

SAFESPILL

Safespill

Tank Truck Discharge Testing

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1 Introduction

1.1 Purpose

Safespill has designed and manufactured a tanker truck unloading station floor system for The Dow Chemical Company. The design of this floor system is shown in Figure 1-1.

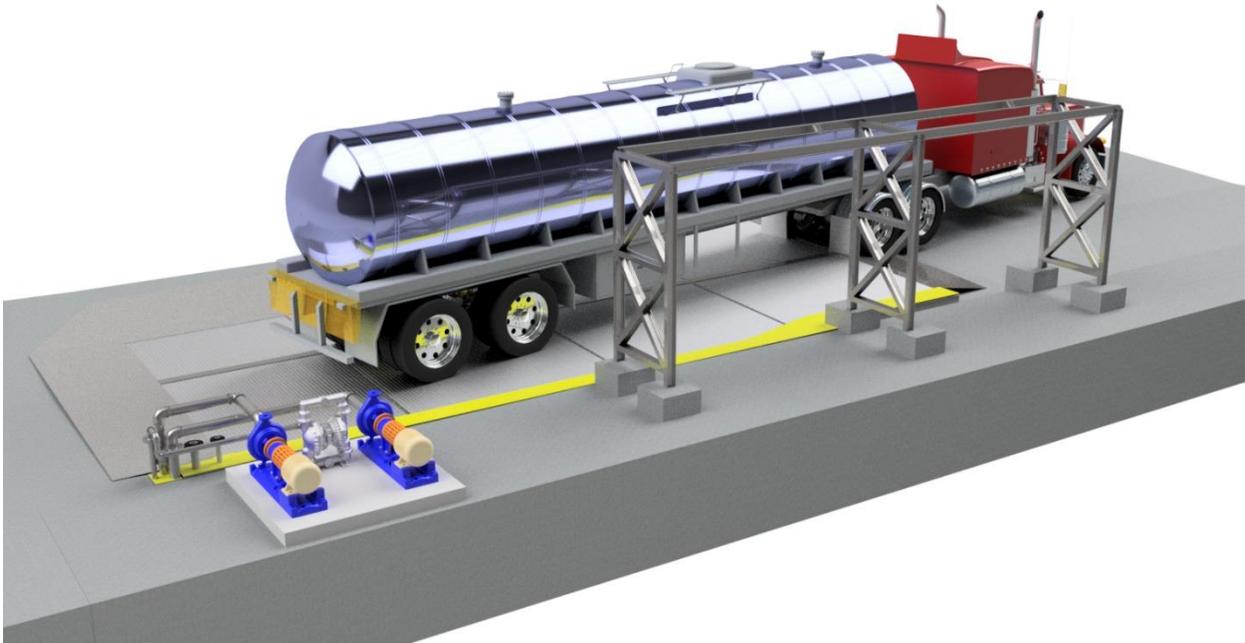


Figure 1-1: Tanker truck unloading station custom design for The Dow Chemical Company.

Although this system is custom-made, this application is a common scenario and there is a need to develop a standardized design which can be used for all tanker truck applications. By experimentally determining the following variables, a standardized design can be developed to use with all tanker truck applications:

- Flow Rate
- Lateral Discharge Distance
- Spill Area

1.2 Test Design

Test set-up (Figure 1-2) was based on research of the following four variables:

- Valve Opening Size: 2", 3", and 4" tested
- Valve Height from Ground (Top surface of floor): 37" (0.94 m)
- Valve Orientation (Horizontal or vertical): Horizontal
- Pressure Head: Initial liquid level at 70" (1.8 m) above valve centerline

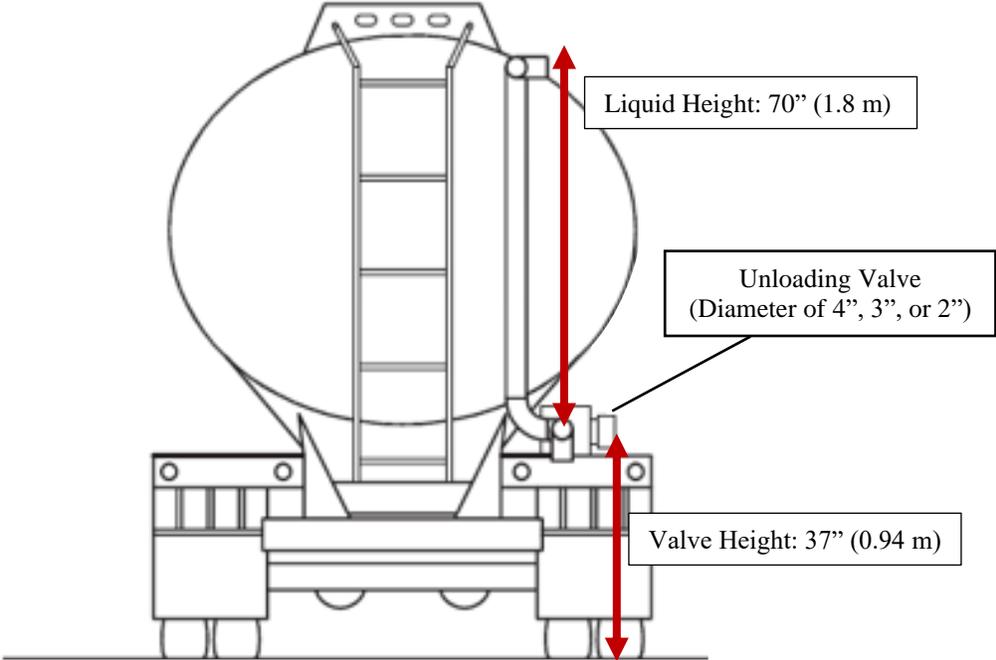


Figure 1-2: Drawing of tanker truck with valve position highlighted. For testing, valve will be positioned as shown in drawing.

Further substantiation for the determination of these variables can be found in Appendix A.

2 Testing Procedure

2.1 Tank Size and Position

All testing was conducted using a 2,000-gallon poly tank. The overall dimensions of the tank were 96" (2.4 m) diameter and 84" (2.1 m) height. Valve centerline was located 8" (0.2 m) above the base of the tank. The tank was placed on top of a wooden platform which elevated it 29" (0.74 m) above the top surface of the floor assembly. The centerline of each valve was located 37" (0.94 m) above the top surface of the floor for all testing. Valve sizes of 2", 3", and 4" were tested.

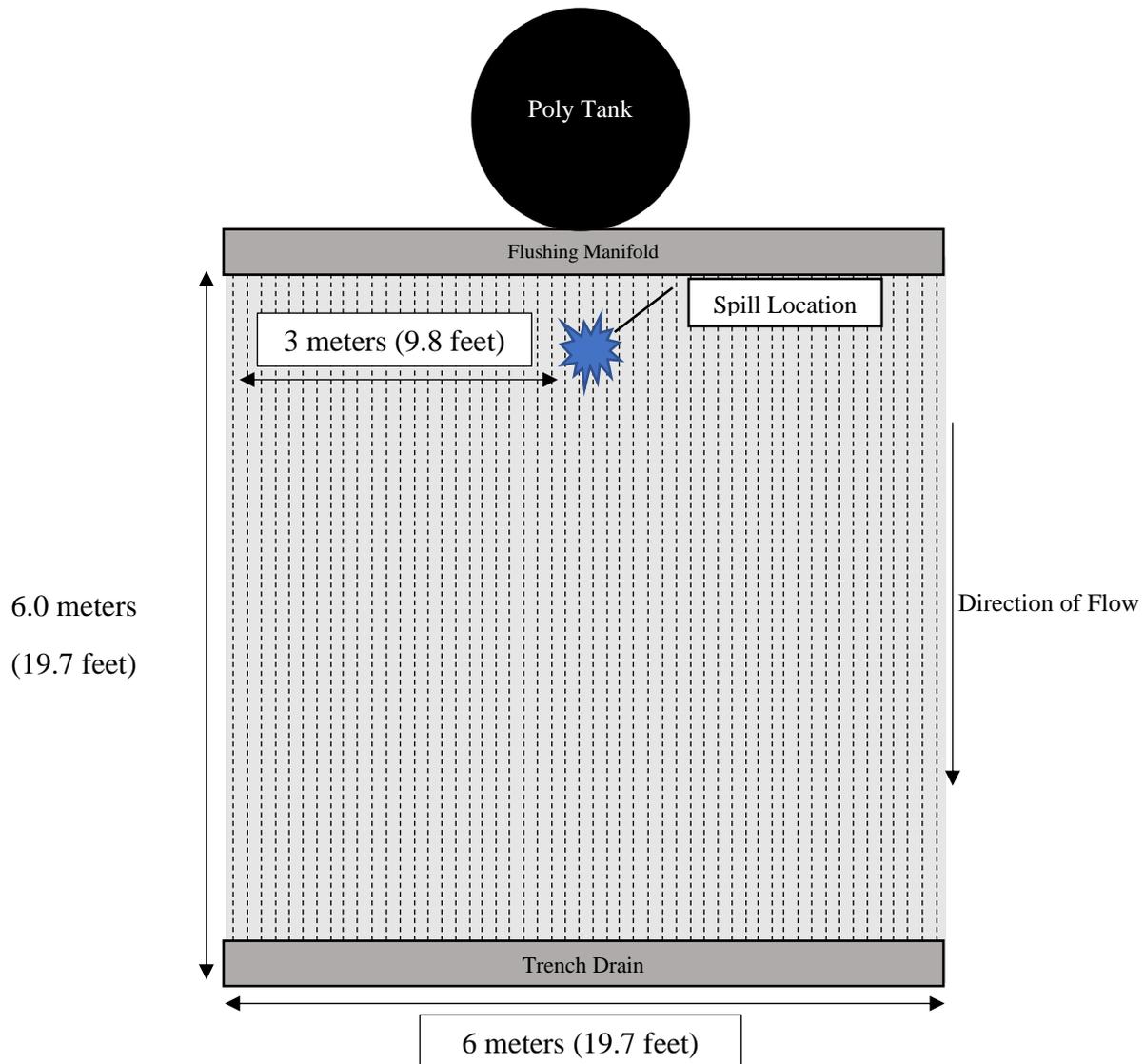


Figure 2-1: Layout of floor assembly and positioning of poly tank.



Figure 2-2: Side view of floor and poly tank positioning. Centerline of valve located 37'' (0.94 m) above top surface of floor.

2.2 Tank Liquid Level

A graduated sight glass was installed on the side of the tank to measure liquid level inside of the poly tank. Video was recorded of liquid level to determine flow rate during testing (Section 3.1). For each test, the initial liquid level was 70'' (1.8 m).

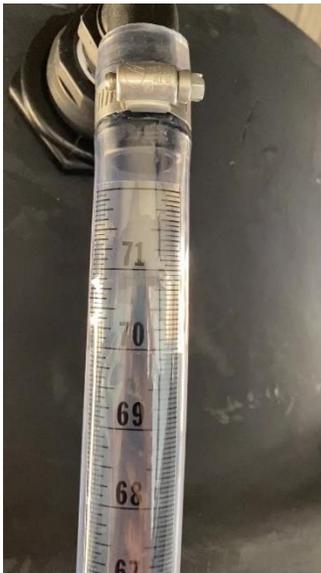


Figure 2-3: Sight glass on side of poly tank.

3 Results

3.1 Flow Rate

Based on data collected in testing, flow rates can be accurately estimated using a form of Bernoulli's equation with an experimentally determined coefficient of discharge. These correlations for 2", 3", and 4" valves are plotted in Figure 3-1.

$$Q = 5.665cD^2\sqrt{H}$$

Where,

Q = Flow Rate in gallons/minute

c = Experimentally determined coefficient of discharge

D = Diameter of valve in inches

H = Liquid level above valve measured in inches

The following values for coefficient of discharge were found,

2" valve, c = 0.925

3" valve, c = 0.875

4" valve, c = 0.625

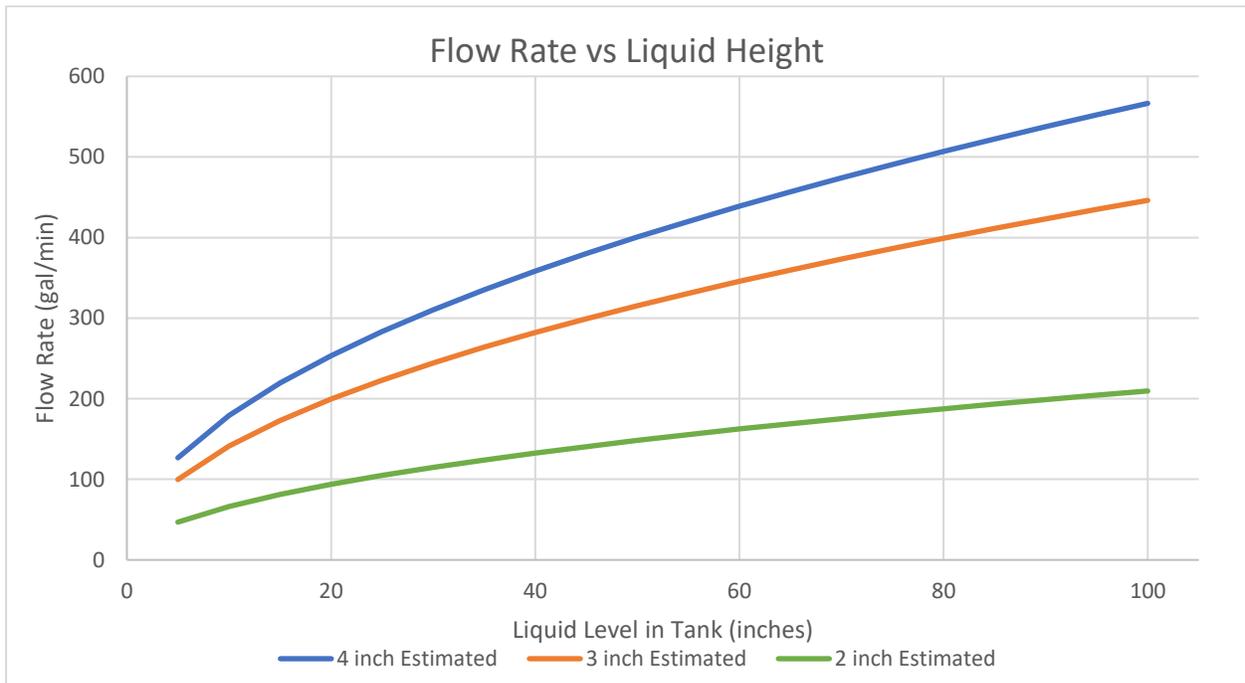


Figure 3-1: Graph showing flow rate from 2", 3", and 4" valves for various liquid levels in tank.

3.2 Lateral Discharge

Lateral discharge was measured as distance from valve face to furthest point where liquid splashes above the surface of the floor (Figures 3-2, 3-3, and 3-4).



Figure 3-2: Lateral discharge for 2" valve at liquid level of 70".



Figure 3-3: Lateral discharge for 3" valve at liquid level of 70".



Figure 3-4: Lateral discharge for 4" valve at liquid level of 70".

3.3 Spill Area

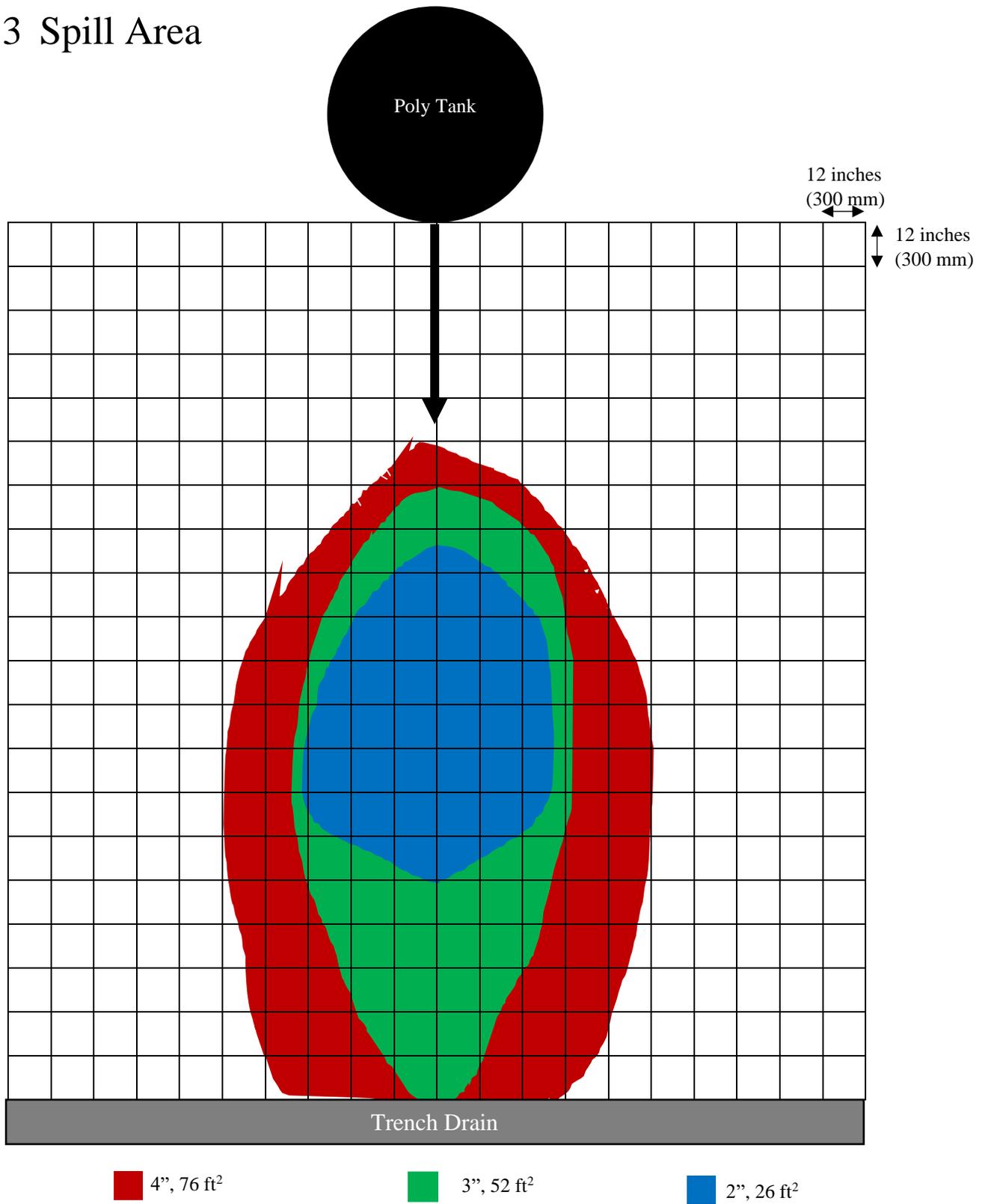


Figure 3-5: Maximum Spill Area for 2", 3", and 4" Valves

4 Conclusion

Based on testing results the following standoff distances are recommended for each tanker truck valve size. Standoff distance should be adjusted based on all possible locations and orientations of truck valve and hoses used for unloading.

The floor width should account for all possible parking positions of the tanker truck as well as the location of the tank which will be unloaded into. The potential failure of a hose and the location and size of the hose should be considered in design as well.

To reduce the required standoff distance, the Safespill floor can be designed with elevated trench drain lids. These lids (Figure 4-1) are elevated 1" (25 mm) above the surface of the floor profiles and allow high velocity liquid traveling along the top surface of the floor profiles to drain directly into the trench drain. The reduced standoff distances are listed in Table 4-1.

Table 4-1: Standoff Distances for Tanker Truck Unloading Floors

| | 2" Valve | 3" Valve | 4" Valve |
|---|----------|----------|----------|
| Lateral Discharge Standoff, ft (m) with Flat Trench Drain Lids | 16 (4.9) | 20 (6.1) | 20 (6.1) |
| Lateral Discharge Standoff, ft (m) with Elevated Trench Drain Lids | 10 (3.0) | 10 (3.0) | 10 (3.0) |

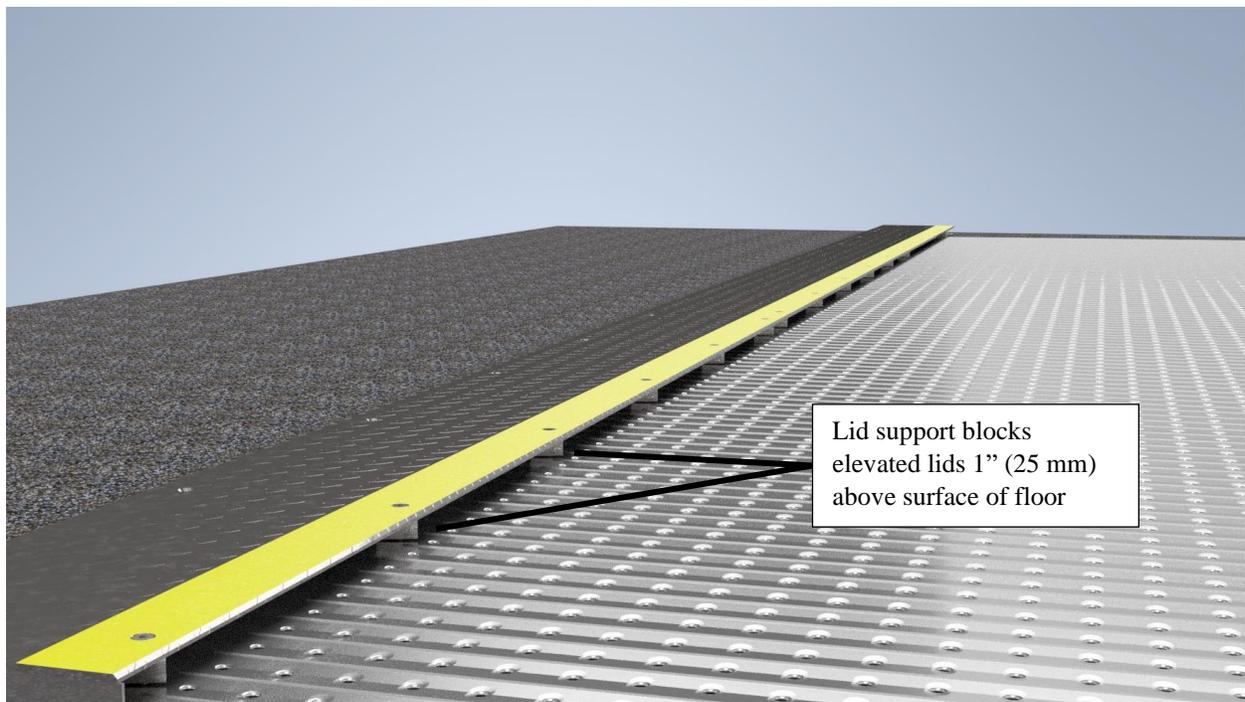


Figure 4-1: Trench drain lids elevated 1" (25 mm) above floor surface to allow liquid to flow directly into trench drain

Appendix A: Substantiation for Tanker Truck Variables

For tanker truck valve testing, four variables are needed to accurately recreate a failure and subsequent spill:

- Valve Opening Size
- Valve Height from Ground (Top surface of floor)
- Valve Orientation (Horizontal or vertical)
- Pressure Head

The following summarizes research on the variables listed above:

Valve Opening Size

In American Petroleum Institute Recommended Practices 1004 [1], it is stated that “the adapter must have a product opening 4 in. (101.6 mm) in diameter at the exposed outer face or closure of the valve.”

In a Dow Chemical document [2], a 3” Unloading Connection is shown. The document also states “that only Department of Transportation specification MC 304 or 307 tank trucks be used.” No other loading or unloading connections are shown.

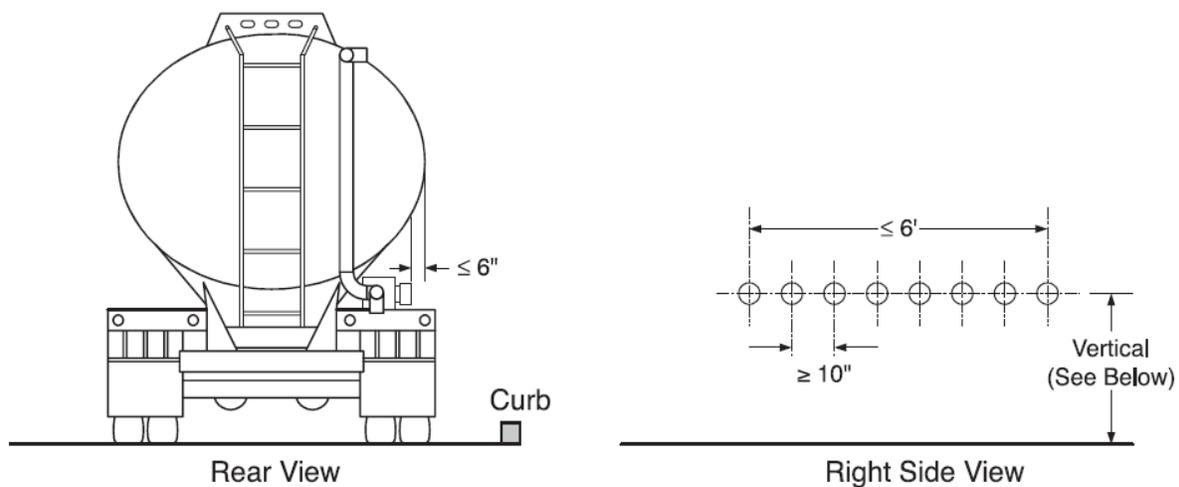
In a Brenner Tank Trailer Product Data Sheet [3], a MC-307/DOT-307 tank trailer is detailed. Listed under “Outlet Valve” is “(1) 3” SS QRB Hydrolet with 90° threaded outlet”

From this information, it is concluded that valve sizes of 3” or 4” should be tested.

Valve Height from Ground

API RP 1004 [1] provides the following requirements, which are summarized simply in the figure below, on vertical height of tank adapters.

“The tank vehicle adapters must be installed on centers that are not more than 4.5 ft (1.37 m) above grade when the vehicle tank is empty and not less than 2 ft (0.61 m) above grade when the tank is full. Experience indicates that for ease of loading, a height of not more than 3.75 ft (1.14 m) and not less than 2.75 ft (0.84 m) is desirable.”



| Vertical Dimensions | | |
|----------------------|------------------|--------------------|
| ≤ 4.5' | When empty (max) | 54" |
| 3.75' to 2.75' | Desired Range | 45" *39" 33" |
| ≥ 2' | When full (min) | 24" |

* Midpoint of desirable range

Figure A-1: Description of tanker truck valve positioning from API RP 1004 [1].

Valve Orientation

In most images showing tanker unloading, valves are shown as oriented in a horizontal position.

In a Brenner Tank Trailer Product Data Sheet [3], a MC-307/DOT-307 tank trailer is detailed. Listed under “Outlet Valve” is “(1) 3” SS QRB Hydrolet with 90° threaded outlet, pointed toward rear.”

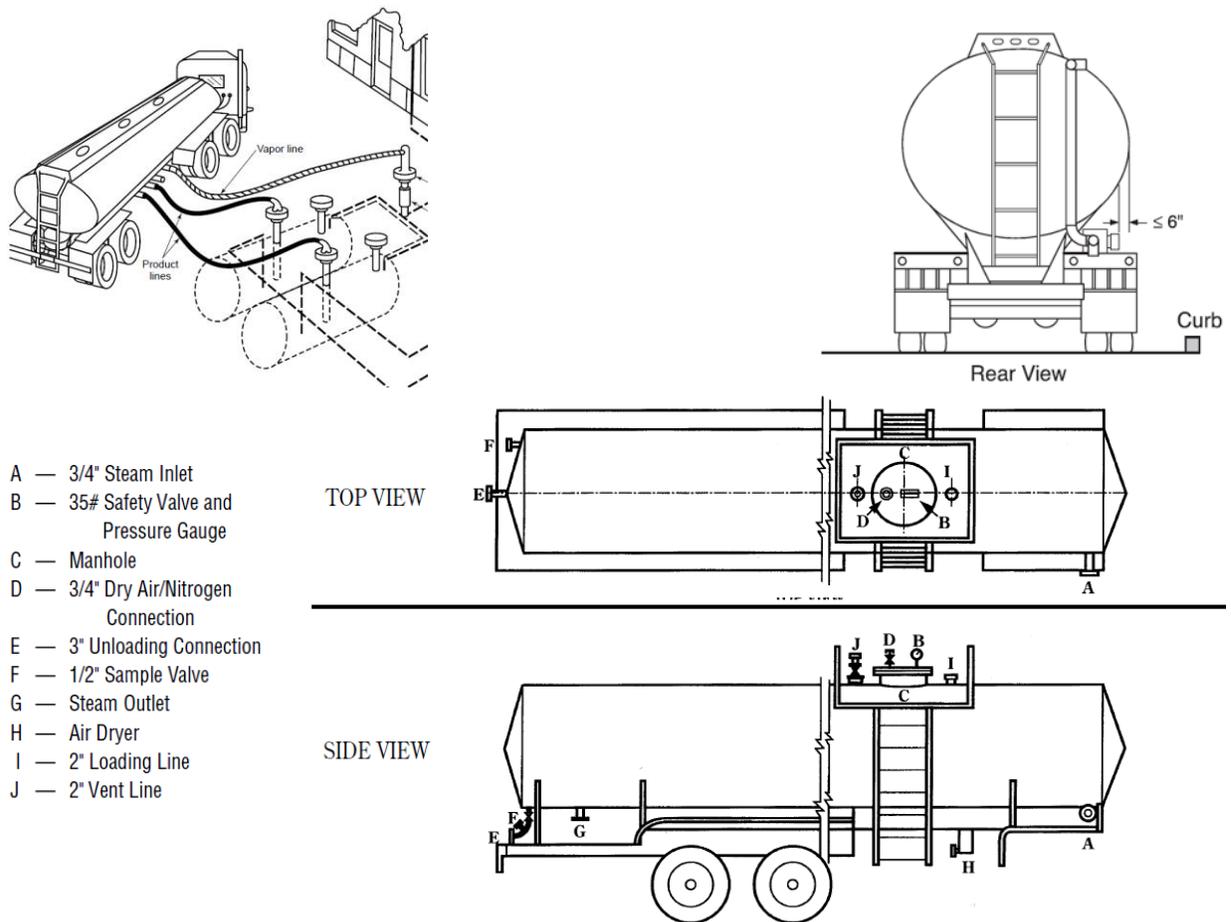


Figure A-2: Drawings of multiple tanker trucks with horizontal unloading valves [1, 2].

Pressure Head

This variable is difficult to narrow down to a single value or series of values. The height of the tank truck can easily be determined and therefore the vertical height of volume can be found. However, many different flammable liquids could be loaded or unloaded from a tanker truck, all with varying densities and viscosities. So an approximate baseline must be used. Water with a pressure head of 70" (1.8 meters) will be used for all testing.

The Brenner Tank Trailer (MC-307/DOT-407) [3] has a tank with a 76" diameter, so a 76" pressure head is approximated.

References

1. API Recommended Practice 1004, "Bottom Loading and Vapor Recovery for M-306 & DOT-406 Tank Motor Vehicles," *8th edition*. **American Petroleum Institute**. January 2003.
2. "Voramate T-80, Toluene Diisocyanates, Tank Truck Unloading Procedures," **The Dow Chemical Company**. April 2000.
3. "Brenner Tank Trailer (Stainless Steel)," *Product Data Sheet*. **Baker Corp.** January 2007. Seal Beach, California.