

ASSESSMENT OF SELF IGNITION TEMPERATURE (COOK-OFF) IN GUN BARRELS

Phil Pitcher¹ and Amer Hameed²

¹Naval Authority Group (Explosives), MoD Abbey Wood, BRISTOL, UK

²Centre for Defence Engineering, DEAS, Cranfield University, Defence Academy of the United Kingdom, Shrivenham, Swindon, UK.

Abstract

When a gun propellant or combustible cartridge case is brought in contact with a hot surface, its temperature increases and there is a corresponding increase in chemical reaction rate (decomposition) leading to self-heating. If the surface temperature is sufficiently high, then the heating due to increased reaction rate exceeds that of the heat lost to the surface and the material ignites or ‘Cooks-Off’.

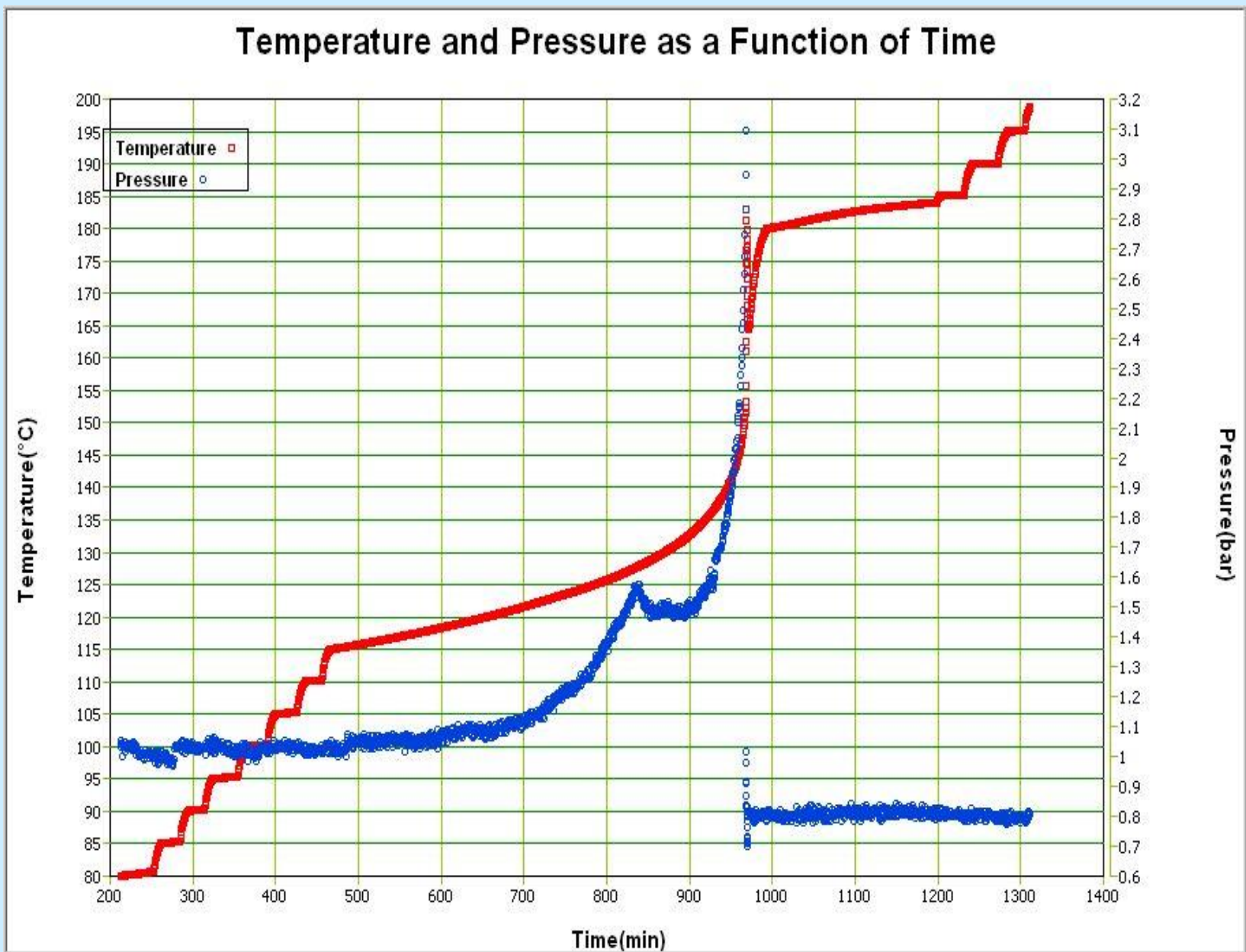
This work investigated the effect of contact time/temperature on cook-off using 7.62mm calibre cartridge cases filled with a commercial off-the-shelf Double Base (DB) propellant. A purpose-made test rig was used to simulate the firing chamber of a small calibre weapon as well as to record temperatures of the cartridge case and propellant which resulted in cook-off. In addition, an analysis was conducted on this propellant looking at the onset temperature of thermal run-away, and the time to detonation using Accelerated Rate Calorimetry (ARC) apparatus. Results have shown good correlation with previous data and have highlighted a need for further investigation to evaluate the accurate cook-off temperature.

ARC Methodology and Results

The apparatus used the Heat-Seek-wait (HWS) method to establish the decomposition rate for further experimentation. The onset temperature started at 115.49°C and the maximum temperature at the final event was 176.51°C.



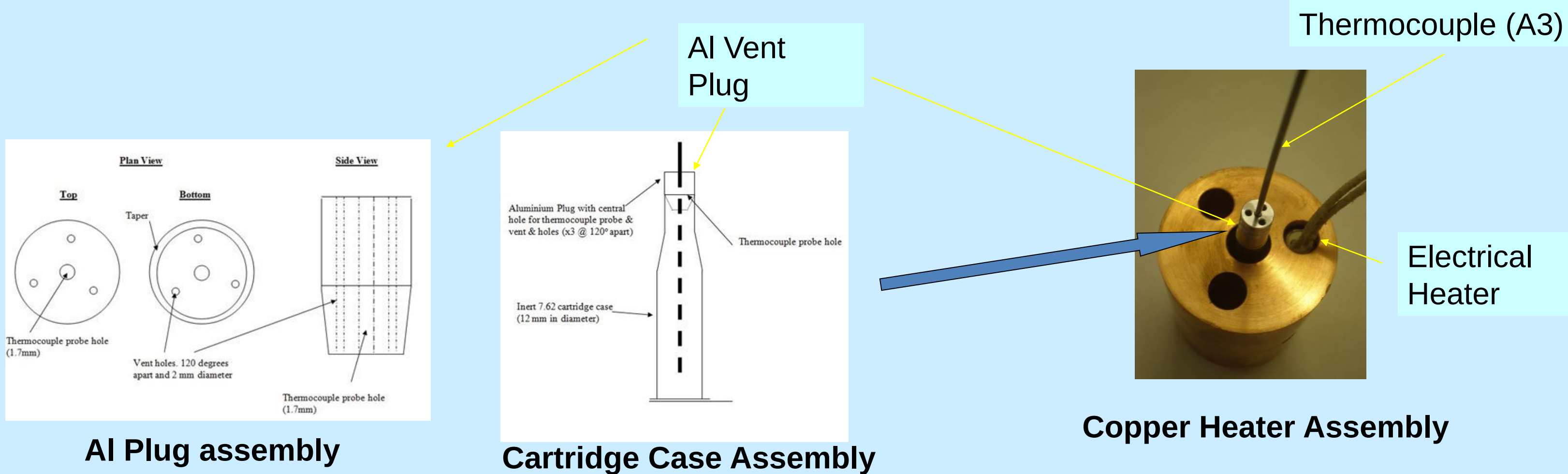
Photo of complete ARC assembly



Graphic results using ARC to identify the onset temperature and the maximum rate of decomposition of the Bulls Eye propellant

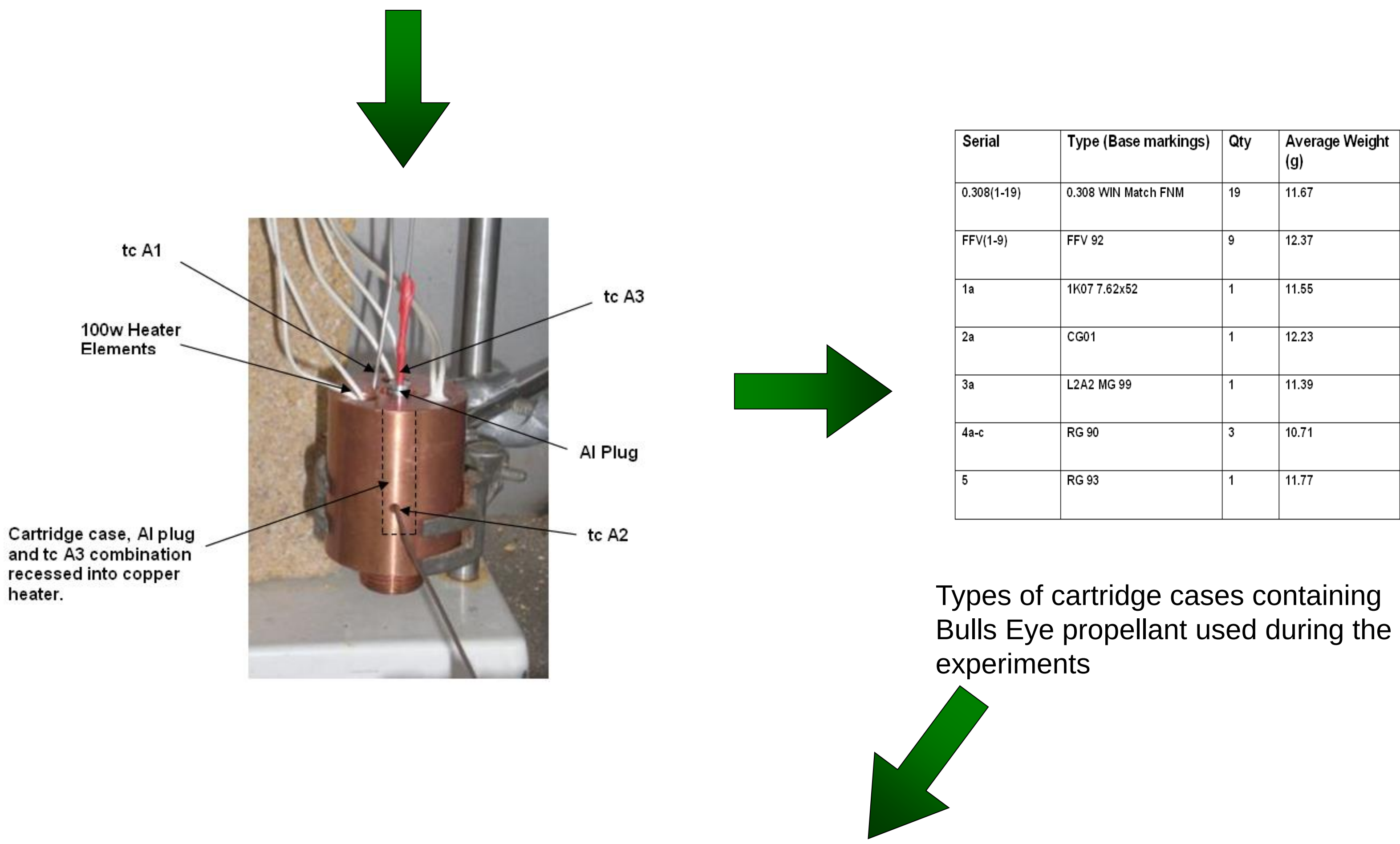
Experimental Cook-Off Test Rig

The experimental apparatus comprised of a copper cylinder with holes drilled to accept a 7.62mm cartridge case containing the Bulls Eye propellant, two thermocouples ‘A1’ and ‘A2’ (measuring the copper cylinder heat rise and the cartridge wall) and three electrical heaters. The cartridge case was modified to accept an aluminum (Al) vent plug and a thermocouple (tc) ‘A3’ to record the propellant core temperature.

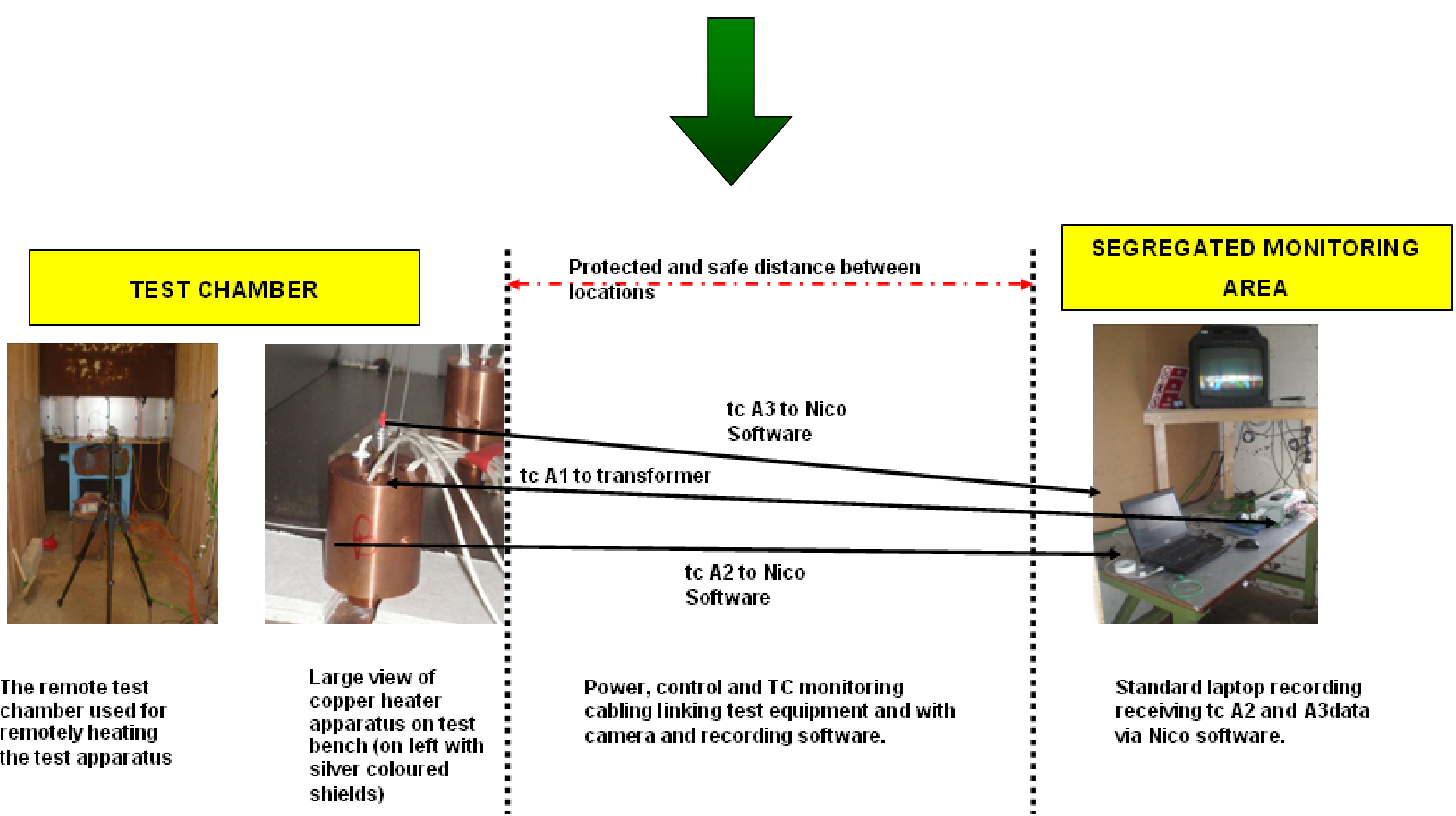


Experiment Method Overview

1. Copper Heater experiments – The cartridges were filled with 2g (+/- 0.01g) of propellant, fitted with a thermocouple (tc)/Al plug combination and inserted into the copper heater rig. Thirty-five experiments were conducted in total.



2. The assembled experimental apparatus was placed in a special type of test chamber where instrumental readings were obtained via cabling to a safely positioned monitoring station. The copper rig was gradually heated over ranges from 150°C to 180°C for the experiments. In some experiments the target temperature was held steady, in other cases the power was switched off once thermocouple tc A1 had reached the required temperature. Temperature readings were recorded on a NICO software system via tc’s A2 and A3 (if cook-off occurred or not).



3. Results were converted to *.xls format for analysis and report purposes. These identified that the cook-off limits depended on the temperature rise-time and the influence of the cartridge case material mass (the less mass, the longer the cook-off time). This test rig has the advantage over existing cook-off testing mechanisms of offering a cheaper, non-destructive solution in a variety of cook-off scenarios and assessments.

