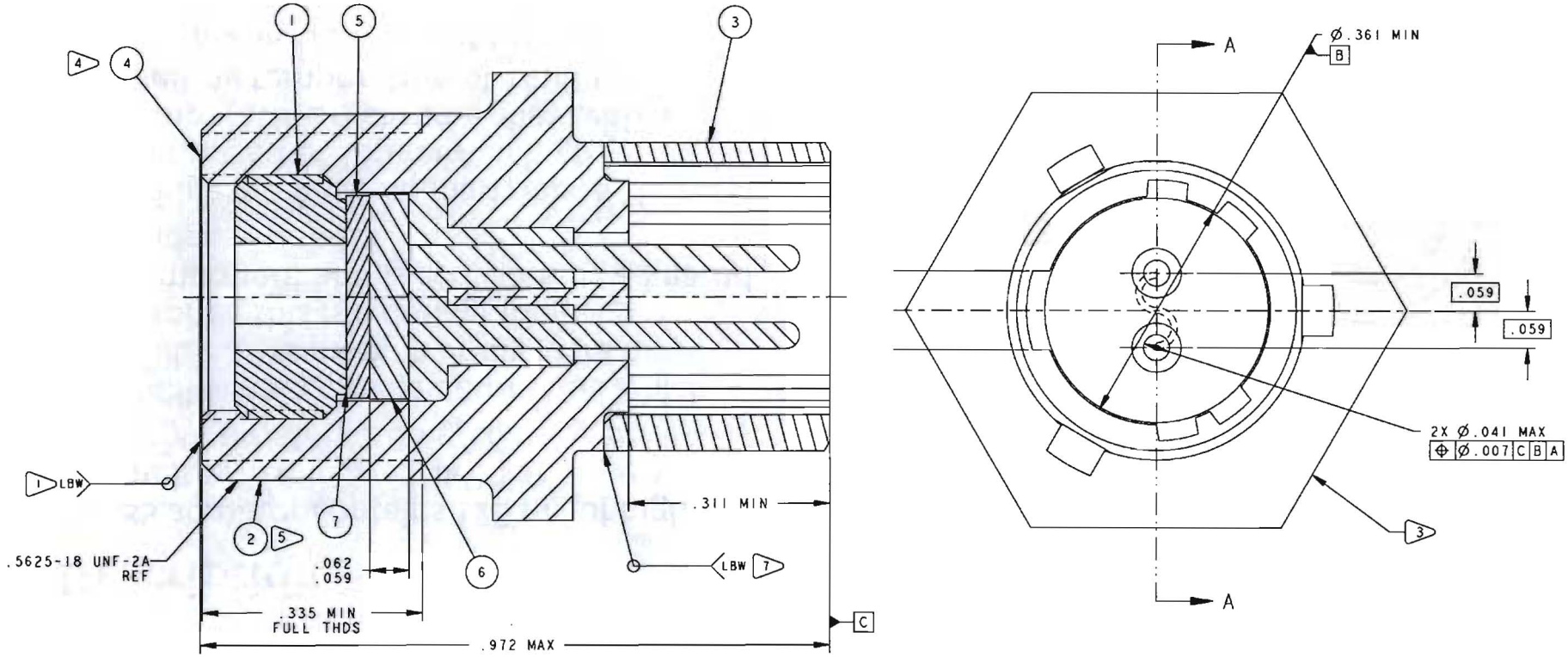
8S Actuator

Description

- 8S actuator contains 125 mg of high melting explosive (HMX) at approximately 1.65 g/cc
- Unlike main charge detonators which utilize an exploding bridge wire or slapper, this is a deflagrating component and is activated by a heated bridge
- Bridge is a flat S-shaped ribbon composed of Tophet A, a high temperature nichrome alloy with a melting temperature of 1400°C
  - Nominal resistance of 1-Ω
  - Required to fire within 30 milliseconds (ms) with an input current of 4.0 amps
  - Nominal 0.001-inch thick



8S Actuator



SECTION A-A

1) barrel, 2) bridged header. 3) connector shell, 4) disc closure, 5) flyer (aluminum), 6) HMX, 125 mg, 7) polyamide epoxy adhesive Note: dimensions are in inches.

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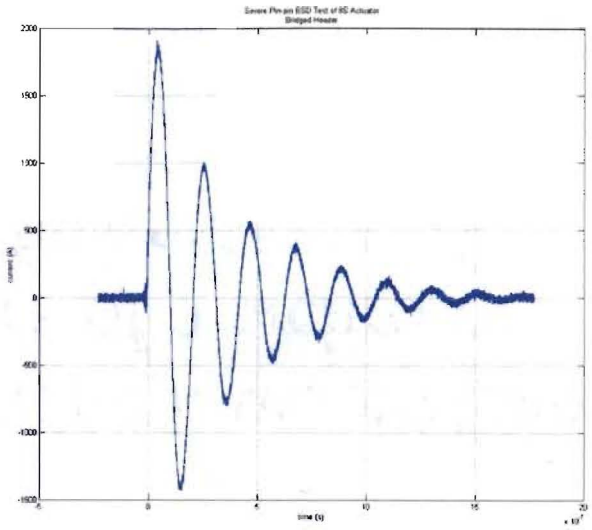
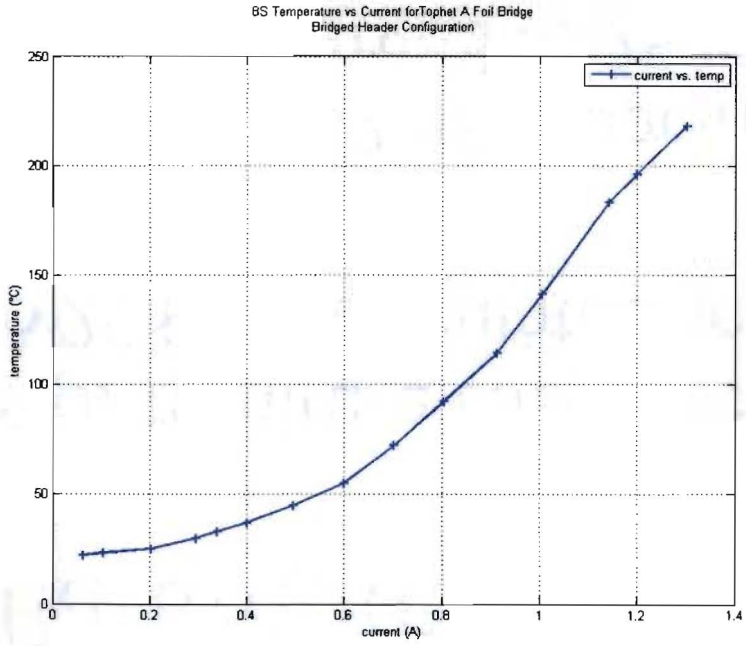
ESD Test Parameters

- An accepted definition for furniture ESD is a 500 pF capacitor charged to 25 kV, a calculated source energy of 156 mJ
- We severely over-test using a 3.52 nF capacitor (derated to 3.27 nF @ 25 kV) charged to 25 kV resulting in a 1 joule source
- If one considers an adiabatic bridge it would take 28.7 mJ to raise the temperature of a nichrome bride by 220°C (assuming specific heat of 450 J/kg-°C with mass 2.9 x 10^{-7}kg

Testing Bridged Header Configuration

- Multiple ESD pulses produced the same ringdown for each of the 5 pulses.
- No indication that bridge was heating during pulses when thermocouple was on bridge.
- Only indication of heating was from application of DC input.
- Lower plot shows steady state temperature versus DC.





Hard-fired Bridged Header

Part Selected: 2S/2052 (422662-00)
Actuator Lot Number: 00
Actuator Serial Number: 00

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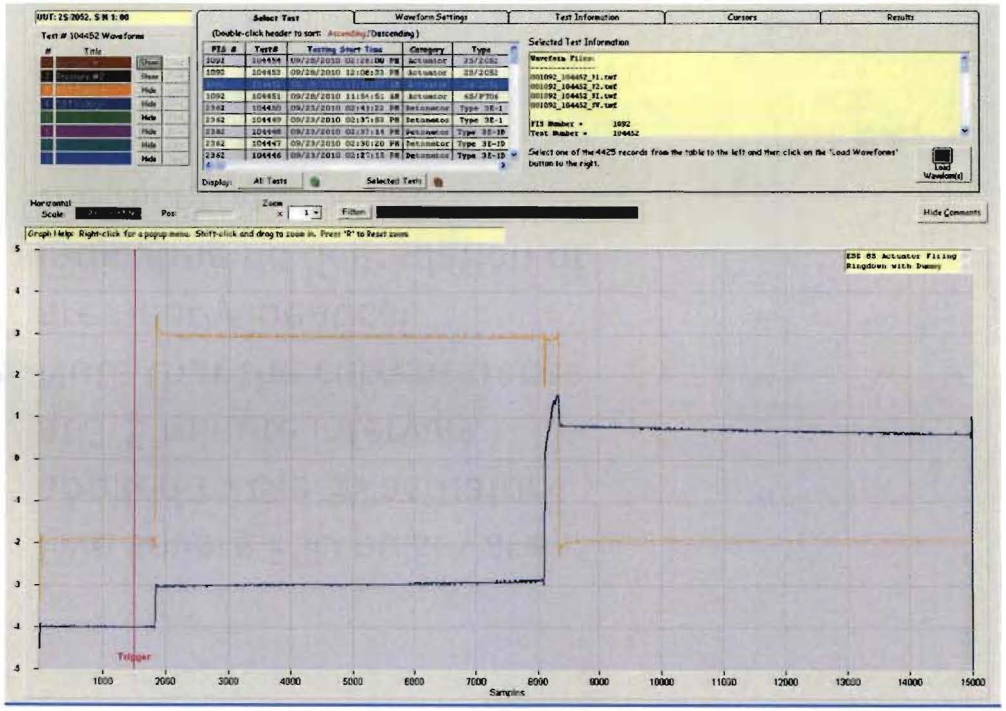
FIS # 001092 Test # 104452
Tester ID: PT3725 SN101
Tested: 09/28/2010 11:59:57 AM



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- The orange waveform is current with a vertical scale of 1 amp/division and blue waveform is voltage with a vertical scale of 5 volts/division. The horizontal resolution is 2 ms/division (1000 samples).
- The bridge wire melts after 13 ms @5-amps

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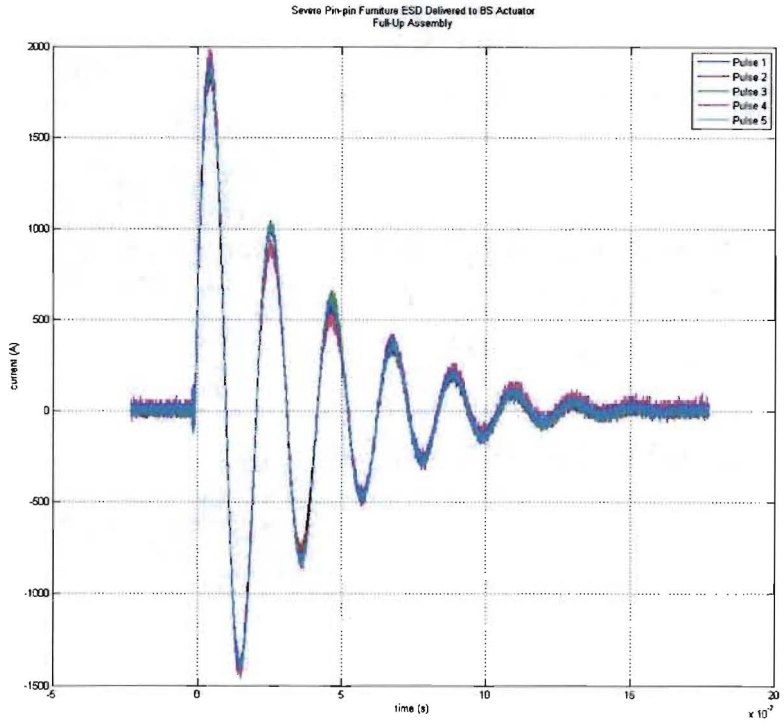
Full-up 8S Actuator Test

- Five severe ESD pulses are applied to the 8S actuator at 1.5 minute intervals.
- Note that the current traces are nearly identical indicating no degradation of the nichrome bridge.



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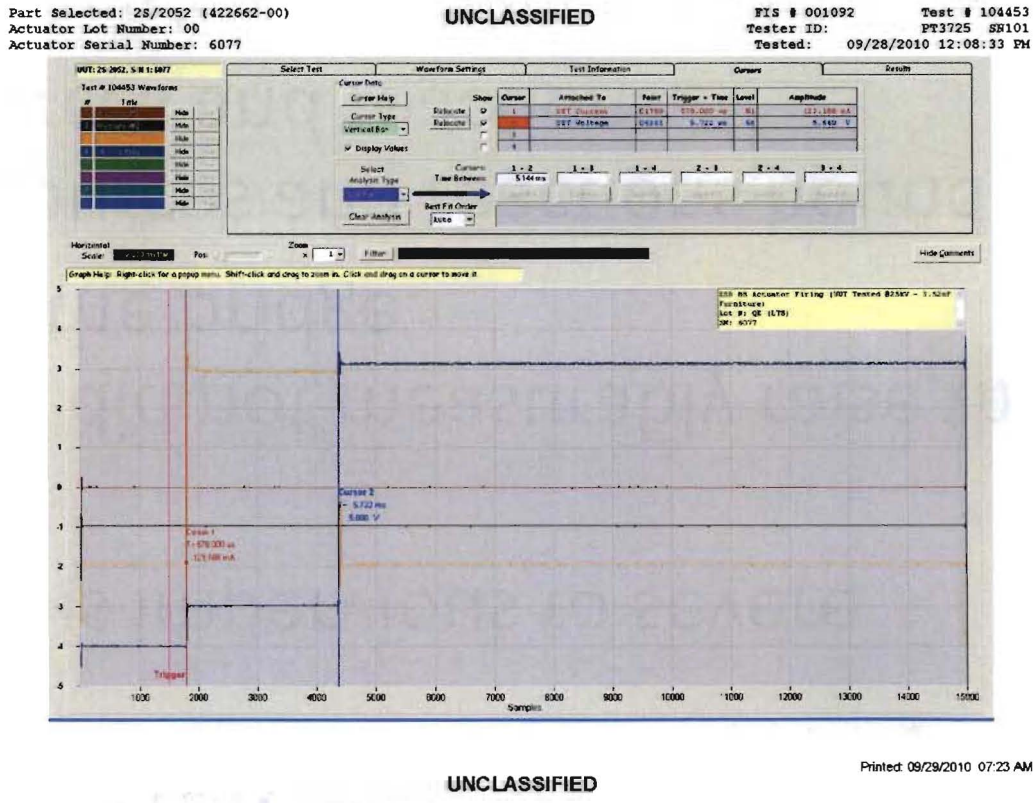
Full-up 8S Actuator Test

- The full-up device functioned as expected.
- Note that time until bridge burst (5.2 ms) is shorter than for the bridged header configuration because of faster heating due to presence of HMX.
- A second full-up 8S actuator was functioned without ESD pulses and the bridge opened after 5.7 ms.



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Conclusions

- The 8S actuator is impervious to severe furniture ESD.
- The 1.0 J source did not measurably raise the temperature of the bridge.
- Furniture ESD sources and reactions bound all human ESD sources and reactions.
- An engineered spark gap makes a pin-to-case energetic reaction for an undamaged actuator impossible.