White Paper

US Field-Portable Gas Fuel UN 6(c) Test Assembly

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Purpose

The purpose of this paper is to articulate the research efforts completed to date on a field-portable gas fuel UN Test 6(c) Assembly with a proposed design which utilizes commonly available carbon steel raw materials and can be, fabricated in sections, transported to remote locations in small trucks and field assembled.

Background

According to the current UN Manual of Tests and Criteria Section 16.6.1.3 Procedure for Conducting the Test 6(c) External Fire (Bonfire Test): "Suitable methods of heating include a wood fire using a lattice of wooden laths, a liquid or gas fuel fire, that produces a flame temperature of at least 800^{o} C". Furthermore, Section 16.6.1.3.4 states that: "If gas is to be used as a fuel, the burning area must extend beyond the packaging or unpackaged articles to a distance of 1.0 m in every direction. The gas must be supplied in such a manner to ensure the fire is evenly distributed around the packages. The gas reservoir should be large enough to keep the fire burning for at least 30 minutes. Ignition of the gas may be accomplished either by remotely ignited pyrotechnics or by remote release of the gas adjacent to a pre-existing source of ignition."

Much UN 6c Testing is still conducted with wood-fuel, although there are obvious advantages using a gas fuel over a wood fuel fire – sustainable constant temperature and less post-test clean-up being two. Similarly, there are obvious advantages using gas fuel over liquid fuel – lack of heavy black smoke and temperature variability being two. PHSMA has assessed the apparent lack of the wide use of a gas fuel fire might be due to a lack of a commonly available practical assembly design and also to the lack of field-portability, since many UN6(c) Tests are conducted in remote areas not easily accessible for larger transport equipment. There are also additional safety measures to consider in isolating the gas fuel storage and feed system from the potential danger of an explosion during the testing. But these issues can be addressed by adequate protection of the gas fuel tanks by remote distance and location behind heavy barricades or in underground trenches.

While liquid petroleum gas (e.g., propane) is typically a more expensive choice of fuel for the UN 6(c) than wood but less than kerosene (per liter), its cost per test can be optimized by closing the gas feed lines, once the last material on the test stand reacts, to economize on fuel consumption. Wood fires usually must burn to completion and liquid fuel fires are almost impossible to extinguish prematurely. Both wood and kerosene leave a costly clean-up.

Analysis

The proposed gas fuel burner assembly is approximately 2.5 meter (m) square when complete and fabricated of carbon steel with inlets for gas at either end. Considerable effort was spent finding the minimum number of liquefied gas cylinders necessary to achieve constant burner flame temperatures for at least 30 minutes without external heat input or evaporation devices to maintain constant flow of gas. This was experimentally determined to be twelve (12) cylinders, if all were surrounded with a sufficiently sized ambient temperature water bath.

A 32-minute field trial was video recorded with a Panasonic AG HVX 200A P2 camera at 60 frames/second and with a Vision Research Phantom Flex v1610 high speed camera with flash memory at 600 frames/second for 20 second intervals. The rate of consumption of propane at the flow rate which sustained a constant flame temperature of 800^{O} +/- C for the 32 minute period was approx. 8.3-8.4 kg/minute (min) (16.9-17.1 l/min) over all 12 cylinders or approx. 0.7 kg/min (1.4 l/min) per cylinder.

To provide a demonstration of the gas fuel propane burner assembly with actual explosive materials, an experimental trial was conducted with two packages of a fast-burning double-base shot-shell propellant (Green Dot®), each containing two inner packagings having 3.6 kg net weight of powder inside fiberboard drums and over-packed in either one or two UN 4G fiberboard boxes. The two fiberboard boxes (each 35.56 cm X 35.56 cm x 30.48 cm in size) contained a total of 14.54 kg of smokeless powder had a combined cubic volume of approx. 0.0766 m3. This constituted only 51.1% % of the 0.15 m3 requirement for a full scale UN6(c) Bonfire test. The two fiberboard boxes containing the smokeless propellant were placed on the test stand and thermal flux gauges were positioned at 5, 10, and 15 m away from two adjacent sides of the fire. As to the relative thermal flux increase seen vs. the Division 1.3/1.4 thermal effects criteria in the UNMTC the three separate events occurred quite close together and did not exceed a 4 kw/m3 maximum allowable increase in at 15 m during this demonstration run, but the test stand was not fully loaded with required 0.15 m3 of smokeless propellant packagings.

Summary

Gas fuel fires may offer:

- The advantage of a cleaner burning fuel than either wood or liquid and, consequently, decreased environmental impacts;
- A much clearer viewing of explosives classification tests, potentially leading to improvements in Division 1.3 vs. 1.4 decisions by virtue of gas' significantly more stable thermal flux outputs; and
- Since the fire can be extinguished easily after all explosives have completely reacted, cost savings in set-up time and fuel use that may quickly offset initial expenditures (i.e., return-on-investment or ROI) for material and labor costs.