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FIRE TEST OF AN UN-T75 PORTABLE TANK ON A FLAT CAR-PHASE II

SUMMARY

The Federal Railroad Administration (FRA) contracted Southwest Research Institute (SwRI) to evaluate the fire performance of an alternative fuel storage tank using analytical methods and fire testing. The objective of this project was to expose an LNG rail storage tank to fire conditions and observe the performance of the pressure relief valve (PRV) system. The tank was filled with liquid natural gas (LNG). SwRI performed the full scale UN-T75 portable tank tire test on June 29, 2022.

An existing International Organization for Standardization (ISO) storage tank, outfitted for LNG service, was procured from Cryogenic Vessel Alternatives, Inc. (CVA). The model number of the tank is CVA-12K-114-ISO and measures 40 ft long, 8.5 ft high and 8 ft wide. Figure 1 shows the tank that was used in this experiment.

On June 28, 2022, Airgas USA, LLC provided the test tank that the research team filled with 9,500 gal of LNG. This resulted in a starting fill level of nominally 78 percent.

Figure 1. UN-T75 Tank Prior to Fire Test

The test tank was exposed to a propane gas burner fire located directly underneath the tank and flatcar. The fire source consisted of a 40 x 13-ft (nominal footprint of ISO tank on flatcar) liquefied petroleum gas (LPG) burner.

The fire test evaluated the performance of the PRV system on the tank. In addition, several types of data were collected during the experiment to understand how the fire exposure affects the internal and external heating of the tank. This information will be used in future computer modeling efforts to predict performance with different tanks and fire scenarios. Figure 2 shows a photograph of the fire test in progress.

Figure 2. Fire Test in Progress (PRV Venting)

BACKGROUND

The railroad industry is actively working on alternative fuels to diesel, including LNG and compressed natural gas (CNG). The safety performance of these alternate fuel tank cars under derailment induced fire conditions has not been verified and is a cause for concern. FRA is interested in methods and approaches, both analytical and experimental, which can evaluate the thermal safety performance of LNG/CNG means of containment (e.g., tanks, ISO tanks, etc.) under fire conditions.

The purpose of the first phase of this project was to conduct fire testing of an ISO tank filled with liquid nitrogen (LN2), located on top of a flat rail car and exposed to a propane pool fire. The second phase of the project was a repeat of the first test with LNG inside the test tank. The research team completed the Phase II test on June 29, 2022, and summarized those test results in this research.

OBJECTIVES

The primary objective of the test was to evaluate the pressure relief system installed on the test tank.

The secondary objectives were to collect data (temperature and pressure) to understand how the fire exposure affects the internal and external heating of the tank. This information can be utilized in future analytical work to predict performance with different tanks and fire scenarios.

METHODS

The test tank was exposed to a propane gas burner fire located directly underneath the tank and flatcar. The fire source consisted of a 40 x 13-ft (nominal footprint of ISO tank on flatcar) liquefied petroleum gas (LPG) burner. A piping array was installed in the steel burner pan. The array had eight branchlines and each branchline had 11 1/8-in. diameter holes evenly across the length.

The piping array was installed in the burner pan with the holes pointed downward, which allowed the LPG to diffuse evenly across the burner pan. LPG was introduced to the burner array at the northeast and southwest corners from a 2-in. buried pipe. An LPG supply system consisting of an 8,000-gal LPG, pump loop, and flow meter was setup approximately 900 ft away from the test area to the west. An emergency stop button allowed test personnel to safely terminate flow of LPG to the burner by routing to the control room. Figure 3 shows the burner construction.

Figure 3. Photograph of LPG Fire Exposure Burner Construction

Researchers used several types of instrumentation. A total of 24 internal temperature measurements were taken, in addition to internal tank pressure, annular space vacuum pressure (between the inner and outer tanks), and pressure relief device line pressure. Externally, 18 thermocouples (TCs) were provided around the tank and fire source to characterize the convective power of the fire and measure boundary layer temperatures.

An additional 18 TCs, referred to as directional flame thermometers (DFTs), were used to characterize the total heat flux from the fire and into the tank at several locations. Incident heat flux was measured at two targets (referred to as copper discs) as well as blast pressure, in the event of a catastrophic failure. Finally, the liquid propane flow rate and the wind speed were measured. The test was also documented with high definition (HD) cameras from two stationary views as well as consumer drone video footage from two alternating drone cameras.

RESULTS

SwRI's Fire Technology Department performed a fire test of an LNG cryogenic tank secured on top of a flat car at SwRI's remote test site in Sabinal, TX. The tank was exposed to the external LPG fire source for approximately 56 minutes.

The tank safely vented its contents and did not rupture. Figure 4 shows an additional photograph from testing and Figure 5 and Figure 6 shows photographs of the post-test conditions of the tank. Figure 7 and Figure 8 show some of the selected internal and external temperature data and Figure 9 shows the internal tank pressure and level throughout data collection.

Figure 4. Test in Progress – PRV Operating (After Fire Source Burner Turned Off)

Figure 5. Post-Test Photograph of East Side of Test Tank

Figure 6. Post-Test Photograph of Piping Cabinet of Test Tank

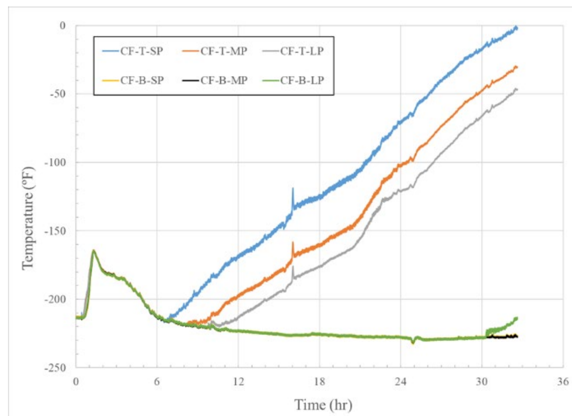

Figure 7. Internal Tank Temperatures (Center Float)

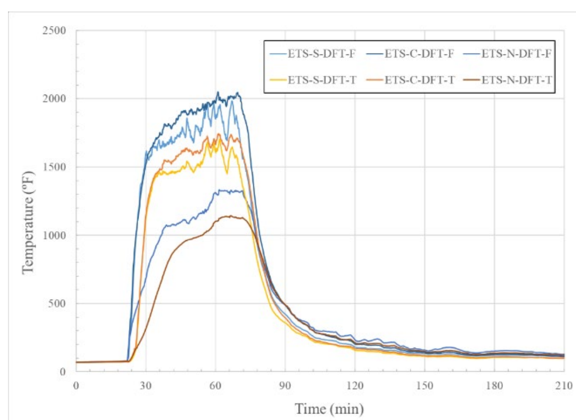

Figure 8. External Temperatures on East Side of Tank

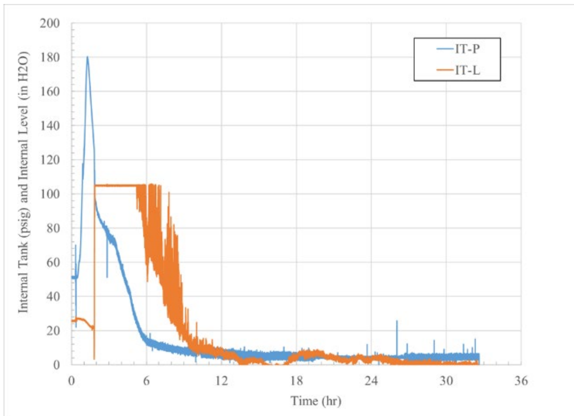

Figure 9. Internal Tank Pressure and Liquid Level Pressure

CONCLUSIONS

The following preliminary conclusions related to the fire test results as follows:

1. An ISO tank, filled with LNG, was exposed to an LPG fire for approximately 56 minutes, after which time, the LNG continued to burn through the PRV and leakages in the piping cabinet for an additional 48 hours.
2. There was no catastrophic failure observed during the test.
3. Based on the internal pressure rise and vacuum pressure measurement, the vacuum likely degraded relatively quickly into the fire exposure. The pressure inside the inner tank increased to a peak of approximately 180 psig.
4. The PRV system worked properly. The pressure valves began operating at approximately 114 psig. The valves intermittently reseated, closed, and reopened before fully opening for most of the test duration.

FUTURE ACTION

Data analysis is ongoing. Researchers should perform forensic analysis of the portable tank, conduct materials testing of the outside and inside tank, and finalize the technical report.

ACKNOWLEDGEMENTS

Test planning, instrumentation, data collection, test conduct and documentation were performed by SwRI.

Friedman Research Corporation performed analytical calculations and modeling in support of test planning and data analysis as well as documentation.

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