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Predicting EBW Detonator Failure Using DSC Data

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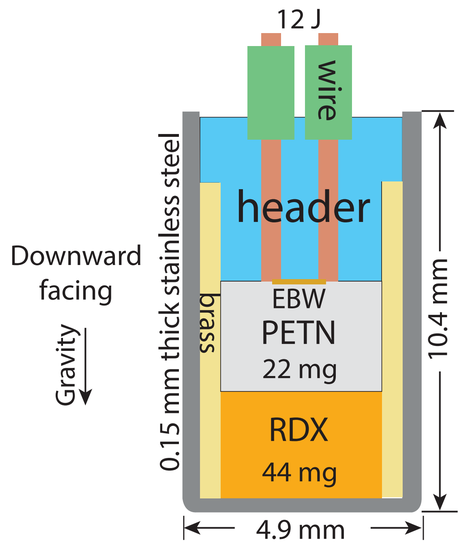
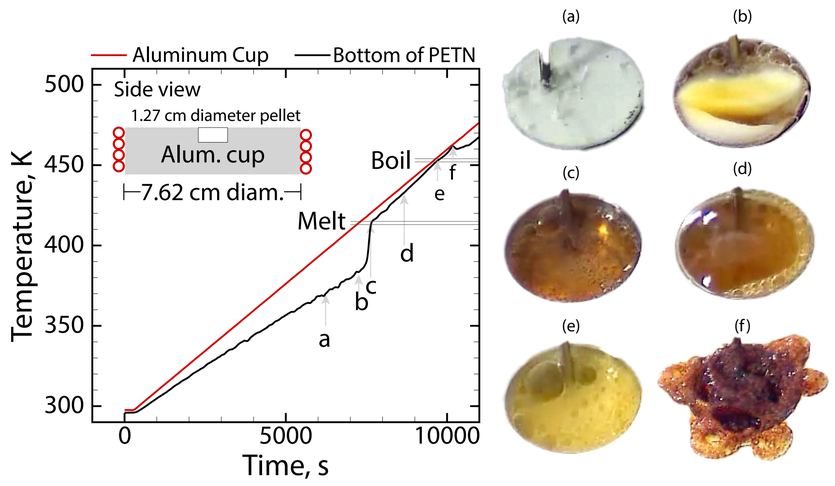
Melting PETN

Detonator



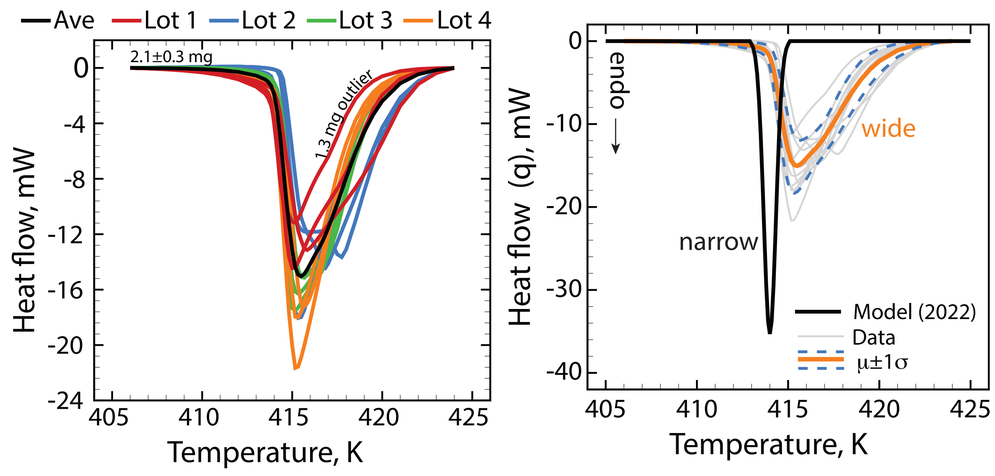
EBW: exploding bridgewire
PETN: pentaerythritol tetranitrate
RDX: 1,3,5-trinitro-1,3,5-triazinane

Mushy melt



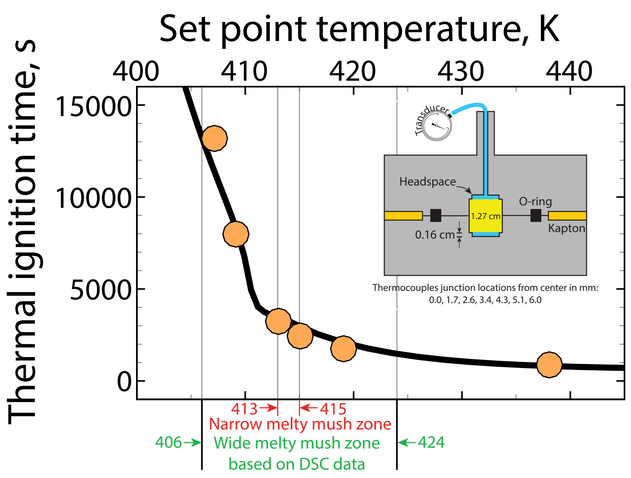
Hobbs ML, Kaneshige MJ, Coronel SA, "Operability Thresholds for Thermally Damaged EBW Detonators," Combust. Flame 238 (2022) 111953.

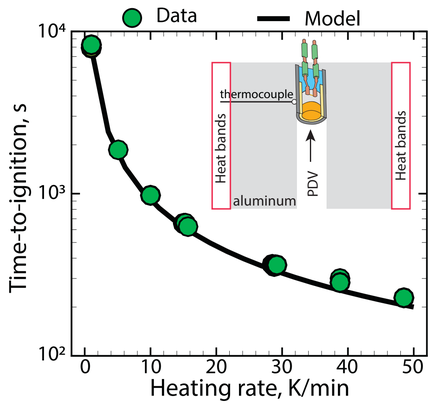
DSC data

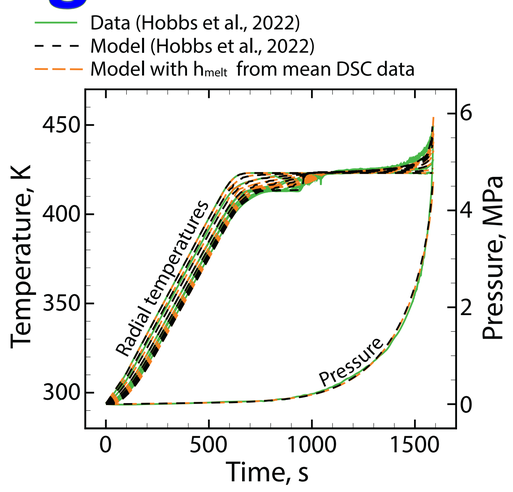


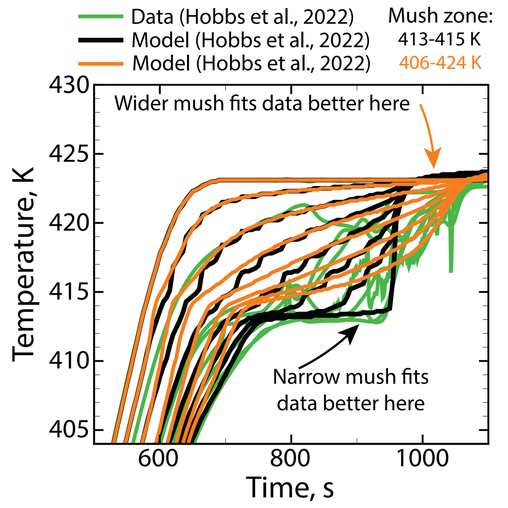
Hobbs, M. L., Wente, W. B., Kaneshige, M. J., "PETN Ignition Experiments and Models," *J. Phys. Chem. A*, **114**, 5306 (2010).

Thermal ignition



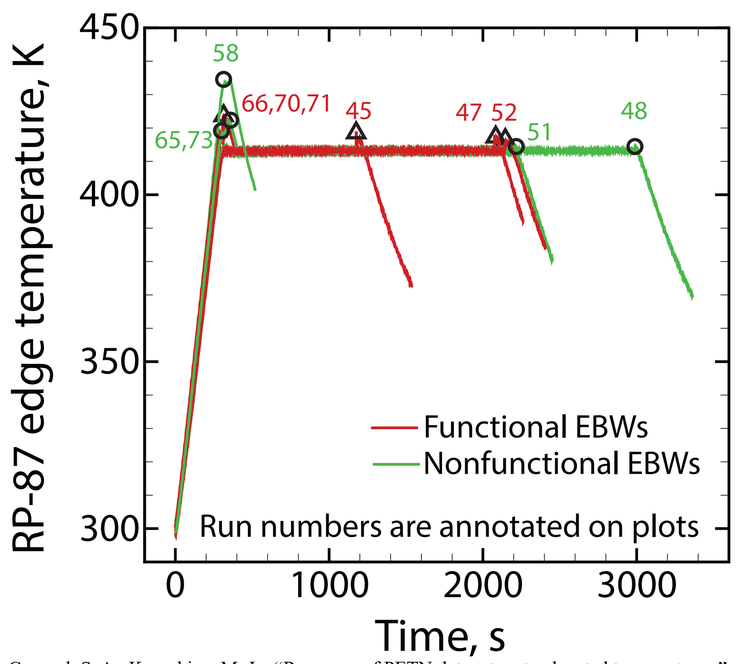




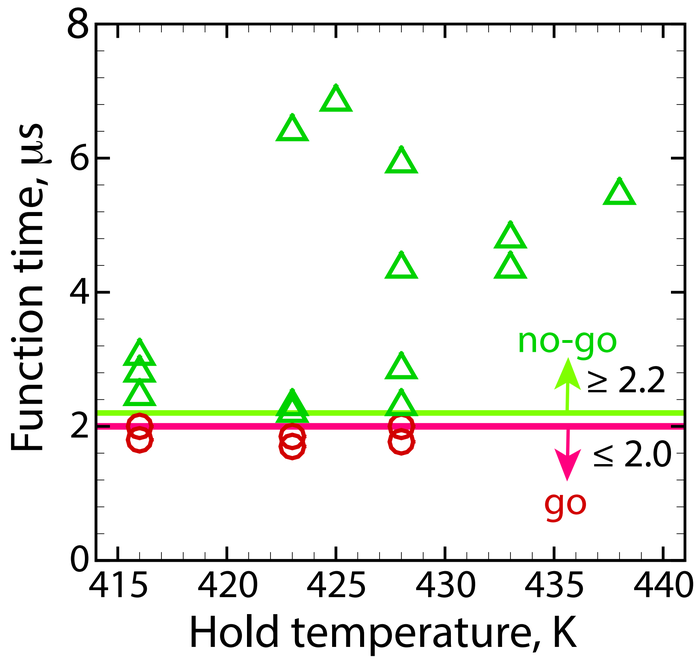


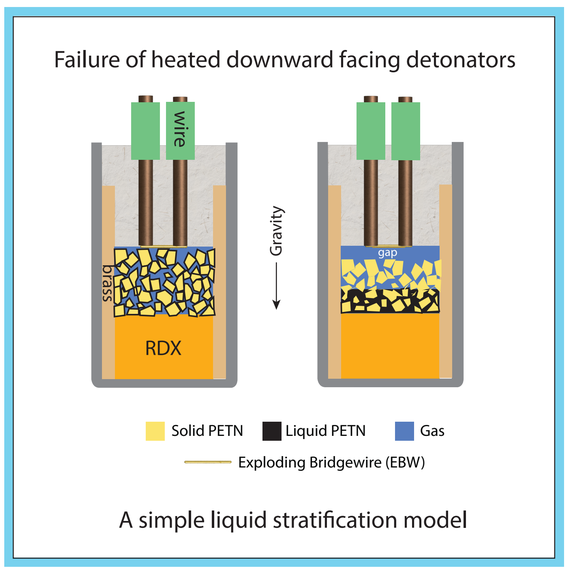
Detonator operability

Synonyms: go, operable, functional; no-go, inoperable, nonfunctional



Coronel, S. A., Kaneshige, M. J.., "Response of PETN detonators to elevated temperatures," *P. Combust. Inst.*, **38**, 4271-4279 (2021).





Hobbs ML, Coronel SA, "Cover: A liquid stratification model to predict failure in thermally damaged EBW detonators," Prop., Explos., Pyrotechn. 47 (October 2022).

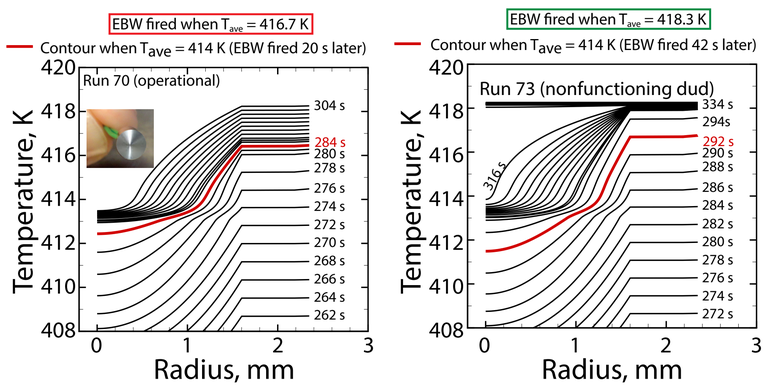
Critical gap distance

Gap calculated using melty mush zone from DSC data are in parenthesis

Run	go/no-go	T_{sp}	T_{fire}, s	t_{414}[a], s	$\bar{T}$, K	Gas vol. frac. $\bar{\phi}_g$	Melt frac., $\bar{m}$	G/H	Gap (G), μm
1	go	413.02	1174	0	413.06 (413.06)	0.4952 (0.4952)	0.0024 (0.0158)	0.001	3.8 (25.2)
2	go	413.10	2140	0	413.23 (413.24)	0.4979 (0.4979)	0.0108 (0.0177)		17.0 (28.2)
3	go	413.10	2074	0	413.26 (413.27)	0.4976 (0.4976)	0.0131 (0.0183)	0.…	20.8 (28.9)
4	no-go	413.10	2192	0	413.27 (413.28)	0.4982 (0.4981)	0.014 (0.0184)	0.0069 (0.0091)	22.1 (29.1)
5	no-go	413.13	2985	0	413.49 (413.54)	0.5093 (0.5093)	0.0629 (0.0216)	0.0291 (0.0104)	93.1 (33.3)
6	go	415.50	315	28 (25)		0.4947 (0.4947)	0.9895 (0.2957)	0.2487 (0.1147)	795.8 (367)
7	go	417.70	305	28 (2…		4947 (0.4947)	1 (0.6447)	0.25 (0.1964)	800 (628)
8	go	418.30	305	30 (26)		0.4947 (0.4947)	1 (0.6646)	0.25 (0.2000)	800 (640)
9	no-go	418.20	335	51 (45)	418.27 (418.10)	0.4947 (0.4947)	1 (0.7989)	0.25 (0.2223)	800 (711)
10	no-go	418.20	340	60 (60)	418.11 (418.02)	0.4947 (0.4947)	1 (0.7893)	0.25 (0.2208)	800 (707)
11	no-go	433.20	350	85 (83)	433.59 (433.59)	0.4948 (0.4948)	1 (1)	0.25 (0.25)	800 (800)

Critical gap

Heat transfer limitations



Width of mush melt zone is not as important as overcoming the latent enthalpy.

Summary and conclusions

- Functional if T < 406 K
- Nonfunctional if T > 414 for 1 min or longer
- Non-functional if bridgewire gap is > 30 μm
- Functionality difficult to determine if PETN is partially melted
- Stratification model can be used for downward facing EBWs
- Stratification model is more complex in other orientations

Explosive community has generally accepted that PETN detonators will fail to function if the PETN input pellet is completely melted. This paper has shown details of why this assertion is correct.

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