US Army TARDEC
Fuels and Lubricants Research Facility

Evaluation of D-1 Fuel Nozzle Failures at Extreme Temperatures

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Problems and Objectives: The objective of this work was to investigate the effect of thermal expansion and vaporization of fuel trapped in the refueling nozzle, and to determine parameters creating observed field failures by simulating solar heating on nozzles full of fuel.

Importance of Project: Testing was conducted to reproduce and verify the failure mode experienced with D-1 nozzles as used with the HEMMT Tanker Aviation Refueling System and the Advanced Aviation Forward Area Refueling System (AAFARS). The D-1 nozzles failed when exposed to high ambient temperatures, which resulted in fuel spillage. In one case, the failed nozzle jammed and could not be disconnected from the aircraft.

Technical Approach: D-1 nozzles from different manufacturers and in differing configurations (with and without hose end regulators (HEPR)) were tested along with a Closed Circuit Refueling (CCR) nozzle. Also, the effect of connecting 50 feet of fuel hose to a Carter D-1 nozzle was investigated. A steel rack holding six nozzles was constructed and placed in an insulated box. A 250-watt infrared heat lamp was suspended approximately 6 inches above each of the nozzles. A thermocouple sensing the temperature of the nozzle skin served as the feedback element to the heat lamp controller for all six of the lamps. The skin temperature controller was set to 125°F. The nozzles were filled with JP-8 fuel at normal hose operating pressures at 80°F. The hose end valve was then closed, trapping the fuel inside the nozzle. The fuel was then heated to 115 to 120°F (temperature change of 35 to 40°F).

Accomplishments: This simulated solar heating of fuel trapped inside the nozzles will result in failure due to over pressurization. In the case of the Whittaker D-1, pre-6500 serial number Carter D-1, and CCR, the nozzle is catastrophically damaged, allowing fuel to pass through freely. The post-6500 serial number Carter D-1, and the pre-6500 Carter D-1 fitted with the new handle assembly, will be partially damaged by over pressurization but will still shut off fuel flow. The pressure-limiting effect of these nozzles, due to bleeding off the expansion volume fuel, appears to provide protection against total failure for temperature changes beyond the 35 to 40°F delta. Nozzle internal pressure will reach 180 psi with a 10°F increase in temperature, after the fuel is trapped inside. With the regulator, an additional 12 to 18°F is added to the allowable temperature increase. However, the standard regulator's ability to absorb the thermal expansion of the fuel can be defeated if the valve is closed when the hose pressure is over 30 psi. The pressure in the D-1 nozzle fitted with the 50-foot hose remained within the designed safe pressure limits of the nozzle.

Military Impact: To avoid nozzle damage, it is recommended to attach 50 feet of hose to the nozzle before any valve. A study could be conducted to determine if a shorter-length hose could also prevent over pressures. If using the hose is not practical, the Model 64349 Carter D-1s with serial numbers below 6500 should be outfitted with the new handle assembly (Carter PN KIT64348-12). The temperature extremes to which the nozzle population may be exposed should be determined to decide if the 12 to 18°F extension of the safe operating temperature delta for the regulator-equipped nozzle is worth the expense of fitting the fielded nozzles with regulators.

D-1 Fuel Nozzle In-Use