SAFESPILL SYSTEMS

Safespill Systems IBC Tote Flare-up Test Report

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1. Introduction

The following test report details the methods and results of a series of tests in which 275-gallon IBC totes were partially filled with ignitable liquids and placed in a fire scenario. These tests were prompted by an unexpected flare-up following the breach of an IBC containing 50 gallons of kerosene. This event occurred during a demonstration test of the Safespill Systems IBC storage Unit (ISU). A rolled cotton igniter was placed in the doghouse of the IBC and caused a breach of the plastic tote. Immediately following this breach, a large vapor fire occurred inside of the ISU and extended approximately 15 feet past the front edge of the ISU. This event was unexpected, as identical tests had been conducted many times before, and this phenomenon had not been observed.

The tests detailed in this report were designed to recreate this phenomenon, adequately document the factors leading up to it, and provide observable evidence of it. With further research into events like this, it will be possible to eliminate the factors that cause them and design systems which prevent damages due to said events.

This test report has been created for the sole purpose of sharing results. It provides information on the procedures used and documents the results of these tests. However, it does not aim to conclude the cause of this phenomenon or attempt to classify it within existing research on the subject.

2. Testing Methods

2.1 Test Design

For this test, a single IBC tote will be placed on the steel containment pan used for unprotected burn tests. The IBC will be filled with approximately 5 gallons of the prescribed ignitable liquid. IBCs will be left outside until adequate vapors have built up inside of the tote to create a flammable environment. After this period, a rolled cotton igniter is placed in the doghouse of the IBC and ignited by a firefighter in full gear using a propane torch. After a breach occurs, the test will be terminated using a fire hose.

Ignitable liquids to be tested include:

- Gasoline
- Acetone
- Kerosene

2.2 Procedure

1. Place steel burn pan so that spill guard on pan is facing the viewing area for the test and a clear line of sight exists for camera placement.
2. Fill IBC tote with prescribed volume of liquid, ensuring that valve is closed, cap is on valve, and cap on top of IBC is fully sealed.
3. Place IBC tote on steel pan, centered left to right and pushed to back of pan, away from spill guard as shown in Figure 2.1.
4. Allow tote to sit on pan and ignitable liquid to vaporize.
5. Firefighter will ignite rolled cotton igniter using propane torch.
6. Once breach has occurred, firefighter will use charged fire hose to extinguish fire terminating test.
7. Contents of steel pan will be drained into IBC tote, and liquid will be discharged to contaminated water storage and processing.

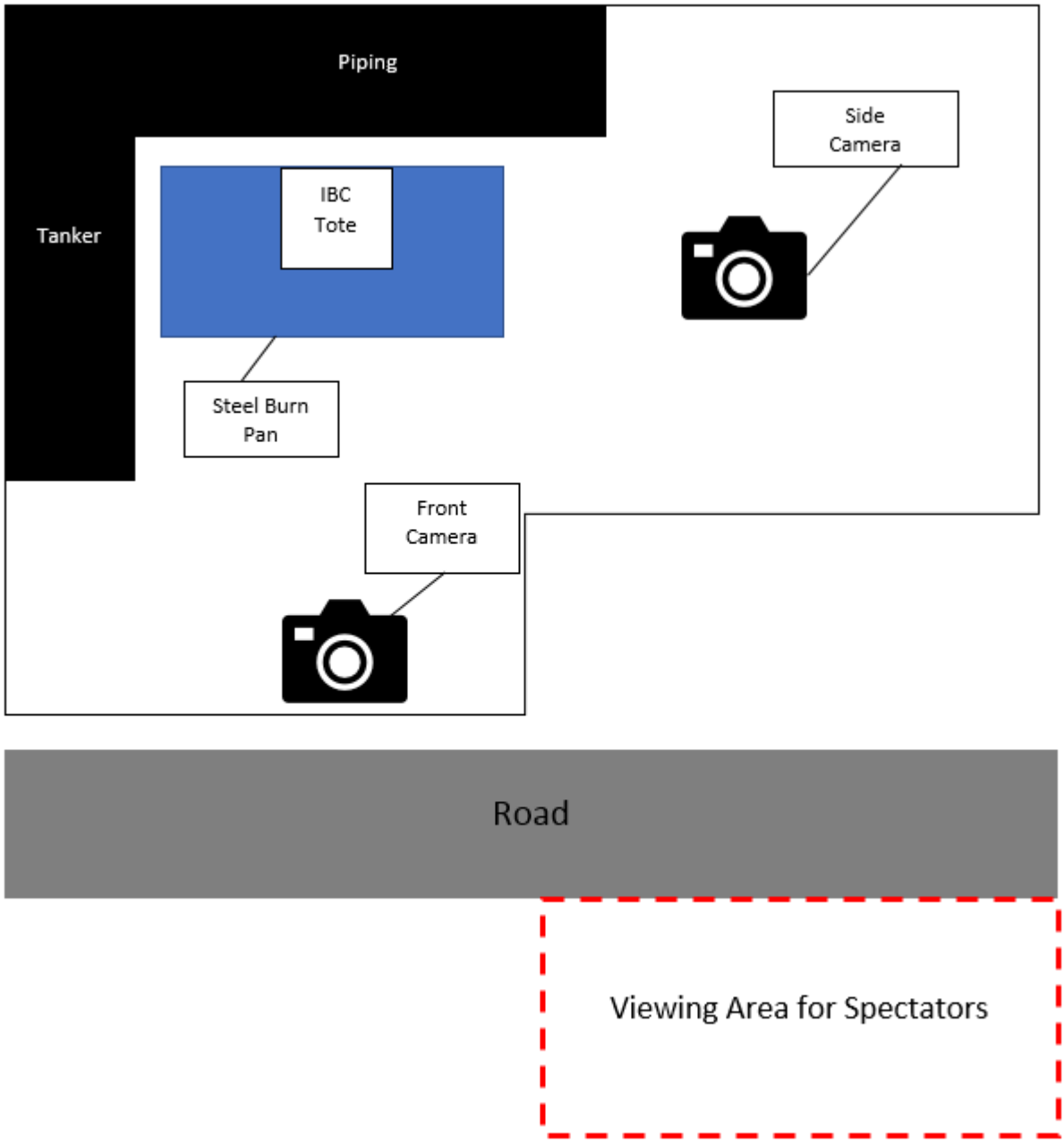

Figure 2.1: Bird's Eye View of Test Layout

Figure 2.2: Testing Area from Front Camera

Figure 2.3: Testing Area from Side Camera

3. Results

3.1 Testing Conditions

Testing occurred on April 4, 2018 between 1 PM and 4 PM at the Fort Bend Fire Field located in Richmond, TX. During the testing period, temperatures ranged from 71 to 74 degrees Fahrenheit, humidity from 23% to 25%. Weather was sunny with light breezes. As shown in the images within this report and in video records of these tests, IBC totes, as well as steel pan, are in direct sunlight.

3.2 Gasoline Test

For the test conducted with gasoline, 5 gallons of gasoline were dispensed into a clean and dry 275-gallon IBC tote. This tote was placed on the steel containment pan as described in Section 2. After being filled and positioned, the IBC rested for approximately 20 minutes before the test was initiated.

The test began with the ignition of a rolled cotton igniter. After 90 seconds, the tote was breached inside of the doghouse, above the liquid level. An audible release of vapor accompanied the visible breach. At 2 minutes and 9 seconds, a large flare-up occurred, as shown in Figure 3.1. Following this vapor release, the fire was reduced to the size that was observed before the flare-up. At 2 minutes and 50 seconds, fire-fighting measures began and the test was terminated.

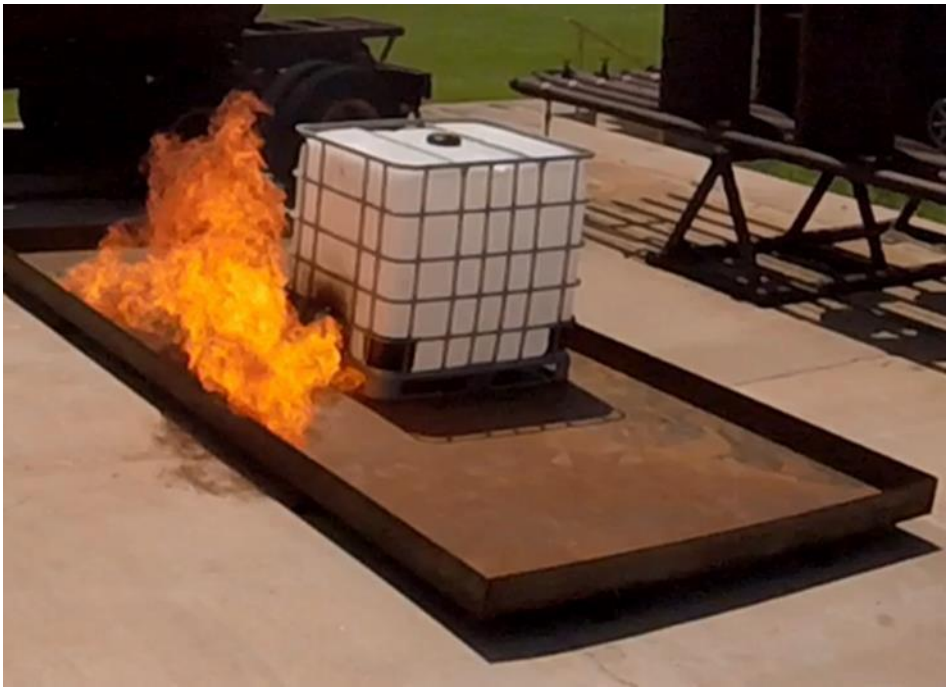

Figure 3.1: Gasoline Flare-up (2:09)

3.3 Acetone Testing

For the test conducted with acetone, 5 gallons of acetone were dispensed into a clean and dry 275-gallon IBC tote. The same procedure used for the gasoline test described above was followed for the acetone test.

The test began with the ignition of a rolled cotton igniter. At 2 minutes and 15 seconds, a small vapor release was observed (Figure 3.2). Acetone burns with a clear flame, so it is difficult to observe the size of this flare up. However, the event is indicated by a change in fire color and size, and the depression of the cap on top of the IBC as pressure is released. Following this vapor release, the IBC began to melt and a plastic fire began to spread, but no additional flare-ups were observed. At 3 minutes and 40 seconds, fire-fighting began and the test was terminated.

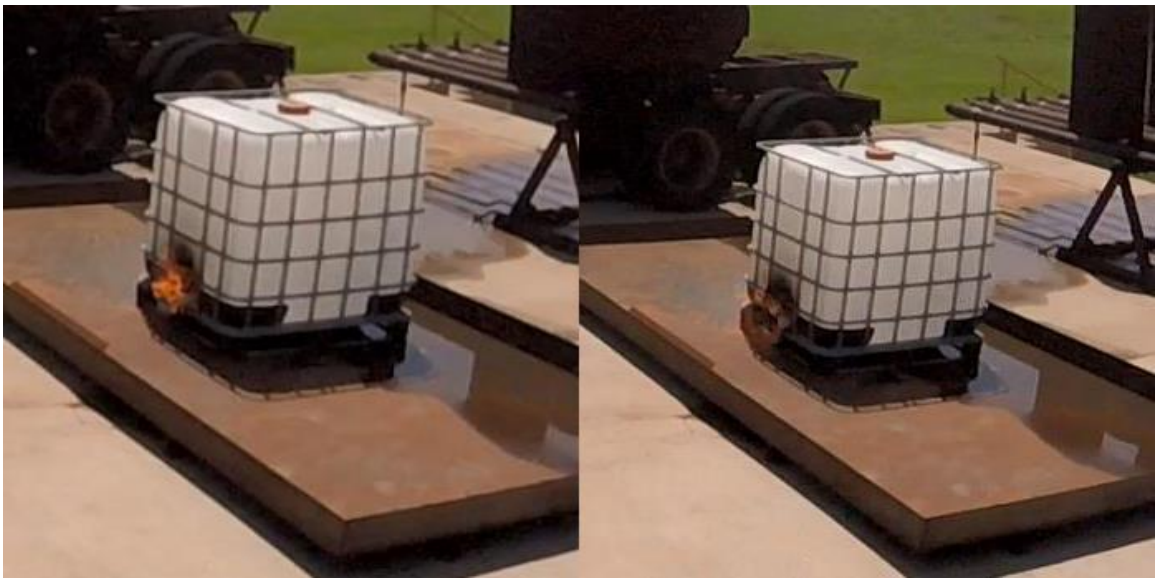

Figure 3.2: Fire from Igniter (Left) vs Fire caused by Acetone Flare-up (Right)

3.4 Kerosene Single-tier

Two tests were conducted using kerosene. For each test, 10 gallons of kerosene were dispensed into a clean and dry 275-gallon IBC tote. 10 gallons of kerosene was used instead of the 5 gallons used in both the gasoline and acetone tests, due to its lower vapor pressure and higher flash point. As the initial event, which inspired these tests, occurred with 50 gallons of kerosene, there were concerns that 5 gallons would not provide adequate vapor production for the desired event to occur.

For the first test, this tote was sealed and allowed to warm up in direct sunlight for approximately 6 hours. Internal pressure within the tote at the initiation of the test was less than 0.1 psig. Tote placement and test procedure were identical to what is described in previous sections for gasoline and acetone tests.

The test began with the ignition of a rolled cotton igniter. At 1 minute and 38 seconds, a major flare-up occurred. The flare-up began with a visible pressure buildup inside of the IBC (Figure 3.3), followed by a release of ignitable vapor (Figure 3.4). This vapor cloud was ignited, leading to a massive fire that engulfed the entire containment pan (Figure 3.5). The design of the pan appears to redirect the expanding gases laterally and the IBC is pushed backward. After the initial flare-up, isolated pool fires remained in the pan, and a plastic fire began to consume the IBC (Figure 3.6). A firefighter intervened at 2 minutes and 20 seconds, extinguishing the fire and terminating the test.

Figure 3.3: IBC inflation and initial vapor release

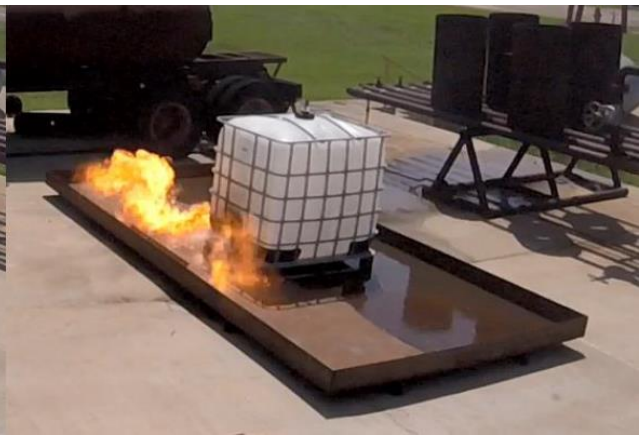

Figure 3.4: Initial vapor ignition

Figure 3.5: Fully ignited vapor cloud

Figure 3.6: Pool fires and burning IBC following flare-up

3.5 Kerosene Second-tier

Following the results of the first kerosene test, a second test was conducted with the filled IBC and rolled cotton igniter moved to a second tier IBC (Figure 3.7). The first tier IBC was clean, dry, and free of ignitable liquids. The second tier IBC was clean, dry, and filled with 10 gallons of kerosene. After filling the second tier IBC, the totes were positioned on the steel containment pan and left in direct sunlight for approximately 30 minutes before the test was initiated.

Figure 3.7: Second Tier IBC Set-up

The test began with the ignition of a rolled cotton igniter. At 2 minute and 41 seconds, a major flare-up occurred. A simultaneous inflation of the second tier IBC and rapid release of partially ignited vapors occurred (Figure 3.8). The vapor cloud was ignited, and the resulting ball of fire extended nearly 30 feet beyond the edge of the containment pan (Figures 3.9 and 3.10). After the flare-up, a pool fire formed on one side of the stacked IBCs and both IBCs began to burn (Figure 3.11). Within 20 seconds of the initial flare-up, both IBCs and the entire containment pan were engulfed in flames (Figure 3.12). A firefighter intervened at 3 minutes and 54 seconds and was eventually able to extinguish the fire.

Figure 3.8: Tote inflation and initial vapor release

Figure 3.9: Vapor ignition

Figure 3.10: Ignited vapors create fire ball extending nearly 40 feet

Figure 3.11: Pool fire fully consumes IBC totes

Figure 3.12: After extensive fire-fighting, IBCs are extinguished

4. Conclusion

Based on the results of these tests, further analysis and testing of these types of events is required. Although significant observations have been presented in this report, it is still unclear what these results mean. Safespill Systems does not claim to be experts in fire testing, and consultation from experts in the field is needed to further understand the results of these tests.

Further Testing

Additional testing, with pressure and temperature recording devices in place, would be beneficial in understanding the scenario that occurred during the kerosene tests. The ability to monitor the pressure and temperature of the contents within the IBCs may provide more evidence to the cause of the event.

A repeated gasoline test would provide more clarity as well. Safespill Systems believes that the gasoline test may have been terminated prematurely. A breach and release of vapor was observed during this test, but it was terminated much earlier than the kerosene tests. In the single-tier kerosene test, an audible release was heard well before the larger flare-up. It is possible that the initial vapor release during the gasoline test was analogous to the audible release during the kerosene test, and had the gasoline test had been extended, a similar flare-up may have occurred.